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(54) **TRANSMISSION AND RECEIVER SYSTEM OPERATING ON MULTIPLE AUDIO PROGRAMS**

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(*) Notice: This patent is subject to a terminal disclaimer.

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(22) Filed: **Dec. 14, 2012**

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H04H 20/26	(2008.01)
H04H 60/13	(2008.01)

(52) **U.S. Cl.**

CPC ***H04H 20/26*** (2013.01); ***H04H 60/13*** (2013.01)

USPC **455/150.1**; 348/725; 348/468; 709/219; 370/392; 370/395.64

(58) **Field of Classification Search**

CPC H04H 20/26; H04H 60/13; H04H 60/25; H04B 1/18

USPC 455/150.1, 156.1, 186.1, 161.1, 158.1; 348/725, 468; 709/219; 370/392, 370/395.64

See application file for complete search history.

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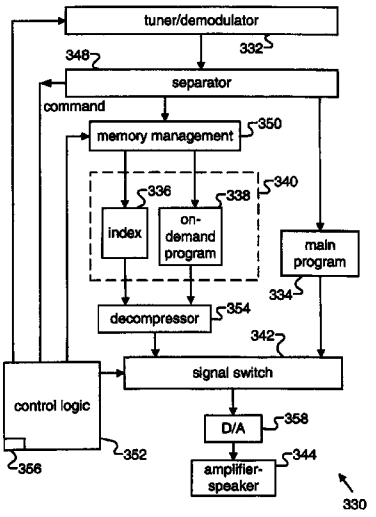
(Continued)

Primary Examiner — Marceau Milord

(57) **ABSTRACT**

A receiver contains a demodulator system that can extract digital data from wireless radio frequency signal. The digital data contains two sets of compressed digital audio data corresponding to two audio programs. The receiver also contains two decompressors. If a user selects a first audio program, a first compressor is used to decompress a first set of compressed digital audio data. If a user selects a second audio program, a second decompressor is used to decompress a second set of compressed digital audio data. The wireless radio frequency signal can be transmitted using a transmitter.

12 Claims, 7 Drawing Sheets



Related U.S. Application Data

7,369,824, which is a continuation of application No. 10/364,554, filed on Feb. 12, 2003, now Pat. No. 6,904,270, which is a continuation of application No. 09/496,528, filed on Feb. 2, 2000, now Pat. No. 6,600,908.

(60) Provisional application No. 60/118,540, filed on Feb. 4, 1999, provisional application No. 60/120,923, filed on Feb. 22, 1999, provisional application No. 60/140,742, filed on Jun. 25, 1999, provisional application No. 60/144,259, filed on Jul. 19, 1999.

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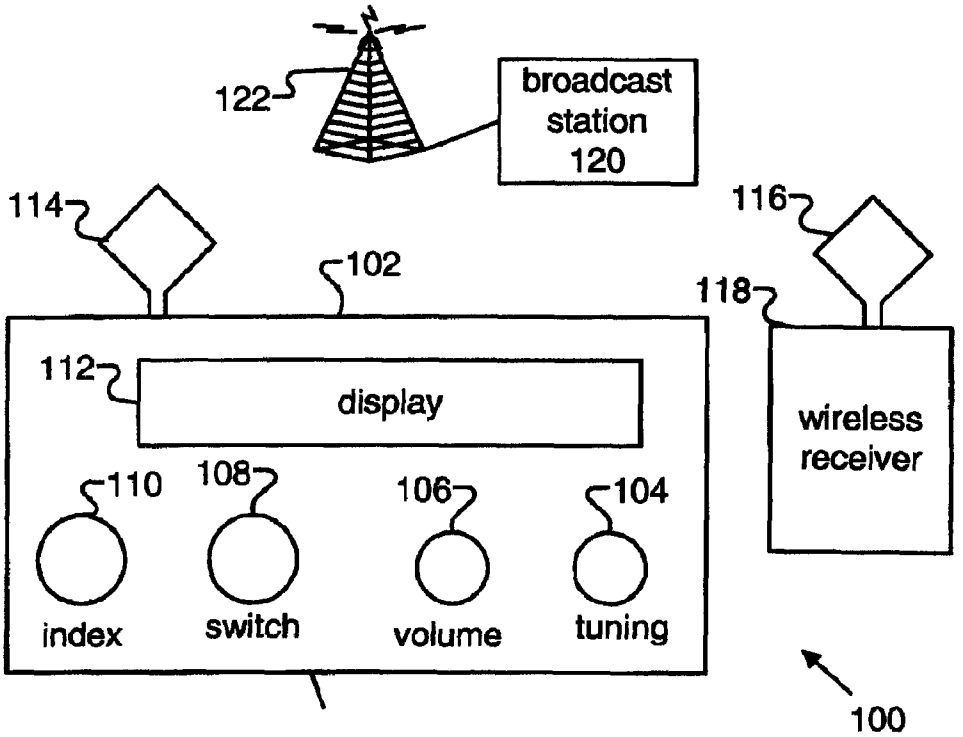
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tuning
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Fig. 1

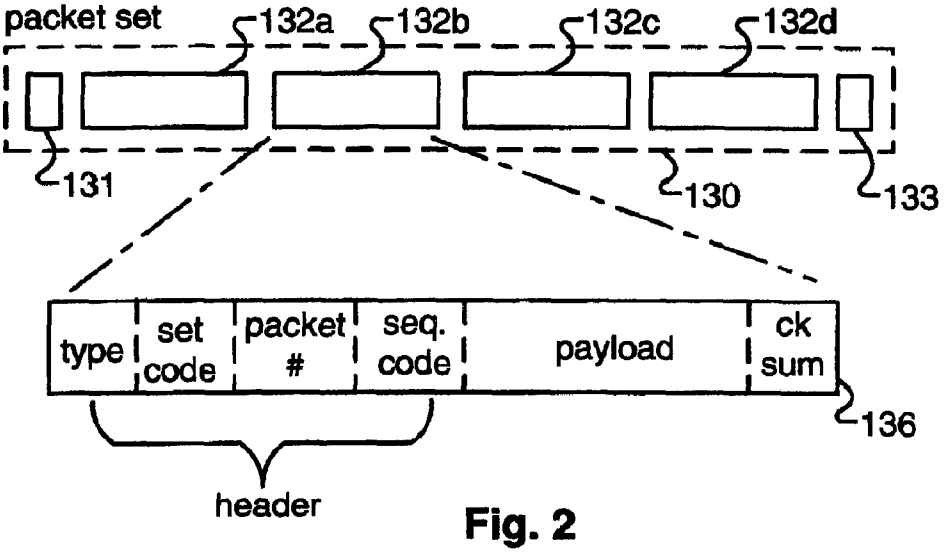
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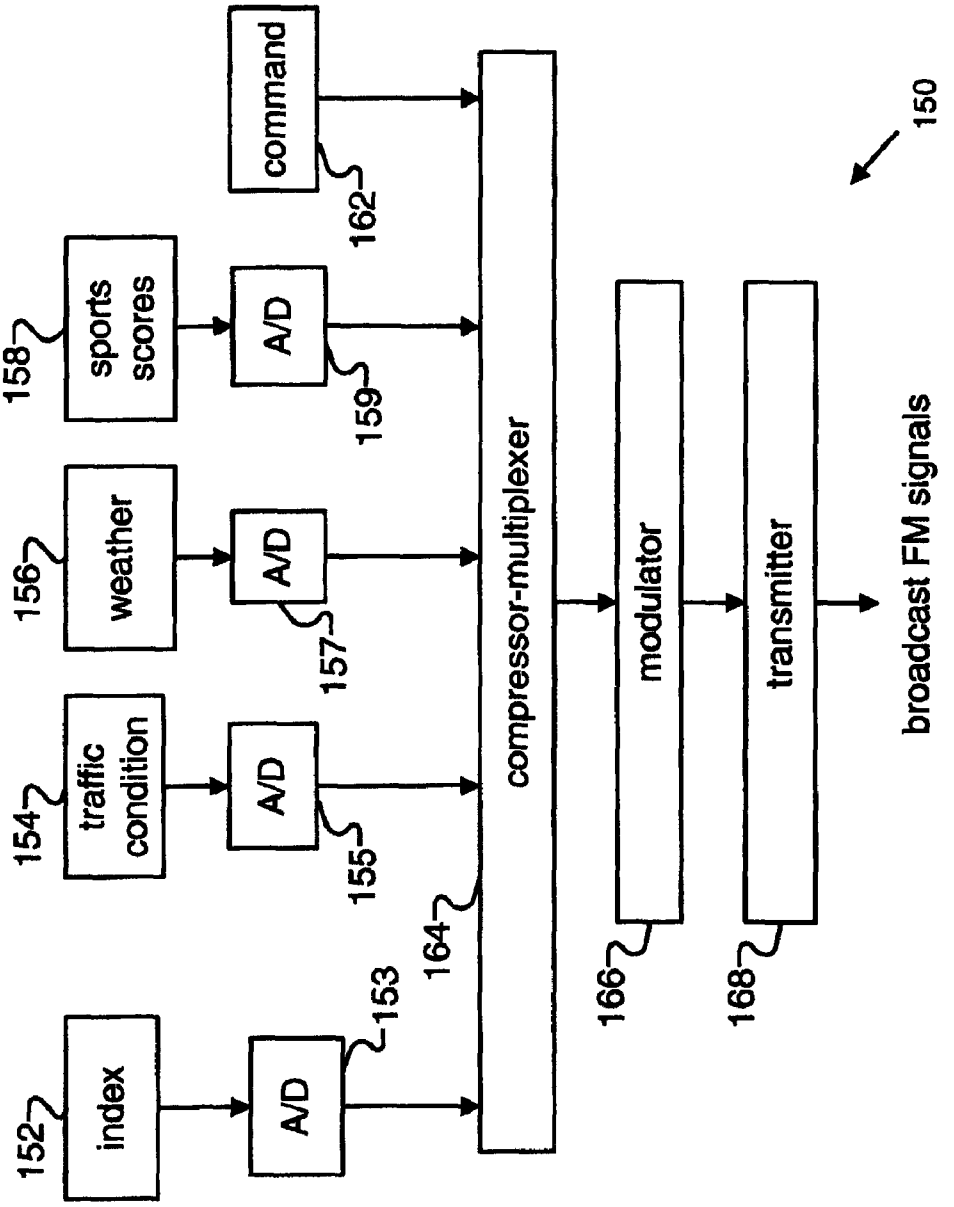
Fig. 2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A/D
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A/D
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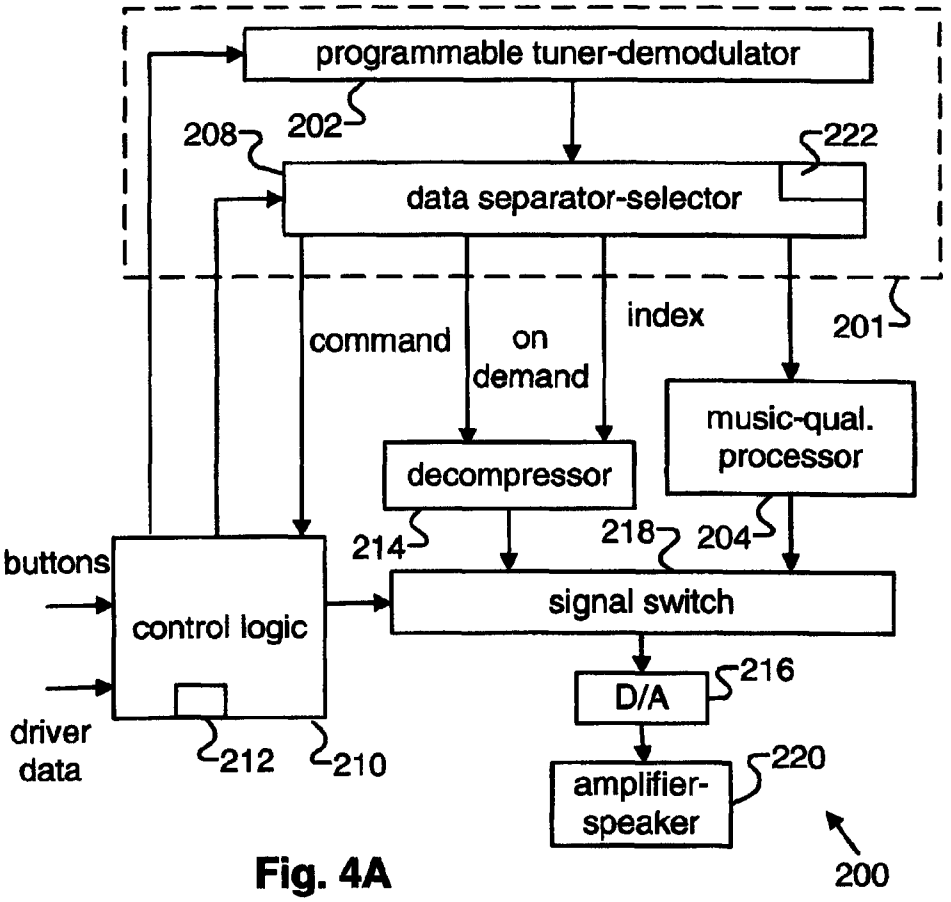
compressor-multiplexer
164
modulator
166
transmitter
168
broadcast FM signals
150

Fig. 3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index
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decompressor
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control logic
signal switch
D/A
216
driver data
212
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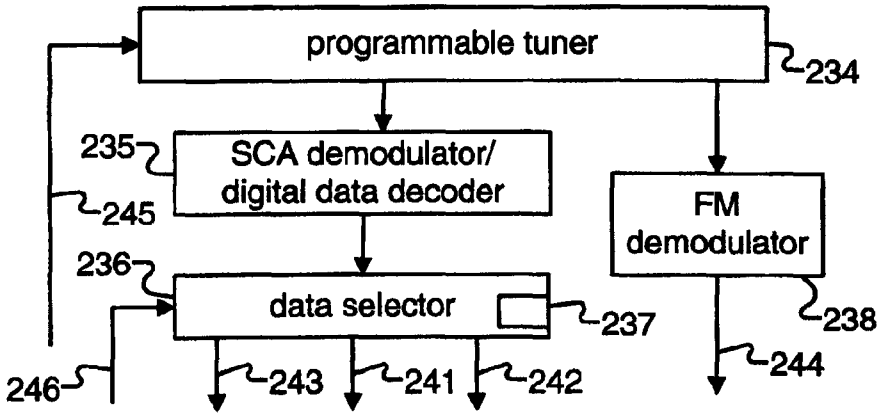
amplifier-speaker
220
200

Fig. 4A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SCA demodulator/ digital data decoder
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FM demodulator
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data selector
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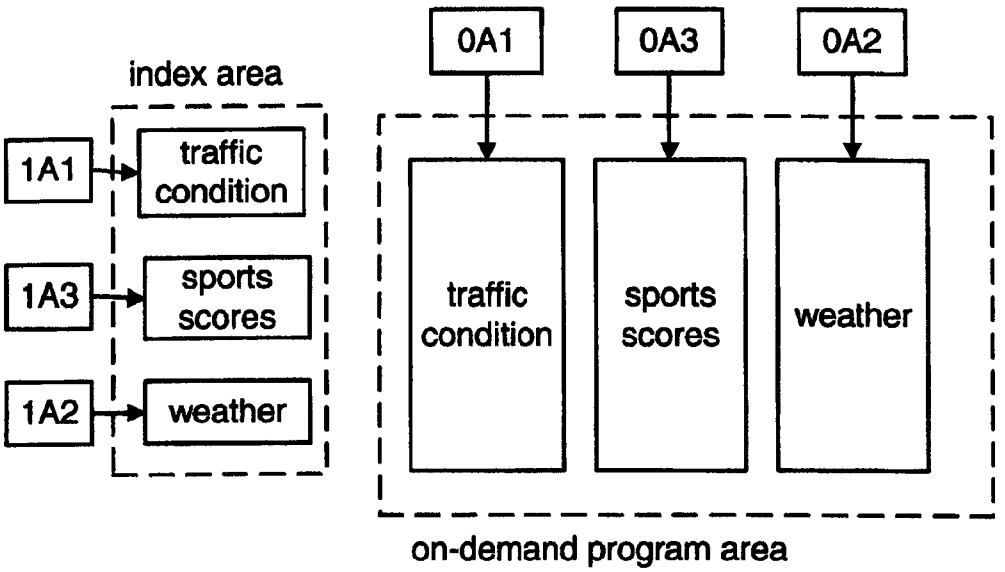
243
241
242
244

Fig. 4B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1A3
sports scores
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weather
0A1
0A3
0A2
traffic condition
sports scores
weather
on-demand program area

Fig. 6

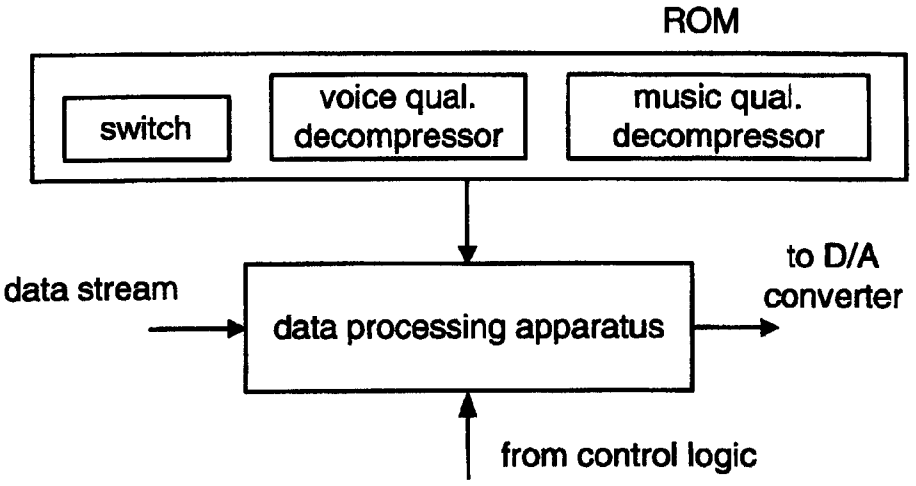
ROM
switch
voice qual. decompressor
music qual. decompressor
data stream
data processing apparatus
to D/A converter
from control logic

Fig. 4C

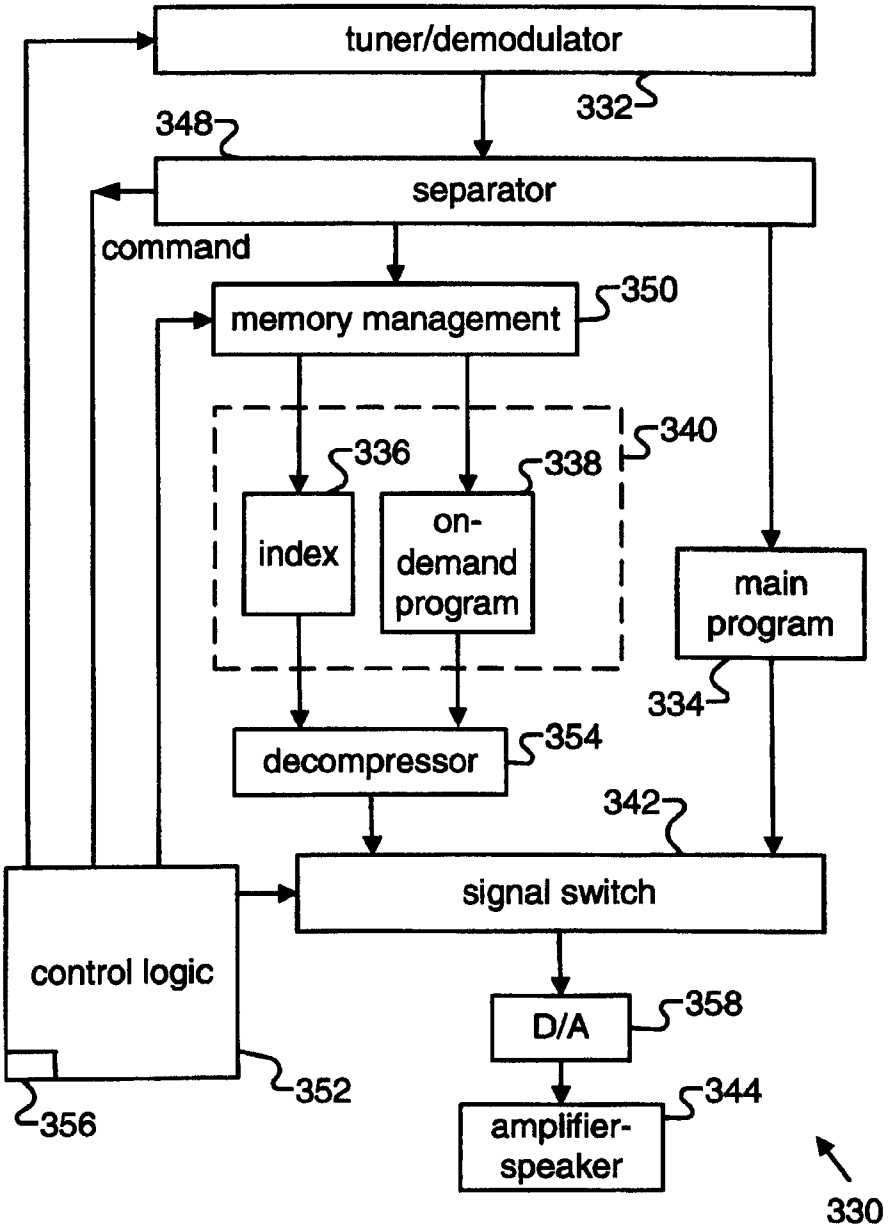
tuner/demodulator
332
348
separator
command
memory management
350
340
336
338
index
on-demand program
main program
334
decompressor
354
342
signal switch
control logic
D/A
358
352
356
amplifier-speaker
344
330

Fig. 5A

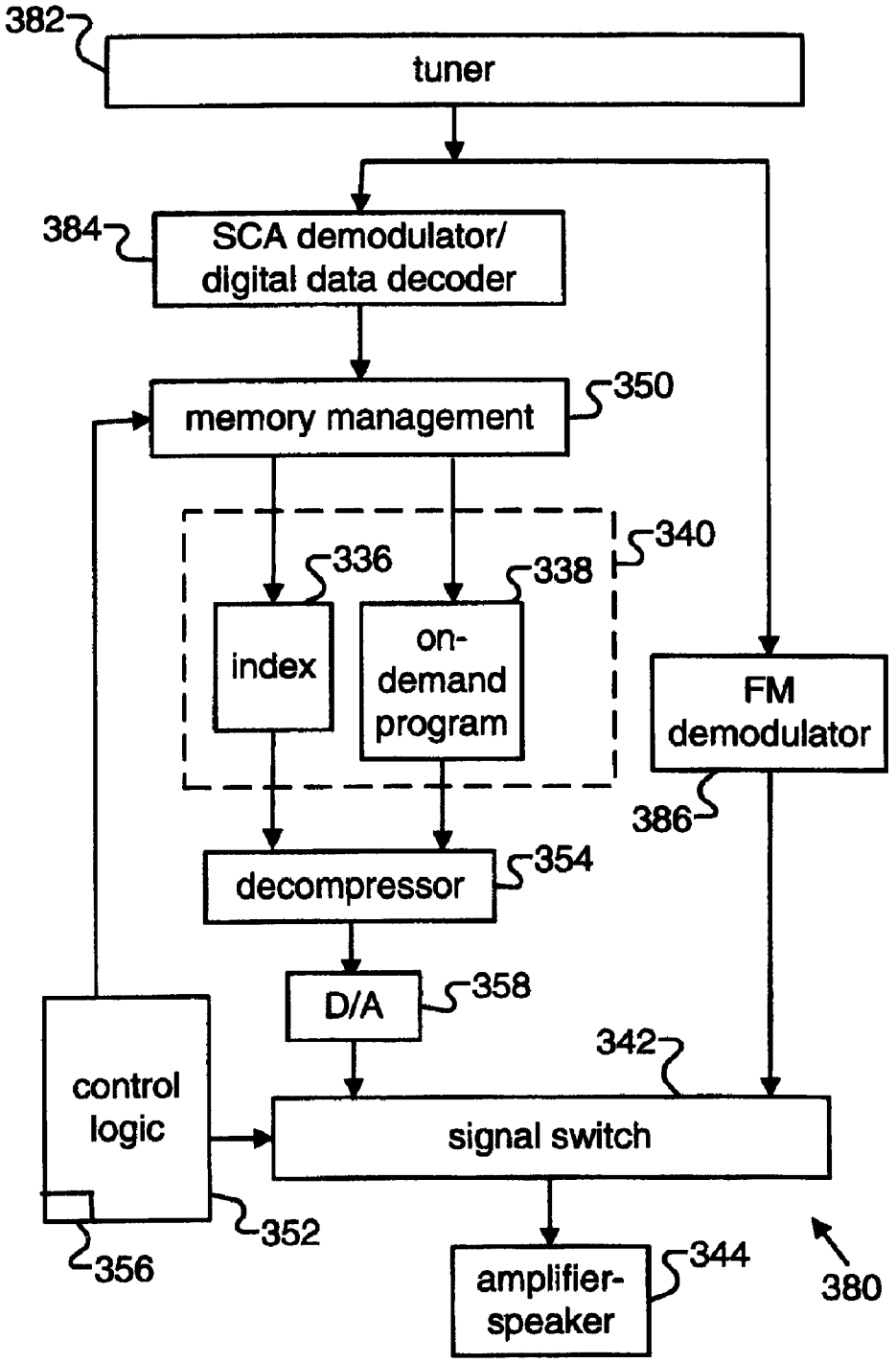
382
tuner
384
SCA demodulator/
digital data decoder
memory management
350
340
336
338
index
on-
demand
program
FM
demodulator
386
decompressor
354
D/A
358
342
control
logic
signal switch
352
356
amplifier-
speaker
344
380

Fig. 5B

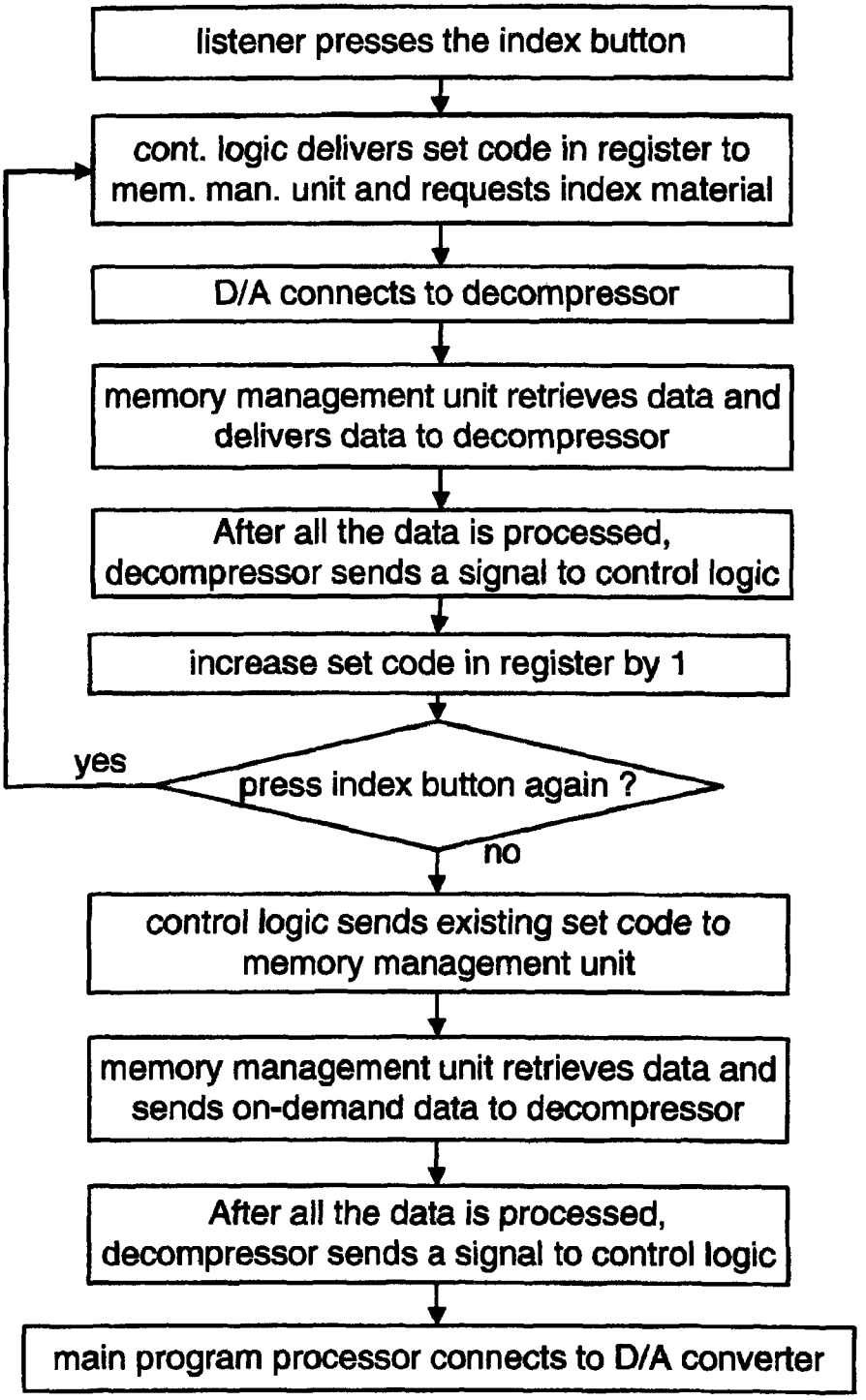
listener presses the index button
cont. logic delivers set code in register to mem. man. unit and requests index material
D/A connects to decompressor
memory management unit retrieves data and delivers data to decompressor
After all the data is processed, decompressor sends a signal to control logic
increase set code in register by 1
yes
press index button again ?
no
control logic sends existing set code to memory management unit
memory management unit retrieves data and sends on-demand data to decompressor
After all the data is processed, decompressor sends a signal to control logic
main program processor connects to D/A converter

Fig. 7

TRANSMISSION AND RECEIVER SYSTEM OPERATING ON MULTIPLE AUDIO PROGRAMS

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of patent application Ser. No. 12/034,566, filed Feb. 20, 2008 now abandoned, which is a continuation of patent application Ser. No. 11/145,136, filed Jun. 3, 2005, now U.S. Pat. No. 7,369,824, which is a continuation of patent application Ser. No. 10/364,554, filed Feb. 12, 2003, now U.S. Pat. No. 6,904,270, which is a continuation of patent application Ser. No. 09/496,528, filed Feb. 2, 2000, now U.S. Pat. No. 6,600,908, which claims the benefit of U.S. Provisional Application Ser. Nos. 60/118,540, filed Feb. 4, 1999, 60/120,923, filed Feb. 22, 1999, 60/140,742 filed Jun. 25, 1999 and 60/144,259 filed Jul. 19, 1999. All these provisional and nonprovisional patent applications are incorporated herein by reference.

BACKGROUND OF THE INVENTION

This invention relates to broadcasting, and more specifically to a broadcasting system that allows a listen to receive, on demand, selected information from a receiver.

Radio and television (TV) receivers are the most widely available entertainment devices in the world. Almost every car has a radio receiver. Radio receivers may also be found in offices, restaurants, etc. Almost every home in U.S. has a TV.

A conventional receiver contains a tuner that can be tuned to broadcast stations, each of them transmits signals at a predetermined radio frequency. In order to attract listeners, many broadcast stations concentrate on predetermined types of program materials. For example, some radio stations spend 80% of broadcast time on news while other stations spend 90% of broadcast time on music. Thus, music lovers would tune to a "music" radio station and news lovers would tune to a "news" station. Similarly, TV stations broadcast movies, sports, news, etc. at pre-scheduled times to match the viewing habit of most viewers. However, the interest of listeners/viewers may change briefly during the day. For example, a music lover may be interested in stock reports (e.g., Dow Jones average) in late afternoon (after the close of the stock exchanges) because he/she owns stocks. Many music stations do not announce stock reports. Thus, the music lover has to switch to a news station because many news stations announce stock reports at more frequent intervals (e.g., once every fifteen minutes). It is unlikely that the switch is made at the exact time when a stock report is announced. Thus, the music lover would have to listen to other news (which may be irrelevant to him/her) for a few minutes. Afterwards, the music lover has to switch back to the original music station. Similarly, almost all TV stations broadcast stock reports only during news programs. Thus, the viewer has to turn to other media (e.g., radios) to obtain the reports. This is frustrating for listener/viewers. It is also undesirable to the broadcast stations because they would like to keep their listeners tuned in all the time.

SUMMARY OF THE INVENTION

The present invention relates to a broadcast system that can provide, on demand, useful information to users. A broadcast station transmits radio frequency signals containing on-demand, main program, and (optional) index materials to a plurality of receivers. The receivers contain means for separating the on-demand (and also the index) materials from the main program material. The receivers contain a signal switch for selecting one of the materials. A user can decide to listen to any of these materials by pressing a button. The receivers contain control logic that can direct the signal switch to select the desired material. After the on-demand material is played, the signal switch automatically switches back to the main program material.

These and other features and advantages of the present invention are described by the following detailed description of the preferred embodiments together with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram showing a broadcasting system of the present invention.

FIG. **2** shows the structure of data packets of the present invention.

FIG. **3** is a block diagram of a transmitter system of the present invention.

FIGS. **4**A and **4**B are schematic diagrams of an electrical portion of a receiver of the present invention.

FIG. **4**C shows another embodiment of a portion of the electrical portion of the present invention.

FIGS. **5**A and **5**B are schematic diagrams of another embodiment of an electrical portion of a receiver of the present invention.

FIG. **6** is a schematic diagram of the logical structure of a memory device of the present invention.

FIG. **7** is a flow chart showing the operation of a receiver of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention comprises a novel broadcast based information on demand system and related methods. The following description is presented to enable any person skilled in the art to make and use the invention. Description of specific applications is provided only as examples. Various modifications to the preferred embodiments will be readily apparent to those skilled in the art, and the general principles defined herein may be applied to other embodiments and applications without departing from the spirit and scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

FIG. **1** is a schematic drawing showing a broadcasting system **100** of the present invention. System **100** contains a broadcast station **120** broadcasting radio frequency signals using an antenna **122** to a plurality of receivers. In FIG. **1**, two receivers **102** and **118** are shown. Broadcasting station **120** broadcasts several program materials to the receivers: a main program material and one or more "audio information on demand" (or simply "on-demand") program materials. Broadcasting station **120** may also broadcast an index to the on-demand program material. The on-demand program materials are information (to be rendered in audio form) that is announced to a listener at the time requested by the listener.

The main program material is material that is of interest to the majority of listeners most of the times. Preferably, most of the broadcasting resources and bandwidth are devoted to broadcasting the main program material. As an example, the main program material of a "music" station consists of music together with occasional announcements and advertisements. Listeners are typically interested in the on-demand information during some of the times. For example, some listeners of the music station may be interested in traffic condition during rush hours and other listeners may be interested in sports scores after sports events. Thus, the on-demand materials of broadcast station **120** consist of traffic condition information and sports scores information.

In some situation, broadcast station **120** may broadcast commands to the radio receivers. These commands instruct the receivers to perform certain tasks. They are not intended to be heard by listeners.

The structure of the receivers is substantially the same, and only receiver **102** is described in detail here. Receiver **102** contains an antenna **114** for receiving radio frequency signals broadcasted by various broadcast stations (including station **120**). A listener can tune to one of the broadcast stations using a tuning button **104**. The listener can use a volume button **106** to adjust the volume level of sound produced by a loudspeaker (not shown). Volume button **106** can also be used to turn on and turn off receiver **102**. Receiver **102** contains an index button **110** for allowing the listener to select the type of on-demand program materials. A switch button **108** is provided so that the listener can switch between the main program material and the on-demand program material selected using index button **110**. A display **112** may optionally be provided to show the status of radio receiver **102** (such as the frequency of the tuned station and the name of the selected on-demand program material). Noted that it may be possible to use a single button to perform more than one function. Further, one of the switch and index buttons may be eliminated (as explained in more details below). In addition, some of the functions may be performed using other means. For example, a voice-activated system or a remote controller can be used in place of buttons. Thus, the buttons in FIG. **1** are shown for illustrative purpose only.

In the present invention, a music station can devote almost all the main program material on music, and does not need to interrupt the music to broadcast other information (e.g., traffic condition during rush hours). If the listener is interested in traffic condition (or weather), he/she can select the on-demand program material for traffic condition (or weather) using index button **110**. Anytime the listener wishes to listen to the traffic condition (or weather), he/she can press switch button **108**, and radio station **102** will announce the most current information on traffic condition (or weather). After the announcement, radio receiver **102** automatically switches back to the main program material (if desired). Compared to conventional broadcasting systems, this system is more useful to the listener because it is convenient and the information can be obtained on demand Broadcast stations also like this system because listeners can stay at the same station all the time and there is no need for the listener to tune to a competing broadcast station (e.g., news station).

In the present invention, the main program material may be analog or digital. However, the on-demand program material and the associated index material are encoded as digital data. In addition, broadcast station **120** may broadcast commands to instruct radio receivers to perform certain tasks. The data and the commands are preferably transmitted as data packets. FIG. **2** shows the structure of the packets of the present invention. The packets can be grouped into sets. For example, the packets for "weather" can be grouped into one set and the packets for "sports" can be grouped into a second set. The structure of an exemplary set is shown as **130** in FIG. **2**. It preferably comprises a start packet **131**, a plurality of content packets (such as packets **132**a-**132**d), and an end packet **133**. The start packet indicates the starting point of a set. It preferably contains other information about the set (such as the total number of packets in the set). The content packets contain the commands or digitized audio data. The end packet preferably contains an error detection index, such as the checksum of all the packets in the set. These three types of packets can be distinguished using conventional methods (e.g., by assigning a "type" field to each packet).

An exemplary packet **136** is shown in FIG. **2**. Packet **136** contains a header, a payload, and an error detection code (such as a check sum of this packet). The header packet preferably contain four fields: The first field ("type") is used to indicate whether it is a start, content, or end packet. The second field ("set code") is used to distinguish between different sets within the type (e.g., set 1 represents traffic condition, set 2 represents weather, etc.). This field may also have an optional subfield to indicate whether the set is on-demand, index, or command materials. The third field (packet #") indicates the position of the current packet within the set (e.g., the fifth packet within a set of ten packets). This field is optional if the delivery mechanism is reliable or if the set contains only one packet (e.g., a command can normally be carried in one packet). However, if some of the packets need to be retransmitted (e.g., they contain error) or are out of order, this field allows the receiver to more easily reassemble the data. Note that other fields may also be added to the packets.

On-demand program packets may optionally contain a field for a sequence code. An example (e.g. "weather") is used here to illustrate the usage of the sequence code. Weather information is typically updated once every one to two hours. Thus, the same information remains unchanged until new update is received. Thus, the on-demand program packets used to deliver the same weather information are assigned the same sequence code. After the weather information is updated, the new set of on-demand program packets for the new announcement is assigned another (e.g., the next) sequence code. The application of the sequence code will be further described below.

The content of the digital data in the payload varies with the type of packets. If the packet is a start packet, the payload preferably contains overall information about the set (e.g., the total number of packets in the set). If the packet is a content packet, the payload contains digitized audio data. If the packet is an end packet, the payload preferably contains a check sum. If the packet is a command packet, the payload contains an instruction to the receivers. An exemplary instruction is to ask the receivers to tune to a new station having a certain frequency.

In the following description, it is assumed (for illustrative purpose only) that there are three kinds of on-demand program materials: traffic condition, weather, and sports scores. The "set code" of the packets contains a code for these kinds (e.g., "A1" for traffic condition, "A2" for weather, "A3" for sports scores, etc.). Each kind of on-demand program is optionally associated with an index packet. If this is the case, the "set code" contains a subfield to distinguish between on-demand content and index packets. For example, "0A1" and "1A1" are used to designate weather-on-demand content and weather-index data, respectively.

The payload of each index packet contains compressed audio data of the name of the corresponding on-demand pro-

gram. For example, the payload of the index packet for "traffic condition" contains compressed audio data of a human voice for the words "traffic condition." The payload of the on-demand program packets contains compressed audio data of the information carried by the program. For example, the payload of the "traffic condition" packet contains compressed audio data of a human voice describing the traffic condition on various highways.

FIG. **3** is a block diagram of the structure of a transmitter system **150** of the present invention located in broadcast station **120**. Transmitter system **150** contains analog source material **152** for the index. This material is the human voice for the words used in the various index packets. The source material is digitized using an analog-to-digital (A/D) converter **153**. Similarly, analog source materials **154**, **156** and **158** for on-demand program materials are human voice for the corresponding on-demand information. They are digitized using A/D converters **155**, **157**, and **159**, respectively. Command material **162** may also be included. Because the command material is digital in nature, it does not need to be converted. The digital data is sent to a compressor-multiplexer **164** that compresses some or all of the digital data (if needed), encapsulate the compressed data in packet form, and combine the packets into a single serial data stream. The data stream is delivered to a modulator **166** that modulates a radio frequency carrier. The radio frequency signal is transmitted using a transmitter **168**.

The index and on-demand program materials are preferably interleaved to take into account of user expectations. For example, the complete set of index packets is preferably transmitted once every one to two seconds. Thus, a listener does not have to wait for too long after pressing index button **110** to listen to the index. In addition, it is known that digital packets corresponding to audio signals need to be delivered to a receiver within certain time intervals (e.g., 120 mini-second between two packets) to maintain normal audio flow. Thus, the packets should be arranged carefully.

An implementation of the present invention in a digital radio broadcast system is now described. In this implementation, all the program materials (main, on-demand and index) broadcasted by broadcast station **120** are in digital format. The main program material is preferably compressed prior to broadcasting in order to reduce bandwidth demand. Because the main program material may contain music, it is important to preserve the high fidelity quality of the original source. Consequently, a music quality compressor (with relatively low compression ratio) is preferably used. On the other hand, the on-demand program and index materials contain mostly voice, and may be compressed using a high compression ratio algorithm.

FIG. **4**A is a schematic diagram of an electrical portion **200** of radio receiver **102** of the present invention. It contains a digital data extractor **201** that comprises a programmable tuner-demodulator **202** and a data separator-selector **208**. Tuner-demodulator **202** can be used by a listener to select a broadcast station. It also demodulates the tuned radio frequency signals and delivers a stream of digital data to a data separator-selector **208**. As explained below, the programmable feature of tuner-demodulator **202** is optional. Data separator-selector **208** delivers the main program material to a music-quality processor **204**. In this embodiment, processor **204** performs decompression function. In one embodiment of the present invention, the main program material is compressed using a music quality compression algorithm called the Motion Picture Experts Group Layer 3 Audio ("MP3"). Note that other high quality compression algorithms may be used. Data separator-selector **208** also decapsulates the packets of the present invention and selects the command material, index material or on-demand program material. The selection is controlled by a control logic **210**.

Control logic **210** is connected to appropriate button(s) of receiver **102** shown in FIG. **1**. Thus, it translates the selection of a listener into actions by receiver **102**. If index button **110** is pressed, control logic **210** instructs data selector **208** to select index material. The selected index material is delivered to a decompressor **214** which processes the voice data in real-time. The decompressed voice data is delivered to a signal switch **218**. At the same time, the set code (e.g., A1) of the selected index material is stored in a register file **212** of control logic **210**. Control logic **210** instructs signal switch **218** to connect decompressor **214** to a digital-to-analog converter **216**, which is in turn connected to an audio output device (such as an amplifier-speaker **220**). Depending on the index material selected by data selector **208**, the appropriate sound signal (e.g., the words "traffic condition") is deliver to amplifier-speaker **220**. Consequently, the listener can hear the sound "traffic condition" from the speaker.

While decompressor **214** is processing the voice data, data selector **208** can continue to receive other index packets. The digital data for each index materials can optionally be stored in a memory **222**. The size of memory **222** should be small because the number of index materials and their sizes are small. This could speed up the response time for the index material because the data is already stored in memory **222**.

If the listener presses index button **110** again within a predetermined time interval (e.g., one to two seconds), it is likely that the listen wishes to listen to other information. Thus, the above-described steps for selecting another index are repeated. Specifically, control logic **210** instructs data selector **208** to select a new index material. Data selector **208** can determine whether an index material is new by using the set codes that have been previously stored in register file **212**. Alternatively, this information can be stored in memory **222**. The new index material is delivered to decompressor **214**. The word "weather" is pronounced by amplifier-speaker **220**. The new index code is stored in register file **212**.

If the listener does not press index button **110** again within the predetermined time interval, control logic **210** assumes that the listener has made a selection. Control logic **210** then sends to data selector **208** the selected set code and a request that the corresponding on-demand program material be selected. Data selector **208** delivers the corresponding on-demand program material to decompressor **214**. Control logic **210** directs signal switch **218** to connect decompressor **214** to D/A converter **216**. The selected on-demand program (e.g., traffic condition) is played on amplifier-speaker **220**. When all the data is processed (indicated by an "end" packet), decompressor **214** sends a notification to control logic **210**. Control logic **210** directs switch **218** to connect music quality processor **204** to D/A converter **216**. As a result, the main program material is automatically played again.

Subsequent to the selection by index button **110**, the listener can press switch button **108** anytime he/she wishes to listen to the selected on-demand program material instead of the main program material. Control logic **210** sends to data selector **208** the set code stored in register file **212** and a request for on-demand program material. Control logic **210** also directs signal switch **218** to connect decompressor **214** to D/A converter **216**. After the on-demand program is played (as indicated by an end packet), decompressor **214** sends a notification to control logic **210**. Control logic **210** then directs switch **218** to connect music quality processor **204** back to D/A converter **216** again.

The human voice used in the index and on-demand program materials is preferably compressed using parametric-type compression algorithms These algorithms deliver human voice of reasonable quality using very low bandwidth. An example of such an algorithm is one described under International Telecommunication Union's Recommendation G.723.1. It can deliver telephone quality sound at 5.3 or 6.3 kilobits per second. Other compression algorithm could also be used.

It should be noted that music-quality processor **204** and decompressor **214** could be software algorithms executed by the same data processing apparatus. FIG. **4**C shows an embodiment in which software modules are used to perform the operation of decompressor **214**, music-quality processor **204** and signal switch **218**. This embodiment contains a data processing apparatus (which could be a digital signal processor or a microcontroller) and a read-only memory (ROM). The ROM contains a switch module, a voice quality decompressor and a music quality decompressor. The data stream from data separator-selector **208** of FIG. **4**A is delivered to the data processing apparatus. Depending on the signal from control logic **210**, the switch module in ROM will select either voice quality decompressor or music quality decompressor for execution. The decompressed data is delivered to D/A converter **216**.

In another embodiment of electrical portion **200**, each of decompressor **214** and music-quality processor **204** is connected to a separate D/A converter before connecting to switch **218**. These two D/A converters can be individually designed to take advantage of the different characteristics of the two decompressors. In this case, D/A converter **216** in FIG. **4**A is not needed.

There are broadcast stations that would like to offer many sets of on-demand program materials. However, the bandwidth assigned to a broadcast station is limited. One way to extend the number of sets is to use the bandwidth of more than one broadcast stations. Another way is to enlist the bandwidth of other frequency bands (such as the vertical and horizontal blanking intervals in the TV band, an unused TV band, or a narrow-band PCS). After data selector **208** of electrical portion **200** receives a command packet, it directs the packet to control logic **210**. If the command is an instruction to temporarily switch to a new broadcast station, control logic **210** first stores the frequency of the old station (e.g., station **120**) in register file **212**. It then instructs tuner **202** to switch to the new broadcast station requested by the command. As a result, additional on-demand program materials can be delivered to the listener using a similar method as described above. When the delivery of the on-demand program materials is completed, control logic **210** instructs tuner **202** to switch back to station **120** using frequency information stored in register file **212**. The switching operations are transparent to the listener. Note that a large number of stations can be accessed using this method. As a result, many sets of on-demand materials can be offered to the listener. Note that if this feature is not needed, tuner **202** does not need to be programmable.

In another embodiment of the present invention, there is no need to broadcast the index material, and consequently, there is no need to have an index button. This is because most on-demand program materials are easily identifiable by its contents. For example, it is easy to distinguish between a traffic condition announcement from a stock report announcement. In many cases, a listener can listen to just a few words, and can identify the kind of on-demand information. Thus, when the listener presses switch button **108** within a predetermined time interval (or while in the middle of an on-demand announcement), the next on-demand program material (e.g., weather) is selected. This is because the listener is likely to change selections if switch button **108** is pressed soon after a previous selection. However, if the listener presses switch button **108** in the middle of a main program, the previously selected on-demand program material is selected. This is because the listener is more likely to listen to the same selection of on-demand program if he/she had selected it before.

One aspect of the present invention is that the number, name and type of on-demand program materials are determined by the broadcast station and can be changed by the station at any time. There is no need to notify the listener before hand. This feature is different from some conventional systems in which the number, name and type of program materials are predetermined and cannot be changed. For these conventional systems, changes need to be pre-announced. A further aspect of the present invention is that the index materials can be announced in an audio form. There is no need for the listener to read display **112** to determine the name of the on-demand program. This feature is especially important when the listener is driving because it will be dangerous for the listener to read display **112**.

As mentioned above, the inputs to control logic **210** are preferably buttons **108** and **110**. An optional input to control logic **210** is the identity of the listener. This option is especially useful for automobile radios. Some automobile contains electrical adjustable seat positions and memory for storing the seat positions of several drivers. When a driver enters an automobile, he/she can press a seat-position selection button, and the seat will be set to a previously adjusted position. Thus, the seat position can be used as means for identifying individual drivers. Control logic **210** may use this button to set the preferred on-demand program material for individual driver. Thus, when the driver presses the seat-position button, the automobile can set the seat position and the on-demand program material (even though these settings have been changed by a previous driver). Thus, each driver can listen to his/her preferred on-demand program material without having to use the index button to re-select the on-demand program material.

An implementation of the present invention in a conventional analog radio broadcast system is now described. In this implementation, the main program materials is broadcasted using conventional AM and FM methods. However, the command, on-demand program and index materials are in digital format. For illustrative purposes, FM broadcast is described here, but the present invention may also be used in AM broadcast. Implementation of the present invention in TV broadcast will be disclosed in later sections.

In FM broadcast, an optional signal band from 53 kHz to 99 kHz may be multiplexed onto the main radio frequency carrier. In the United States, this optional band is called the Subsidiary Communications Authorization (SCA). This band can be used to carry analog and/or digital signals. In the present invention, a portion of this band may be devoted to carry the command, index and on-demand program materials. Methods have been developed to achieve a bandwidth of more than 16 kilobits per second in the SCA. Thus, at least two sets of on-demand program materials can be delivered in the SCA.

In order to implement this embodiment, only the digital data extractor **201** portion of the circuit in FIG. **4**A and music quality processor **204** need to be changed. The changes are shown in FIG. **4**B. A programmable tuner **234** is used to allow a user (and if necessary, control logic **210** of FIG. **4**A) to select a broadcast station. The tuned signal is separated into two parts: the main program and SCA. The main program mate-

rial (riding on the main radio frequency carrier) is delivered to a FM demodulator **238**. It is an analog demodulator that derives an analog audio signal from the tuned radio frequency signal. The analog audio signal is connected to signal switch **218** of FIG. **4**A through a line **244**. The SCA signal is delivered to a SCA demodulator and digital data decoder **235**. It recovers a stream of digital data corresponding to the serial data stream generated by transmitter system **150**. This stream is delivered to a data separator-selector **236** that decapsulates the packets and selects the command material, index material or on-demand program material. The data on a line **243** corresponds to commands, and should be delivered to control logic **210**. The data on lines **241** and **242** corresponds to on-demand and index materials, and should be delivered to decompressor **214**. Data separator-selector **236** optionally contains a memory **237** that serves a similar function as memory **222** of FIG. **4**A.

Programmable tuner **234** and data separator-selector **236** can be controlled by control logic **210** through lines **245** and **246**, respectively.

Recently, there is research on a hybrid digital/analog radio broadcast system that simultaneously transmits both analog and digital signals within an allocated channel mask. The digital signals offers music quality audio broadcast. An advantage of this system is that it is backward compatible with existing analog receivers because the same program material is transmitted in both digital and analog forms. Based on the promoters of this system, it is believed that a FM-based system can provide an ancillary data channel having bandwidth substantially higher than that of the SCA. The same research indicates that a slower ancillary data channel can also be obtained in AM transmission. These ancillary data channels can be used to carry the compressed index and auxiliary program materials of the present invention. Consequently, the present invention is also applicable to this hybrid radio broadcast system.

Storing Index and On-Demand Program Material in Memory

In a different embodiment of the present invention, the index and/or on-demand program material may be stored in a memory of a radio receiver.

FIG. **5**A is a schematic diagram of an electrical portion **330** of radio receiver **102** of the present invention. Portion **330** contains a tuner/demodulator **332** that can be tuned to a station selected by a listener. It also demodulates, if needed, at least a portion of the radio frequency signal. As pointed out above in connection with FIG. **4**A, tuner/demodulator **332** could be programmable. A separator **348** separates the received signal into individual portions: a main program portion, an (optional) index portion, and an on-demand program portion (which may contains several on-demand program materials). The main program portion is processed by a main program processor **334**, and then delivered to a digital signal switch **342**. The index and on-demand program portions are delivered to a memory management unit **350**, which stores these portions into appropriate places in a memory **340**. FIG. **5**A shows that the index portion is stored in an index area **336** and the on-demand program portion is stored in an on-demand program area **338**. The data stored in the index and on-demand program areas may be processed by a decompressor **354** (if the data transmitted by broadcast station **120** is compressed). Decompressor **354** is connected to signal switch **342**, which is in turn connected to a digital-to-analog (D/A) converter **358**. Converter **358** is connected to an amplifier-speaker **344**

FIG. **6** is a schematic diagram showing the logical structure of memory **340**. This structure is managed by memory management unit **350**. The set codes (e.g., A1, A2, etc.) and the subfield (e.g., "0" for on-demand program material and "1" for index material) can be used as pointers to the appropriate position in the index and on-demand program areas. Thus, FIG. **6** shows pointers "1A1", "1A2" and "1A3" pointing to the "traffic condition", "weather" and "sports scores" blocks, respectively, of the index area. The compressed voice data of the words "traffic condition", "weather" and "sports scores" will be stored in the appropriate blocks of the index area. Similarly, pointers "0A1", "0A2" and "0A3" point to the "traffic condition", "weather" and "sports scores" blocks, respectively, of the on-demand program area. Thus, the compressed voice data of the "traffic condition", "weather" and "sports scores" information will be stored in the appropriate blocks in the on-demand program area. It should be noted that even though each of the on-demand program materials (e.g., traffic condition) are shown to be located in one block, the data could be physically dispersed as long as they are logically linked together. Methods for linking physically separated data into a logical block are well known in the art.

In the present invention, broadcast station **120** broadcasts in regular time intervals the index packets. These packets are stored in the index area. Broadcast station **120** also broadcasts in regular intervals the on-demand program packets for each on-demand program. These packets are stored in the designated block of the on-demand program area. As explained below, the index and on-demand program materials can be accessed by the listener by pressing appropriate buttons of radio receiver **102**.

In one embodiment of the present invention, memory management unit **350** examines the sequence code and packet number of the received index and on-demand program material. If the sequence code and packet number is the same as that of a previously validly stored data, memory management unit **350** does not need to process the data. Otherwise, the data in memory **340** is updated.

The use of memory **340**, packet number, and check sum for each packet may improve performance. The reception of the on-demand and index portions is typically not as reliable as that of the main program material (e.g., the SCA power is typically lower than the main program power). This is especially true for automobile radio receivers because the automobile may pass through areas with high multipath interference. Thus, some of the on-demand/index packets may contain errors. The use of packet number and check sum allows these error packets to be identified. When a set with the same sequence code is broadcasted a second time, this embodiment allows the correct data to be stored in memory **340**.

Returning to FIG. **5**A, a control logic **352** is used to interface between the buttons of FIG. **1** and electrical portion **330**. When the listener presses index button **110**, control logic **352** looks up a register **356** that stores the set code that is being processed (e.g., A1). It delivers to memory management unit **350** this set code and a request to retrieve the corresponding index material. Memory management unit **350** retrieves the corresponding data in the index area and sends it to decompressor **354**. At about the same time, control logic **352** directs signal switch **342** to connect decompressor **354** to D/A converter **358**. The words "traffic condition" are pronounced by amplifier-speaker **344**. Decompressor **354** sends a notification to control logic **352** after the words are processed. Control logic **352** increases the set code in register **356** by 1 (e.g., from A1 to A2).

In most cases, these words of the index are short. Thus, these words will be spoken before the listener can take additional action. In another embodiment of the invention, it may not be necessary for decompressor **354** to send the notifica-

tion to control logic **352**. Electrical portion **330** can assume that the words will be announced before the listen takes any other action.

If the listener presses index button **110** again within a predetermined time interval (e.g., one to two seconds), it is likely that the listen wishes to listen to other information. Thus, the above-described steps for selecting another index are repeated. Specifically, control logic **352** delivers the new set code to memory management unit **350**, which retrieves the corresponding data in the index area and sends it to decompressor **354**. The word "weather" is pronounced by amplifier-speaker **344**. If the listener does not press index button **110** again within the predetermined time interval, control logic **352** assumes that the listener has made a selection. Control logic **352** then sends to memory management unit **350** the selected set code and a request that the corresponding on-demand program material be retrieved. Memory management unit **350** retrieves the corresponding data in the on-demand program area and sends it to decompressor **354**. Control logic **352** directs signal switch **342** to connect decompressor **354** to D/A converter **358**. The selected on-demand program (e.g., traffic condition) is played on amplifier-speaker **344**. When all the data is processed, decompressor **354** notifies control logic **352**. Control logic **352** directs switch **342** to connect main program processor **334** to converter **358**. As a result, the main program material is automatically played.

FIG. **7** shows a flowchart describing the above-described operation of the present invention.

Subsequent to the selection by index button **110**, the listener can press switch button **108** anytime he/she wishes to listen to the selected on-demand program material instead of the main program material. Control logic **352** sends to memory management unit **350** the index code stored in register **356** and a request for on-demand program material. Control logic also directs signal switch **342** to connect D/A converter **358** to decompressor **354**. After the on-demand program is played, control logic **352** directs switch **342** to connect main program processor **334** back to converter **358** again.

It should be noted that the index material and index button **110** are optional, as discussed above in connection with FIG. **4**A. A similar procedure can be used to handle this situation. In this case, memory **340** does not need to have an index area.

In an alternative embodiment of FIG. **5**A, decompressor **354** can be placed ahead of memory management unit **350**. In this embodiment, the digital data for the index and on-demand program materials are decompressed first before being stored in memory **340**. This embodiment may not use memory **340** as efficient as the original embodiment. On the other hand, the response time may be faster because the decompression operation has been performed prior to storage. It should also be noted that main program processor **334** and decompressor **354** may be software modules executed by the same data processing apparatus. In this case, signal switch **342** is replaced by a software command that causes the data processing apparatus to execute different software modules.

In one embodiment of the present invention, the operation of receiving signals from a broadcast station using tuner **332** and storing the index and on-demand program materials in memory **340** is performed at all times, ever after the listener turns off the radio receiver (e.g., using volume button **106**). This requires that power be constantly supplied to electrical portion **330** even though other parts of radio receiver **102** do not receive power (e.g., display and amplifier-speaker). It is not a problem for automobile radio receivers because they can obtain power from the car battery at all times. An advantage of this embodiment is that the listen can hear the on-demand program materials instantaneously after the receiver is turned on by the listener. There is no need to wait for data to be received and stored into memory **340**. This advantage is especially important when the listener wishes to hear traffic condition information before he/she leave the parking lot so that he/she can select the best route to the destination.

In another embodiment of electrical portion **330**, each of decompressor **354** and main program processor **334** is connected to a separate D/A converter before connecting to switch **342**. These two D/A converters can be individually designed to take advantage of the different characteristics of the two decompressors. In this case, D/A converter **358** in FIG. **5**A is not needed.

In one embodiment of the present invention, a music quality decompressor (such as a MP3 decoder) is used to implement main program processor **334** and a voice quality decompressor (such as a G.723.1 decoder) is used to implement decompressor **354**.

An implementation of the present invention in a conventional analog radio broadcast system is now described. FIG. **5**B is a schematic diagram of an electrical portion **380** of an implementation of radio receiver **102**. Reference numerals that are the same in FIGS. **5**A and **5**B refer to substantially the same elements. The structure of electrical portion **380** is similar to that of electrical portion **330**, with the following exceptions: (1) The main program processor **334** corresponds to an FM demodulator **386**, (2) a SCA demodulator/decoder **384** is used to separate the SCA band from the main carrier and decode the digital data therein, and (3) tuner **382** does not perform demodulation. FM demodulator **386** is an analog demodulator that derives an analog audio signal from a radio frequency signal. FM demodulator **386** and SCA demodulator/decoder **384** work on different frequency bands within an allocated FM channel mask, thus performing the operation of separator **348** of FIG. **5**A.

The principle of the embodiments in FIGS. **5**A and **5**B is also applicable to the hybrid digital/analog radio broadcast system that simultaneously transmits both analog and digital signals within an allocated channel mask.

It should be noted that the tuners in FIGS. **5**A-**5**B could also be programmable.

Extension to TV

The present invention can also be extended to TV (transmitted via cable or wireless). In TV broadcast, it is possible to introduce a datacast channel along side the main TV channel. As an example, some TV stations use the vertical blanking interval (VBI) to broadcast data. As another example, a portion of the high definition TV frequency spectrum can be used for datacasting. The bandwidth of these datacast channels is typically higher than that of the SCA. Thus, it is possible to use all or just a portion of the TV datacast channel for the present invention.

In order to facilitate disclosure of the present invention, FIGS. **4**A-**4**B and **5**A-**5**B are used. FIG. **4**A would be applicable to the digital TV situation. In this case, data separator-selector **208** separates the datacast channel from the main TV broadcast channel. Because of the wider bandwidth of the TV datacast channel, decompressor **214** could be a music quality decompressor. In FIG. **4**B, SCA demodulator/digital data decoder **235** would be a decoder for the datacast channel (e.g., VBI). FM demodulator block **238** would be the audio demodulator for the main TV channels. In FIG. **5**A, separator **348** separates the datacast portion from the main TV channels. In FIG. **5**B, SCA demodulator/digital data decoder **384** would be a decoder for the datacast channel (e.g., VBI). FM demodulator block **386** would be the audio demodulator for the main TV channel.

In these embodiments, the switch and index buttons could be built into a TV set or a remote controller associated with the TV set. If a remote controller is used, the numeric keys (used for selecting TV channels) could be used to select the on-demand information (e.g., key "1" for traffic condition, key "2" for weather, etc.)

In a separate embodiment of the present invention, the main channel could be a regular FM or AM radio channel while the on-demand program is broadcast on a TV datacast channel. In this way, the wider bandwidth of the TV datacast channel is available to radio listeners.

The invention has been described with reference to specific exemplary embodiments thereof. Various modification and changes may be made thereunto without departing from the broad spirit and scope of the invention. The specification and drawings are, accordingly, to be regarded in an illustrative rather than a restrictive sense; the invention is limited only by the provided claims.

I claim:

[1. An apparatus for generating analog audio signal, comprising:

a demodulator for retrieving digital data from wireless radio frequency signal, the digital data comprising a first set of compressed digital audio data associated with a first audio program and a second set of compressed digital audio data associated with a second audio program, the first set of compressed digital audio data having been compressed outside of the apparatus from a first set of digital audio data, the second set of compressed digital audio data having been compressed outside of the apparatus from a second set of digital audio data;

a first decompressor comprising a first digital audio decompression algorithm;

a second decompressor comprising a second digital audio decompression algorithm;

a user interface allowing a user to select the first or the second audio program; and

a control subsystem for applying the first decompressor to decompress the first set of compressed digital audio data if the user selects the first audio program and applying the second decompressor to decompress the second set of compressed digital audio data if the user selects the second audio program.**]**

[2. The apparatus of claim **1** wherein at least one of the first and the second decompression algorithms comprises a motion picture experts group decompression algorithm.**]**

[3. The apparatus of claim **1** wherein at least one of the first and the second decompression algorithms comprises a voice quality decompression algorithm.**]**

[4. The apparatus of claim **1** wherein at least one of the first and the second sets of compressed digital audio data has a bit rate of less than 7 kilobits per second.**]**

[5. The apparatus of claim **1** wherein the radio frequency signal comprises FM modulated radio frequency signal.**]**

[6. The apparatus of claim **1** wherein at least the demodulator is powered by a battery of an automobile.**]**

[7. The apparatus of claim **1** wherein one of the first and the second sets of compressed digital audio data has been compressed using a parametric compression algorithm.**]**

[8. The apparatus of claim **7** wherein another of the first and the second sets of compressed digital audio data has been compressed using a motion picture experts group compression algorithm.**]**

[9. The apparatus of claim **1** wherein the first decompressor and the second decompressor are software modules in a ROM.**]**

[10. The apparatus of claim **1** wherein the digital data comprises a command instructing the apparatus to perform a task.**]**

[11. An apparatus for sending wireless radio frequency signal to a receiving device, the apparatus comprising a wireless transmitter for transmitting the wireless radio frequency signal modulated by a stream of digital data, the stream of digital data comprising a first set of compressed digital audio data associated with a first audio program and a second set of compressed digital audio data associated with a second audio program, the first set of compressed digital audio data having been compressed outside of the receiving device using a first digital audio compression algorithm and the second set of compressed digital audio data having been compressed outside of the receiving device using a second digital audio compression algorithm.**]**

[12. The apparatus of claim **11** wherein the first compression algorithm comprises a motion picture experts group compression algorithm.**]**

[13. The apparatus of claim **11** wherein the second compression algorithm comprises a voice quality compression algorithm.**]**

[14. The apparatus of claim **13** wherein the second set of compressed digital audio data has a bit rate of less than 7 kilobits per second.**]**

[15. The apparatus of claim **11** wherein the radio frequency signal comprises FM modulated radio frequency signal.**]**

[16. The apparatus of claim **11** wherein the digital data comprises a command instructing the receiving device to perform a task.**]**

[17. The apparatus of claim **11** wherein one of the first and the second sets of compressed digital audio data has been compressed using a parametric compression algorithm and another of the first and the second sets of compressed digital audio data has been compressed using a motion picture experts group compression algorithm.**]**

[18. An apparatus for generating analog audio signal, comprising:

a demodulator for retrieving digital data from wireless radio frequency signal, the digital data comprising a first set of compressed digital audio data associated with a first audio program and a second set of compressed digital audio data associated with a second audio program the first set of compressed digital audio data having been compressed outside of the apparatus from a first set of digital audio data, the second set of compressed digital audio data having been compressed outside of the apparatus from a second set of digital audio data;

a first decompressor comprising a first digital audio decompression algorithm;

a second decompressor comprising a second digital audio decompression algorithm;

a memory system for storing the first set of compressed digital audio data retrieved from the demodulator and not the second set of compressed digital audio data retrieved from the demodulator;

user interface allowing a user to select the first or the second audio program; and

a control subsystem for applying the second decompressor to decompress the second set of compressed digital audio data if the user selects the second audio program and for retrieving the first set of compressed digital audio data from the memory system and delivering to the first decompressor when the user selects the first audio program.**]**

[19. The apparatus of claim 18 wherein at least one of the first and the second decompression algorithms comprises a voice quality decompression algorithm.]

[20. The apparatus of claim 18 wherein one of the first and the second sets of compressed digital audio data has been compressed using a parametric compression algorithm.]

[21. The apparatus of claim 20 wherein another of the first and the second sets of compressed digital audio data has been compressed using a motion picture experts group compression algorithm.]

[22. The apparatus of claim 18 wherein:

the digital data comprises a third set of compressed digital audio data associated with a third audio program,

the memory system further for storing the third set of compressed digital audio data,

the user interface comprises a first button to select one of the first and the third audio programs and a second button to select the second audio program, and

the control subsystem further for retrieving the third set of compressed digital audio data from the memory system and delivering to the first decompressor when the user selects the third audio program.]

[23. The apparatus of claim 18 wherein the user interface allows the user to turn off power to at least a portion of the apparatus, and wherein the memory system stores the first set of compressed digital audio data even after the user activates the user interface to turn off the power.]

[24. The apparatus of claim 18 wherein the first decompressor and the second decompressor are software modules in a ROM.]

[25. The apparatus of claim 8 wherein the digital data comprises a command instructing the apparatus to perform a task.]

26. A method for an apparatus to process digital audio data, comprising:

demodulating wireless radio frequency signals transmitted by a first remote station to generate a plurality of sets of compressed digital audio data, at least one other set of compressed digital audio data and a command instructing the apparatus to switch to a second remote station, the command being transmitted without responding to an input by a user of the apparatus, the plurality of sets of compressed digital audio data and the at least one other set of compressed digital audio data being compressed outside of the apparatus;

storing the plurality of sets of compressed digital audio data in a memory of the apparatus but not the at least one other set of compressed digital audio data;

allowing the user to select at least one of the plurality of sets of compressed digital audio data stored in the memory;

if the user selects one set of the plurality of sets of compressed digital audio:

retrieving from the memory at least a portion of the selected set of compressed digital audio data;

decompressing the retrieved portion of the selected set of compressed digital audio data using a first digital audio decompression algorithm to generate a first set of decompressed digital audio data; and

processing the first set of decompressed digital audio data to generate a first analog audio signal;

allowing the user to select the at least one other set of compressed digital audio data that is not stored in the memory;

if the user selects the at least one other set of compressed digital audio data:

decompressing at least a portion of the at least one other set of compressed digital audio data using a second digital audio decompression algorithm to generate a second set of decompressed digital audio data; and

processing the second set of decompressed digital audio data to generate a second analog audio signal; and

responsive to the command: demodulating wireless radio frequency signals transmitted by the second remote station to generate an additional set of compressed digital audio data, the additional set of compressed digital audio data being compressed outside of the apparatus and can be decompressed by the apparatus using one of the first and the second digital audio decompression algorithms.

27. The method of claim 26 wherein at least one of the first and the second digital audio decompression algorithms comprises a motion picture experts group decompression algorithm.

28. The method of claim 26 wherein at least one of the first and the second digital audio decompression algorithms comprises a voice quality decompression algorithm.

29. The method of claim 26 wherein at least one of the first and the second digital audio decompression algorithms is software module in a ROM.

30. The method of claim 26 wherein the memory continues to store the plurality of sets of compressed digital audio data after at least a portion of the apparatus is not powered.

31. The method of claim 26 further comprising:

storing the additional set of compressed digital audio data in the memory;

allowing the user to select the additional set of compressed digital audio data in the memory; and

if the user selects the additional set of compressed digital audio data:

retrieving from the memory at least a portion of the additional set of compressed digital audio data; and

decompressing the retrieved portion of the additional set of compressed digital audio data using the first digital audio decompression algorithm.

32. An apparatus comprising:

a demodulator for demodulating wireless radio frequency signals transmitted by a first remote station to generate a plurality of sets of compressed digital audio data, at least one other set of compressed digital audio data and a command instructing the apparatus to switch to a second remote station, the command being transmitted without responding to an input by a user of the apparatus, the plurality of sets of compressed digital audio data and the at least one other set of compressed digital audio data being compressed outside of the apparatus;

a first decompressor comprising a first digital audio decompression algorithm;

a second decompressor comprising a second digital audio decompression algorithm;

memory for storing the plurality of sets of compressed digital audio data generated by the demodulator but not the at least one other set of compressed digital audio data generated by the demodulator;

a user interface allowing the user to select at least one set of the plurality of sets of compressed digital audio data in the memory;

a control subsystem for retrieving at least a portion of the selected set of compressed digital audio data from the memory and delivering to the first decompressor after selection by the user;

the user interface also allowing the user to select the at least one other set of compressed digital audio data;

the control subsystem also for delivering at least a portion of the at least one other set of compressed digital audio data to the second decompressor after selection by the user; and

responsive to the command, the demodulator also demodulates wireless radio frequency signals transmitted by the second remote station to generate an additional set of compressed digital audio data, the additional set of compressed digital audio data being compressed outside of the apparatus and can be decompressed by the apparatus using one of the first and the second decompressors.

33. The apparatus of claim 32 wherein at least one of the first and the second digital audio decompression algorithms comprises a motion picture experts group decompression algorithm.

34. The apparatus of claim 32 wherein at least one of the first and the second digital audio decompression algorithms comprises a voice quality decompression algorithm.

35. The apparatus of claim 32 wherein at least one of the first and the second decompressors comprises software module in a ROM.

36. The apparatus of claim 32 wherein the user interface allows the user to turn off power to at least a portion of the apparatus, and wherein the memory stores the plurality of sets of compressed digital audio data even after the user uses the user interface to turn off the power.

37. The apparatus of claim 32 wherein the memory also stores the additional set of compressed digital audio data, the user interface also allows the user to select the additional set of compressed digital audio data in the memory, and the control subsystem also retrieves at least a portion of the additional set of compressed digital audio data from the memory and delivers to the first decompressor after selection by the user.

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