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(54) **Radio receiving apparatus and output restoring method**

(57) A radio receiving apparatus including: a first receiving unit that receives a first broadcast signal broadcast in a first frequency band; a second receiving unit that receives a second broadcast signal broadcast in a second frequency band; a switching unit that switches a program based on the second broadcast signal received by the second receiving unit to output from the output unit, when the first receiving unit ceases to receive the first broadcast signal while a program based on the first broadcast signal received by the first receiving unit is being output from a predetermined output unit; and a restoring unit that performs forced restoration to output the program based on the first broadcast signal from the output unit, when a specific operation is detected to have been performed while the program based on the second broadcast signal switched by the switching unit is being output.

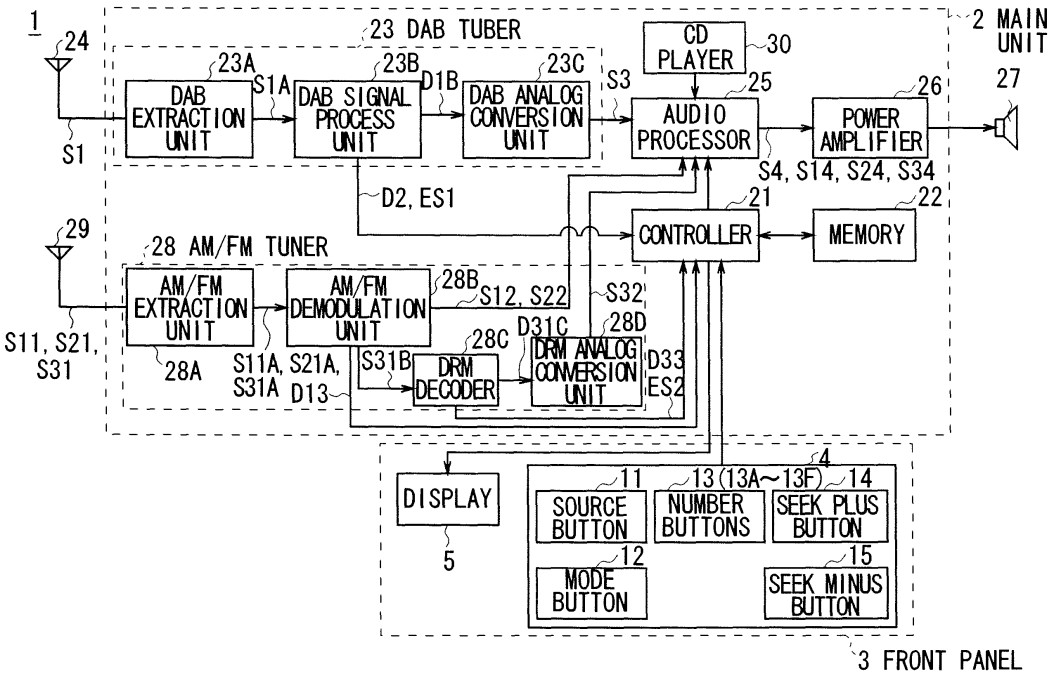

FIG. 4

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present invention contains subject matter related to Japanese Patent Application JP2008-031828 filed in the Japanese Patent Office on February 13, 2008, the entire contents of which being incorporated herein by reference.

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0002] The present invention relates to a radio receiving apparatus and an output restoring method, which are suitable for use in vehicle audio apparatuses configured to receive digital audio broadcasting (DAB) and FM broadcasting which transmits programs of the same content, enabling users to listen to DAB programs and FM-broadcast programs.

DESCRIPTION OF THE RELATED ART

[0003] Hitherto, any vehicle audio apparatus receives, for example, DAB programs (i.e., digital audio broadcast programs in Europe) and frequency modulated (FM) broadcast programs (i.e., analog broadcast programs). The vehicle audio apparatus therefore enables the users to listen to the DAB programs and the FM-broadcast programs.

[0004] Since DAB is digital data broadcasting, it can provide users with a program of high-quality sound. However, its service area is smaller than that of FM broadcasting, because its transmitter infrastructure has delayed as compared to the FM broadcasting. FM broadcasting is indeed inferior to DAB in terms of sound quality because it is analog broadcasting, but its service area is broad because the frequency is low. In many cases, DAB and FM-broadcasting transmit programs of the same content.

[0005] Therefore, vehicle audio apparatuses of some types have the function of switching the broadcasting band to the FM-broadcasting band when the apparatus fails to receive the DAB program the user has been enjoying, enabling the apparatus to start receiving the FM-broadcast program of the same content. (Hereinafter, this function shall be called FM link function.) (See, for example, Jpn. Pat. Appln. Laid-Open Publication No. 2000-236272.)

[0006] For example, as shown in FIG. 1, the vehicle audio apparatus goes from the start step of routine RT1 to the next step, i.e., Step SP1. In Step SP1, the FM link function is activated in accordance with the user's instructions. The vehicle audio apparatus then goes to Step SP2.

[0007] In Step SP2, the vehicle audio apparatus sets the broadcasting band to the DAB band. On receiving a DAB signal broadcast in the DAB band, the vehicle audio apparatus extracts the program of the broadcasting station the user has selected from the DAB signal. The program extracted is supplied to the speaker (not shown). The speaker generates sound, enabling the user to listen to the DAB program. Then, the apparatus goes to the next step, i.e., Step SP3.

[0008] In Step SP3, whether the vehicle audio apparatus determines whether it can keep receiving the DAB signal. If Yes, the apparatus returns to Step SP2 and keeps outputting the program. If No, the apparatus goes to the next step, i.e., Step SP4.

[0009] In Step SP4, the broadcasting band is switched from the DAB signal and to the FM-broadcasting band because the vehicle audio apparatus is not able to receive the DAB signal. Thus, the apparatus receives the FM-broadcast signal transmitted in the FM-broadcasting band and extracts the FM-broadcast program of the same content as the program output in Step SP2 from FM-broadcast signal. The FM-broadcast program extracted is supplied to the speaker, which generates sound, enabling the user to listen to the FM-broadcast program which transmits programs of the same content as the DAB. Then, the apparatus goes to the next step, i.e., Step SP5.

[0010] At this point, the vehicle audio apparatus displays, at the display (not shown) provided on the front, to display the broadcasting band, the broadcasting frequency, and the broadcasting station name. The user can therefore visually recognize in which band he or she is enjoying the program, DAB band or FM-broadcasting band.

[0011] However, in the vehicle audio apparatus, after the broadcasting band has been automatically switched from the DAB band to the FM-broadcasting band by using the FM link function, the user may push the seek button (not shown) to change the channel and thereby to listen to another program broadcast in another DAB band from a different station, not looking at the display and, hence, not knowing that the apparatus is now receiving an FM-broadcast program.

[0012] In this case, the vehicle audio apparatus determines, in Step SP5, that the user has pushed the seek button. Then, the apparatus goes to the next step, i.e., Step SP6.

[0013] In Step SP6, the vehicle audio apparatus retrieves another program that can be received in the FM-broadcasting band form any station other than the station that is transmitting the program now being received, because the broadcasting band has been switched shortly before, and outputs audio of the retrieved another program from the speaker. The apparatus then goes to the next step, i.e., Step SP7.

[0014] If the user finds that the vehicle audio apparatus is receiving an FM-broadcast program, he or she will push a mode button (not shown) to switch the broadcasting band from the FM-broadcasting band, back to the DAB band. Hence, in Step SP7, the vehicle audio apparatus

determines whether the mode button (not shown) has been pushed to switch the output band. If No, that is, if the mode button has not been pushed, the vehicle audio apparatus goes to Step SP11. In Step SP11, the vehicle audio apparatus stops performing the process.

[0015] If Yes in Step SP7, this means that the user has noticed the receipt of the FM-broadcast program and pushed the mode button then pushed the mode button to switch the broadcasting band from the FM-broadcasting band, back to the DAB band. In this case, the vehicle audio apparatus switches the broadcasting band back to the DAB band from the FM-broadcasting band. Then, the vehicle audio apparatus goes to the next step, i.e., Step SP8.

[0016] Vehicle audio apparatuses of some types have a plurality of FM-broadcasting bands, such as "FM1", "FM2" and "FM3", as output bands to output FM-broadcast programs. Any vehicle audio apparatus has a plurality of AM-broadcasting bands such as "AM1" and "AM2", and a plurality of DAB broadcasting bands such as "DAB1", "DAB2", and "DAB3" like FM-broadcasting bands

[0017] In FM-broadcasting band "FM1," for example, the vehicle audio apparatus can output a program broadcast in a FM-broadcasting band. The apparatus has six number buttons (not shown), which may be pushed to register the broadcasting frequencies of given six broadcasting stations.

[0018] The vehicle audio apparatus can also output programs broadcast in FM-broadcasting band "FM2" and "FM3," like in the FM-broadcasting band "FM1." The six number bottoms may be pushed to register the broadcasting frequencies of given six broadcasting stations for each of FM-broadcasting band "FM2" and "FM3".

[0019] Moreover, the vehicle audio apparatus can output programs broadcast in the AM-broadcasting bands "AM1" and "AM2" (hereinafter called AM-broadcasting band), more precisely, in long wave (LW) broadcasting band and middle wave (MW) broadcasting band, both used in Europe. The six number bottoms may be pushed to register the broadcasting frequencies of six broadcasting stations for each of AM-broadcasting bands "AM1" and "AM2".

[0020] The vehicle audio apparatus can output programs that are broadcast in DAB bands such as "DAB1", "DAB2" and "DAB3". The six number bottoms may be pushed to register the broadcasting frequencies of six broadcasting stations for each of DAB bands "DAB1", "DAB2" and "DAB3".

[0021] If the mode button is pushed while the speaker is outputting a FM-broadcast program in, for example, FM-broadcasting band "FM1", the vehicle audio apparatus switches the output band from FM-broadcasting band "FM1" to the FM-broadcasting band "FM2".

[0022] As the mode button is repeatedly pushed, the vehicle audio apparatus switches the output band from FM-broadcasting band "FM1" to FM-broadcasting band "FM2", then to FM-broadcasting band "FM3", further to AM-broadcasting band "AM1", to AM-broadcasting band "AM2", then to DAB band "DAB1", thence to DAB band "DAB2", and finally to DAB band "DAB3".

[0023] The vehicle audio apparatus switches the output band back to the FM-broadcasting band "FM1" from the DAB band "DAB3" when mode button is pushed while outputting the DAB program in, for example, the DAB band "DAB3". In the FM-broadcasting band "FM1", the vehicle audio apparatus outputs the FM-broadcast program.

[0024] Thus, the output band of the vehicle audio apparatus is switched to FM-broadcasting band "FM1", FM-broadcasting band "FM2", FM-broadcasting band "FM2", FM-broadcasting band "FM3", AM-broadcasting band "AM1", AM-broadcasting band "AM2", DAB band "DAB1", DAB band "DAB2", and DAB band "DAB3" as the mode button is repeatedly pushed.

[0025] Hence, with the vehicle audio apparatus, the mode button may be pushed five times while an FM-broadcast program is being output in, for example, FM-broadcasting band "FM1", in order to switch the broadcasting mode back to the DAB band "DAB1". In this case, the broadcasting mode is switched from FM-broadcasting band "FM1" to FM-broadcasting band "FM2", FM-broadcasting band "FM3", AM-broadcasting band "AM1", AM-broadcasting band "AM2", and DAB band "DAB1".

[0026] In Step SP8, the vehicle audio apparatus determines whether the seek button has been pushed. If Yes in Step SP8, or if the user has pushed the seek button to switch the broadcasting station to another. In this case, the vehicle audio apparatus goes to Step SP9.

[0027] In Step SP9, the vehicle audio apparatus searches for broadcasting stations other than the band of broadcasting station now broadcasting a program, which can received programs in DAB band. Then, the vehicle audio apparatus returns to the previous step, i.e., Step SP8.

[0028] In Step SP8, the vehicle audio apparatus determines whether the seek button has been pushed again. If No in Step SP8, or if the user has not pushed the seek button again because the apparatus already searched, in Step SP9, for broadcasting stations that can receive signals in DAB band. Hence, the vehicle audio apparatus goes to Step SP10.

[0029] In Step SP10, the vehicle audio apparatus outputs the audio data of the program transmitted from the broadcasting station set in Step SP9 to a speaker, which generates sound. The user can listen to the DAB program. Then, the apparatus goes to Step SP11, terminating the process.

[0030] Thus, if the broadcasting band is automatically switched, for example, from a DAB band "DAB1" to a FM-broadcasting band "FM1" by the FM link function in Step SP7, the user needs to push the mode button several times in order to switch the broadcasting band from the FM-broadcasting band "FM1", back to the DAB band "DAB1".

[0031] In the vehicle audio apparatus described above, the user has to look at the display to determine whether he or she is listing to the DAB program or the FM-broadcasting program, as long as the FM link function remains on. Here arises a problem. A station broadcasting an FM program will be inevitably searched for, if the user pushes the seek button to find a station that can receive DAB programs, not looking at the display and determining whether he or she is listing to a DAB or FM-broadcasting program, after the FM link function has automatically switched the broadcasting band, for example, from DAB band "DAB1" to FM-broadcasting band "FM1".

[0032] Further, to switch the broadcasting band, from the FM-broadcasting band "FM1" back to the DAB band "DAB1", for example, from FM-broadcasting band "FM1" to DAB band "DAB1" after the FM link function has automatically switched the vehicle audio apparatus, for example from DAB band "DAB1" to FM-broadcasting band "FM1," the user has to push the mode button in several times. This is quite a troublesome operation for the user.

SUMMARY OF THE INVENTION

[0033] This invention has been made in view of the foregoing. It is desirable to be provided invention proposes a radio receiving apparatus and an output restoring method, which enable the user to listen to a program received in the very frequency band in which he or she was listening to a program shortly before, without performing a troublesome operation.

[0034] To achieve the above, in a radio receiving apparatus and output restoring method according to an embodiment of the present invention, a first receiving unit receives a first broadcast signal broadcast in a first frequency band, a second receiving unit receives a second broadcast signal broadcast in a second frequency band, a switching unit switches a program based on the second broadcast signal received by the second receiving unit to output from the output unit when the first receiving unit ceases to receive the first broadcast signal while a program based on the first broadcast signal received by the first receiving unit is being output from a specific output unit; and the program based on the first broadcast signal is forcedly output from the output unit when a specific operation is detected to have been performed while the program based on the second broadcast signal is being output because of the switching performed by the switching unit.

[0035] Thus, the output unit can output the program based on the first broadcasting band from the output unit merely by performing the specific operation, while the user is listening to the program broadcast in the second broadcasting band because the program broadcast in the first broadcasting band, which the user has first been listening to, ceased to be received.

[0036] That is, if the user listens to the program broadcast in the second broadcasting band, because the program broadcast in the first broadcasting band, which the user has first been listening to, ceased to be received, the output unit can output the program broadcast in the first broadcasting band again merely by performing the specific operation. Hence, this invention can provide a radio receiving apparatus and output restoring method, which enable the user to listen to a program received in the frequency band in which he or she was first listening to a program shortly, without performing a troublesome operation.

[0037] The nature, principle and utility of the invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings in which like parts are designated by like reference numerals or characters.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] In the accompanying drawings:

FIG. 1 is a flowchart explaining the sequence of a DAB restoring process achieved by the conventional FM link function;

FIGS. 2A and 2B are diagrams showing the overall configuration of a vehicle audio apparatus;

FIG. 3 is a diagram showing the configuration of the front panel the vehicle audio apparatus has;

FIG. 4 is a block diagram showing the circuit configuration of the vehicle audio apparatus;

FIG. 5 is a flowchart explaining the sequence of a DAB restoring process achieved by the FM function according to an embodiment of the present invention;

FIG. 6 is a flowchart explaining the sequence of a DAB restoring process achieved by a DRM link function; and

FIG. 7 is a flowchart explaining the sequence of a DAB restoring process achieved by a DAB link function.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0039] An embodiment of the present invention will be described in detail with reference to the accompanying drawings.

(1) Overall Configuration of Vehicle Audio Apparatus

[0040] FIGS. 2A and 2B show the overall configuration of a vehicle audio apparatus 1 according to an embodiment of the present invention. The vehicle audio apparatus 1 has a main unit 2. A front panel 3 is provided on the front of the main unit 2. When the user operates the front panel 3, the apparatus 1 receives radiobroadcast program or plays back a CD or the like. The apparatus 1 supplies audio data contained in the program or recorded in the CD, to the speakers (not shown) connected to the main unit 2 and provided in a vehicle. From the audio

data, the speakers generate sound, to which the user listens.

[0041] When the vehicle audio apparatus 1 is installed in the vehicle (not shown), a greater part of the main unit 2 is set within the dashboard of the vehicle, due to the limited space in the vehicle. The apparatus 1 is so installed that only the front panel 3 is exposed outside the dashboard.

[0042] The vehicle audio apparatus 1 conforms to so-called Deutsche Industrie Normen (DIN) size. The main unit 2 and the front panel 3 are so designed that the apparatus 1 is 178 mm wide and about 50 mm tall.

[0043] The front panel 3 has operation buttons 4 and a display 5 on the front 3A. The buttons 4 may be operated by the user. The display 5 is, for example, a liquid crystal display (LCD), an electroluminescence (EL) display, or a vacuum fluorescent display (VFD). The display 5 servers as a so-called user interface to provide various information items to the user.

[0044] The front panel 3 (FIG. 2B) has a display-supporting plate 6, on which the display 5 is arranged. The display-supporting plate 6 can slide downwards. As the plate 6 is moved down, a button-holding plate 7 comes forward from the front of the main unit 2. The plate 7 is provided below the display-supporting plate 6, holding some of the operation buttons 4.

[0045] When the display-supporting plate 6 is slid down, the front panel 3 is exposed in part. The exposed part of the front panel 3 has a disk insertion slot 8 and a disk ejection button 9. Through the disk insertion slot 8, a medium such as a compact disc (CD) or a digital versatile disc (DVD) can be inserted into, and ejected from, the main unit 2. The disk ejection button 9 may be pushed to eject a medium such as CD or DVD from the main unit 2 though the disk insertion slot 8.

[0046] The front panel 3 can be removed from the main unit 2 and taken away from the vehicle. The panel 3 removed may be stored somewhere as long as the vehicle is parked, thus preventing the theft of the front panel 3. Note that a connector (not shown) can electrically connect and disconnect the front panel 3 to and from the main unit 2.

(2) Configuration of the Front Panel

[0047] The configuration of the front panel 3 will be described in detail. As shown in FIG. 3, the front panel 3 has operation buttons 4, and a button-holding plate 7. The buttons 4 are arranged on the button-holding plate 7, which is provided below the display 5. The buttons 4 include a source button 11, a mode button 12, and a number buttons 13. The number buttons 13 includes six number buttons 13A to 13F. On the front panel 3, a seek plus button 14 and a seek minus button 15 are arranged on the right of display 5.

[0048] Every time the source button 11 is pushed, the vehicle audio apparatus 1 (FIGS. 2A and 2B) switches the source, from the radio broadcasting to the CD, or other way around. The speakers provided in the vehicle generate sound from the radio broadcasting selected corresponding to the push operation or from data read from the CD.

[0049] The user may push the mode button 12 after the pushing the source button 11, thus switching the source to radio broadcasting. As the user repeatedly pushes the mode button 12 in this condition, the output band is switched to FM-broadcasting bands "FM1", "FM2" and "FM3", AM-broadcasting bands "AM1" and "AM2", DAB bands "DAB1", "DAB2" and "DAB3", DRM bands "DRM1", "DRM2" and "DRM3", one after another. Note that "DRM" stands for "Digital Radio Mondiale", i.e., radio programs broadcast in the form of digital data in the AM-broadcasting bands.

[0050] When any one of the number buttons 13A to 13F is pushed while the output band remains set to, for example, DAB band "DAB1," the vehicle audio apparatus 1 causes the speakers provided in the vehicle to generate the sound of the program now being broadcast in the frequency allocated to the station registered in association with the number button 13A to 13F pushed.

[0051] When the seek plus button 14 is pushed while the output band remains set to, for example, DAB band "DAB1", the vehicle audio apparatus 1 searches for a station from which programs can be received in a DAB band higher than the frequency now set. Then, the apparatus 1 causes the speaker provided in the vehicle to generate the sound of the program now broadcast from the station found.

[0052] When the seek minus button 15 is pushed while the output band remains set to, for example, DAB band "DAB1", the vehicle audio apparatus 1 searches for a station from which programs can be received in a DAB band lower than the frequency now set. Then, the apparatus 1 causes the speaker provided in the vehicle to generate the sound of the program now broadcast from the station found.

(3) Circuit Configuration of the Vehicle Audio Apparatus

[0053] The circuit configuration of the main unit 2 and front panel 3 that constitute the vehicle audio apparatus 1 will be described. The vehicle audio apparatus 1 is configured to be driven with power supplied from the battery provided in the vehicle (not shown).

[0054] As shown in FIG. 4, the main unit 2 incorporates a controller 21 that is a central processing unit (CPU). The controller 21 reads an operating system from a read only memory (ROM) and extends the system in a random access memory (RAM). Using the operating system, the controller 21 controls the other components of the vehicle audio apparatus 1. Further, the controller 21 receives and outputs radio broadcasting and plays back a CD in accordance with various application programs.

[0055] The controller 21 is connected to a memory 22. The memory 22 is, for example, a nonvolatile memory. In the memory 22, the frequencies allocated to given six

DAB-band stations are registered in association with the six number buttons 13A to 13F of the number buttons 13.

[0056] Like the frequencies allocated to six DAB1-band stations, the frequencies allocated to six DAB2-band stations, the frequencies allocated to six DAB3-band stations, the frequencies allocated to six FM1-band stations, the frequencies allocated to six FM2-band stations, the frequencies allocated to six FM3-band stations, the frequencies allocated to six AM1-band stations, the frequencies allocated to six AM2-band stations, the frequencies allocated to six DRM1-band stations, the frequencies allocated to six DRM2-band stations, and the frequencies allocated to six DRM3-band stations are registered in the memory 22 in association with the six number buttons 13A to 13F of the number buttons 13.

[0057] When the source button 11 or mode button 12 is pushed and DAB band "DAB1," for example, is selected, the controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the characters of "DAB1." Seeing the characters, the user can visually confirm that DAB band "DAB1" has been duly selected.

[0058] The user may push one of the number buttons 13A to 13F and then push the seek plus button 14 or seek minus button 15, while DAB band "DAB1," "DAB2" or "DAB3" remains selected, thereby selecting the station he or she wants. In this case, the controller 21 of the vehicle audio apparatus 1 controls a DAB tuner 23, an audio processor 25 and a power amplifier 26, so that the program broadcast by the station thus selected may be output.

[0059] A DAB antenna 24 receives a DAB signal S1 transmitted in the DAB band. The DAB signal S1 is supplied to the DAB tuner 23. In the DAB tuner 23, a DAB extraction unit 23A extracts from the DAB signal S1 only the DAB channel signal S1A coming from the station the user wants, and a DAB signal process unit 23B demodulates and decodes the DAB channel signal S1A, generating DAB data.

[0060] In the DAB tuner 23, the DAB signal process unit 23B processes the DAB data, extracting DAB audio data D1B and DAB data D2. The DAB audio data D1B is sent to a DAB analog conversion unit 23C, and the DAB data D2 is sent to the controller 21. Note that the DAB data D2 contains various DAB information items such as the station name, the program name, and the alternative frequencies. The alternative frequencies are those allocated to the FM broadcasting and DRM stations that broadcast programs identical in content to the program broadcast by the station selected.

[0061] In the DAB tuner 23, the DAB signal process unit 23B is configured to detect the error rate of DAB data. If the error rate detected is equal to or higher than a prescribed threshold value, it is determined that the DAB channel signal S1A coming from the station the user wants has not been received. In this case, a DAB error signal ES1 is sent to the controller 21.

[0062] In the DAB tuner 23, the DAB analog conversion unit 23C performs analog conversion on the DAB audio data D1B, generating a DAB audio signal S3. The DAB audio signal S3 is sent to the audio processor 25.

[0063] The audio processor 25 performs audio adjustment such as equalization or volume control on the DAB audio signal S3 supplied from the DAB tuner 23, generating a DAB audio signal S4. The DAB audio signal S4 thus generated is sent to the power amplifier 26,

[0064] The power amplifier 26 amplifies the DAB audio signal S4 supplied from the audio processor 25 to a prescribed level. The DAB audio signal S4 so amplified is sent to a speaker 27. The speaker 27 generates sound from the DAB audio signal S4. Thus, the user can listen to the DAB program he or she wants.

[0065] The controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the station name, program name, etc. contained in the DAB data D2 supplied from the DAB signal process unit 23B of the DAB tuner 23. The user can therefore visually confirm the station name, the program name, etc.

[0066] One of the number buttons 13A to 13F, the seek plus button 14 or seek minus button 15 may be pushed while FM-broadcasting band "FM1", "FM2" or "FM3" remains selected, and the station allocated with an FM-broadcasting band, which the user wants, may then be selected. In this case, the controller 21 of the vehicle audio apparatus 1 controls a AM/FM tuner 28, the audio processor 25 and the power amplifier 26, to output the program being broadcast from this station.

[0067] When the AM/FM tuner 28 receives via an AM/FM antenna 29 an FM-broadcast signal S11 transmitted in the FM-broadcasting band selected, the AM/FM extraction unit 28A extracts, from the FM-broadcast signal S11, only the FM-broadcast signal S11A coming from the station the user wants. In the AM/FM tuner 28, an AM/FM demodulation unit 28B demodulates the FM-broadcast signal S11A, generating an FM-broadcast audio signal S12 and radio data system (RDS) data D13 that has been multiplexed on the FM-broadcast audio signal S12.

[0068] At this point, the AM/FM demodulation unit 28B of the AM/FM tuner 28 supplies the FM-broadcast audio signal S12 to the audio processor 25 and supplies the RDS data D13 to the controller 21. Note that the RDS data D13 contains RDS information including the station name, the program name and the alternative frequencies. The alternative frequencies are those allocated to the DAB stations that broadcast programs identical in content to the program broadcast by the station selected.

[0069] Thereafter, in the vehicle audio apparatus 1, the audio processor 25 and the power amplifier 26 process the FM-broadcast audio signal S12 in the same way as they process the above-mentioned DAB audio signal S3. That is, the audio processor 25 performs audio adjustment on the FM-broadcast audio signal S12, generating an FM-broadcast audio signal S14. The FM-broadcast audio signal S14 thus generated is sent to the power amplifier 26. The power amplifier 26 amplifies the FM-broadcast audio signal S14 to a prescribed level. The

FM-broadcast audio signal S14 so amplified is sent to the speaker 27. The speaker 27 generates sound from the FM-broadcast audio signal S14. Thus, the user can listen to the FM program he or she wants.

[0070] The controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the station name, program name, etc., all contained in the RDS data D13 supplied from the AM/FM tuner 28. The user can therefore visually confirm the station name, the program name, etc.

[0071] One of the number buttons 13A to 13F and the seek plus button 14 or seek minus 15 may be pushed while the AM band "AM1" or "AM2" remains selected, and a station allocated with an AM-broadcasting band, which the user wants, may then be selected. In this case, the controller 21 of the vehicle audio apparatus 1 controls the AM/FM tuner 28, audio processor 25 and power amplifier 26, to output the program being broadcast from this station.

[0072] When the AM/FM tuner 28 receives via the AM/FM antenna 29, an AM-broadcast signal S21 transmitted in the AM-broadcasting band selected, the AM/FM extraction unit 28A extracts, from the FM-broadcast signal S21, only the AM-broadcast channel signal S21A coming from the station the user wants. In the AM/FM tuner 28, the AM/FM demodulation unit 28B demodulates the AM-broadcast channel signal S21A, generating an AM-broadcast audio signal S22. The AM-broadcast audio signal S22 is sent to the audio processor 25.

[0073] Thereafter, in the vehicle audio apparatus 1, the audio processor 25 and the power amplifier 26 process the AM-broadcast audio signal S22 in the same way as they process the above-mentioned DAB audio signal S3. That is, the audio processor 25 performs audio adjustment process on the AM-broadcast audio signal S22, generating an AM-broadcast audio signal S24. The AM-broadcast audio signal S24 thus generated is sent to the power amplifier 26. The power amplifier 26 amplifies the AM-broadcast audio signal S24 to a prescribed level. The AM-broadcast audio signal S24 so amplified is sent to the speaker 27. The speaker 27 generates sound from the AM-broadcast audio signal S24. Thus, the user can hear the AM-broadcast program he or she wants.

[0074] One of the number buttons 13A to 13F and the seek plus button 14 or seek minus 15 may be pushed while the DRM band "DRM1", "DRM2" or "DR3" remains selected, and a DRA station allocated with an AM-broadcasting band, which the user wants, may then be selected. In this case, the controller 21 of the vehicle audio apparatus 1 controls the AM/FM tuner 28, audio processor 25 and power amplifier 28, to output the program being broadcast from this station.

[0075] When the AM/FM tuner 28 receives via the AM/FM antenna 29, an DRM signal S31 transmitted in the AM-broadcasting band selected, the AM/FM extraction unit 28A extracts, from the DRM signal S31, only the DRM channel signal S31A coming from the station the user wants. The AM/FM demodulation unit 28B demodulates the DRM channel signal S31A, generating a DRM channel signal S31B. The DRM channel signal S31B is sent to a DRM decoder 28C.

[0076] The DRM decoder 28C of the AM/FM tuner 28 decodes the DRM channel signal S31B, generating DRM data. From the DRM data, DRM audio data D31C and DRM data D33 are extracted. The DRM audio data D31C is sent to a DRM analog conversion unit 28D, and the DRM data D33 is sent to the controller 21. Note that the DRM data D33 contains DRM information including the station name, the program name and the alternative frequencies. The alternative frequencies are those allocated to the DAB stations that broadcast programs identical in content to the program broadcast by the DAB station selected.

[0077] In the AM/FM tuner 28, the DRM decoder 28C is configured to detect the error rate of DRM data. If the error rate detected is equal to or higher than a prescribed threshold value, it is determined that the DRM channel signal S31A coming from the station the user wants has not been received. In this case, an error signal ES2 is sent to the controller 21.

[0078] In the AM/FM tuner 28, the DRM analog conversion unit 28D performs analog conversion on the DRM audio data D31C supplied from the DRM decoder 28C, generating a DRM audio signal S32. The DRM audio signal S32 is sent to the audio processor 25.

[0079] Thereafter, in the vehicle audio apparatus 1, the audio processor 25 and the power amplifier 26 process the DRM audio signal S32 in the same way as they process the above-mentioned DRM audio signal S3. That is, the audio processor 25 performs audio adjustment process on the DRM audio signal S32, generating a DRM audio signal S34. The DRM audio signal S34 thus generated is sent to the power amplifier 26. The power amplifier 26 amplifies the DRM audio signal S34 to a prescribed level. The DRM audio signal S34 so amplified is sent to the speaker 27. The speaker 27 generates sound from the DRM audio signal S34. Thus, the user can hear the DRM program he or she wants.

[0080] The controller 21 of the vehicle audio apparatus 1 is configured to cause the display 5 to display the station name, program name, etc. contained in the RDS data D33 supplied from the AM/FM tuner 28. The user can therefore visually confirm the station name, the program name, etc.

[0081] The controller 21 of the vehicle audio apparatus 1 is configured to cause a CD player 30 to play back the CD music data recorded in a CD medium, when "CD" is selected as the source button 11, for example, is pushed. The CD music data is supplied to the audio processor 25.

[0082] In the vehicle audio apparatus 1, the audio processor 25 and power amplifier 26 process the CD music data. The CD music data processed is supplied to the speaker 27. The speaker 27 generates the CD music supplied from the CD player 30, to which the user can listen.

(4) DAB Restoring Sequence Achieved by the FM link Function

[0083] While the FM link function remains on in the vehicle audio apparatus 1, the user may perform an operation to search for a DAB-band station after the broadcasting band has been automatically switched from the DAB band to the FM band. In this case, the broadcasting band is switched back to the DAB band, thereby to output a DAB program. How this DAB restoration is performed will be explained with reference to FIG. 5.

[0084] The controller 21 of the vehicle audio apparatus 1 starts operating in the start step of routine RT2 and then goes to Step SP21. In Step SP21, the controller 21 turns on the FM link function when the source button 11 is pushed, setting the broadcasting band DAB band "DAB1." Then, the controller 21 goes to the next step, Step SP22.

[0085] In the vehicle audio apparatus 1, the FM link function remains on as long as the default is set. Therefore, the FM link function is automatically activated, and the user need not activate the FM link function. Nonetheless, the user may perform some operation to turn the FM link function on.

[0086] In Step SP22, the controller 21 of the vehicle audio apparatus 1 causes the DAB tuner 23 to receive a DAB signal S1 via the DAB antenna 24 when one of the number buttons 13A to 13F and the seek plus button 14 or seek minus button 15 is pushed, selecting the DAB band "DAB1" station the user wants. The DAB tuner 23 then extracts a DAB audio signal S3 corresponding to the station the user wants from the DAB signal S1. The audio processor 25 performs audio adjustment process on the DAB audio signal S3, generating a DAB audio signal S4. The DAB audio signal S4 thus generated is sent to the power amplifier 26 and thence to the speaker 27 to output sound from the DAB audio signal S4. The controller 21 then goes to the next step, i.e., Step SP23.

[0087] At this point, the controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the station name, program name, etc. which are contained in the DAB data D2 supplied from the DAB signal process unit 23B of the DAB tuner 23. At the same time, the controller 21 causes the AM/FM tuner 28 to supply to the audio processor 25 the FM-broadcast audio signal S12 corresponding to the alternative FM frequency and contained in the DAB data D2.

[0088] The controller 21 of the vehicle audio apparatus 1 controls the audio processor 25 to supply the DAB audio signal S4 only, but not the FM-broadcast audio signal S14, to the power amplifier 26.

[0089] In Step SP23, the controller 21 of the vehicle audio apparatus 1 determines whether the DAB signal process unit 23B of the DAB tuner 23 has supplied the error signal ES1. If the decision made is negative, the control 21 returns to Step SP22, in which the program is continuously output.

[0090] If the decision made in Step S23 is affirmative, this means that no DAB channel signals S1A have been received from the station now broadcasting the program. In this case, the controller 21 of the vehicle audio apparatus 1 goes to the next step, i.e., Step SP24.

[0091] In Step SP24, the controller 21 of the vehicle audio apparatus 1 sends an output-switching instruction signal to the audio processor 25. In response to the instruction signal, the audio processor 25 supplies to the power amplifier 26 the FM-broadcast audio signal S14 obtained performing audio adjustment process on the FM-broadcast audio signal S12 supplied from the AM/FM tuner 28. The controller 21 causes the speaker 27 to generate the sound of the FM program identical in content to the DAB program that the user was listening to in Step SP22. Then, the controller 21 goes to the next step, i.e., Step SP25.

[0092] At this point, the controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the station name, program name, etc. contained in the RDS data D13 supplied from the AM/FM tuner 28, and to display the characters "FM1" indicating that the broadcasting band has been switched from DAB band "DAB1" to, for example, FM-broadcasting band "FM1".

[0093] If the user becomes tired of the program he or she has been listening to, he or she may push the seek plus button 14 or the seek minus button 15 in order to hear a program broadcast by any other station.

[0094] Therefore, in Step SP25, the controller 21 of the vehicle audio apparatus 1 determines whether the seek plus button 14 or the seek minus button 15 has been pushed. If the decision is negative, the controller 21 returns to Step S25 and waits until the seek plus button 14 or the seek minus button 15 is pushed. If the decision is affirmative, the controller 21 goes to the next step, i.e., Step SP 26.

[0095] In Step S26, the controller 21 of the vehicle audio apparatus 1 switches FM-broadcasting band "FM1" back to DAB band "DAB1". If the seek plus button 14 is found in Step SP25 to have been pushed, the controller 21 searches for a station broadcasting a program that can be received in a DAB band higher than the frequency set in Step SP22. The controller 21 then goes to the next step, i.e., Step SP27.

[0096] If the seek minus button 15 is found in Step SP25 to have been pushed, the controller 21 of the vehicle audio apparatus 1 searches for a station broadcasting a program that can be received in a DAB band lower than the frequency set in Step SP22. The controller 21 then goes to the next step, i.e., Step SP27.

[0097] In Step SP27, the controller 21 of the vehicle audio apparatus 1 causes the DAB tuner 23 to extract the DAB audio signal S3 coming from the station found when the user pushes the seek plus button 14 or the seek minus button 15. The audio processor 25 performs audio adjustment process on the DAB audio signal S3, generating a DAB audio signal S4. The DAB audio signal S4 is supplied to the power amplifier 26 and thence to the speaker 27, enabling the user to listen to the DAB pro-

gram. Then, the controller 21 goes to the next step, i.e., Step SP28. The process is thereby terminated.

[0098] Thus, the controller 21 of the vehicle audio apparatus 1 ceases to receive the DAB channel signal S1A from the station that has been outputting the DAB channel signal S1A in, for example, DAB band "DAB1", in accordance with the DAB restoring sequence of the above-mentioned FM link function. If the FM link function switches the broadcasting band to FM-broadcasting band "FM1", the broadcasting band is switched from FM-broadcasting band "FM1" back to DAB band "DAB1" when the seek plus button 14 or the seek minus button 15 is pushed. Then, a station from which programs can be received in DAB band "DAB1" is searched for. The vehicle audio apparatus 1 therefore outputs the DAB program broadcast by the station thus found.

[0099] While the FM link function remains on and the user is listening to a program in DAB band "DAB1," the broadcasting band may be switched from DAB band "DAB1" to FM-broadcasting band "FM1". In this case, the controller 21 of the vehicle audio apparatus 1 automatically searches for a station from which a program can be received in DAB band "DAB1" upon detecting that the seek plus button 14 or the seek minus button 15 has been pushed. After switching the broadcasting band from the FM-broadcasting band "FM1" back to DAB band "DAB1", the vehicle audio apparatus 1 enables the user to listen to the program broadcast by the station of DAB band "DAB1."

(5) DAB Restoring Sequence Achieved by the DRM Link Function

[0100] The vehicle audio apparatus 1 may no longer receive a DAB channel signal S1A, while the DAB tuner 23 is receiving a DAB signal S1 and the user is therefore listening to the DAB program based on the DAB channel signal S1A corresponding to the station the user wants. In this case, the AM/FM tuner 28 receives a DRM-broadcast signal S31. Therefore, the vehicle audio apparatus 1 enables the user to hear the DRM program based on the DRM channel signal S31A, which is identical in content to the DAB program the user has been listening to. This function of the vehicle audio apparatus 1 shall be hereinafter referred to as "DRM link function."

[0101] While the DRM link function remains on in the vehicle audio apparatus 1, the user may operate the front panel 3 to search for a DAB-band station after the broadcasting band has been automatically switched from the DAB band to the DRM band. Then, the broadcasting band is switched back to the DAB band. How this is done will be explained with reference to FIG. 6.

[0102] The controller 21 of the vehicle audio apparatus 1 starts operating in the start step of routine RT3 and then goes to Step SP31. In Step SP31, the controller 21 turns on the DRM-link function when the source button 11 is pushed, setting the broadcasting band DAB band "DAB1." Then, the controller 21 goes to the next step, Step SP32.

[0103] In Step SP32, when one of the number buttons 13A to 13F and the seek plus button 14 or seek minus button 15 is pushed, thus selecting a DAB-band "DAB1" station the user wants, the controller 21 of the vehicle audio apparatus 1 causes the DAB tuner 23 to receive the DAB signal S1 via the DAB antenna 24 and to extract the DAB audio signal S3 corresponding to the station the user wants. The controller 21 then causes the audio processor 25 to perform audio adjustment process on the DAB audio signal S3, generating a DAB audio signal S4. The DAB audio signal S4 is supplied via the power amplifier 26 to the speaker 27. The speaker 27 generates sound from the DAB audio signal S4. The controller 21 then goes to the next step, i.e., Step SP33.

[0104] At this point, the controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the station name, program name, etc. contained in the DAB data D2 supplied from the DAB signal process unit 23B of the DAB tuner 23, and causes the AM/FM tuner 28 to supply to the audio processor 25 the DRM audio signal S32 corresponding to the alternative DRM frequency contained in the DAB data D2.

[0105] The controller 21 of the vehicle audio apparatus 1 controls the audio processor 25 to supply the DAB audio signal S4, but not the DRM audio signal S34, to the power amplifier 26.

[0106] In Step SP33, the controller 21 of the vehicle audio apparatus 1 determines whether the DAB signal process unit 23B of the DAB tuner 23 has supplied a DAB error signal ES1. If the decision is negative, the controller 21 returns to Step SP32, in which the program is continuously output.

[0107] If the decision made in Step SP33 is affirmative, this means that the DAB channel signal S1A is not able to be received from the station broadcasting the program that is now being output. The controller 21 of the vehicle audio apparatus 1 therefore goes to the next step, i.e., Step SP34.

[0108] In Step SP34, the controller 21 of the vehicle audio apparatus 1 sends an output-switching instruction signal to the audio processor 25. The output-switching instruction signal instructs the audio processor 25 to supply, to the power amplifier 26, the DRM audio signal S34 generated by performing audio adjustment process on the DRM audio signal S32 supplied from the AM/FM tuner 28. The controller 21 then causes the speaker 27 to generate the sound of the DRM program that is identical in content to the DAB program the user was hearing in Step SP32.

[0109] At this time, the controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the station name, program name, etc. contained in the DRM data D33 supplied from the AM/FM tuner 28 and to display characters "DRM1" indicating that the broadcasting band has been switched from DAB band "DAB1" to, for example, DRM band "DRM1."

[0110] If the user becomes tired of the program he or

she has been listening to, he or she may push the seek plus button 14 or the seek minus button 15 in order to hear a program broadcast by any other station.

[0111] Therefore, in Step SP35, the controller 21 of the vehicle audio apparatus 1 determines whether the seek plus button 14 or the seek minus button 15 has been pushed. If the decision is negative, the controller 21 returns to Step S35 and waits until the seek plus button 14 or the seek minus button 15 is pushed. If the decision is affirmative, the controller 21 goes to the next step, i.e., Step SP 36.

[0112] In Step S36, the controller 21 of the vehicle audio apparatus 1 switches the broadcasting band from DRM band "DRM1" back to DAB band "DAB1." If the seek plus button 14 is found in Step SP35 to have been pushed, the controller 21 searches for a station broadcasting a program that can be received in a DAB band higher than the frequency set in Step SP32. The controller 21 then goes to the next step, i.e., Step SP37.

[0113] If the seek minus button 15 is found in Step SP35 to have been pushed, the controller 21 of the vehicle audio apparatus 1 searches for a station broadcasting a program that can be received in a DAB band lower than the frequency set in Step SP32. The controller 21 then goes to the next step, i.e., Step SP37.

[0114] In Step SP37, the controller 21 of the vehicle audio apparatus 1 causes the DAB tuner 23 to extract the DAB audio signal S3 coming from the station found when the user pushes the seek plus button 14 or the seek minus button 15. The audio processor 25 performs audio adjustment process on the DAB audio signal S3, generating a DAB audio signal S4. The DAB audio signal S4 is supplied to the power amplifier 26 and thence to the speaker 27, enabling the user to listen to the DAB program. Then, the controller 21 goes to the next step, i.e., Step SP38. The process is thereby terminated.

[0115] Thus, the controller 21 of the vehicle audio apparatus 1 ceases to receive the DAB channel signal S1A from the station that has been outputting the signal SA1 in, for example, DAB band "DAB1", in accordance with the DAB restoring sequence of the above-mentioned DRM link function. If the DRM link function switches the broadcasting band to DRM band "DRM1", the broadcasting band is switched from DRM band "DRM1" back to DAB band "DAB1" when the seek plus button 14 or the seek minus button 15 is pushed. Then, the controller 21 searches for a station from which programs can be received in DAB band "DAB1". The vehicle audio apparatus 1 therefore outputs the DAB program broadcast by the station thus found.

[0116] While the FM link function remains on and the user is listening to a program in DAB band "DAB1", the broadcasting band may be switched from DAB band "DAB1" to DRM band "DRM1". In this case, the controller 21 of the vehicle audio apparatus 1 automatically searches for a station from which a program can be received in DAB band "DAB1" upon detecting that the seek plus button 14 or the seek minus button 15 has been pushed. After switching the broadcasting band from the DRM band "DRM1" back to DAB band "DAB1", the vehicle audio apparatus 1 enables the user to listen to the program broadcast by the station of DAB band "DAB1".

(6) Operation and Effect

[0117] In the vehicle audio apparatus 1 so configured as described above, if the controller 21 ceases to receive the DAB channel signal S1A from the station that has been outputting the signal SA1 in, for example, DAB band "DAB1". After the FM link function has switched the broadcasting band to FM band "FM1", the broadcasting band may be switched from FM band "FM1" back to DAB band "DAB1" when the seek plus button 14 or the seek minus button 15 is pushed. Then, a station from which programs can be received in DAB band "DAB1" is searched for. The vehicle audio apparatus 1 therefore enables the user to listen to the DAB program broadcast by the station thus found.

[0118] The vehicle audio apparatus 1 can provide a radio-program receiving method that is as user-friendly as described below. In the vehicle audio apparatus 1, even if the FM link function switches the broadcasting band from DAB band "DAB1" to FM-broadcasting band "FM1" while the user is listening to a program broadcast in, for example, DAB band "DAB1", the user may not notice that the broadcasting band has been so switched, because the program broadcast in FM-broadcasting band "FM1" is the same in content.

[0119] Not noticing that the broadcasting band has been switched from DAB band "DAB1" to FM-broadcasting band "FM1", the user, who has become tired of the program he or she is listening to, may push the seek plus button 14 or seek minus button 15. This is because the user thinks that the vehicle audio apparatus 1 will search for another station of the DAB band.

[0120] If the seek plus button 14 or seek minus button 15 is pushed after the FM link function has switched the broadcasting band from DAB band "DAB1" to FM-broadcasting band "FM1", however, the vehicle audio apparatus 1 searches for another FM-broadcasting band station and outputs the program the other FM-broadcasting band station is broadcasting. At this point, the user finds that he or she is listening to an FM-broadcast program. Inevitably, the user has to push the mode button 12 in order to switch the broadcasting band back to, for example, DAB band "DAB1."

[0121] If the user becomes tired of the program he or she is listening to and if he or she pushes the seek plus button 14 or seek minus button 15, the vehicle audio apparatus 1 switches the broadcasting band from FM-broadcasting band "FM1" back to DAB band "DAB1" no matter whether the user knows that the FM link function has switched the broadcasting band to FM-broadcasting band "FM1". The user can therefore hear a DAB program. Hence, the user can enjoy another DAB program merely by pushing the seek plus button 14 or seek minus button

15, not caring about which band the broadcasting band is set to, DAB band "DAB1" or FM-broadcasting band "FM1."

[0122] To switch FM-broadcasting band "FM1" back to DAB band "DAB1," the vehicle audio apparatus 1 searches for a frequency at which programs broadcast in DAB band "DAB1" can be received, because the possibility of receiving the DAB channel signal S1A of the frequency at which the user first hears is low. The apparatus 1 outputs a DAB program broadcast in the frequency found, which the user listens to. Thus, the user can hear a DAB program, merely by performing an easy operation at the front panel 3, without necessity of pushing any button to search for that frequency.

[0123] Further, if the broadcasting band is automatically switched from DAB band "DAB1" to FM-broadcasting band "FM1" because the FM link function remains on, the vehicle audio apparatus 1 can switch FM-broadcasting band "FM1" back to DAB band "DAB1" when the seek plus button 14 or seek minus button 15 is pushed. Therefore, the user need not repeatedly push the mode button as with the conventional apparatus. That is, the user can listen to a program broadcast in DAB band "DAB1", by performing an easy operation at the front panel 3.

[0124] In the vehicle audio apparatus 1, after the FM link function has automatically switches the broadcasting band from DAB band "DAB1" to FM-broadcasting band "FM1", the broadcasting band is switched from FM band "FM1" back to DAB band "DAB1" when the seek plus button 14 or seek minus button 15 is pushed. When the seek plus button 14 or the seek minus button 15 is pushed to search for a station from which programs can be received in DAB band "DAB1", it is unnecessary to visually show the user in which band, FM-broadcasting band "FM1" or DAB band "DAB1", he or she is listening to the program. This renders the vehicle audio apparatus 1 more user-friendly.

[0125] In the vehicle audio apparatus 1, the controller 21 may cease to receive the DAB channel signal S1A from the station that has been outputting the signal SA1 in, for example, DAB band "DAB1," and the DRM link function may switches the broadcasting band to DRM band "DRM1." In this case, the broadcasting band is switched from DRM band "DRM1" back to DAB band "DAB1" when the seek plus button 14 or the seek minus button 15 is pushed. Then, a station from which programs can be received in DAB band "DAB1" is searched for. The vehicle audio apparatus 1 therefore enables the user to listen to the DAB program broadcast by the station thus found.

[0126] In the vehicle audio apparatus 1 so configured as described above, the seek plus button 14 or seek minus button 15 may be pushed while the FM link function or DRM-link function remains on and the user is listening to a program in DAB band "DAB1." In this case, the FM band "FM1" or DRM band "DRM1" is switched back to DAB band "DAB1" and a station from which programs can be received in DAB band "DAB1" is searched for. Thus, the apparatus 1 enables the user to hear a DAB program.

(7) Other Embodiments

[0127] In the embodiment described above, if the seek plus button 14 or seek minus button 15 is pushed after the FM function has automatically switched the broadcasting band from DAB band "DAB1" to FM band "FM1" while the FM link function remains on,FM band "FM1" is switched back to DAB band "DAB1." This invention is not limited to this. For example, the source button 11, mode button 12 or any one of the number buttons 13A to 13F may be pushed to switch FM band "FM1" back to DAB band "DAB1."

[0128] In this case, the vehicle audio apparatus 1 switches FM band "FM1" back to DAB band "DAB1" when the source button 11 or mode button 12 is pushed after the FM link function has automatically switched DAB band "DAB1" to FM band "FM1" while the FM link function remains on. When FM band "FM1" is thus switched back to DAB band "DAB1", the possibility of receiving the DAB channel signal S1A of the station at which the user first hear is low. A station is searched for, from which programs can be received in DAB band "DAB1", so that the user may listen to a DAB program broadcast by the station thus found. The same advantage can therefore be achieved as in the above-described embodiment.

[0129] In the vehicle audio apparatus 1, the broadcasting band is automatically switched from DAB band "DAB1" to FM band "FM1" while the FM link function remains on. When any one of the number buttons 13A to 13F is pushed after the broadcasting band has been so switched, the frequency corresponding to the number button pushed is read from the memory 22. The apparatus 1 then outputs a DAB program broadcast by the station allocated with the frequency read from the memory 22.

[0130] In the embodiment described above, the broadcasting band is switched back to DAB band "DAB1," outputting a DAB program, when the seek plus button 14 or seek minus button 15 is pushed after the FM link function or DRM link function has switched DAB band "DAB1" to FM band "FM1" or DRM band "DRM1." This invention is not limited to this, nevertheless. If DAB link function may be used to switch the broadcasting band, for example, from DRM band "DRM1" to DAB band "DAB1." In this case, when the seek plus button 14 or seek minus button 15 is pushed, the broadcasting band is switched back to DRM band "DRM1," thereby outputting a DRM program.

[0131] The "DAB link function" is a function that enables the user to listen to a DAB program based on the DAB channel signal S1A, which is identical in content to the DRM program the user hears while the DAB tuner 23 is receiving the DAB signal S1, if the apparatus 1 ceases to receive the DRM channel signal S31A while AM/FM tuner 28 is receiving DRM signal S31. Thus, the DAB link

function enables the user to listen to the DRM-base program based on the DRM channel signal S31A coming from the station the user wants.

[0132] As shown in FIG. 7, the controller 21 of the vehicle audio apparatus 1 starts operating in the start step of routine RT4 and then goes to Step SP41. In Step SP41, the controller 21 turns on the DAB-link function when the source button 11, for example, is pushed, thus setting the broadcasting band DRM band "DRM1". Then, the controller 21 goes to the next step, Step SP42.

[0133] In Step SP42, when one of the number buttons 13A to 13F and the seek plus button 14 or seek minus button 15 is pushed, selecting a DRM band "DRM1" station the user wants, the controller 21 of the vehicle audio apparatus 1 causes the AM/FM tuner 28 to receive the DRM signal S31 via the AM/FM antenna 29 and to extract the DRM audio signal S32 corresponding to the station the user wants. The controller 21 then causes the audio processor 25 to perform audio adjustment process on the DRM audio signal S32, generating a DRM audio signal S34. The DRM audio signal S34 is supplied via the power amplifier 26 to the speaker 27. The speaker 27 generates sound from the DRM audio signal S34. The controller 21 then goes to the next step, i.e., Step SP43.

[0134] At this point, the controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the station name, program name, etc. contained in the DRM data D33 supplied from the DRM decoder 28C of the AM/FM tuner 28, and causes the DAB tuner 23 to supply to the audio processor 25 the DAB audio signal S3 corresponding to the alternative DAB frequency contained in the DRM data D33.

[0135] The controller 21 of the vehicle audio apparatus 1 controls the audio processor 25 to supply the DRM audio signal S34, but not the DAB audio signal S4, to the power amplifier 26.

[0136] In Step SP43, the controller 21 of the vehicle audio apparatus 1 determines whether the DRM decoder 28C of the AM/FM tuner 28 has supplied a DRM error signal ES2. If the decision is negative, the controller 21 returns to Step SP42, in which the program is continuously output.

[0137] If the decision made in Step SP43 is affirmative, this means that the DRM channel signal S31A is not able to be received from the station broadcasting the program that is now being output. The controller 21 of the vehicle audio apparatus 1 therefore goes to the next step, i.e., Step SP44.

[0138] In Step SP44, the controller 21 of the vehicle audio apparatus 1 sends an output-switching instruction signal to the audio processor 25. The output-switching instruction signal instructs the audio processor 25 to supply, to the power amplifier 26, the DAB audio signal S4 generated by performing audio adjustment process on the DAB audio signal S3 supplied from the DAB FM tuner 23. The controller 21 then causes the speaker 27 to generate the sound of the DAB program that is identical in content to the DRM program the user was hearing in Step SP42.

[0139] At this time, the controller 21 of the vehicle audio apparatus 1 causes the display 5 to display the station name, program name, etc. contained in the DAB data D2 supplied from the DAB tuner 23 and to display characters "DAB1" indicating that the broadcasting band has been switched from DRM band "DRM1" to, for example, DAB band "DAB1".

[0140] If the user becomes tired of the program he or she has been listening to, he or she may push the seek plus button 14 or the seek minus button 15 in order to hear a program broadcast by any other station.

[0141] Hence, in Step SP45, the controller 21 of the vehicle audio apparatus 1 determines whether the seek plus button 14 or the seek minus button 15 has been pushed. If the decision is negative, the controller 21 returns to Step S45 and waits until the seek plus button 14 or the seek minus button 15 is pushed. If the decision is affirmative, the controller 21 goes to the next step, i.e., Step SP 46.

[0142] In Step S46, the controller 21 of the vehicle audio apparatus 1 switches DAB band "DAB1" back to DRM band "DRM1". If the seek plus button 14 is found in Step SP45 to have been pushed, the controller 21 searches for a station broadcasting a program that can be received in a AM band higher than the frequency set in Step SP42. The controller 21 then goes to the next step, i.e., Step SP47.

[0143] If the seek minus button 15 is found in Step SP45 to have been pushed, the controller 21 of the vehicle audio apparatus 1 searches for a station broadcasting a program that can be received in a AM band lower than the frequency set in Step SP42. The controller 21 then goes to the next step, i.e., Step SP47.

[0144] In Step SP47, the controller 21 of the vehicle audio apparatus 1 causes the AM/FM tuner 28 to extract the DRM audio signal S32 coming from the station found when the user pushes the seek plus button 14 or the seek minus button 15. The audio processor 25 performs audio adjustment process on the DRM audio signal S32, generating a DRM audio signal S34. The DAB audio signal S34 is supplied to the power amplifier 26 and thence to the speaker 27, enabling the user to listen to the DRM program. Then, the controller 21 goes to the next step, i.e., Step SP48. The process is thereby terminated.

[0145] Thus, the controller 21 of the vehicle audio apparatus 1 ceases to receive the DRM channel signal S31A from the station that has been outputting the signal SA31 in, for example, DRM band "DRM1," in accordance with the DRM restoring sequence of the above-mentioned DAB-link function. If the DAB-link function switches the broadcasting band to DAB band "DAB1," the broadcasting band is switched from DAB band "DAB1" back to DRM band "DAM1" when the seek plus button 14 or the seek minus button 15 is pushed. Then, the controller 21 searches for a station from which programs can be received in DRM band "DRM1." The vehicle audio apparatus 1 therefore outputs the DRM program broad-

cast by the station thus found. The user can therefore hear the DAB program.

[0146] In the embodiment described above, the FM link function automatically switches the broadcasting band from DAB band "DAB1" to FM band "FM1". The invention is not limited to this, nevertheless. The broadcasting band may be switched from DAB band "DAB1" to FM band "FM2" or to FM band "FM3".

[0147] In the embodiment described above, if the controller 21 ceases to receive an FM-broadcasting channel signal S11A of the station that has been outputting it in FM band "FM1" and if the FM link function switches the broadcasting band to DAB band "DAB1," the FM program identical in content to the DAB program is output through the speaker 27. This invention is not limited to this, nonetheless. An FM program different in content from the DAB program may be output through the speaker 27 if the controller 21 ceases to receive the FM-broadcasting channel signal S11A of the station that has been outputting it in FM band "FM1".

[0148] Further, the embodiment described above can receive programs broadcast in DRM bands "DRM1," "DRM2" and "DRM3." The invention is not limited to this. The apparatus 1 need not be configured to receive programs broadcast in DRM bands "DRM1," "DRM2" and "DRM3," if DRM programs are contained in analog programs broadcast in AM bands.

[0149] In this case, the controller 21 of the vehicle audio apparatus 1 switches the broadcasting band, from DAB band "DAB1" to AM band "AM1," if the DAB channel signal S1A can no longer be received from the station transmitting the program being output, while the user is listening to a desired program broadcast in DAB band "DAB1" in the DAB restoring sequence of the above-mentioned DRM-link function. The DRM program identical in content to the DAB program broadcast in AM band "AM1" can therefore output through the speaker 27.

[0150] Further, the controller 21 of the vehicle audio apparatus 1 switches the broadcasting band, from AM band "AM1" to DAB band "DAB1", if the DRM channel signal S31A can no longer be received from the station transmitting the program being output, while the user is listening to a desired program broadcast in AM-broadcasting band "AM1" in the DRM restoring sequence of the above-mentioned DAB-link function. The DAB program identical in content to the DRM program broadcast in DAB band "DAB1" can therefore output through the speaker 27.

[0151] When seek plus button 14 or seek minus button 15 is pushed, the controller 21 of the vehicle audio apparatus 1 switches DAB band "DAB1" back to AM band "AM1". The DRM program broadcast from the station found as the user pushes the seek plus button 14 or seek minus button 15 is then output through the speaker 27.

[0152] In the embodiment described above, the controller 21 of the vehicle audio apparatus 1 performs the DAB restoring sequence in the FM link function (routine RT2), the DAB restoring sequence in the DRM link function (routine RT3), and the DRM restoring sequence in the DAB link function (routine RT4), in accordance with the application program stored in the ROM. The invention is not limited to this, nevertheless. The controller 21 may perform the DAB restoring sequence in the FM link function, the DAB restoring sequence in the DRM link function, and the DRM restoring sequence in the DAB link function, in accordance with application programs installed from recording media, with application programs downloaded from the Internet, or with application programs installed through other various routes.

[0153] In the embodiment described above, the DAB tuner 23 is used as first reception unit, the AM/FM tuner 28 as second reception unit, the audio processor 25 as switch unit, the controller 21 as restoration unit. These units constitute the vehicle audio apparatus 1, or a radio receiving apparatus according to the embodiment of the present invention. This invention is not limited to the vehicle audio apparatus 1. The radio receiving apparatus according to the embodiment of the present invention may include a first reception unit, a second reception unit, a switch unit and a restoration unit, which are different in configuration from the DAB tuner 23, AM/FM tuner 28, audio processor 25 and controller 21, respectively.

[0154] The radio receiving apparatus according to the embodiment of the present invention can be applied as only to vehicle audio apparatuses, but also as portable music players, tabletop radio receivers and other various types of radio receivers. Further, the output-switching sequence according to the embodiment of the present invention can be applied to various output-switching sequences.

[0155] It should be understood by those skilled in the art that various modifications, combinations, sub-combinations and alterations may occur depending on design requirements and other factors insofar as they are within the scope of the appended claims or the equivalents thereof.

Claims

1. A radio receiving apparatus comprising:

first receiving means for receiving a first broadcast signal broadcast in a first frequency band;
second receiving means for receiving a second broadcast signal broadcast in a second frequency band;
switching means for switching a program based on the second broadcast signal received by the second receiving means to output from the output means, when the first receiving means ceases to receive the first broadcast signal while a program based on the first broadcast signal received by the first receiving means is being output from predetermined output means; and
restoring means for performing forced restora-

tion to output the program based on the first broadcast signal from the output means, when a predetermined operation is detected to have been performed while the program based on the second broadcast signal switched by the switching means is being output.

2. The radio receiving apparatus according to claim 1, wherein the restoring means causes the output means to output the program based on the first broadcast signal able to be received by the first receiving means, upon detecting that the predetermined operation has been performed.

3. The radio receiving apparatus according to claim 2, wherein the restoring means causes the output means to output a program based on the first broadcast signal able to be received by the first receiving means, the program being different from the program output before the switching by the switching means, upon detecting that the predetermined operation has been performed.

4. The radio receiving apparatus according to claim 1, 2 or 3, wherein:

the first receiving means receives a digital audio broadcasting (DAB) signal broadcast as the first broadcast signal in a DAB band used as the first frequency band; and
the second receiving means receives a frequency modulation (FM) broadcasting signal broadcast as the second broadcast signal in an FM broadcasting band used as the second frequency band.

5. The radio receiving apparatus according to claim 4, wherein the second receiving means receives the second broadcast signal broadcasting a program identical in content to the program based on the first broadcast signal.

6. The radio receiving apparatus according to one of the claims 1 to 5, wherein the restoring means causes the output means to output a program broadcast by a station allocated to a frequency of the first frequency band, the frequency having been registered via predetermined registering means in advance, upon detecting that the predetermined operation has been performed.

7. An output restoring method comprising:

a first receiving step of receiving a first broadcast signal broadcast in a first frequency band, by using first receiving means;
a second receiving step of receiving a second broadcast signal broadcast in a second frequency band, by using second receiving means;
a switching step for switching a program based on the second broadcast signal received by the second receiving means to output from the output means by using switching means, when the first receiving means ceases to receive the first broadcast signal while a program based on the first broadcast signal received by the first receiving means is being output from predetermined output means;
a restoring step of performing forced restoration to output the program based on the first broadcast signal by using restoring means, when a predetermined operation is detected to have been performed while the program based on the second broadcast signal switched by the switching means is being output.

8. The output restoring method according to claim 7, wherein, in the restoring step, the output means outputs the program based on the first broadcast signal able to be received by the first receiving means, upon detecting that the predetermined operation has been performed.

9. The output restoring method according to claim 8, wherein in the restoring step, the output means outputs a program based on the first broadcast signal able to be received by the first receiving means, the program being different from the program output before the switching by the switching means, upon detecting that the predetermined operation has been performed.

10. The output restoring method according to claim 7, 8 or 9, wherein:

in the first receiving step, a digital audio broadcasting (DAB) signal is received as the first broadcast signal in a DAB band used as the first frequency band; and
in the second receiving step, a frequency modulation (FM) broadcasting signal is received as the second broadcast signal in an FM broadcasting band used as the second frequency band.

11. The output restoring method according to claim 10, wherein in the second receiving step, the second broadcast signal is received, the signal broadcasting a program identical in content to the program based on the first broadcast signal.

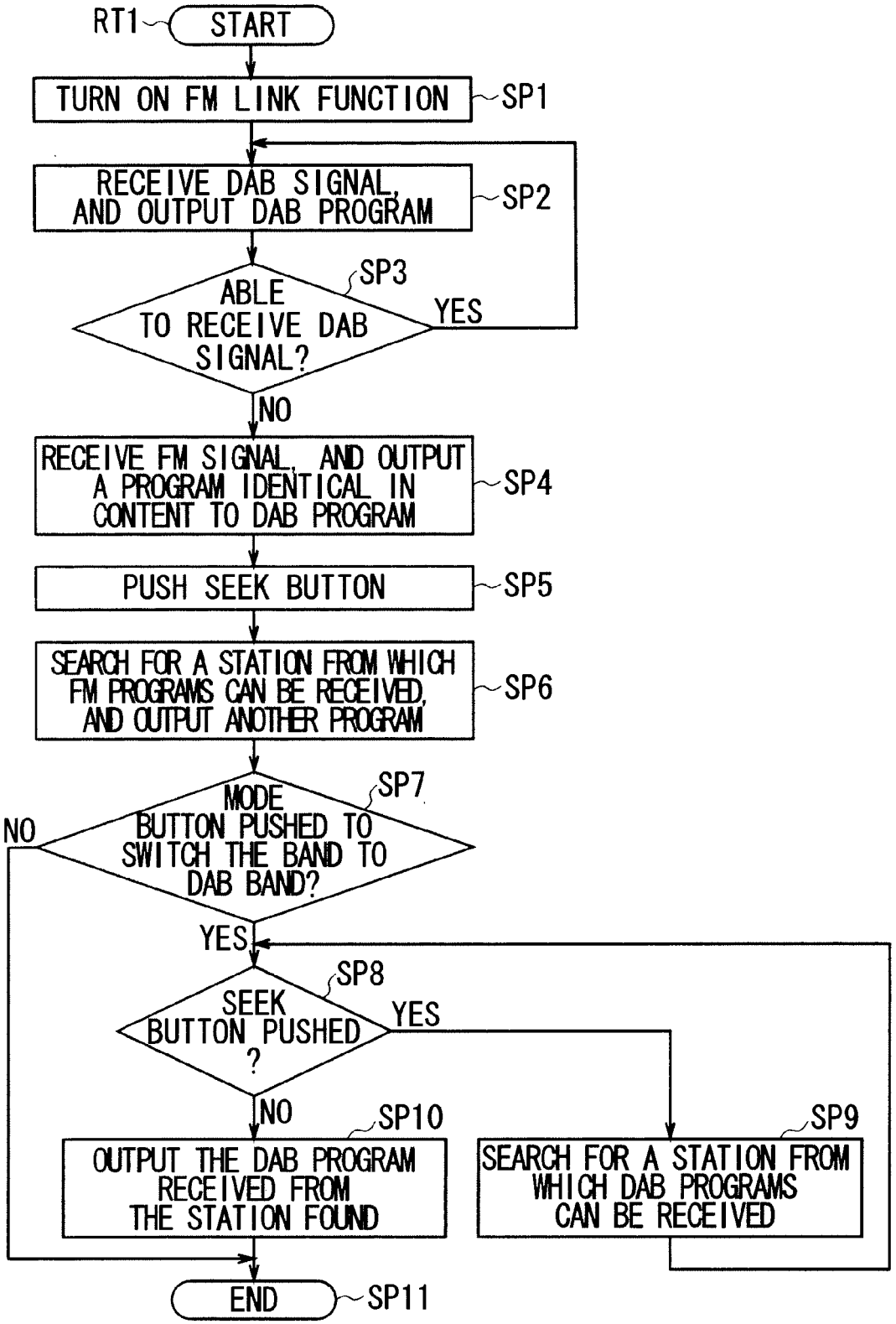

FIG. 1 (RELATED ART)

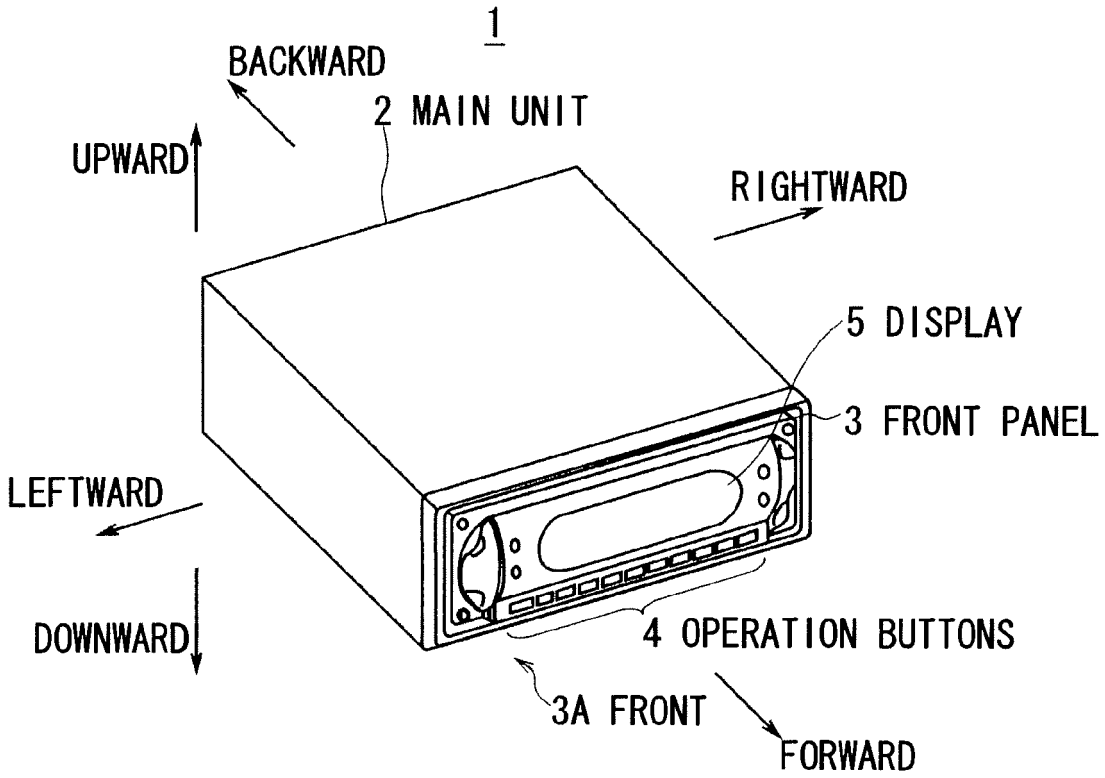
1
BACKWARD
2 MAIN UNIT
UPWARD
RIGHTWARD
5 DISPLAY
3 FRONT PANEL
LEFTWARD
DOWNWARD
4 OPERATION BUTTONS
3A FRONT
FORWARD

FIG. 2A

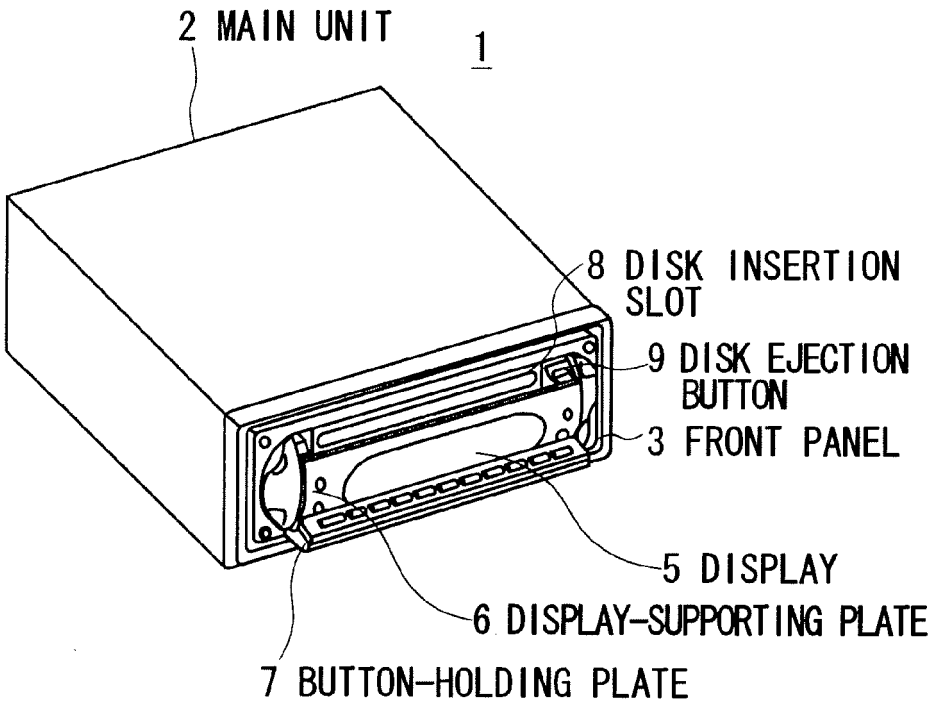
2 MAIN UNIT
1
8 DISK INSERTION SLOT
9 DISK EJECTION BUTTON
3 FRONT PANEL
5 DISPLAY
6 DISPLAY-SUPPORTING PLATE
7 BUTTON-HOLDING PLATE

FIG. 2B

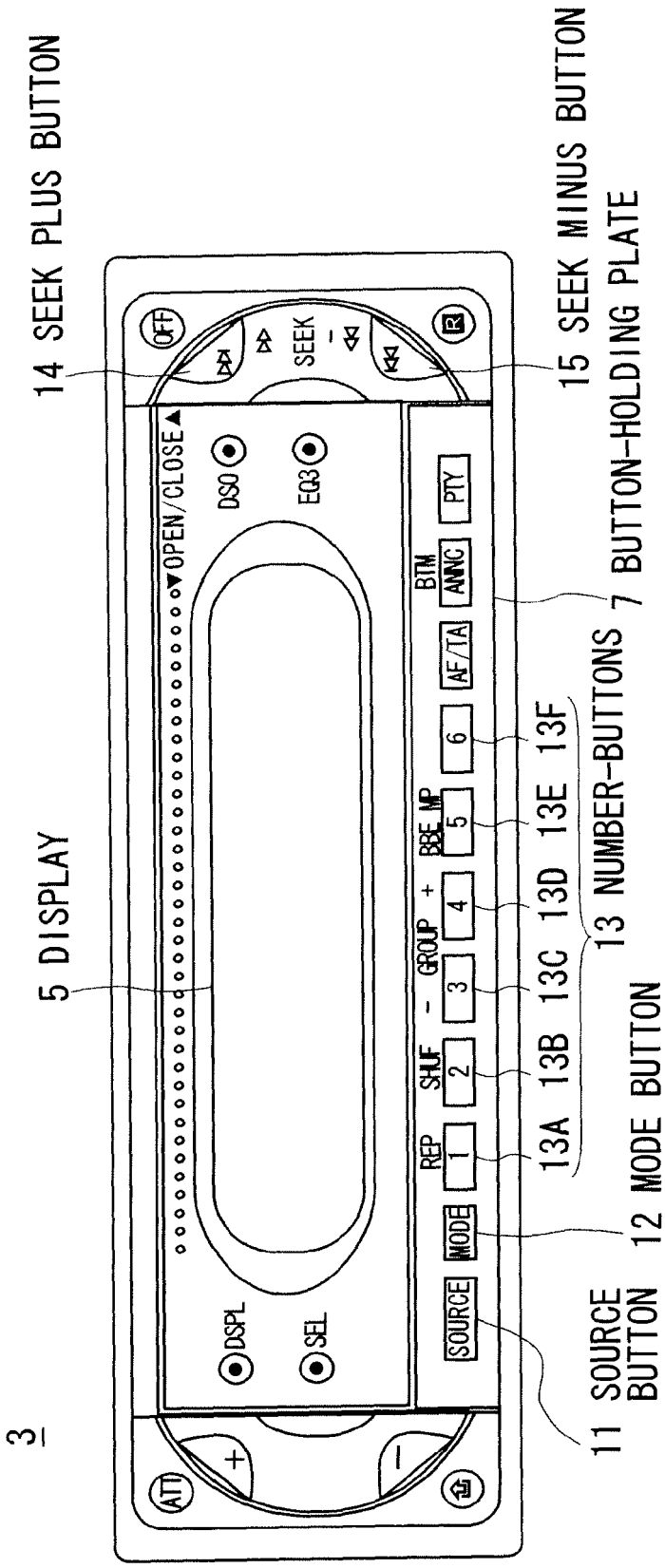
3
5 DISPLAY
14 SEEK PLUS BUTTON
15 SEEK MINUS BUTTON
7 BUTTON-HOLDING PLATE
13 NUMBER-BUTTONS
13A 13B 13C 13D 13E 13F
12 MODE BUTTON
11 SOURCE BUTTON
OFF
SEEK
OPEN/CLOSE
DSO
EQ3
BTM
ANNC
PTY
AF/TA
6
5
4
3
2
1
REP
SHUF
GROUP
BBE MP
MODE
SOURCE
DSPL
SEL
ATT

FIG. 3

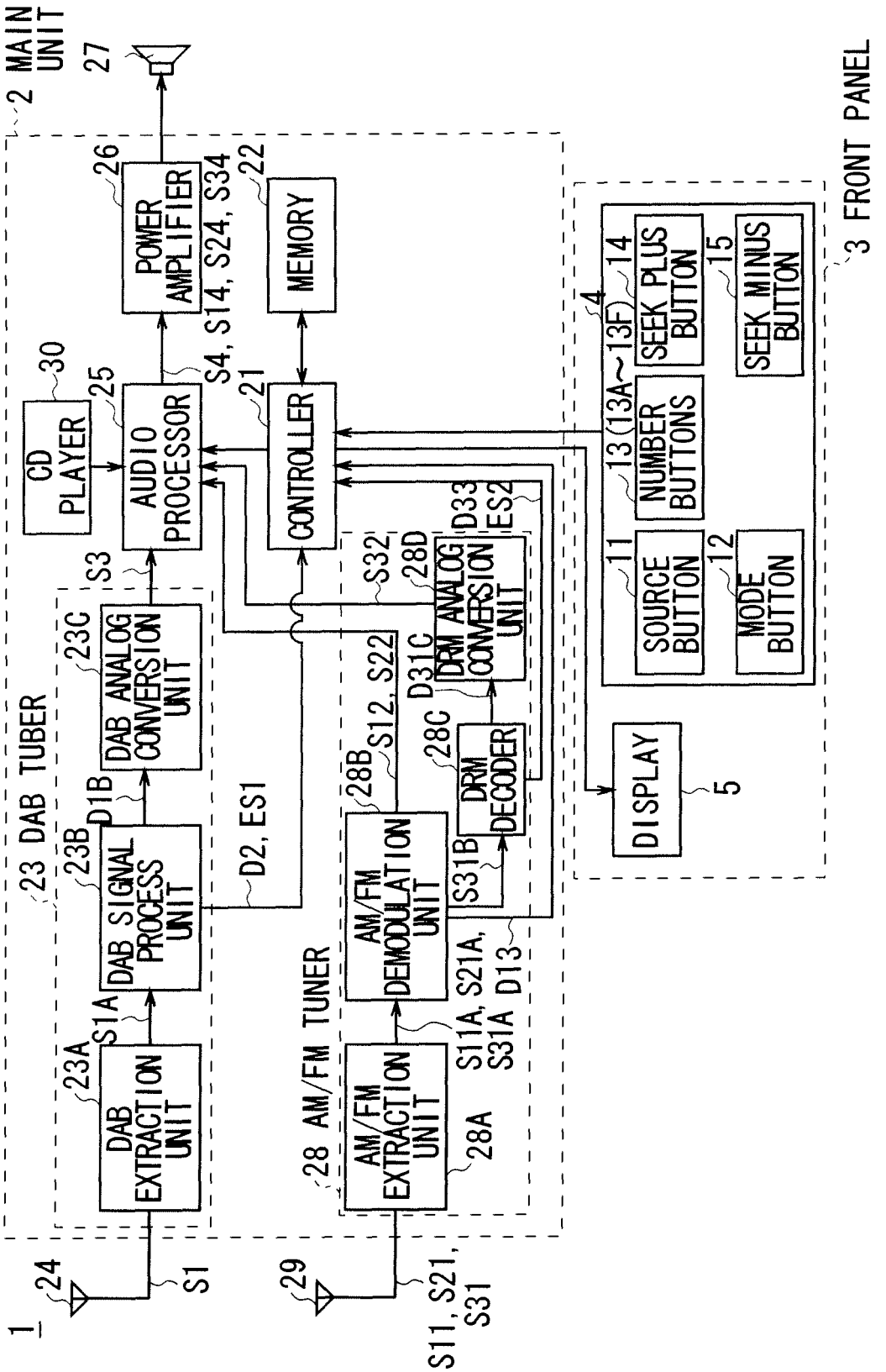
1
2 MAIN UNIT
3 FRONT PANEL
23 DAB TUBER
28 AM/FM TUNER
24
29
27
26
POWER AMPLIFIER
22
MEMORY
30
CD PLAYER
25
AUDIO PROCESSOR
21
CONTROLLER
4
13 (13A~13F)
NUMBER BUTTONS
14
SEEK PLUS BUTTON
15
SEEK MINUS BUTTON
11
SOURCE BUTTON
12
MODE BUTTON
DISPLAY
5
23C
DAB ANALOG CONVERSION UNIT
23B
DAB SIGNAL PROCESS UNIT
23A
DAB EXTRACTION UNIT
28B
AM/FM DEMODULATION UNIT
28C
DRM DECODER
28D
DRM ANALOG CONVERSION UNIT
28A
AM/FM EXTRACTION UNIT
S1
S1A
D1B
D2, ES1
S3
S4, S14, S24, S34
S11, S21, S31
S11A, S21A, S31A
S12, S22
S31B
D13
D31C
S32
D33
ES2

FIG. 4

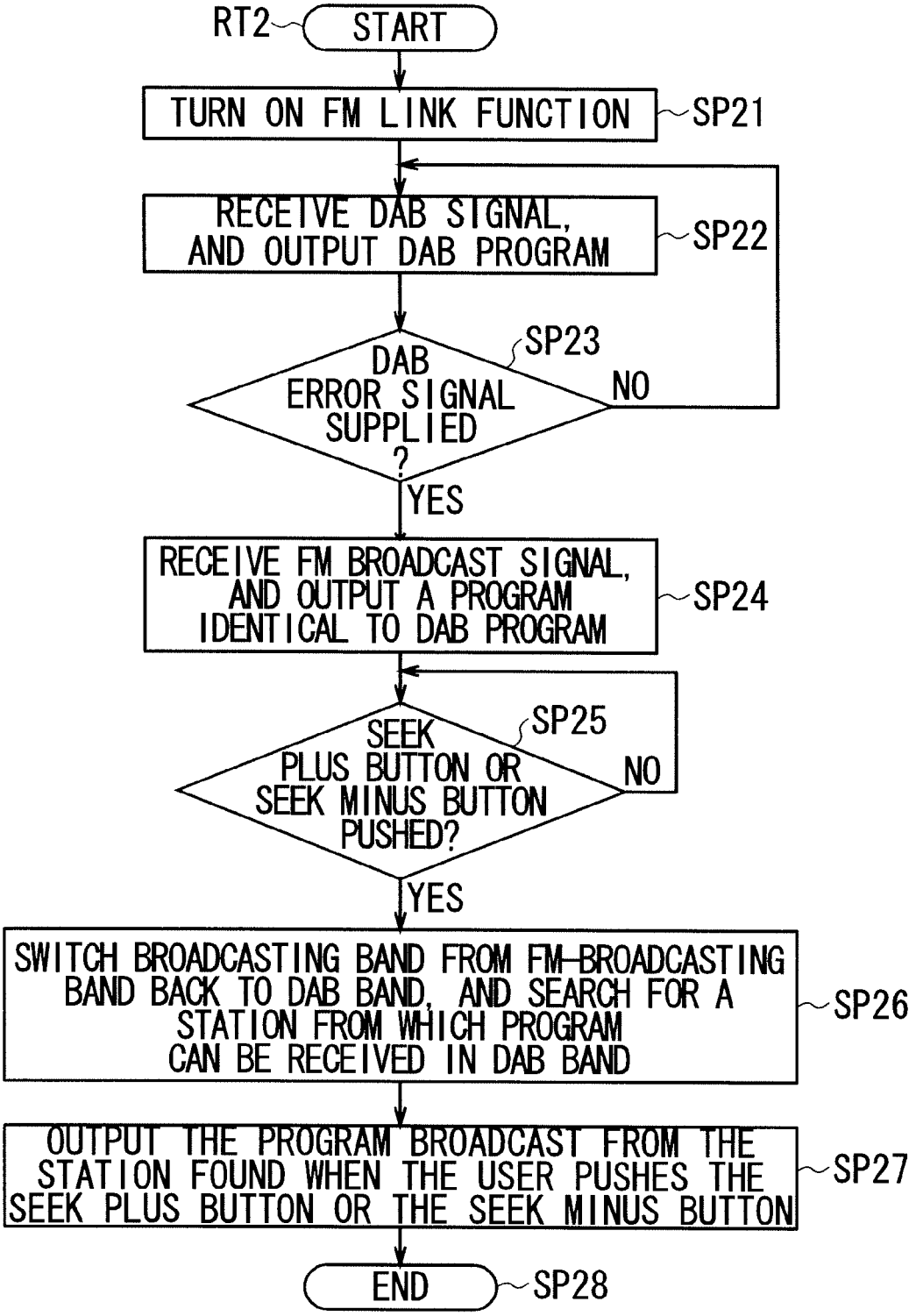
RT2
START
TURN ON FM LINK FUNCTION
SP21
RECEIVE DAB SIGNAL, AND OUTPUT DAB PROGRAM
SP22
DAB ERROR SIGNAL SUPPLIED ?
SP23
NO
YES
RECEIVE FM BROADCAST SIGNAL, AND OUTPUT A PROGRAM IDENTICAL TO DAB PROGRAM
SP24
SEEK PLUS BUTTON OR SEEK MINUS BUTTON PUSHED?
SP25
NO
YES
SWITCH BROADCASTING BAND FROM FM-BROADCASTING BAND BACK TO DAB BAND, AND SEARCH FOR A STATION FROM WHICH PROGRAM CAN BE RECEIVED IN DAB BAND
SP26
OUTPUT THE PROGRAM BROADCAST FROM THE STATION FOUND WHEN THE USER PUSHES THE SEEK PLUS BUTTON OR THE SEEK MINUS BUTTON
SP27
END
SP28

FIG. 5

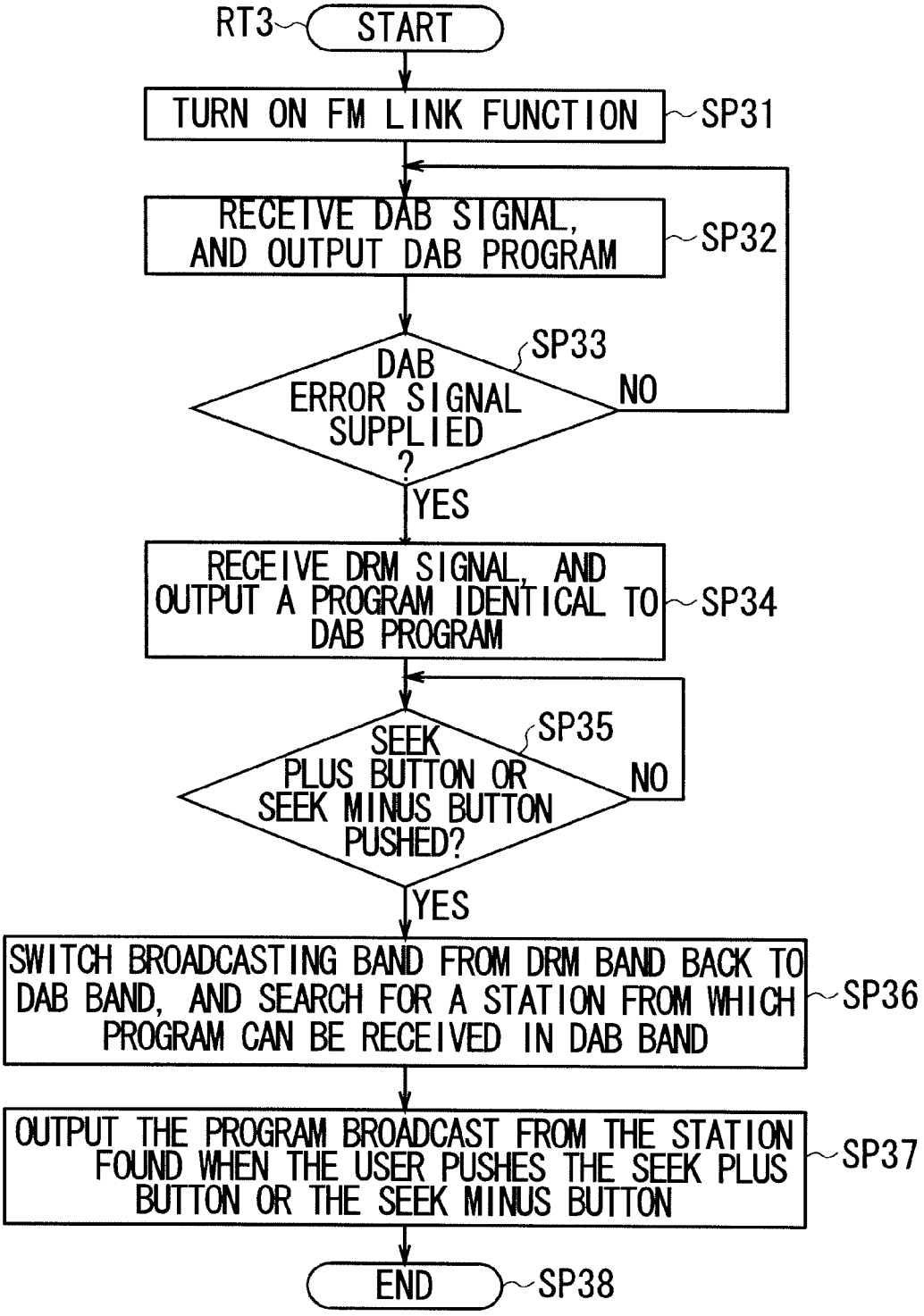
RT3
START
TURN ON FM LINK FUNCTION
SP31
RECEIVE DAB SIGNAL, AND OUTPUT DAB PROGRAM
SP32
DAB ERROR SIGNAL SUPPLIED ?
SP33
NO
YES
RECEIVE DRM SIGNAL, AND OUTPUT A PROGRAM IDENTICAL TO DAB PROGRAM
SP34
SEEK PLUS BUTTON OR SEEK MINUS BUTTON PUSHED?
SP35
NO
YES
SWITCH BROADCASTING BAND FROM DRM BAND BACK TO DAB BAND, AND SEARCH FOR A STATION FROM WHICH PROGRAM CAN BE RECEIVED IN DAB BAND
SP36
OUTPUT THE PROGRAM BROADCAST FROM THE STATION FOUND WHEN THE USER PUSHES THE SEEK PLUS BUTTON OR THE SEEK MINUS BUTTON
SP37
END
SP38

FIG. 6

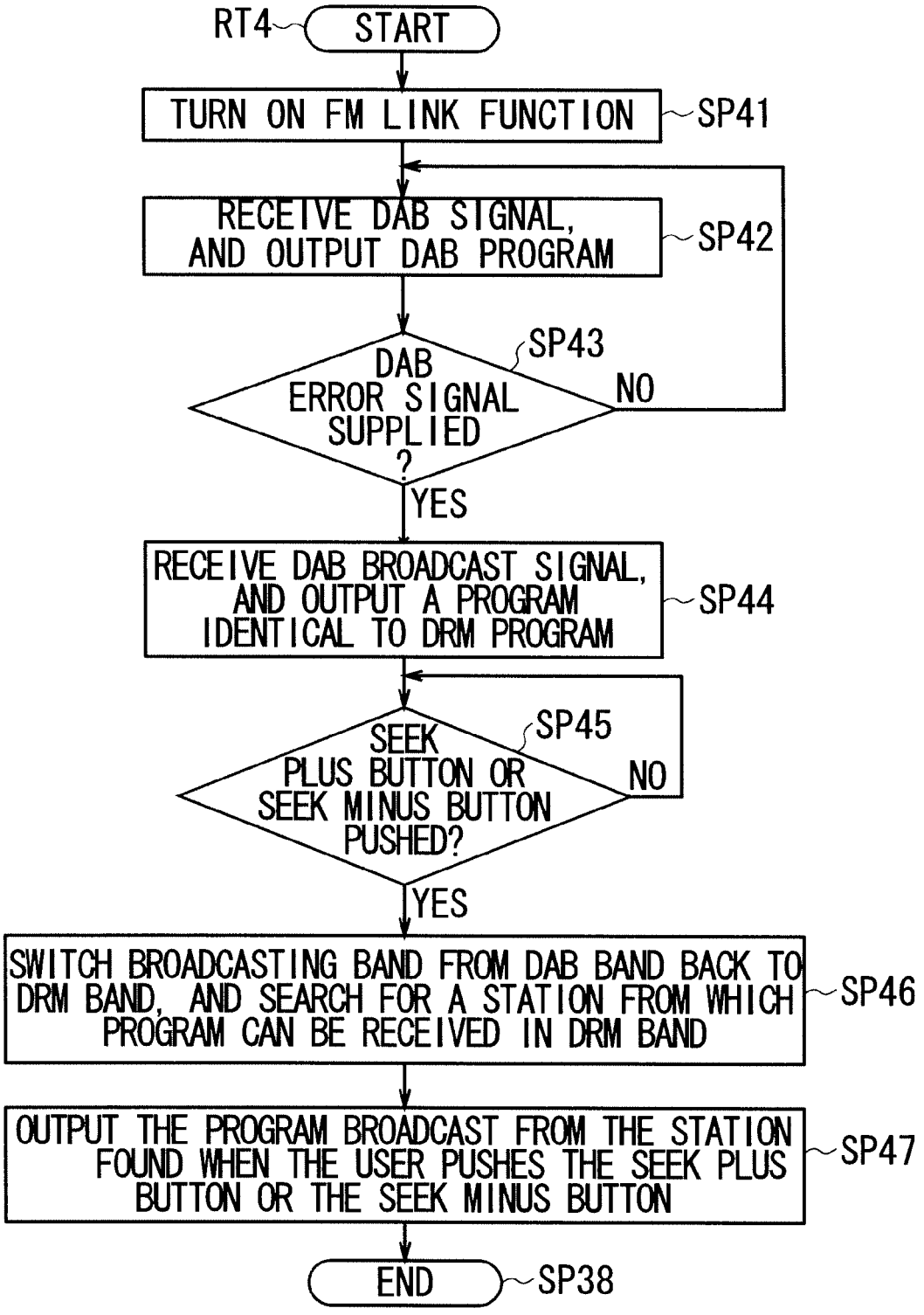
RT4
START
TURN ON FM LINK FUNCTION
SP41
RECEIVE DAB SIGNAL, AND OUTPUT DAB PROGRAM
SP42
DAB ERROR SIGNAL SUPPLIED ?
SP43
NO
YES
RECEIVE DAB BROADCAST SIGNAL, AND OUTPUT A PROGRAM IDENTICAL TO DRM PROGRAM
SP44
SEEK PLUS BUTTON OR SEEK MINUS BUTTON PUSHED?
SP45
NO
YES
SWITCH BROADCASTING BAND FROM DAB BAND BACK TO DRM BAND, AND SEARCH FOR A STATION FROM WHICH PROGRAM CAN BE RECEIVED IN DRM BAND
SP46
OUTPUT THE PROGRAM BROADCAST FROM THE STATION FOUND WHEN THE USER PUSHES THE SEEK PLUS BUTTON OR THE SEEK MINUS BUTTON
SP47
END
SP38

FIG. 7

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008031828 A **[0001]**
- JP 2000236272 A **[0005]**