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# (54) Radio receiver capable of receiving signals from a plurality of trnsmission systyms such as Digital Audio Broadcast (DAB) and Radio Data System (RDS)

(57) In a car-mount DAB/RDS radio receiver 40, interrupt information of both DAB and RDS can be listen. A user preselects a combination of broadcast systems (DAB and RDS) which an interrupt is accepted, and interrupt information of the selected broadcast system is listen from speakers 54.

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## Description

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a radio receiver capable of receiving signals of a plurality of transmission systems such as Digital Audio Broadcasting (DAB) and Radio Data System (RDS), and more particularly to a radio receiver with an improved interrupt process.

#### 2. Description of the Related Art

DAB has drawn attention as a radio broadcasting system capable of dealing with sound quality deterioration to be caused by interference between a plurality of FM broadcasting stations and with difficulty of good reception at a mobile site. Developments of DAB have started at EUREKA (European leading-edge technologies development plan) and its specifications are already defined. DAB adopts $\pi/4$ shift DQPSK-OFDM (Differential Quadrature Phase Shift Keying - Orthogonal Frequency Division) as modulation scheme and has the characteristics that it is hard to be affected by fading or multi-path. It also makes it possible to have a number of stereo broadcasting and data broadcasting in a transmission bandwidth of 1.5 MHz by using high efficiency MPEG layer II as voice coding.

RDS is a presently used radio broadcasting system. Similar to a radio receiver capable of receiving both AM and FM radio broadcasting as in Japan, a radio receiver capable of receiving both RDS and DAB broadcasting is now under development. A radio wave of DAB and RDS includes audio data as well as interrupt data. When an interrupt data is received, this data is output as audible information when and as necessary.

Similar to an AM/FM radio receiver, a DAB/RDS radio receiver can reproduce interrupt information of either the DAB system or the RDS system whichever is now under reproduction from speakers. Further, during playing a CD (compact disk), speakers and the like are switched to the output of CD so that even if interrupt information is received, a user cannot know the interrupt information.

### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a radio receiver capable of solving the above problem.

A radio receiver (40) of this invention can receive signals transmitted from different transmission systems, each signal containing audio data and interrupt information data. During the reproduction of the audio data of a program of a predetermined transmission system, the radio receiver (40) receives both a signal of the predetermined transmission system and a signal of another transmission system, and outputs the interrupt information data contained in the signals of the predetermined transmission system and the other transmission system in audible sounds.

The transmission system is not limited only to the form of radio waves, but other systems may be used such as electrical signals transmitted via cables and optical signals transmitted via optical fibers.

Audio sounds my be reproduced not only by speakers but also by head phones or ear phones.

A user can listen interrupt information contained in a signal of not only the transmission system for a program currently listening but also another transmission system for a program not currently listening.

A radio receiver (40) of this invention can receive signals transmitted from different transmission systems, each signal containing audio data and interrupt information data. Under the operation of an audio reproducer, the radio receiver receives signals of different transmission systems and outputs the interrupt information data contained in the signal of each transmission system in audible sounds.

The audio reproducer includes not only a CD player but also other audio reproducers capable of reproducing recorded audio data, such as an MD player and a tape player. "Under the operation of an audio reproducer" includes not only an actual reproduction operation but also a program selection operation, a tape rewinding operation and the like.

A user can listen interrupt information without fail even under the operation of an audio reproducer such as during the actual reproduction operation.

The radio receiver (40) of this invention comprises: (a) selecting means (30) for selecting one or a plurality of transmission systems and allowing to output the interrupt information data; and (b) audio output means (46) for outputting the interrupt information data contained in a signal of the transmission system selected by the selecting means (30) in audible sounds.

A user can listen only desired interrupt information by selecting one or a plurality of transmission systems for which the interrupt information is output in audible signals.

In the radio receiver (40) of the invention, the audio output means (46) outputs the interrupt information data of a predetermined type in audible sounds irrespective of the selection by the selecting means (30).

There are a plurality types of interrupt information, such as traffic information and alarm information for urgent cases of disasters or the like. The latter alarm information is urgent and very strict. Therefore, this alarm is output in audio sounds and notified of a user, irrespective of the user selection by the selecting means (30).

The radio receiver of the invention, further comprises interrupt mode display means (32) for displaying an interrupt mode of the transmission system selected by the selecting means (30).

A user can visually know the current interrupt mode.

The radio receiver of the invention further comprises interrupt display means (32) for displaying the state of interrupt while the audio output means (46) outputs the interrupt information in audible sounds.

The interrupt mode display means (32) and the interrupt display means (32) may be the same display unit, or different display units. Examples of interrupt displays may be a simple "under interrupt" or "outputting interrupt information from RDS" indicating the interrupt originating system.

A user can therefore confirm that audio sounds reproduced from the speakers or the like are interrupt information.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flow chart illustrating an interrupt process allocation routine.

Fig. 2 is a flow chart illustrating an interrupt mode switching routine.

Fig. 3 is a diagram showing the details of feed keys and the change in display of a display unit when each feed key is operated upon during the interrupt switching mode.

Fig. 4 is a diagram showing the structure of a DAB tuner system.

Fig. 5 is a block diagram of a car-mount DAB/RDS radio.

Fig. 6 is a diagram showing the structure of a DAB transmission frame.

Fig. 7 is an illustrative diagram showing a DAB service structure.

Fig. 8 is a diagram showing the structure of FIB.

Fig. 9 is a diagram showing the structure of a FIG data area when the FIG type is 0.

Fig. 10 is a diagram showing the structure of FIG0/FIG18.

Fig. 11 is a diagram showing the structure of FIG0/FIG19.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the invention will be described with reference to the accompanying drawings.

Fig. 4 is a diagram showing the structure of a DAB tuner system 10. The DAB tuner 10 has a main unit 12 and a DAB control microcomputer 26 or the like separate from the main unit 12. The main unit 12 has a DAB system microcomputer 14 and a memory 16, and designates one ensemble from a plurality of ensembles. Each ensemble is broadcast as a radio broadcasting wave modulated through DQPSK-OFDM, has a bandwidth of about 1.5 MHz, and generally contains six radio programs. The DAB system microcomputer 14 sends the ensemble designating information to an RF block 18. The RF block 18 derives a radio frequency (RF) signal from the ensemble designated by the DAB system microcomputer 14, and sends it to a demodulating block 20. The demodulating block 20 demodulates the RF signal sent from the RF block 18, and this signal demodulated by the demodulating block 20 is decoded by a channel decoding block 22. In this manner, the channel decoding block 22 obtains all digital data of one ensemble designated by the DAB system microcomputer 14 and informed to the RF block 18. Of the digital signals decoded by the channel decoding block, the audio data is sent from the channel decoding block 22 to an audio decoding block 24. FIG data (to be later described) of program type or the like other than the audio data is sent from the channel decoding block 22 to a DAB system microcomputer 14. Of the audio data input from the channel decoding block 22, the audio data of a subchannel designated by the DAB system microcomputer 14 is decoded by the audio decoding block 24 and supplied to right and left speakers 54 (Fig. 5). The DAB control microcomputer 26 has a memory 28 to transfer data to and from the DAB system microcomputer 14 of the main unit 12. An instruction from a user is entered via a key 30 to the DAB control microcomputer 26, and predetermined data is supplied from the DAB control microcomputer to a display unit 32 to display information and inform a user of it.

Fig. 5 is a block diagram of a car-mount DAB/RDS radio 40. Outputs from a CD player 42, a RDS tuner 44 and a DAB tuner 10 are applied to a switch 48. A microcomputer 46 functions as the DAB system microcomputer 14 and DAB control microcomputer 26 shown in Fig. 4, and controls the connection of the switch 48 between a volume unit 50 and the CD player 42, RDS tuner 44 and DAB tuner 10 to select one of the outputs from the CD player 42, RDS tuner 44 and DAB tuner 10 and send the selected output to the volume unit 50. The volume unit 50 controls the magnitude of sounds to be output from speakers 54. An output of the volume unit 50 is amplified by the amplifier 52 and output from the speakers 54. A user operates upon the key 30 to enter a desired input to the microcomputer 46 which in turn displays data on the display unit 32.

In the following, communication protocols of various elements of DAB such as a transmission frame will be described. The details of which may be referred to European Telecommunications Standard published by European Telecommunications Standards Institute.

Fig. 6 shows the structure of a DAB transmission frame. The transmission frame includes, starting from the header side, a synchronization channel, a fast information channel (FIC) and a main service channel (MSC). FIC is constituted of a plurality of fast information blocks (FIBs), and MSC is constituted of a plurality of common interleaved frames (CIFs). Modes 1 to 3 are defined in the specifications of DAB. Each mode has a different transmission frame duration and a different number of FIBs and CIFs in one transmission frame. For example, the mode 1 has one transmission frame duration of 96 ms and 12 FIBs and 4 CIFs in each transmission frame.

Fig. 7 is an illustrative diagram of a DAB service structure. An ensemble having an ensemble label "DAB ENSEMBLE ONE" contains a plurality of services such as those with a service label "ALPHA 1 RADIO", a service label "BETA RADIO" and a service label "ALPHA 2 RADIO". A user can listen a selected service from the DAB radio 10.

The "alpha 1 radio" service has one main service component and two subsidiary service components. The main service component is an audio component, and the subsidiary service components are a traffic message channel (TMC) component and a service information (SI) component. The audio component and SI component are transmitted via different sub-channels in MSC, whereas the TMC component is transmitted via a fast information data channel (FIDC) in FIC.

The "beta radio" service has two service components, an audio component and a secondary audio component both of which are transmitted via sub-channels of MSC.

The "alpha 2 radio" service has the same TMC and SI components as the "alpha 1 radio". Depending upon the switching, the "alpha 2 radio" may have the same audio component as the "alpha 1 radio".

Fig. 8 shows the structure of FIB. FIB is constituted of 256 bits forming a front FIB data field of 30 bytes and a rear CRC (cyclic redundancy check) word of 16 bits. The FIB field is constituted of a plurality of fast information groups (FIGs), one end marker and one padding (insertion of "0" into remaining bits in order for the FIB data field have 30 bytes), from the head to the end in this field. FIG constitutes a useful data field. Each FIG is constituted of an FIG type field, a length field (indicating the bit length of the following FIG data field) and an FIG data field, from the head to the end in FIG. The FIG type and length constitute an FIG header.

Fig. 9 shows the structure of the FIG data field of an FIG type 0 (000 in 3-bit binary representation). The FIG data field is constituted of a current/next (C/N) field, another ensemble field (OE), a program/data (P/D) field, an extension filed and a type 0 field, sequentially from the head thereof. If the extension is 1 to 4 or 7, it means that the FID data field is of the current multi-structure if C/N =0, whereas it means that the FID data field is of the next multi-structure if C/N = 1. If C/N = 1, the type 0 field is for the next array. If the extension is 6, 9, 11, 18, 21, 22, 23, 24, 25, 27, or 30, C/N indicates the version number of the type 0 field. OE is used if the extension is 12, 16, 17, 21, 24 or 30. OE = 0 means that the information in the type 0 field is used for the subject ensemble, whereas OE = 1 means that the information in the type 0 field is used for another ensemble. P/D = 1 means that a service identifier (SId) in the type 0 field is 16-bit SId used for program service, whereas P/D = 0 means that Sid in the type 0 field is SiD bits for the display unit 32 used for data service. P/D is used when the extension is 2, 9, 23, or 24, and when it is not used, SId has a 16-bit format.

Fig. 10 shows the structure of the type 0 field of FIG shown in Fig. 9 and having an extension of 18 (hereinafter, each FIG is represented by the FIG type and extension, such as FIG0/18). The type 0 field is constituted of a plurality of announcement support fields, announcement corresponding interrupt. Each announcement support field includes an SId, announcement support flags (Asu flags), a cluster number, and cluster IDs. Sid identifies the type of service. Each bit of the announcement flags corresponds to the type of interrupt information (e.g., alarm interrupt information corresponds to the 0th bit). The cluster ID identifies the cluster to which Sid belongs. If SId has the same cluster ID, it shares the interrupt information with another SId.

Fig. 11 shows the structure of the type 0 field of FIG shown in Fig. 9 and having an extension of 19 (FIG0/19). The type 0 field is constituted of a plurality of announcement switching fields each including announcement switching flags (Asw flags), a cluster ID, a sub-channel ID (SubChid) and the like. Each bit of the announcement switching flags has the same meaning as that of the announcement flags of FIG0/18, and corresponds to the type of interrupt information. The cluster ID identifies the cluster, and the sub-channel ID identifies the sub-channel which transmits the interrupt information of the cluster. If FIG0/19 is received, it means an occurrence of an announcement (interrupt). An interrupt occurs when FIG0/18 or FIG0/19 is received, and it can know which sub-channel has the contents of the interrupt information.

Fig. 1 is a flow chart illustrating an interrupt process allocation routine. At Step S60 it is checked whether an interrupt request occurs. If YES, the flow advances to Step S62, whereas if NO, the flow returns to Step S60. At Step S62 it is checked whether the interrupt is alarm information. If YES, the flow advances to Step S86 to perform an alarm interrupt process, whereas if NO, the flow advances to Step S64. At Step S64 it is checked whether the interrupt function is on, i.e., whether the user admits to accept the interrupt information. If YES, the flow advances to Step S66, whereas if NO, the flow returns to Step S60. At Step S66 it is checked whether the interrupt mode is an automatic mode. If YES, the flow advances to Step S72, whereas if NO, the flow advances to Step S68. At Step S68 it is checked whether an interrupt is accepted only from DAB. If YES, the flow advances to Step S76, whereas if NO, the flow advances to Step S70. At Step S70 it is checked whether the interrupt mode is RDS only, i.e., whether an interrupt is accepted only from RDS. If YES, the flow advances to Step S82, whereas if NO, this routine is terminated. At Step S72 it is checked whether CD is being played (under reproduction). If YES, the flow advances to Step S74, whereas if NO, the flow advances to Step S78. At Step S74 it is checked whether the band received before the reproduction of CD is DAB or RDS. If DAB, the flow advances to Step S76, whereas if RDS, the flow advances to Step S80. At Step S76 it is checked whether the interrupt is a DAB interrupt. If YES, the flow advances to Step S84, whereas if NO, the flow returns to Step S60. At Step S78 it is checked whether the currently received band is DAB or RDS. If DAB, the flow advances to Step S76, whereas if RDS, the flow advances to Step S80. At Sep S80 it is checked whether the interrupt if a RDS interrupt request. If YES, the flow advances to Step S82, whereas if NO, the flow returns to Step S60. At Step S82 the RDS interrupt process is performed, and at Step S84 the DAB interrupt process is performed.

In the flow chart shown in Fig. 1, if the judgement of the automatic mode at Step S66 is YES, the flow advances to Step S72. An alternative method may be used. For example, if YES, it is checked whether the interrupt is RDS or DAB interrupt. If RDS interrupt, the RDS interrupt process is performed at Step S82, whereas if DAB interrupt, the DAB interrupt process is performed at S82.

Fig. 2 is a flow chart illustrating the interrupt mode switching routine. At Step S90 it is checked whether the current mode is an interrupt switching mode. At Step S92 it is checked whether the feed key is operated upon. In Fig. 3, right and left two feed keys are provided. The right feed key is operated at Step S92. If YES, the flow advances to Step S94, whereas if NO, this routine is terminated. At Step S94 it is checked whether the state before the feed key is operated upon is the automatic mode. If YES, the flow advances to Step S98 to switch to a DAB-only mode, whereas if NO, the flow advances to Step S96. At Step S96 it is checked whether the state before the feed key is operated upon is the DAB-only mode. If YES, the flow advances to Step S100 to switch to an RDS-only mode, whereas if NO, the flow advances to Step S102 to switch to the automatic mode.

Fig. 3 shows the details of the key 30 and the change in display of the display unit 32 when a feed key is operated upon during the interrupt switching mode. The key 30 has right and left feed keys. Each time the feed key is operated upon, the display on the display unit 32 is switched in the counter-clockwise or clockwise direction between the automatic mode, DAB-only mode and RDS-only mode.

## Claims

1. A radio receiver (40) capable of receiving signals transmitted from different transmission systems, each signal containing audio data and interrupt information data, wherein:

   during the reproduction of the audio data of a program of a predetermined transmission system, a signal of the predetermined transmission system and a signal of another transmission system are both received and the interrupt information data contained in the signals of the predetermined transmission system and the other transmission system is reproduced into audible sounds.

2. A radio receiver (40) capable of receiving signals transmitted from different transmission systems, each signal containing audio data and interrupt information data, wherein:

   under the operation of an audio reproducer, signals of different transmission system are received and the interrupt information data contained in the signal of each transmission system is reproduced into audible sounds.

3. A radio receiver according to claim 1 or 2, comprising:

   (a) selecting means (30) for selecting one or a plurality of transmission systems and allowing to output the interrupt information data; and

   (b) audio output means (46) for outputting the interrupt information data contained in a signal of the transmission system selected by said selecting means (30) in audible sounds.

4. A radio receiver according to claim 3, wherein said audio output means (46) outputs the interrupt information data of a predetermined type in audible sounds irrespective of the selection by said selecting means (30).

5. A radio receiver according to claim 3 or 4, further comprising interrupt mode display means (32) for displaying an interrupt mode of the transmission system selected by said selecting means (30).

6. A radio receiver according to any one of claims 3 to 5, further comprising interrupt display means (32) for displaying the state of interrupt while said audio output means (46) outputs the interrupt information in audible sounds.

Fig. 1

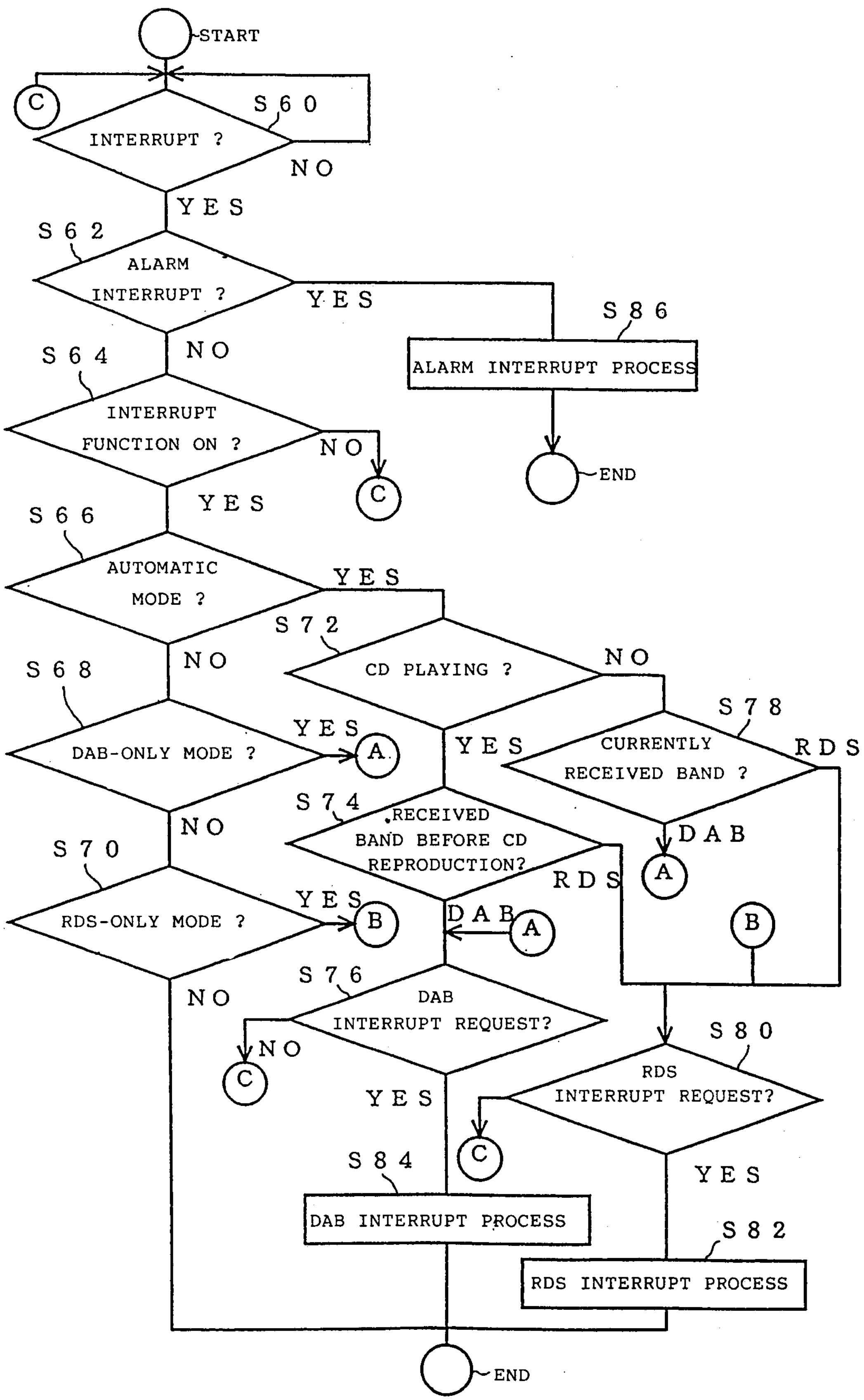
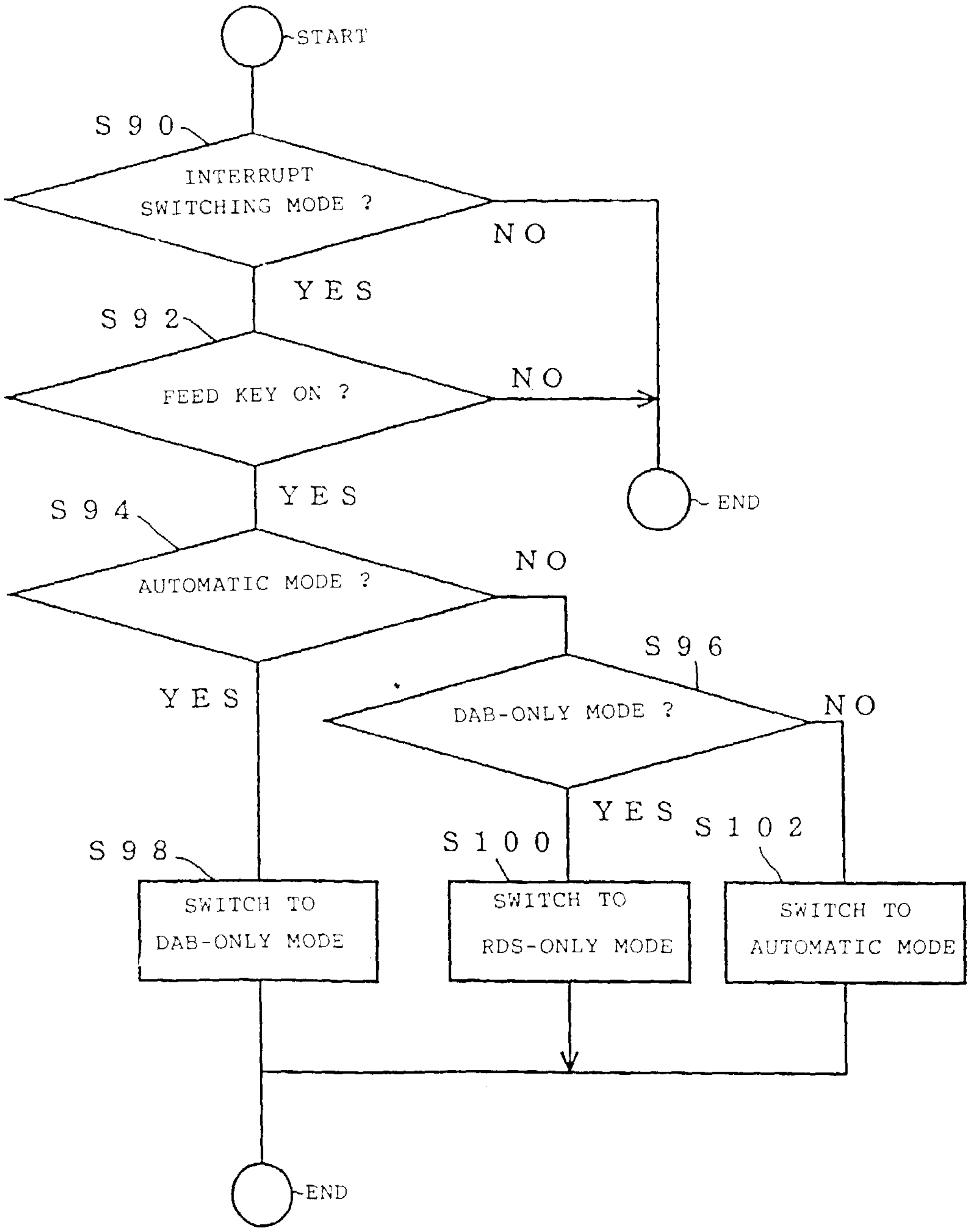

START
S60
INTERRUPT ?
NO
YES
C
S62
ALARM INTERRUPT ?
YES
S86
ALARM INTERRUPT PROCESS
END
NO
S64
INTERRUPT FUNCTION ON ?
NO
YES
S66
AUTOMATIC MODE ?
YES
S72
CD PLAYING ?
NO
S78
CURRENTLY RECEIVED BAND ?
RDS
DAB
A
NO
S68
DAB-ONLY MODE ?
YES
YES
S74
RECEIVED BAND BEFORE CD REPRODUCTION?
RDS
DAB
NO
S70
RDS-ONLY MODE ?
YES
B
NO
S76
DAB INTERRUPT REQUEST?
NO
YES
S84
DAB INTERRUPT PROCESS
S80
RDS INTERRUPT REQUEST?
YES
S82
RDS INTERRUPT PROCESS
END

Fig. 2


START
S90
INTERRUPT SWITCHING MODE ?
NO
YES
S92
FEED KEY ON ?
NO
END
YES
S94
AUTOMATIC MODE ?
NO
S96
DAB-ONLY MODE ?
NO
YES
YES
S98
SWITCH TO DAB-ONLY MODE
S100
SWITCH TO RDS-ONLY MODE
S102
SWITCH TO AUTOMATIC MODE
END

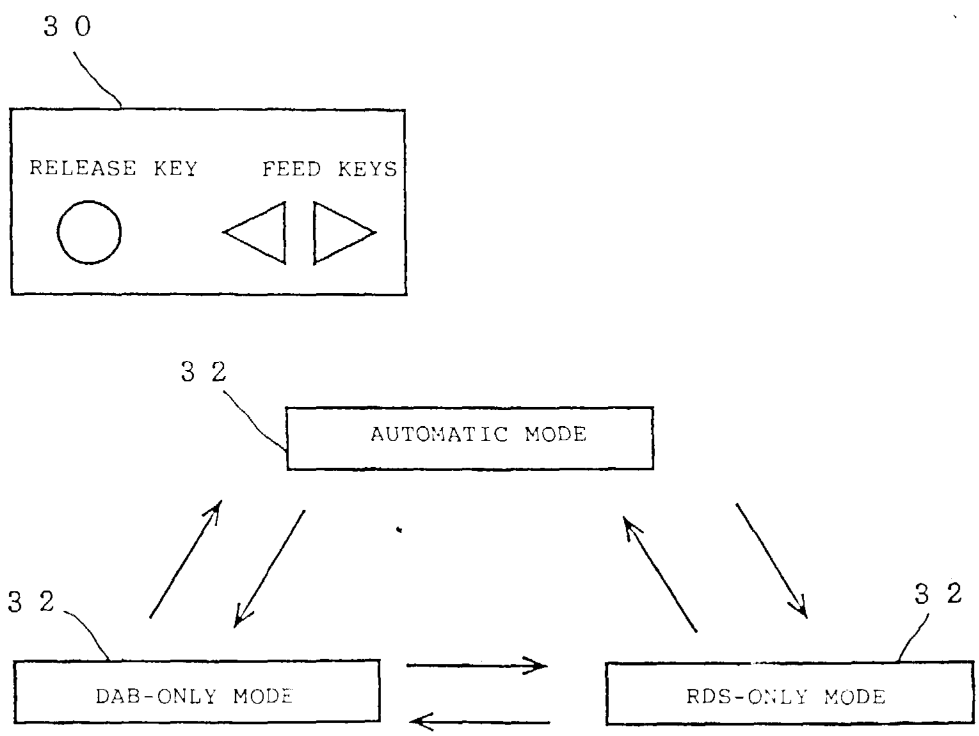

30
RELEASE KEY
FEED KEYS
32
AUTOMATIC MODE
32
DAB-ONLY MODE
32
RDS-ONLY MODE

Fig. 3

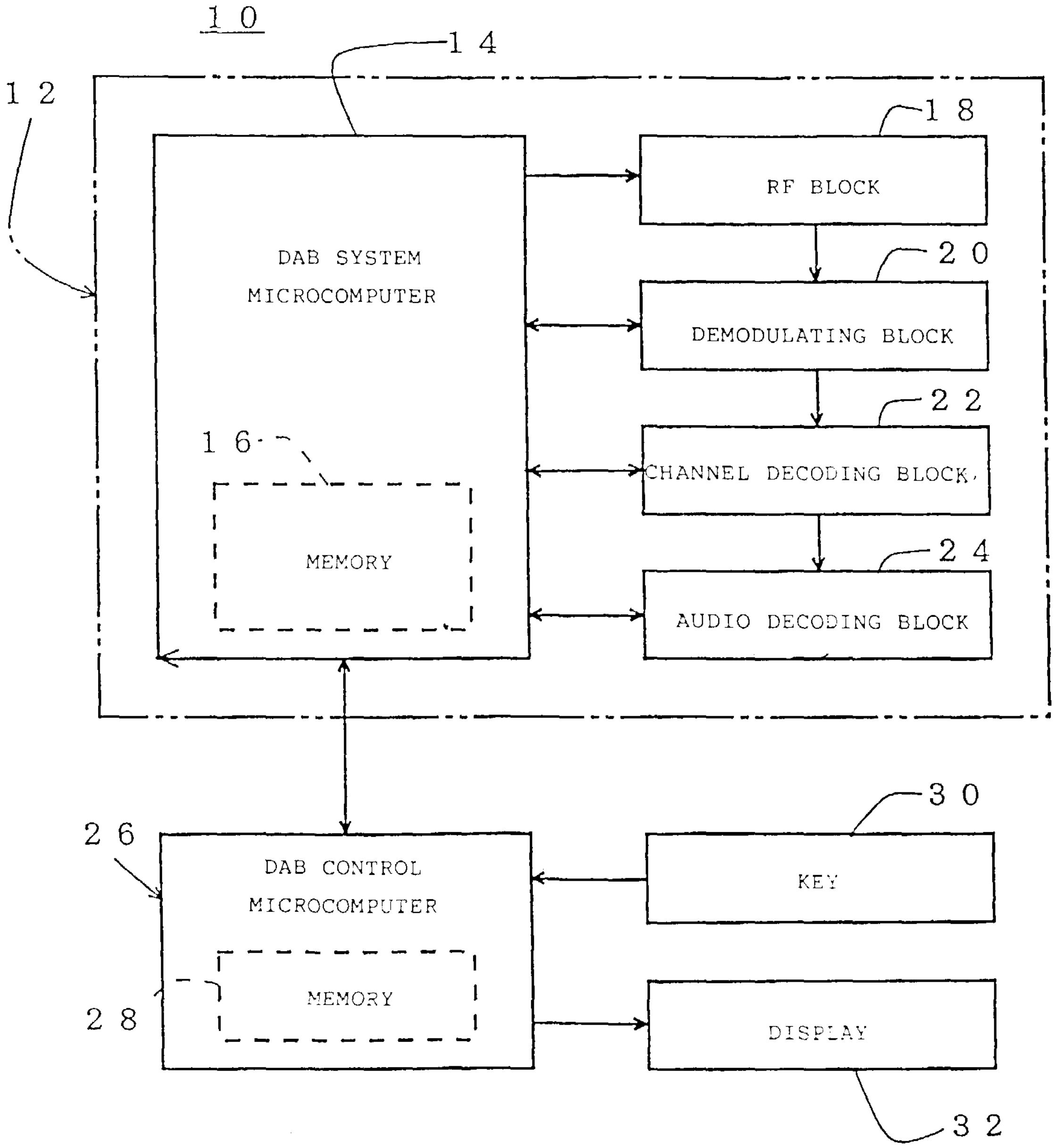

10
14
12
18
RF BLOCK
DAB SYSTEM
MICROCOMPUTER
20
DEMODULATING BLOCK
22
16
CHANNEL DECODING BLOCK
24
MEMORY
AUDIO DECODING BLOCK
30
26
DAB CONTROL
MICROCOMPUTER
KEY
MEMORY
28
DISPLAY
32

Fig. 4

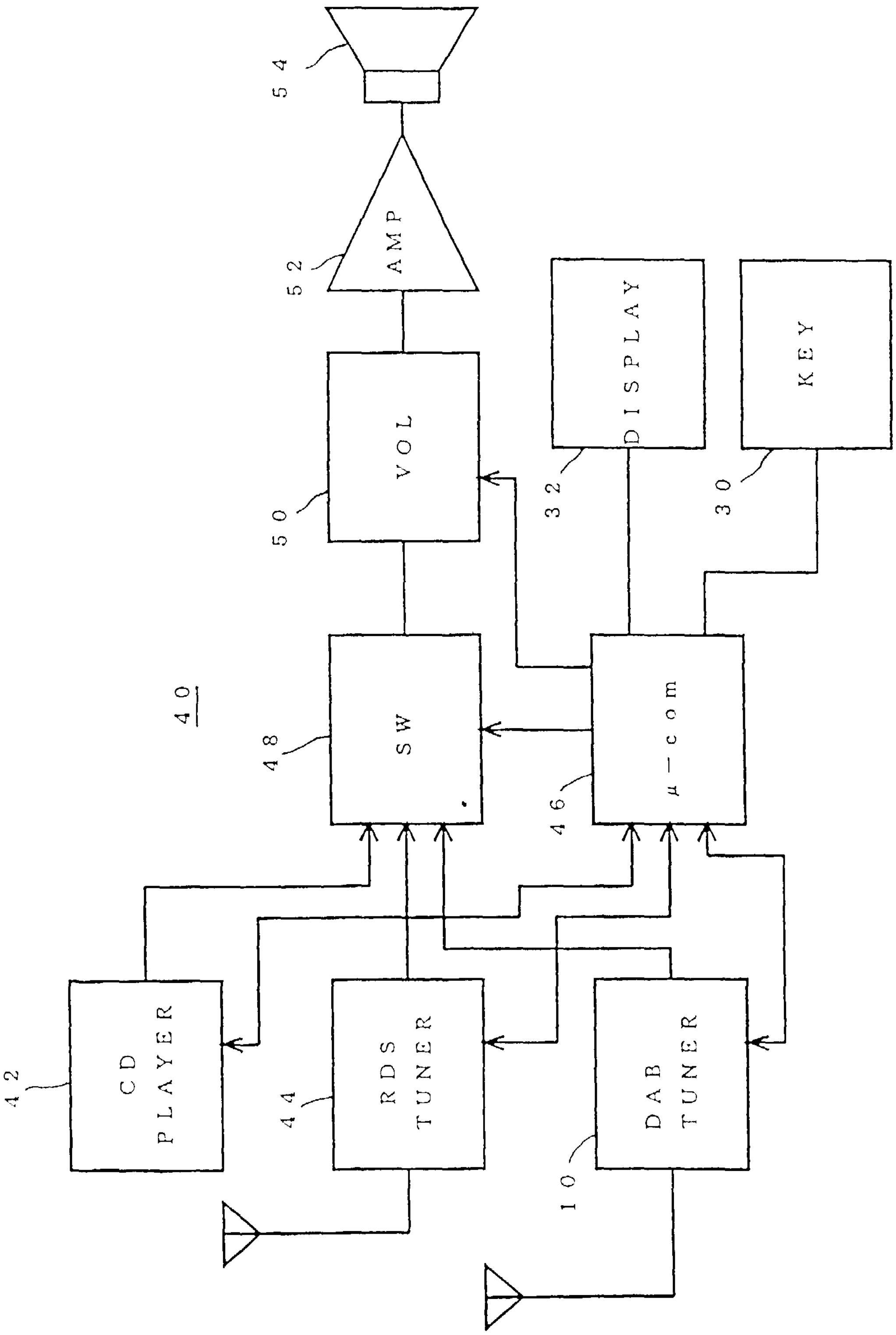

40
42
CD PLAYER
44
RDS TUNER
10
DAB TUNER
48
SW
46
μ-com
50
VOL
52
AMP
54
32
DISPLAY
30
KEY

Fig. 5

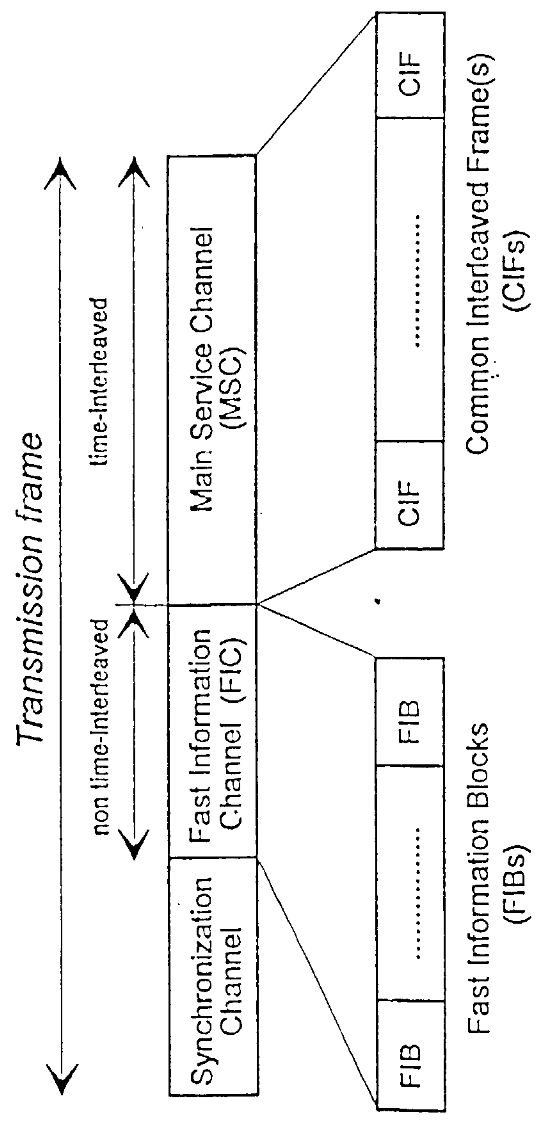

Transmission frame
non time-Interleaved
time-Interleaved
Synchronization Channel
Fast Information Channel (FIC)
Main Service Channel (MSC)
FIB
..............
FIB
CIF
..............
CIF
Fast Information Blocks (FIBs)
Common Interleaved Frame(s) (CIFs)

Fig. 6

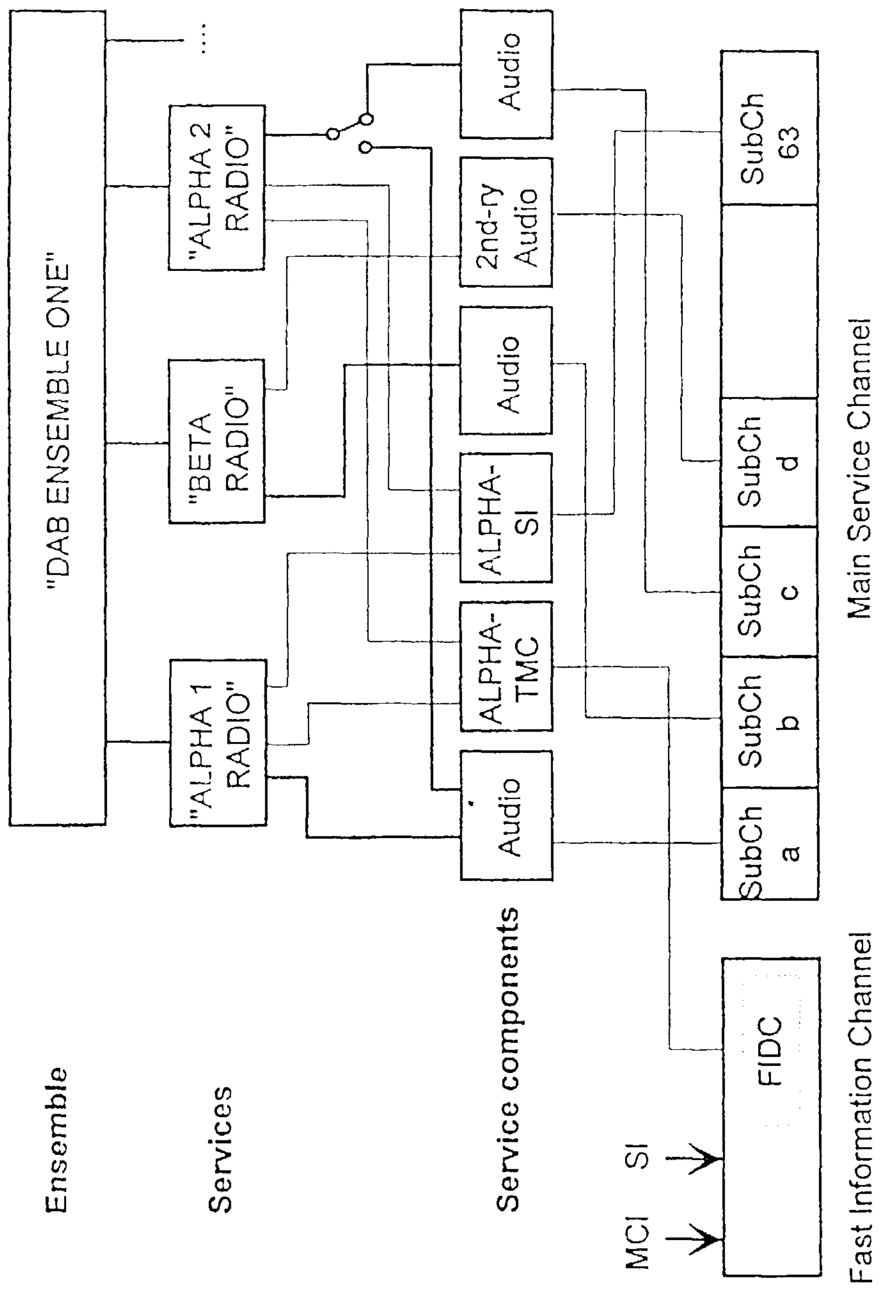

Ensemble
Services
Service components
"DAB ENSEMBLE ONE"
"ALPHA 1 RADIO"
"BETA RADIO"
"ALPHA 2 RADIO"
Audio
ALPHA-TMC
ALPHA-SI
Audio
2nd-ry Audio
Audio
MCI
SI
FIDC
Fast Information Channel
SubCh a
SubCh b
SubCh c
SubCh d
SubCh 63
Main Service Channel

Fig. 7

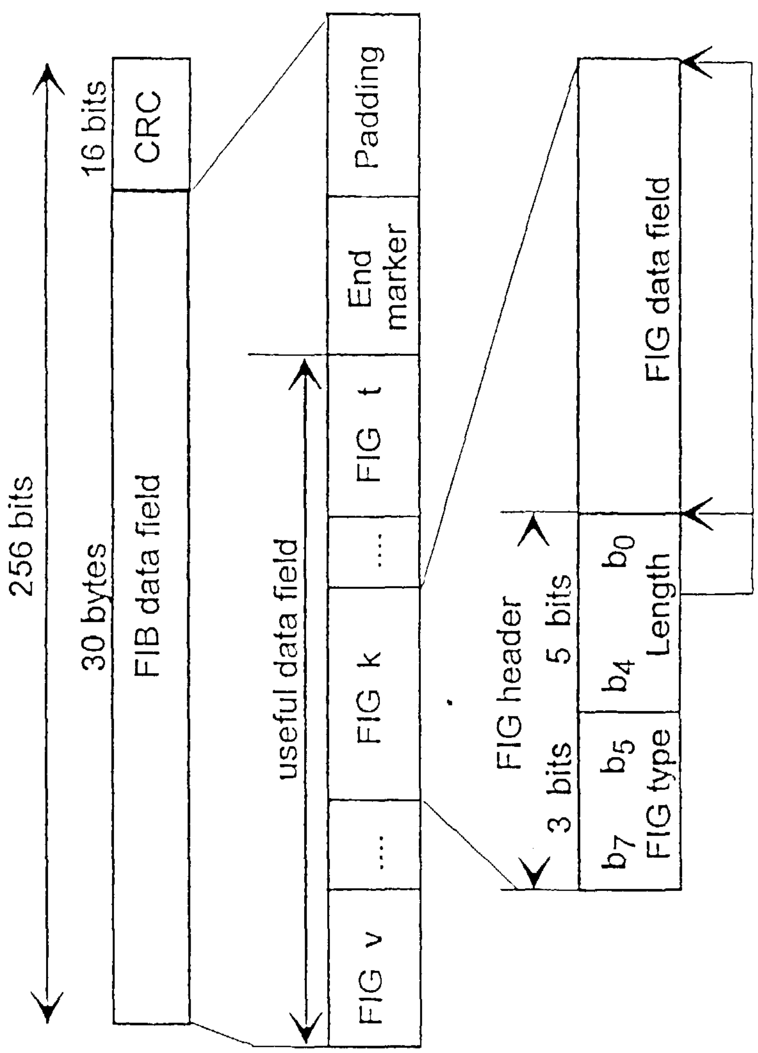

256 bits
30 bytes
16 bits
FIB data field
CRC
useful data field
FIG v
....
FIG k
....
FIG t
End marker
Padding
FIG header
3 bits
5 bits
$b_7$
$b_5$
$b_4$
$b_0$
FIG type
Length
FIG data field

Fig. 8

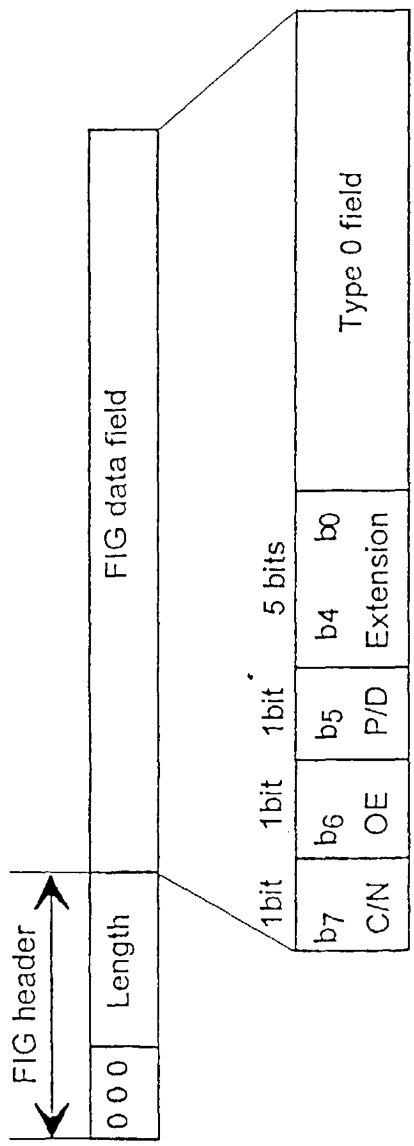


FIG header
0 0 0
Length
FIG data field
1bit
1bit
1bit
5 bits
b7
b6
b5
b4
b0
C/N
OE
P/D
Extension
Type 0 field

Fig. 9

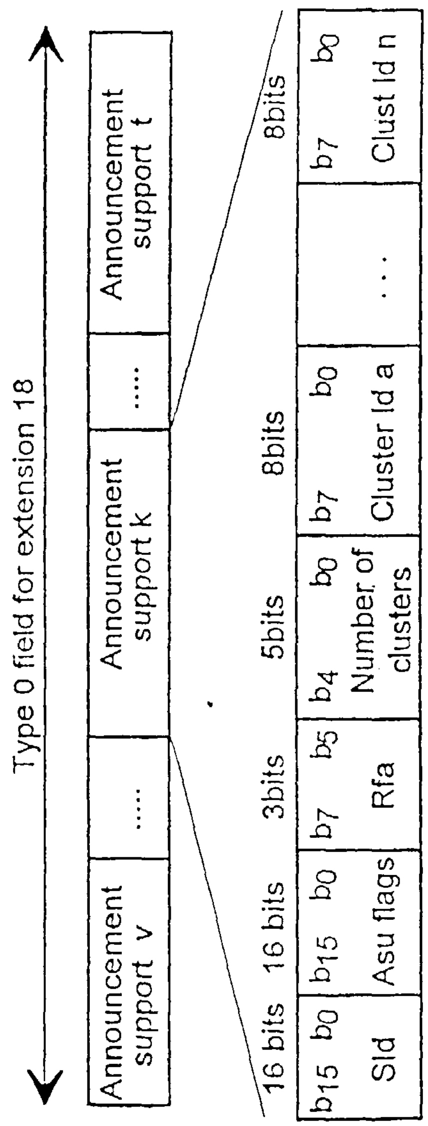

Type 0 field for extension 18
Announcement support v
.....
Announcement support k
.....
Announcement support t
16 bits
16 bits
3bits
5bits
8bits
8bits
b15 b0
b15 b0
b7 b5
b4 b0
b7 b0
b7 b0
SId
Asu flags
Rfa
Number of clusters
Cluster Id a
...
Clust Id n

Fig. 10

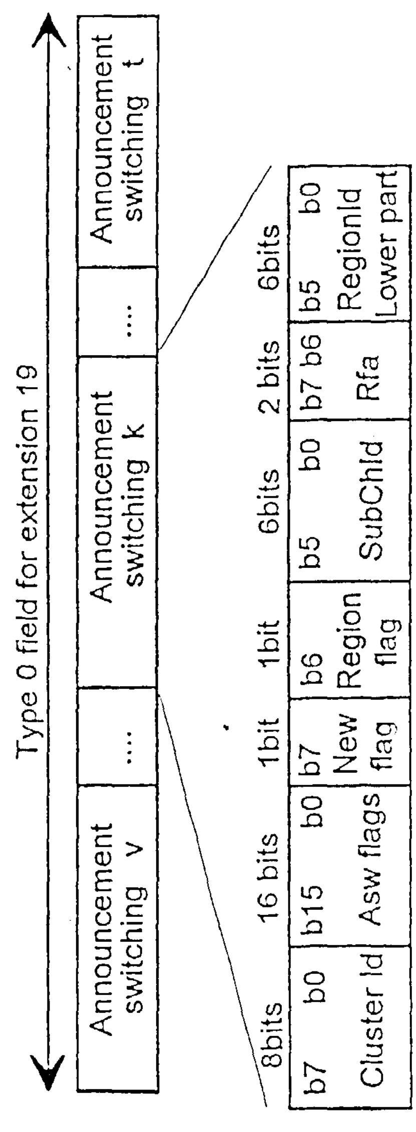

Type 0 field for extension 19
Announcement switching v
....
Announcement switching k
....
Announcement switching t
8bits
16 bits
1bit
1bit
6bits
2 bits
6bits
b7 b0
Cluster Id
b15 b0
Asw flags
b7
New flag
b6
Region flag
b5 b0
SubChId
b7 b6
Rfa
b5 b0
RegionId Lower part

Fig. 11