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PATENT REQUEST: STANDARD PATENT/PATENT OF ADDITION

We, being the person identified below as the Applicant, request the grant of a patent to the person identified below as the Nominated Person, for an invention described in the accompanying standard complete specification.

Full application details follow.

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[54] Invention Title: MOBILE RADIO COMMUNICATION SYSTEM

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BASIC CONVENTION APPLICATION DETAILS

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KABUSHIKI KAISHA TOSHIBA

By:

Registered Patent Attorney

TO: THE COMMISSIONER OF PATENTS
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NOTICE OF ENTITLEMENT

We, KABUSHIKI KAISHA TOSHIBA, of 72, Horikawa-cho, Saiwai-ku, Kawasaki-shi, Kanagawa-ken, Japan, being the applicant and nominated person in respect of Application No. 55222/94, state the following:-

The person nominated for the grant of the patent has entitlement from the actual inventors KISABURO KASUYA and KOICHI ITO by virtue of the following:

The said inventors assigned their rights in the invention to KABUSHIKI KAISHA TOSHIBA

The basic application listed on the Request Form is the first application made in a Convention country in respect of the invention.

KABUSHIKI KAISHA TOSHIBA
By their Patent Attorneys
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Registered Patent Attorney

Date: 21 June 1995.

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MOBILE RADIO COMMUNICATION SYSTEM

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(56) Prior Art Documents
EP 539220
EP 245077
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(57) Claim

1. A radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; one or both of said base stations and said telecommunication apparatus including:

receiving means (21,61) for receiving the first signal;

checking means (30, 71) responsive to the receiving means (21, 61) for checking a signal quality of the first received signal; and

comparing means (30, 71) responsive to the checking means (30, 71) for comparing the signal quality to a criterion;

.../2

said base station including:

designating means (71) responsive to the comparing means (30, 71) for designating a non-used one of the slots if the signal quality is less than the criterion;

said one or both of said based station and said radio telecommunication apparatus including:

sending means (55, 15) responsive to the designating means (71) for sending a second signal including information in the predetermined slot and for sending a third signal including the information in the designated slot;

said receiving means (21, 61) operating also to receive the second signal and the third signal, and said checking means (30, 71) also being responsive to the receiving means (21, 61) for checking each signal quality of the second received signal and the third received signal,

both of said base stations and said radio telecommunication apparatus including adopting means (30, 71) responsive to the checking means (30, 71) for adopting one of the second received signal and the third received signal if the signal quality of one is higher than the signal quality of the other.

16. A method of communicating a signal in a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; the method comprising at one or both of said base stations and said telecommunication apparatus:

receiving the first signal;

checking a signal quality of the first received signal; and

comparing the signal quality to a criterion;

at said base station:

designating a non-used ones of the slots if the signal quality is less than the criterion;

at said one or both of said based station and said radio telecommunication apparatus:

sending a second signal including information in the predetermined slot and sending a third signal including the information in the designated slot;

receiving the second signal and the third signal, and checking each signal quality of the second received signal and the third received signal,

at both of said base stations and said radio telecommunication apparatus adopting one of the second received signal and the third received signal if the signal quality of one is higher than the signal quality of the other.

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COMPLETE SPECIFICATION
FOR A STANDARD PATENT

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Invention Title: **MOBILE RADIO COMMUNICATION SYSTEM**

The following statement is a full description of this invention, including the best method of performing it known to us:

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to a radio telecommunication system for use in a radio telecommunication apparatus such as a portable telecommunication apparatus or a mobile telecommunication apparatus, and more particularly to a radio telecommunication system capable of maintaining the quality of signals received by the radio telecommunication apparatus.

Description of the Related Art

FIG. 17 shows a block diagram illustrating a digital radio telecommunication system. The system includes a control station CS connected to a landline network NW. The control station CS is further connected to plural base stations BS1, BS2, BS3 ... over landlines CL1, CL2, CL3,.... Each base station has its own radio zone E1, E2, E3,.... Each portable apparatus communicates over radio channels with the base station in the radio zone in which it is located. Further each portable apparatus is connected to the landline network NW through the base station BS and the control station CS.

This system adopts a time division multiple access system, referred to as a TDMA system, as a communication system. In the TDMA system, each radio channel for a downward channel and for an upward channel includes a plurality of time frames. Each frame includes six time slots. In the event that a communication link is formed between the base station and the portable station, one time slot for the downward signal is assigned from the downward

radio channel and one time slot for the upward signal is assigned from the upward radio channel. After that, the portable apparatus receives the downward signal in the assigned downward slot and sends the upward signal in the assigned upward slot. FIG. 18 shows downward slots in each downward channel and upward slots in each upward channel. Referring to FIG. 18, if the portable apparatus PS is assigned TS1 as a downward slot and assigned TS1' as an upward slot, the portable apparatus PS sends the intermittent upward signal to the base station BS during a period corresponding to the upward slot TS1'. Furthermore, the portable apparatus PS receives the downward signal during a period corresponding to a downward slot TS1. Thus, the upward slot TS1' is defined as a transmit slot and the downward slot TS1 is defined as a receive slot. During a period corresponding to the downward slots TS2, TS3, TS4, TS5, the apparatus PS sends no signal to the base station BS. Therefore, the slots corresponding to the slots TS2, TS3, TS4, TS5 are defined as an idle slot. The above six slots TS1 ~ TS6 repeat in every frame. However, if an obstacle such as a tall building is located between the base station and the portable apparatus, the quality of signals received by the portable apparatus becomes low. As a result, it is difficult for the user to listen to the decoded speech sound. This difficulty occurs when the signal is reflected from other buildings and the portable apparatus receives the reflected signal.

SUMMARY OF THE INVENTION

Accordingly, the present invention has been made in view of the above circumstances and has an object to provide a radio

telecommunication system that compensates for deterioration of the quality of signals received by a radio telecommunication apparatus used in the radio telecommunication system.

Additional objects and advantages of the invention will be set forth in part in the description which follows and in part will be apparent from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the written description and claims hereof as well as appended drawings.

To achieve these and other objects and advantages and in accordance with one aspect of the invention, there is provided a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; one or both of said base stations and said telecommunication apparatus including:

receiving means for receiving the first signal;

checking means responsive to the receiving means for checking a signal quality of the first received signal; and

comparing means responsive to the checking means for comparing the signal quality to a criterion;

said base station including:

designating means responsive to the comparing means for designating a non-used one of the slots if the signal quality is less than the criterion;

said one or both of said based station and said radio telecommunication apparatus including:

sending means responsive to the designating means for sending a second signal including information in the predetermined slot and for sending a third signal including the information in the designated slot;

said receiving means operating also to receive the second signal and the third signal, and said checking means

also being responsive to the receiving means for checking each signal quality of the second received signal and the third received signal,

both of said base stations and said radio telecommunication apparatus including adopting means responsive to the checking means for adopting one of the second received signal and the third received signal if the signal quality of one is higher than the signal quality of the other.

In accordance with another aspect of the invention there is provided a radio telecommunication system having radio channels, each radio channel including a plurality of slots generated by time division, the system communicating a first signal in a predetermined one of the slots characterised in that the system comprises:

receiving means for receiving the first signal;

checking means responsive to the receiving means for checking a signal quality of the first received signal;

comparing means responsive to the checking means for comparing the signal quality to a criterion;

designating means responsive to the comprising means for designating at least a non-used one of the slots if the signal quality is less than the criterion; and

communicating means responsive to the designating means for communicating a second signal in the predetermined slot and the designated slot.

In accordance with yet another aspect of the invention there is provided a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; one or both of said base stations and said telecommunication apparatus including:

receiving means for receiving the first signal;

checking means responsive to the receiving means for checking a signal quality of the first received signal; and

comparing means responsive to the checking means for

comparing the signal quality to a criterion;

said base station including:

designating means responsive to the comparing means for designating a plurality of non-used one of the slots if the signal quality is less than the criterion;

said one or both of said based station and said radio telecommunication apparatus including:

sending means responsive to the designating means for sending a second signal including information in the predetermined slot and for sending a third signal including the information in each of the designated slots;

said receiving means operating also to receive the second signal and the third signals, and said checking means also being responsive to the receiving means for checking each signal quality of the second received signal, and the third received signals,

both of said base stations and said radio telecommunication apparatus including adopting means responsive to the checking means for adopting one of the second received signals and the third received signals if the signal quality of one is higher than the signal quality of the others.

Yet another aspect of the invention provides a radio telecommunication apparatus for use in a radio telecommunication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas having a base station, each of which communicates a first signal with the apparatus in a predetermined one of the slots characterised in that the apparatus comprises:

first receiving means for receiving the first signal;

checking means responsive to the first receiving means for checking a signal quality of the first received signals;

comparing means responsive to the checking means for comparing the signal quality to a criterion;

second receiving means for receiving a designating signal designating a non-used one of the slots if the signal quality is less than the criterion; and

communicating means responsive to the designating means

for communicating a second signal in the predetermined slot and the designated slot.

An aspect of the invention also extends to a method of communicating a signal in a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; the method comprising at one or both of said base stations and said telecommunication apparatus:

receiving the first signal;

checking a signal quality of the first received signal; and

comparing the signal quality to a criterion;

at said base station:

designating a non-used one of the slots if the signal quality is less than the criterion;

at said one or both of said based station and said radio telecommunication apparatus:

sending a second signal including information in the predetermined slot and sending a third signal including the information in the designated slot;

receiving the second signal and the third signal, and checking each signal quality of the second received signal and the third received signal,

at both of said base stations and said radio telecommunication apparatus for adopting one of the second received signal and the third received signal if the signal quality of one is higher than the signal quality of the other.

An aspect of the invention extends to a method of communicating a signal in a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio

telecommunication apparatus; the method comprising at one or both of said base stations and said telecommunication apparatus:

receiving the first signal;

checking a signal quality of the first received signal; and

comparing the signal quality to a criterion;

at said base station:

designating a non-used one of the slots if the signal quality is less than the criterion; and

at said one or both of said based station and said radio telecommunication apparatus.

A further aspect of the invention extends to a method of communicating a signal in a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; the method comprising at one or both of said base stations and said telecommunication apparatus:

receiving the first signal;

checking a signal quality of the first received signal; and

comparing the signal quality to a criterion;

at said base station:

designating a plurality of non-used ones of the slots if the signal quality is less than the criterion;

at said one or both of said based station and said radio telecommunication apparatus:

sending a second signal including information in the predetermined slot and sending a third signal including the information in the designated slots;

receiving the second signal and the third signals, and

checking each signal quality of the second received signal and the third received signals,

at both of said base stations and said radio telecommunication apparatus adopting one of the second

received signal and the third received signal if the signal quality of one is higher than the signal quality of the other.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated herein and constitute a part of this specification, illustrate several embodiments of the invention and, together with the description, serve to explain the objects, advantages, and principles of the invention. In the drawings, FIG. 1 is a block diagram illustrating a radio telecommunication apparatus according to a first embodiment of the present invention;

FIG. 2 is a block diagram illustrating an error correction coder of the first embodiment;

FIG. 3 shows the contents of a slot before and after the error correction coding of the first embodiments;

FIG. 4 is a block diagram illustrating a base station of the first embodiment;

FIG. 5 is a flow chart illustrating a connection control operation sequence in the first embodiment;

FIG. 6 is a block diagram illustrating time slots before and after the operation of FIG 5;

FIG. 7 is a flow chart illustrating a downward signal connection control operation sequence that is performed after certain steps of FIG. 5 in the first embodiment;

FIG. 8 is a flow chart illustrating an upward signal connection control operation sequence that is performed after certain steps of FIG. 5 in the first embodiment;

FIG. 9 is a flow chart illustrating a connection control operation sequence in the first embodiment when a signal quality is recovered;

FIG. 10 is a flow chart illustrating a connection control operation sequence in a second embodiment of the present invention;

FIG. 11 is a block diagram illustrating a third embodiment of the present invention;

FIG. 12 is a flow chart illustrating a downward signal connection control operation sequence that is performed after certain steps of FIG. 5 in the third embodiment;

FIG. 13 is a flow chart illustrating a connection control operation sequence in the third embodiment when a signal quality is recovered;

FIG. 14 is a block diagram illustrating the radio telecommunication system according to a fourth embodiment of the present invention;

FIG. 15 is a diagram illustrating a time period during which the portable apparatus operates according to a TDMA system of the fourth embodiment;

FIG. 16 is a flow chart illustrating a connection control operation sequence of the fourth embodiment;

FIG. 17 shows a block diagram illustrating time slots before and after operation of another embodiment;

FIG. 18 is a diagram illustrating a conventional radio telecommunication system; and

FIG. 19 is an upward signal format from the apparatus to a base station and a downward signal format from the base station to the apparatus in the TDMA system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings.

A portable radio telecommunication apparatus referred to as a portable apparatus hereinafter in accordance with the present invention will be detailed with reference to the attached drawings.

FIG. 1 shows a block diagram of the portable apparatus for use in a radio telecommunication system in accordance with an embodiment of the present invention.

The portable apparatus is roughly divided into transmission, reception, and control sections. Reference numeral 40 denotes a power supply such as a battery. The transmission section comprises a microphone 11, a speech coder (SPCOD) 12, an error

correction coder (CHCOD) 13, a digital modulator (MOD) 14, an adder 15, a power amplifier (PA) 16, a high frequency switch circuit (SW) 17, and an antenna 18.

A transmit audio signal from the microphone 11 is subjected to a coding at the speech coder 12. The speech coder 12 outputs the digital transmit signal. The error correction coder 13 performs its error correction coding operation on the digital transmit signal and a digital control signal issued from a control circuit 30 (which will be explained later).

The digital modulator 14 generates a modulation signal corresponding to a digital transmit signal issued from the error correction coder 13. The adder 15 adds the modulation signal received from the digital modulator 14 and a carrier signal received from a synthesizer 31 to perform frequency conversion. The power amplifier 16 amplifies a high frequency signal received from the adder 15 to a predetermined level and provides a transmit signal.

The high frequency switch 17 is turned ON only for a period of time corresponding to a transmit time slot designated by the control circuit 30. During this time, the high frequency switch 17 receives the transmit signal from the power amplifier 16 and supplies it to the antenna 18. The transmit signal is transmitted toward a base station (not shown) in the form of a radio transmit signal.

The receiver section includes a receiver (RX) 21, a digital demodulator (DEMOD) 22, an error correction decoder (CHDEC) 23, a speech decoder (SPDEC) 24 and a speaker 25.

The receiver 21 performs its frequency converting operation over a radio receiver signal received from the antenna through the high frequency switch 17 and outputs a receive signal. The digital demodulator 22 performs bits and frame synchronizing operations over the receive signal from the receiver 21 to obtain a synchronized signal and supplies the synchronized signal to the control circuit 30 and a demodulation signal to the error correction decoder 23. The bit and frame synchronizing operations are defined as a word synchronization. The error correction decoder 23 performs its error correction decoding operation over the digital demodulation signal received from the digital demodulation 22 to obtain a digital receive signal.

Furthermore, the error correction decoder 23 provides a digital control signal for scanning channels and communication, to the control circuit 30.

The digital receive signal issued from the error correction decoder 23 is sent to the speech decoder 24. The speech decoder 24 performs its decoding operation over the digital receive signal to provide an analog receive signal. The analog receive signal is then applied to the speaker 25.

Further, the control section includes the control circuit 30, the frequency synthesizer (SYN) 31, a key unit 32, an ID-ROM 33, a RAM 34, an LCD driver 36 and an LCD 37. The synthesizer 31 generates an oscillation frequency necessary for radio communication with the base station under control of the control circuit 30. Furthermore, the control section includes a received

electric field intensity detector (RSSI) 39 for detecting electric field intensity of the received signal.

Reference numeral 40 denotes a battery. The battery is connected to a battery circuit 41. The battery circuit 41 receives an output voltage and changes the output voltage to a predetermined voltage Vcc. The predetermined voltage Vcc is supplied to each section in the apparatus.

FIG. 2 shows a detailed block diagram of the error correction coder 13. Referring to FIG. 2, the speech coder 12 converts the analog transmit audio signal to the digital transmit audio signal. There is a total of 159 bits in the digital audio transmit signal and digital control signal from the control circuit 30. The speech coder 12 separates the 159 bits into 77 class 1 bits and 82 class 2 bits. A coder 50 performs its error correction coding operation over only the 77 class 1 bits of information. The coder 50 uses an error correction coding operation as described in "Cellular System Dual-Mode Mobile Station - Base Station Compatibility Standard IS-54B"; TELECOMMUNICATIONS INDUSTRY ASSOCIATION, Apr. 1992, Washington, D.C., U.S.A., referred to IS-54B herein. Other embodiments may use a different error correcting coding operation. As a result, the coder 50 outputs 178 error correction coded class 1 bits. A converter 52 converts the 178 error correction coded class 1 bits and the 82 class 2 bits into 260 bits of serial signal and outputs the serial signal to the modulator 14. FIG. 3 shows the content of bits before and after error correction coding. Referring to FIG. 3, the 260 bits are included in one slot. Since the number of bits included in

one slot is limited to 260, the number of bits subjected to the error correction coding is limited to the 77 class 1 bits.

The error correction decoding is the reverse of the error coding operation. That is, the error correction decoder 23 subjects 178 error correction coded class 1 bits of the received digital signal to the error correction decoding. The error correction decoder 23 determines the number of corrected bits. In response to the recognition, the control circuit 30 divides the number of corrected bits by the total number of error correction coded class 1 bits, i.e., 178 bits. The result (corresponding to the number of the corrected bit/178) is called a bit error rate and referred to as a BER. The control circuit recognizes the BER of the received signal and is capable of checking the signal quality of the received signal in response to the BER.

FIG. 4 shows a block diagram of the base station including transmission, reception and control sections. Referring to FIG. 4, the transmission section comprises a hybrid circuit 51, a speech coder (SPCOD) 52, an error correction coder (CHCOD) 53, a digital modulator (MOD) 54, an adder 55, a power amplifier (PA) 56, a duplexer 57, and an antenna 58.

The speech coder 52 performs coding of a signal from landlines CL1 ~ CLn. The speech coder 52 outputs the digital transmit signal. The error correction coder 53 performs its error correction coding operation over the digital transmit signal and a digital control signal issued from a control circuit 71. The error correction coder 53 operates in a same manner as the error correction coder 13 provided in the portable apparatus.

The digital modulator 54 generates a modulation signal corresponding to a digital transmit signal issued from the error correction coder 53. The adder 55 adds the modulation signal received from the digital modulator 54 and a carrier signal received from a synthesizer 72 to perform frequency conversion. The power amplifier 56 amplifies a high frequency signal received from the adder 55 to a predetermined level and provides a transmit signal. The duplexer 57 receives the transmit signal from the power amplifier 56 and supplies it to the antenna 58. The transmit signal corresponding to a downward signal is transmitted toward a plurality of portable apparatus in the form of a radio transmit signal.

The receiver section includes a receiver (RX) 61, a digital demodulator (DEMOD) 62, an error correction decoder (CHDEC) 63, and a speech decoder (SPDEC) 64.

The receiver 61 performs its frequency converting operation over a radio receiver signal received from the antenna through the duplexer 57 and outputs a receive signal. The digital demodulator 62 performs bit and frame synchronizing operations over the receive signal received from the receiver 61 to obtain a synchronized signal and supplies the synchronized signal to the control circuit 71 and a demodulation signal to the error correction decoder 63. The bit and frame synchronizing operations are defined as a word synchronization. The error correction decoder 63 performs its error correction decoding operation on the

digital demodulation signal received from the digital demodulation 22 to obtain a digital receive signal in a same manner as the error correction decoder 23 provided in the portable apparatus.

Furthermore, the error correction decoder 63 provides a digital control signal for scanning channels and communication to the control circuit 71.

The digital receive signal issued from the error correction decoder 63 is sent to the speech decoder 64. The speech decoder 64 performs its decoding operation over the digital receive signal to provide an analog receive signal. The analog receive signal is then applied to the hybrid circuit 51.

Further, the control section includes the control circuit 71, the frequency synthesizer (SYS) 72, and a received electric field intensity detector (RSSI) 73. The synthesizer 72 generates an oscillation frequency necessary for radio communication with the portable apparatus under control of the control circuit 71. The receive electric field intensity detector 73 detects electric field intensity of the received signal.

FIG. 5 shows an operation of the portable apparatus and the base station. The steps of FIG. 5 are performed by the control circuit 30 and the control circuit 71. Referring to FIG. 5, the portable apparatus communicates with the base station a downward information signal in a downward slot TS1 and an upward information signal in an upward slot TS1' (step 100,200). While communicating with the base station, the portable apparatus receives a downward information signal including speech

information and control information from the base station. Furthermore, the portable apparatus checks a BER of the received downward information in the downward slot TS1 (step 102). Thereafter, the portable apparatus compares the BER to a criterion, which is, for example, 3%. If the BER exceeds the criterion (step 104), the portable apparatus sends a first detection signal over the upward slot TS1' (step 106). This signal indicates that the received signal quality is low. Otherwise, the portable apparatus repeats the check of BER of a received downward information signal.

If the base station receives the first detection signal during communication with the portable apparatus (step 202), the base station checks whether or not there is at least one non-used slot in a downward channel over which the base station sends the information signal to the portable apparatus (step 204). If there is at least one non-used slot in the channel, the base station selects one of the non-used slots (step 206).

FIG. 6 shows a plurality of slots in the downward channel over which the base station sends the downward information signal. Referring to FIG. 6(a), it is found that the slot TS1 is a used one and that the slots TS2, TS3, TS4, TS5 and TS6 are non-used ones. If the BER of the received information signal exceeds the criterion in this state, the base station, in step 206, selects the slot TS4. This is because referring to FIG. 6(b), the slot TS4 is located far away from the slot TS1-A and a following slot TS1-B. Therefore, it is possible to decrease probability that the obstacle between the base station and the portable apparatus

influences information signals in two slots TS1, TS4 simultaneously.

Referring again to FIG. 5, after the step 206, the portable apparatus sends a first instruction signal including information indicative of the selected slot TS4 using the downward slot TS1 (step 208). If the portable apparatus receives the first instruction signal during a predetermined period of time after the portable apparatus sends the first detection signal (step 108), the portable apparatus sends an acknowledge signal using the upward slot TS1' to the base station (step 110). Otherwise, the portable apparatus sends the first detection signal again. If the base station receives the acknowledge signal after the base station sends the first instruction signal (step 210), the base station inserts the information signal into the selected slot TS4 (step 212) as shown in FIG. 7. Thereafter, the base station sends the information signals in the downward slots TS1, TS4 to the portable apparatus (step 214). If the portable apparatus receives the information signals in the downward slots TS1, TS4 during a predetermined period of time after sending the acknowledge signal (step 112), the portable apparatus checks each BER of each received information signal (step 114). Thereafter, the portable apparatus compares the BER of the received information signal in the downward slot TS1 to the BER of the received information signal in the downward slot TS4. In response to the comparison, the portable apparatus adopts the information signal having lower BER (step 116).

Referring again to FIG. 5, after the base station receives the acknowledgment signal (step 210), the portable apparatus sends an upward information signal to the base station in the same manner as the operation in which the base station sends the downward information signals using the slots TS1, TS4. After a predetermined period of time of the step 110 of FIG. 5, as shown in FIG. 8, the portable apparatus inserts the information signal into the selected upward slot TS4' and the upward slot TS1' (step 120). Thereafter, the portable apparatus sends the upward information signals in the upward slots TS1', TS4' (step 122). If the base station receives the upward information signals in the upward slot TS1', TS4' (step 220), the base station checks a BER of the received upward information signal in the upward slot TS1' and a BER of the upward received information signal in the upward slot TS4' (step 222). Thereafter, the base station adopts the upward information signal having lower BER (step 224).

FIG. 9 shows an operation in the event that the signal quality is recovered while the portable apparatus communicates the information signals using the downward slots TS1, TS4 and the upward slots TS1', TS4' with the base station. Referring to FIG. 9, the portable apparatus checks a BER of a received downward information signal in the downward slot TS1 (step 130). Thereafter if the BER is at or below the criterion (step 132), the portable station sends a second detection signal using the upward slots TS1', TS4' (step 134). This means that the signal quality of the received downward information signal is recovered. The second detection signal includes an indication that the downward

slot TS1 should be used instead of downward slots TS1, TS4 and that the upward slot TS1' should be used instead of upward slots TS1', TS4'. Otherwise, the portable apparatus repeats the check. If the base station receives the second detection signal (step 230), the base station sends a second instruction signal to the portable apparatus using the downward slots TS1, TS4 (step 232). If the portable apparatus receives the second instruction signal during a predetermined period of time after sending the second detection signal (step 136), the portable apparatus sends acknowledge signal using the upward slots TS1', TS4' (step 138) to the base station. If the base station receives the acknowledge signal (step 234), the base station communicates the downward and upward information signals using only the downward slot TS1 and the upward slot TS1' with the portable apparatus.

According to the embodiment, lowering of the information signal quality is detected at the portable apparatus during the communication. The portable apparatus sends the detection signal to the base station. The base station checks whether or not there is non-used slot in the channel over which the base station sends the information signal to the portable apparatus.

The base station sends the instruction signal including an indication that two slots should be used instead of one slot. Then, slots used for communication between the base station and the portable apparatus are altered from one to two. Therefore, even if the information signal quality is lowered, it is possible to compensate the lowering of the information signal quality, compared with a conventional system wherein the information signal

is communicated using only one slot. In addition, since alternation from one slot to two slots is performed only when there is a non-used slot in the channel over which the base station communicates the information signal with the portable apparatus, this operation does not interrupt the communication between the other portable apparatus and the base station. Since a non-used slot is effectively used, it is possible to increase an efficiency of the availability of the radio channel.

Furthermore, if the information signal quality recovers during communicating the information signals using each assigned two slots of the downward slots and the upward slots, the base station changes the number of slots for use from two to one as shown in FIG. 9. Therefore, this embodiment prevents the two slots being used even if the information signal quality recovers. As a result, the base station is capable of assigning limited slots effectively and therefore maintains high efficiency of using the slots.

This invention is not limited to the embodiment. FIG. 10 shows a second embodiment. The second embodiment differs from the first embodiment with respect to the detection of the information signal quality. Referring to FIG. 10, the base station receives an upward information signal in the upward slot TS1' from the portable apparatus and checks a BER of the received upward information signal (step 250). If the BER exceeds the criterion (step 252), the base station checks whether or not there is at least one non-used slot (step 254). Otherwise, the base station repeats the above operation. If there is at least one non-used

slot, the base station selects one of the non-used slots (step 256). Thereafter, the base station sends a first instruction signal using a downward slot TS1 including information indicative of the selected slot (step 258). If the portable apparatus receives the first instruction signal during communication with the base station (step 150), the portable apparatus sends an acknowledge signal using an upward slot TS1' (step 152). If the base station receives the acknowledge signal (step 260), the base station communicates the information signal using the downward and upward slots TS1, TS1' and the selected downward and upward slots TS4 and TS4' with the portable apparatus in the same manner as the first embodiment.

FIG. 11 shows a third embodiment and a difference between the first and third embodiments. Referring to FIG. 11, in the first embodiment, the speech coder 12 outputs the 77 class 1 bits and the 82 class 2 bits. The error correction coding is applied to only the 77 class 1 bits. As a result, the 77 class 1 bits are changed to the 178 error correction coded class 1 bits. The error correction coding is not applied to the 82 class 2 bits because one slot assigned to a portable apparatus has only 260 bits, and has room only for the error correction coded 178 class 1 bits and the non-error correction coded 82 class 2 bits.

On the contrary, in the third embodiment, in the event that the portable apparatus is assigned two slots in step 210 of FIG. 5, the two slots having 520 bits has room for not only the error correction coded 178 class 1 bits but also for more than 82 error correction coded class 2 bits. Therefore, an error

correction coder 45 in the third embodiment applies the error correction coding to not only the class 1 bits but also the class 2 bits. This error correcting operation applied to the 82 class 2 bits is same as that applied to the 77 class 1 bits.

FIG. 12 shows the operation of the third embodiment. After the step 210 of FIG. 5, the base station applies the error correction coding to the 77 class 1 bits and the 82 class 2 bits (step 264). Thereafter, the base station inserts the error correction coded class 1 bits and the error correction coded class 2 bits into the downward slots TS1, TS4 (step 264). After that, the base station sends a downward information signal corresponding to the error correction coded class 1 bits and the error correction coded class 2 bits using the slots TS1, TS4 (step 266).

If the portable apparatus receives the information signal (step 160), the portable apparatus applies the error correction decoding to the error correction coded class 1 bits and the error correction coded class 2 bits (step 162). Otherwise, the portable apparatus waits to receive the information signal.

An upward signal operates in a same manner as the downward information signal operation.

FIG. 13 shows an operation after the BER of a received information signal is recovered. Referring to FIG. 13, during communication using the downward slots TS1, TS4 and the upward slots TS1', TS4', the portable apparatus checks the BER of a received downward information signal in the downward slots TS1,

TS4 (step 164). If the BER is at or below the criterion (step 166), the portable apparatus sends the second detection signal using the upward slot TS1', TS4' (step 134). Following operations are same as that of FIG. 5 and therefore further such description of the operations is unnecessary.

Obstacles between the portable station and the base station are not the only cause of low signal quality. FIG. 14 shows another possible reason. Referring to FIG. 14, a base station BS1 covers an area E1. A base station BS2 covers an area E2. An area EN is covered by the areas E1 and E2. A portable apparatus PS is located in the area EN. In this state, the lowering of the signal quality of the downward signal from the base station BS1 occurs because the portable apparatus is far away from the base station BS1.

FIG. 15 shows time periods during which the portable apparatus PS communicates with the base station BS1. Referring to FIGS. 14, 15, the portable apparatus PS sends an upward signal a1 to the base station BS1 during a time period T1 corresponding to a transmit slot.

The portable apparatus PS receives a downward signal a2 from the base station BS1 during a time period R1 corresponding to a receive slot. Further, the portable apparatus PS receives a signal b from the adjacent base station BS2 during a period I1 corresponding to an idle slot. After receiving the signal b, the portable apparatus PS detects an electric field intensity of the received signal b using the RSSI 39. Thereafter, the portable apparatus sends an upward signal a3 including the electric field

intensity of the received signal b to the base station BS1 during a period T2. The base station BS1 receives the upward signal a3 and stores the electric field intensity of the signal b into its memory.

In this state, referring again to FIG. 5, in step 100, the portable station receives a downward signal from the base station BS1. If the BER of the received downward signal exceeds the criterion, the portable apparatus sends the first detection signal to the base station BS1 (step 102, 104, 106). The base station BS1 receives the first detection signal (step 202). FIG. 16 shows a fourth embodiment including steps inserted between step 202 and step 204 of FIG. 5 in the first embodiment. If the stored electric field intensity of the signal b from the adjacent base station BS2 to the portable apparatus PS is less than a criterion, e.g., -110dBm, (step 270), the base station BS1 performs the operation in the manner indicated from step 204 onward. Otherwise, the base station BS1 sends a signal to and receives a signal from the adjacent base station BS2 to confirm whether or not there is a non-used slot in each channel over which the adjacent base station can send signals (step 272). If there is a non-used slot, the base station BS1 requests the control station CS to change a slot assigned to the portable apparatus PS from TS1 to the confirmed non-used slot in a channel over which the adjacent base station BS2 can send signals (step 274). Otherwise, if there is no non-used slot, the base station BS1 performs the same operation as step 204. In this case, if the base station BS1

receives an acknowledge signal from the control station (step 276), the base station BS1 sends an indicating signal to the portable apparatus PS using the downward slot TS1 (step 278). If the portable apparatus PS receives the indicating signal, the portable apparatus PS sends an acknowledge signal to the base station using the upward slot TS1' (step 170).

If the base station BS1 receives the acknowledge signal from the portable apparatus, the base station BS1 sends a confirmation signal to the control station CS (step 280). After that, the control station CS changes the slot assigned to the portable apparatus PS from TS1 to the confirmed non-used slot. As a result, the communication between the portable apparatus PS and the base station BS1 ceases and a communication between the portable apparatus PS and the base station BS2 starts (steps 190, 290). This operation from steps 270 to 290 and steps 170, 190 is called a "hand-off" operation, and is described generally in the IS-54B.

In the embodiments, the BER is used for detecting the received information signal quality. This invention is not limited to the embodiments described. The electrical field intensity of the received information signal also may be used for detecting the signal quality. In fact, any known method of detecting signal quality may be used.

Furthermore, in the described embodiments, when the signal quality is lower than a criterion, the number of time slots used is altered from one to two. However, one slot also may be altered

to a number of slots that is more than two slots. FIG. 17 shows a slot alternation from one slot to six slots.

Furthermore, in the embodiment, it is explained that one criterion is set to detect the lowering of the signal quality and the number of the used slot is altered in two steps in response to the results of the detection. However, a plurality of criteria may be set to detect the lowering of the signal quality. The number of the slots may be altered in or above three steps in response to results of the detection.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. A radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; one or both of said base stations and said telecommunication apparatus including:

receiving means (21,61) for receiving the first signal;

checking means (30, 71) responsive to the receiving means (21, 61) for checking a signal quality of the first received signal; and

comparing means (30, 71) responsive to the checking means (30, 71) for comparing the signal quality to a criterion;

said base station including:

designating means (71) responsive to the comparing means (30, 71) for designating a non-used one of the slots if the signal quality is less than the criterion;

said one or both of said based station and said radio telecommunication apparatus including:

sending means (55, 15) responsive to the designating means (71) for sending a second signal including information in the predetermined slot and for sending a third signal including the information in the designated slot;

said receiving means (21, 61) operating also to receive the second signal and the third signal, and said checking means (30, 71) also being responsive to the receiving means

(21, 61) for checking each signal quality of the second received signal and the third received signal,

both of said base stations and said radio telecommunication apparatus including adopting means (30, 71) responsive to the checking means (30, 71) for adopting one of the second received signal and the third received signal if the signal quality of one is higher than the signal quality of the other.

2. A radio telecommunication system having radio channels, each radio channel including a plurality of slots generated by time division, the system communicating a first signal in a predetermined one of the slots characterised in that the system comprises:

receiving means (21, 61) for receiving the first signal;

checking means (30, 71) responsive to the receiving means (21, 61) for checking a signal quality of the first received signal;

comparing means (30, 71) responsive to the checking means (30, 71) for comparing the signal quality to a criterion;

designating means (71) responsive to the comprising means (30, 71) for designating at lest a non-used one of the slots if the signal quality is less than the criterion; and

communicating means (55, 21, 15, 61) responsive to the designating means (71) for communicating a second signal in the predetermined slot and the designated slot.

3. The radio telecommunication system of claim 2, characterised in that the system further comprises means

(30, 71) responsive to the communicating means, for comparing the signal quality of the second communication signal to the criterion, and means (55, 21, 15, 61) for communicating only a third signal in the predetermined slot if the signal quality is at or above the criterion.

4. The radio telecommunication system of claim 2, characterised in that each signal quality of at least one of the first received and second communicated signals is a bit error rate generated by dividing a number of error corrected bits of the received signal by a number of error correction coded bits of the received signal.

5. A radio telecommunication system of claim 2, characterised in that each signal quality of at least one of the first received and second communicated signals is an electric field intensity of one of the signals.

6. A radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; one or both of said base stations and said telecommunication apparatus including:

receiving means (21,61) for receiving the first signal;

checking means (30, 71) responsive to the receiving means (21, 61) for checking a signal quality of the first received signal; and

comparing means (30, 71) responsive to the checking means (30, 71) for comparing the signal quality to a

criterion;

said base station including:

designating means (71) responsive to the comparing means (30, 71) for designating a plurality of non-used one of the slots if the signal quality is less than the criterion;

said one or both of said based station and said radio telecommunication apparatus including:

sending means (55, 15) responsive to the designating means (71) for sending a second signal including information in the predetermined slot and for sending a third signal including the information in each of the designated slots;

said receiving means (21, 61) operating also to receive the second signal and the third signals, and said checking means (30, 71) also being responsive to the receiving means (21, 61) for checking each signal quality of the second received signal, and the third received signals,

both of said base stations and said radio telecommunication apparatus including adopting means (30, 71) responsive to the checking means (30, 71) for adopting one of the second received signals and the third received signals if the signal quality of one is higher than the signal quality of the others.

7. The radio telecommunication system of claim 1 or 6,characterised in that the system further comprises means (30, 71), responsive to the second checking means (30, 71) for comparing the signal quality of the second received signal to the criterion, and means (55, 15) for sending only a fourth signal including the information in the

predetermined slot if the signal quality is at or above the criterion.

8. The radio telecommunication system of claim 1 or 6, characterised in that each signal quality of at least one of the first, second and third received signals is a bit error rate generated by dividing a number of error corrected bits of the received signal by a number of error correction coded bits of the received signal.

9. The radio telecommunication system of claim 1 or 6, characterised in that each signal quality of at least one of the first, second and third received signals is an electric field intensity of one of the first, second and third received signals.

10. A radio telecommunication apparatus for use in a radio telecommunication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas having a base station, each of which communicates a first signal with the apparatus in a predetermined one of the slots characterised in that the apparatus comprises:

first receiving means (21) for receiving the first signal;

checking means (30) responsive to the first receiving means (21) for checking a signal quality of the first received signals;

comparing means (30) responsive to the checking means (30) for comparing the signal quality to a criterion;

second receiving means (21) for receiving a designating

signal designating a non-used one of the slots if the signal quality is less than the criterion; and

communicating means (21, 15) responsive to the designating means for communicating a second signal in the predetermined slot and the designated slot.

.1. The radio telecommunication apparatus of claim 10 characterised in that the apparatus further comprises means (30), responsive to the communicating means (21, 15) for comparing the signal quality of the second communicated signal to the criterion, and means (21, 15) for communicating only a third signal in the predetermined slot if the signal quality is at or above the criterion.

12. The radio telecommunication apparatus of claim 10 wherein each signal quality of at least one of the first received and second communicated signals is a bit error rate generated by dividing a number of error corrected bits of the received signal by a number of error correction codes bits of the received signal.

13. The radio telecommunication apparatus of claim 10, characterised in that each signal quality of at least one of the first received and second communicated signals is an electric field intensity of one of the signals.

14. A radio telecommunication base station communicating with a radio telecommunication apparatus for use in a radio telecommunication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein each base station communicates a first signal with the apparatus in a predetermined slot characterised in that the base station

comprises:

receiving means (61) for receiving the first signal;

checking means (71) responsive to the receiving means (61) for checking a signal quality of the first received signal;

comparing means (71) responsive to the checking means (71) for comparing the signal quality to a criterion;

designating means (71) responsive to the comprising means (71) for designating a non-used one of the slots if the signal quality is less than the criterion; and

communicating means (61, 55) responsive to the designating means (71) for communicating a second signal in the predetermined slot and the designated slot.

15. The radio telecommunication base station communicating with a radio telecommunication apparatus for use in a radio telecommunication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the base station communicates a first signal with the apparatus in a predetermined slot characterised in that the base station comprises:

receiving means (61) for receiving an indicating signal indicating that a signal quality of the signal received by the apparatus is less than a criterion;

designating means (71) responsive to the receiving means (61) for designating a non-used one of the slots if the signal quality is less than the criterion; and

communicating means (55, 61) responsive to the designating means for communicating a second signal in the

predetermined slot and the designated slot.

16. A method of communicating a signal in a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; the method comprising at one or both of said base stations and said telecommunication apparatus:

receiving the first signal;

checking a signal quality of the first received signal; and

comparing the signal quality to a criterion;

at said base station:

designating a non-used ones of the slots if the signal quality is less than the criterion;

at said one or both of said based station and said radio telecommunication apparatus:

sending a second signal including information in the predetermined slot and sending a third signal including the information in the designated slot;

receiving the second signal and the third signal, and checking each signal quality of the second received signal and the third received signal,

at both of said base stations and said radio telecommunication apparatus adopting one of the second received signal and the third received signal if the signal quality of one is higher than the signal quality of the

other.

17. The method of claim 16 characterised in that the method further comprises the steps of comparing the signal quality of the second received signal to the criterion and sending only a fourth signal including the information in the predetermined slot if the signal quality is at or above the criterion.

18. A method of communicating a signal in a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; the method comprising at one or both of said base stations and said telecommunication apparatus:

receiving the first signal;

checking a signal quality of the first received signal; and

comparing the signal quality to a criterion;

at said base station:

designating a non-used one of the slots if the signal quality is less than the criterion; and

at said one or both of said based station and said radio telecommunication apparatus:

communicating a second signal in the predetermined slot and the designated slot

19. A method of communicating a signal in a radio communication system having radio channels, each radio channel including a plurality of slots generated by time division, wherein the system encompasses a plurality of

areas each having a base station, each of which communicates a first signal in a predetermined one of the slots with a radio telecommunication apparatus; the method comprising at one or both of said base stations and said telecommunication apparatus:

receiving the first signal;

checking a signal quality of the first received signal; and

comparing the signal quality to a criterion;

at said base station:

designating a plurality of non-used ones of the slots if the signal quality is less than the criterion;

at said one or both of said based station and said radio telecommunication apparatus:

sending a second signal including information in the predetermined slot and sending a third signal including the information in the designated slots;

receiving the second signal and the third signals, and

checking each signal quality of the second received signal and the third received signals,

at both of said base stations and said radio telecommunication apparatus adopting one of the second received signal and the third received signal if the signal quality of one is higher than the signal quality of the other.

20. The method of claim 18 or 19 characterised in that the method further comprises the steps of comparing the signal quality of the second communicated signal to the criterion and sending only a third signal including the

information in the predetermined slot if the signal quality is at or above the criterion.

DATED this 21 day of June 1995

KABUSHIKI KAISHA TOSHIBA
By their Patent Attorneys
CULLEN & CO.

ABSTRACT

A radio telecommunication system has radio channels, each radio channel including a plurality of slots generated by time division. The system encompasses a plurality of areas having a base station which sends a first signal over a predetermined slot of the slots. If the signal quality of the first signal received by a portable apparatus is less than a criterion, non-used at least one of the slots is designated. The portable apparatus sends a second signal over the predetermined slot and the designated slot.

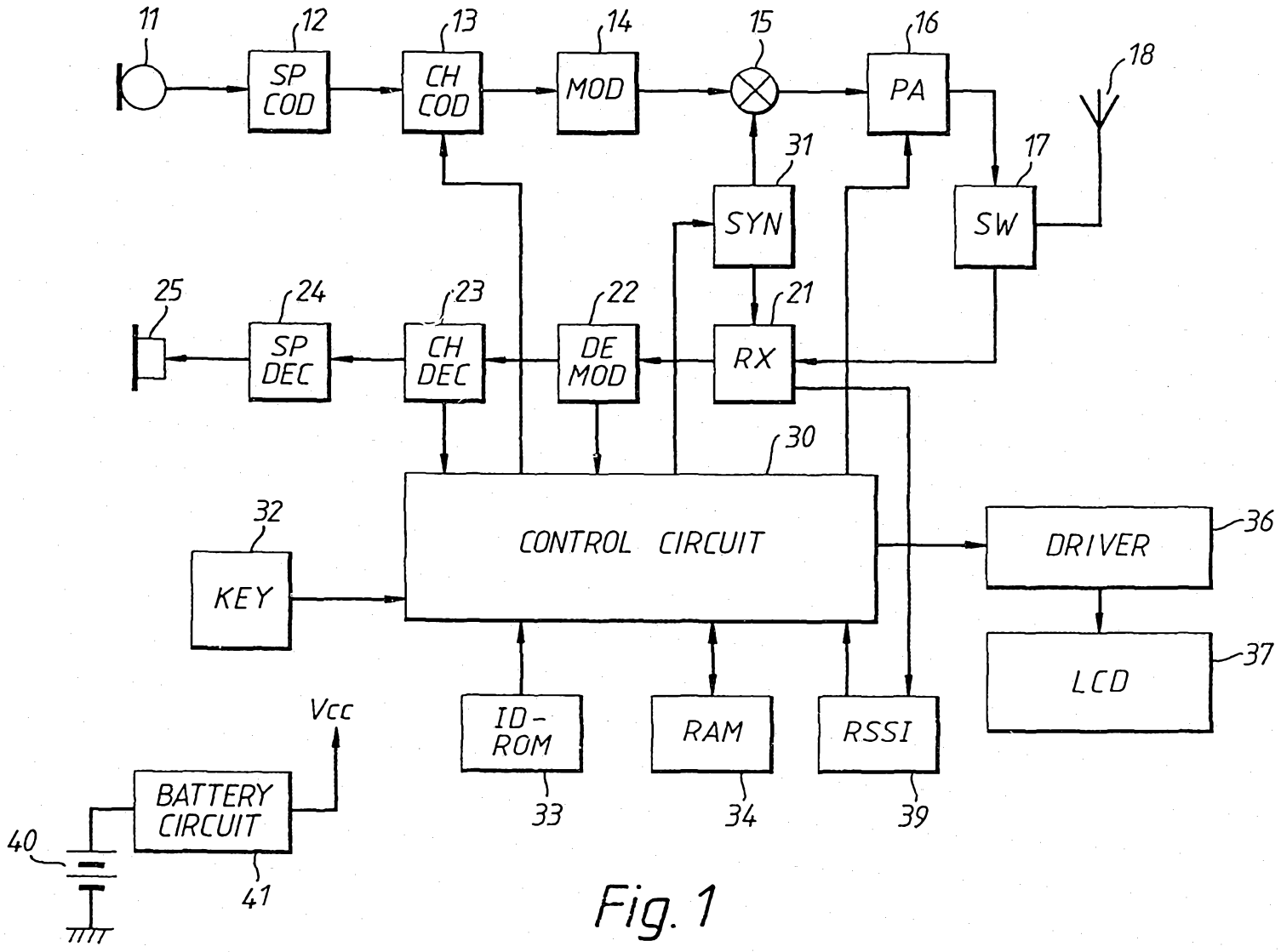

Fig. 1

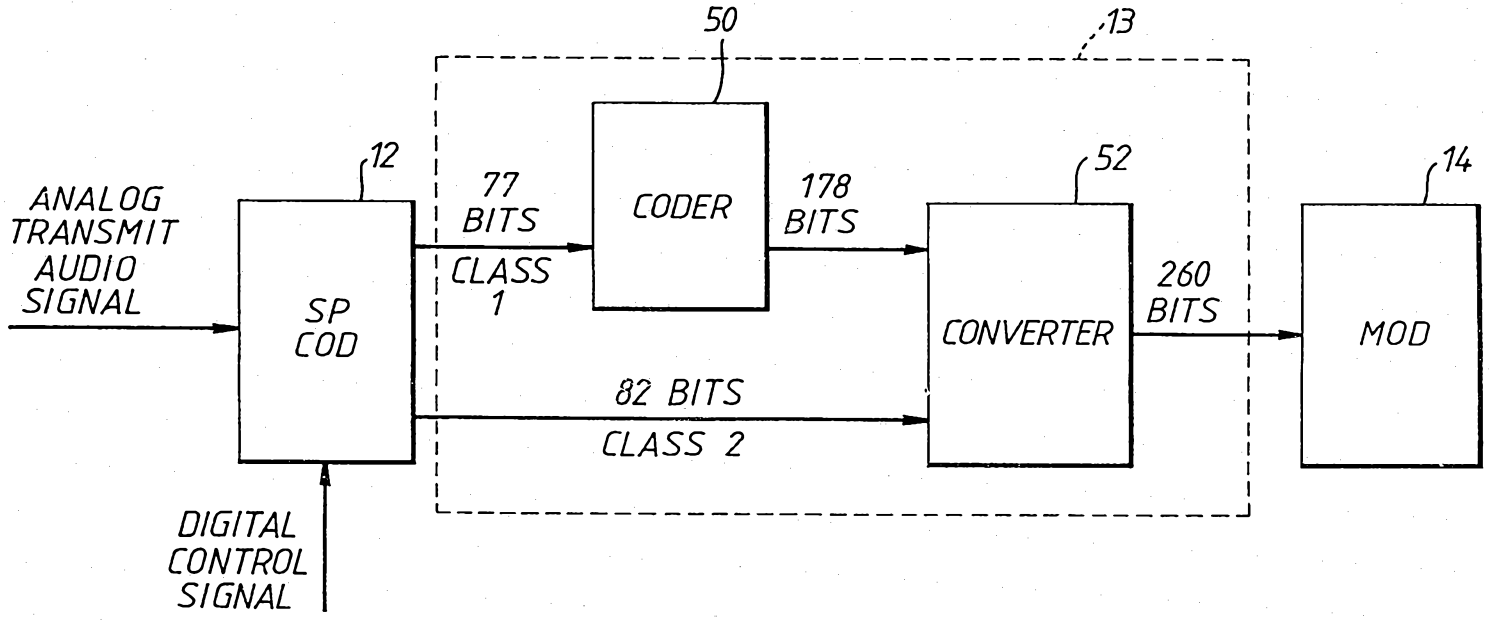
50
13
12
52
14
ANALOG TRANSMIT AUDIO SIGNAL
SP COD
77 BITS
CLASS 1
CODER
178 BITS
CONVERTER
260 BITS
MOD
82 BITS
CLASS 2
DIGITAL CONTROL SIGNAL

Fig. 2

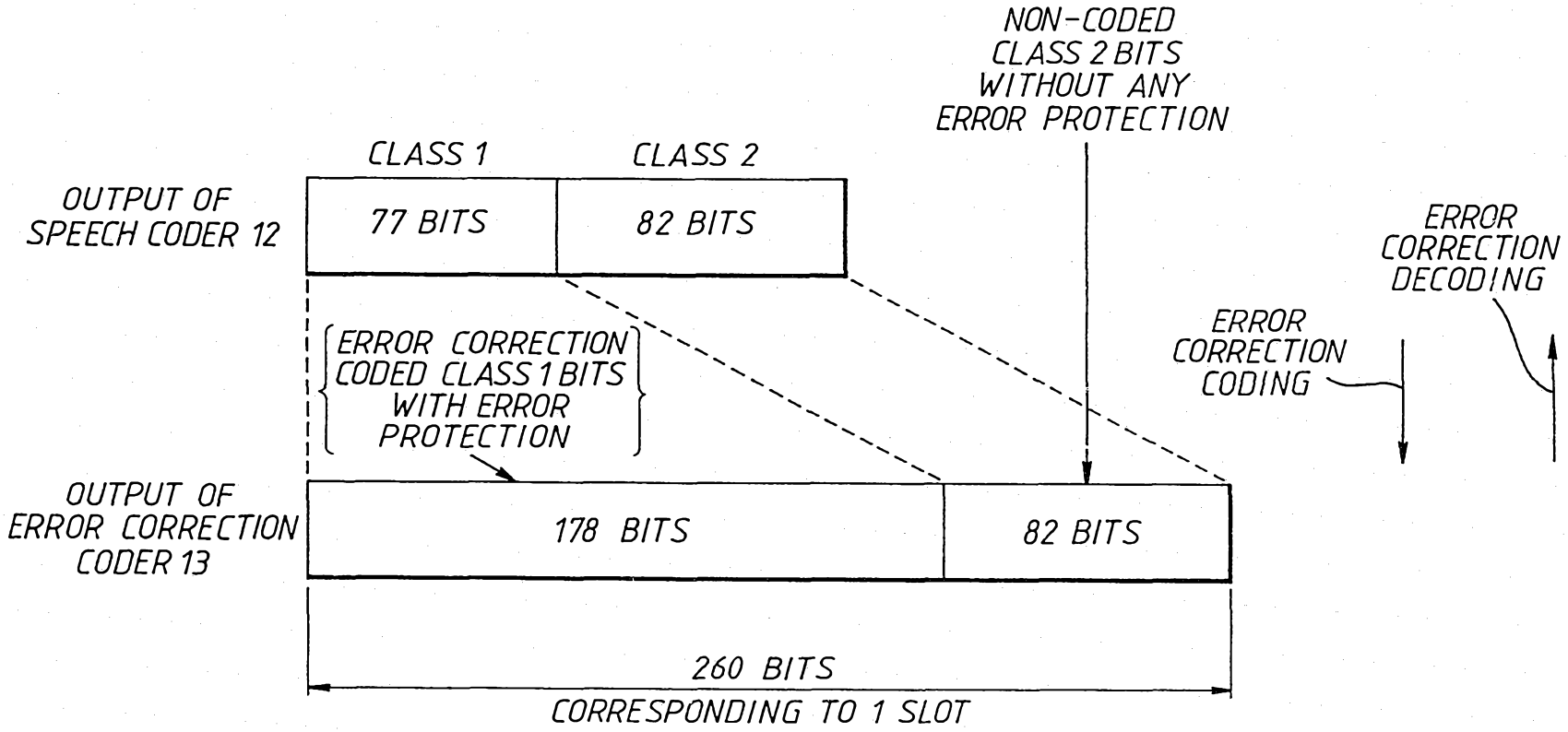
NON-CODED
CLASS 2 BITS
WITHOUT ANY
ERROR PROTECTION
CLASS 1
CLASS 2
OUTPUT OF
SPEECH CODER 12
77 BITS
82 BITS
ERROR
CORRECTION
DECODING
ERROR
CORRECTION
CODING
ERROR CORRECTION
CODED CLASS 1 BITS
WITH ERROR
PROTECTION
OUTPUT OF
ERROR CORRECTION
CODER 13
178 BITS
82 BITS
260 BITS
CORRESPONDING TO 1 SLOT

Fig. 3

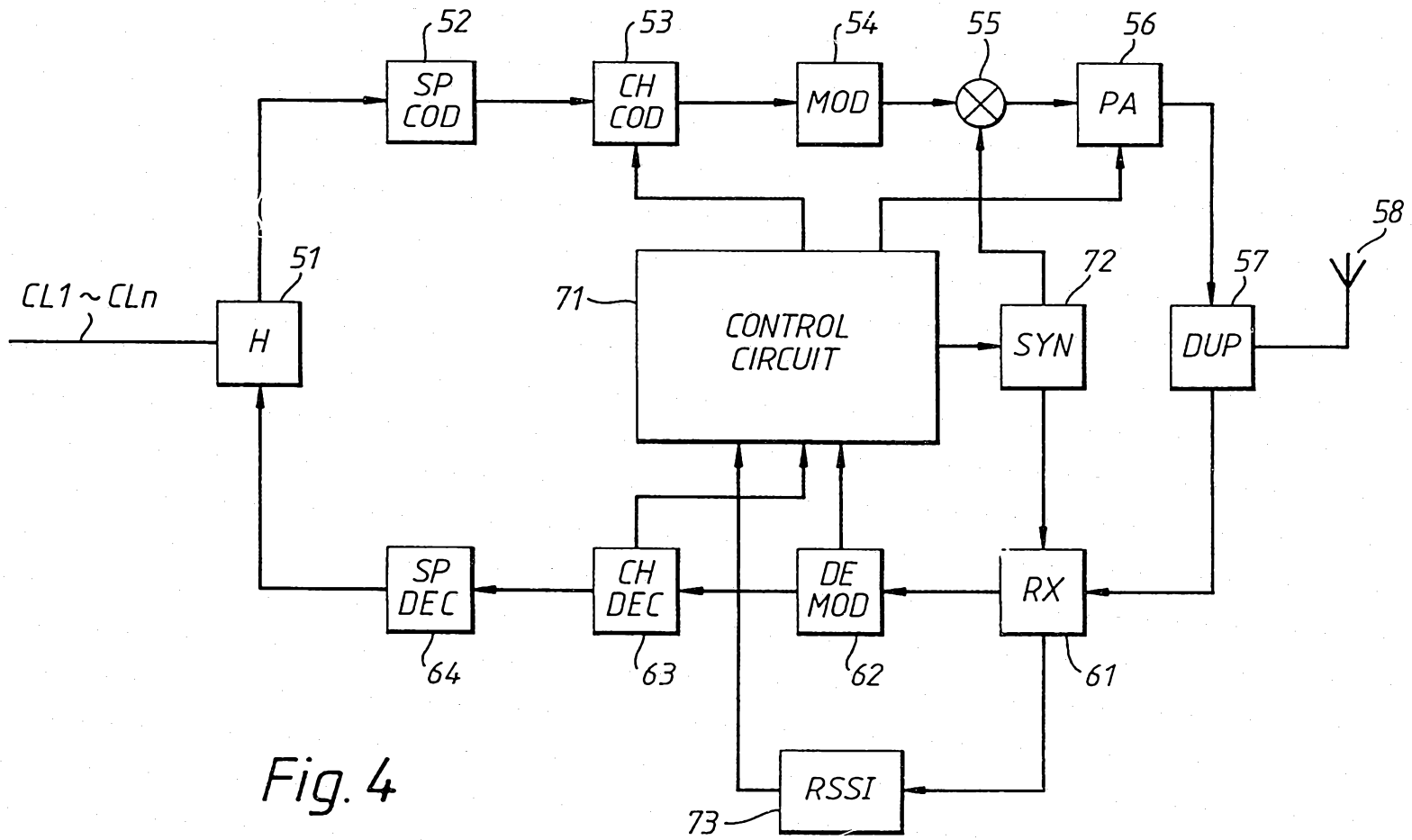
52
53
54
55
56
SP COD
CH COD
MOD
PA
58
51
72
57
CL1 ~ CLn
71
CONTROL CIRCUIT
H
SYN
DUP
SP DEC
CH DEC
DE MOD
RX
64
63
62
61
RSSI
73

Fig. 4

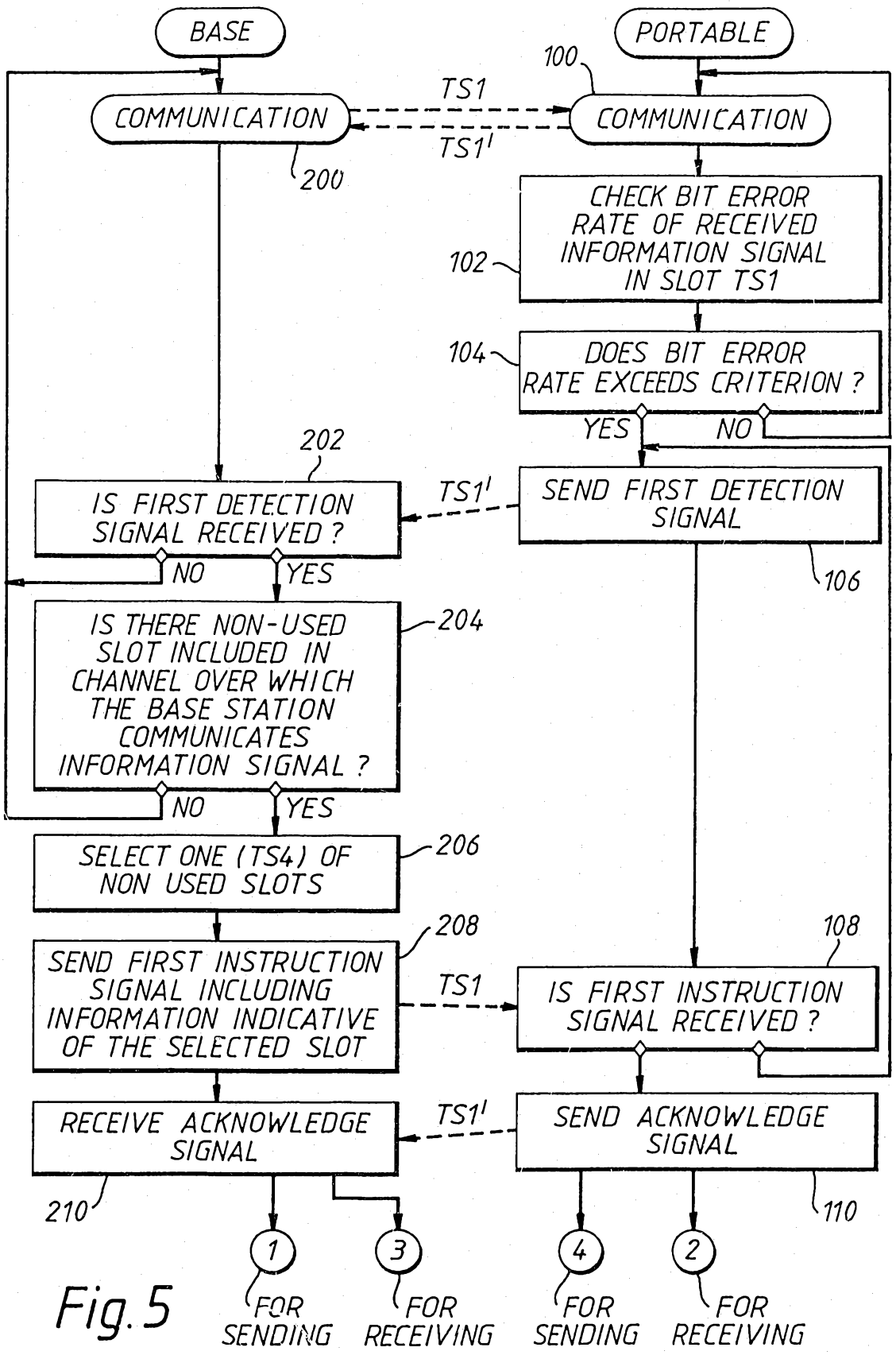
BASE
PORTABLE
100
TS1
COMMUNICATION
COMMUNICATION
TS1'
200
CHECK BIT ERROR RATE OF RECEIVED INFORMATION SIGNAL IN SLOT TS1
102
DOES BIT ERROR RATE EXCEEDS CRITERION ?
104
YES
NO
202
IS FIRST DETECTION SIGNAL RECEIVED ?
TS1'
SEND FIRST DETECTION SIGNAL
106
NO
YES
IS THERE NON-USED SLOT INCLUDED IN CHANNEL OVER WHICH THE BASE STATION COMMUNICATES INFORMATION SIGNAL ?
204
NO
YES
SELECT ONE (TS4) OF NON USED SLOTS
206
208
SEND FIRST INSTRUCTION SIGNAL INCLUDING INFORMATION INDICATIVE OF THE SELECTED SLOT
TS1
IS FIRST INSTRUCTION SIGNAL RECEIVED ?
108
RECEIVE ACKNOWLEDGE SIGNAL
TS1'
SEND ACKNOWLEDGE SIGNAL
210
110
1
3
4
2
FOR SENDING
FOR RECEIVING
FOR SENDING
FOR RECEIVING

Fig. 5

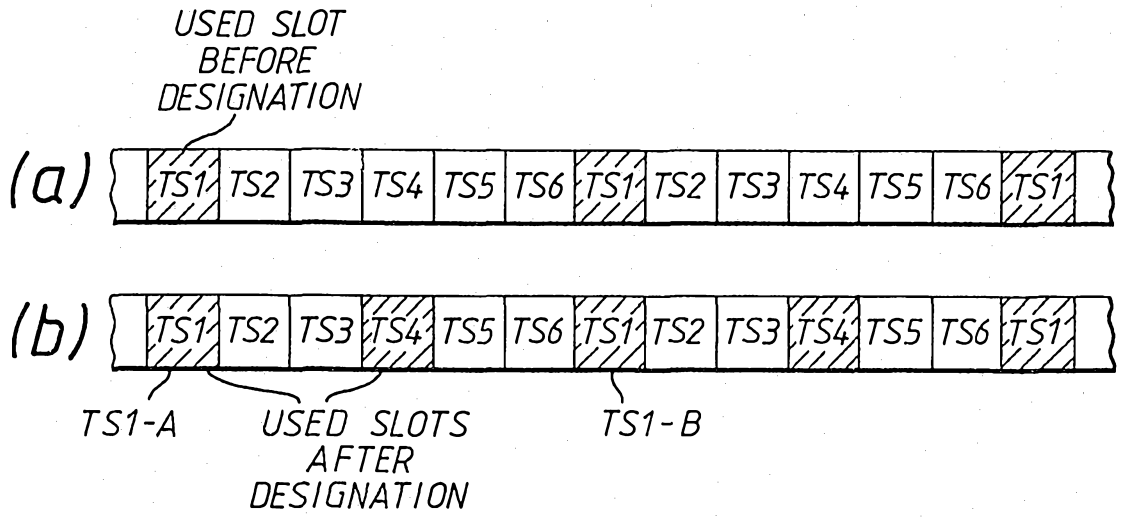
USED SLOT
BEFORE
DESIGNATION
(a)
TS1 TS2 TS3 TS4 TS5 TS6 TS1 TS2 TS3 TS4 TS5 TS6 TS1
(b)
TS1 TS2 TS3 TS4 TS5 TS6 TS1 TS2 TS3 TS4 TS5 TS6 TS1
TS1-A
USED SLOTS
AFTER
DESIGNATION
TS1-B

Fig. 6

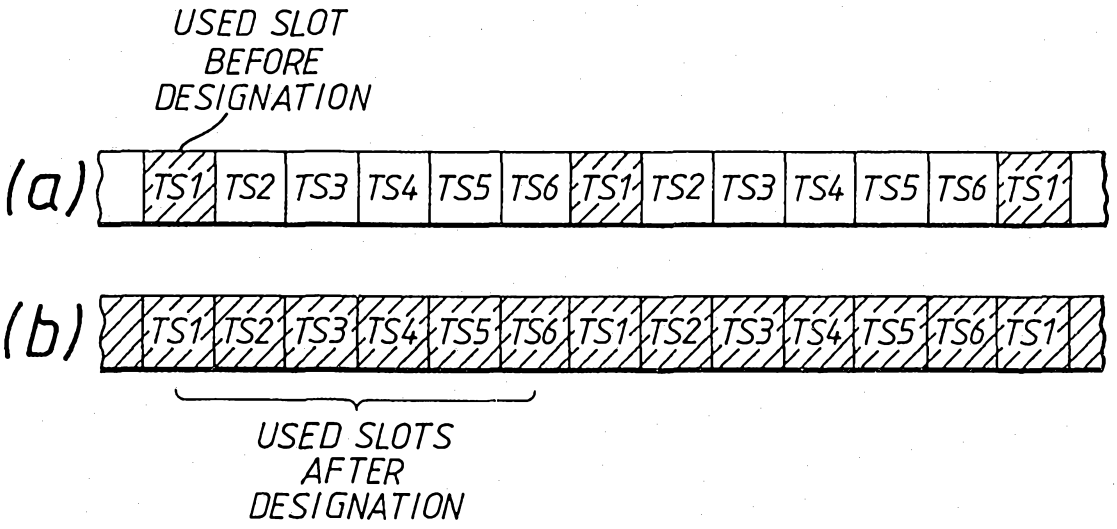
USED SLOT
BEFORE
DESIGNATION
(a)
TS1 TS2 TS3 TS4 TS5 TS6 TS1 TS2 TS3 TS4 TS5 TS6 TS1
(b)
TS1 TS2 TS3 TS4 TS5 TS6 TS1 TS2 TS3 TS4 TS5 TS6 TS1
USED SLOTS
AFTER
DESIGNATION

Fig. 17

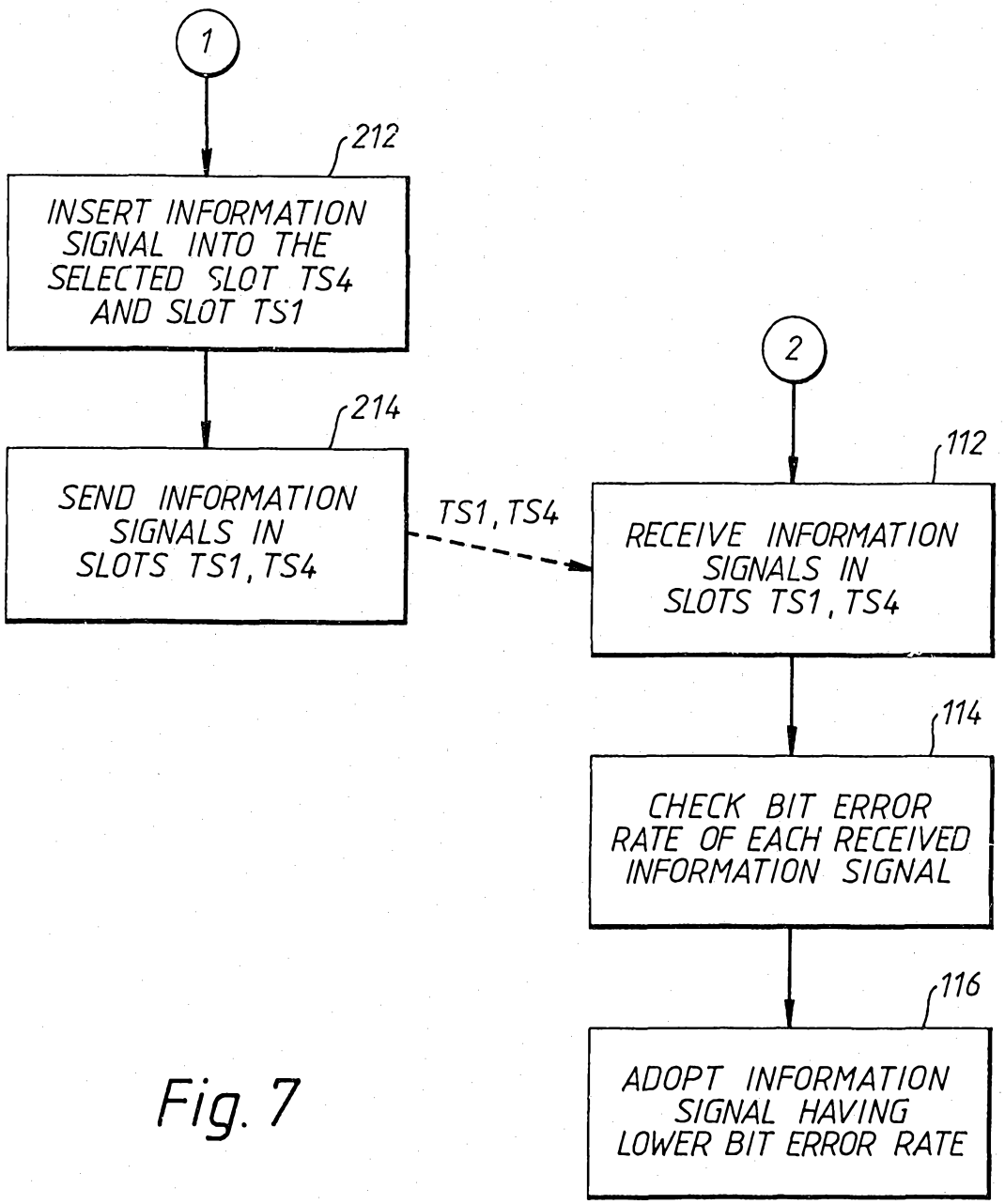
1
212
INSERT INFORMATION SIGNAL INTO THE SELECTED SLOT TS4 AND SLOT TS1
214
SEND INFORMATION SIGNALS IN SLOTS TS1, TS4
TS1, TS4
2
112
RECEIVE INFORMATION SIGNALS IN SLOTS TS1, TS4
114
CHECK BIT ERROR RATE OF EACH RECEIVED INFORMATION SIGNAL
116
ADOPT INFORMATION SIGNAL HAVING LOWER BIT ERROR RATE

Fig. 7

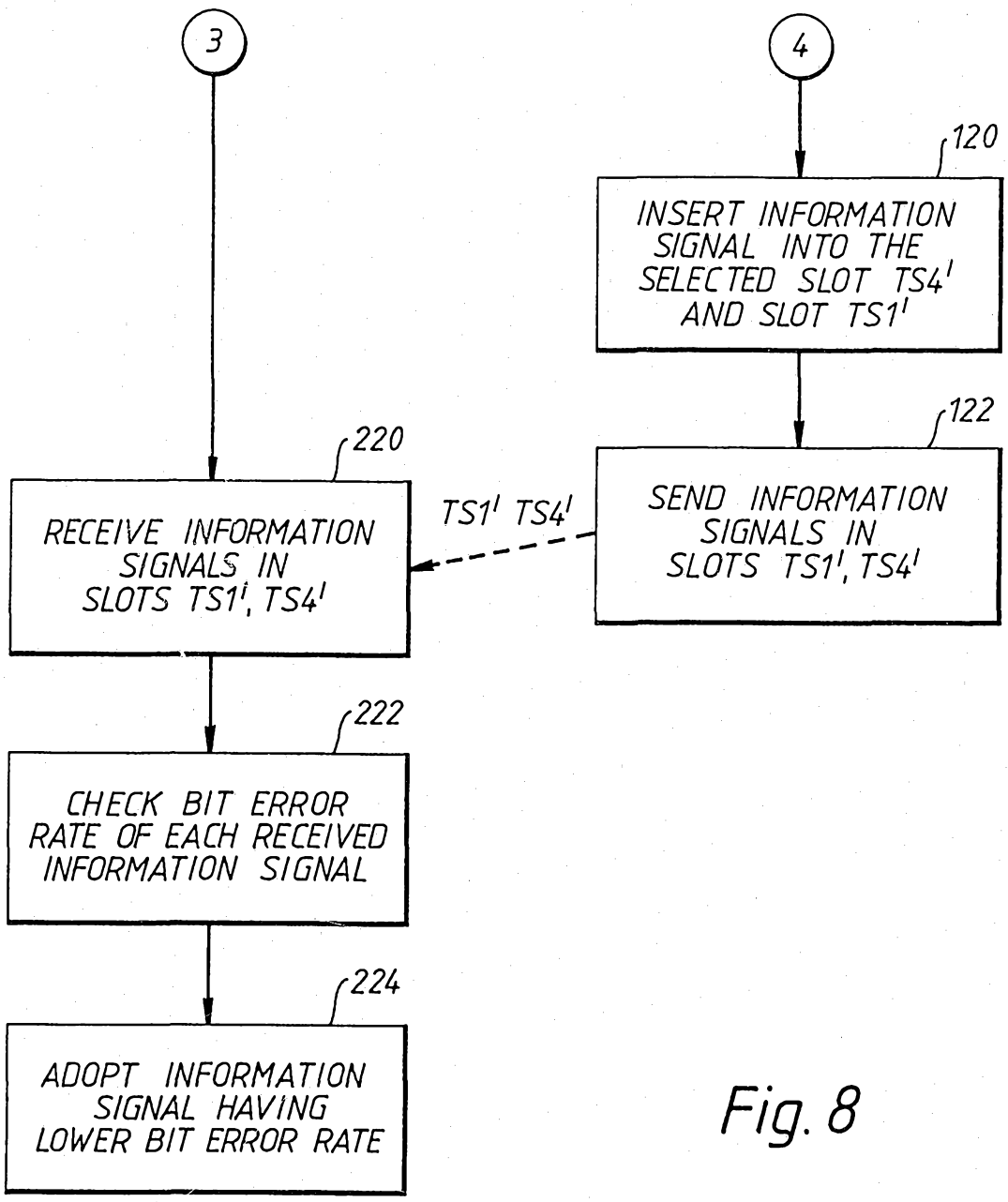
3
4
120
INSERT INFORMATION SIGNAL INTO THE SELECTED SLOT TS4' AND SLOT TS1'
122
SEND INFORMATION SIGNALS IN SLOTS TS1', TS4'
TS1' TS4'
220
RECEIVE INFORMATION SIGNALS IN SLOTS TS1', TS4'
222
CHECK BIT ERROR RATE OF EACH RECEIVED INFORMATION SIGNAL
224
ADOPT INFORMATION SIGNAL HAVING LOWER BIT ERROR RATE

Fig. 8

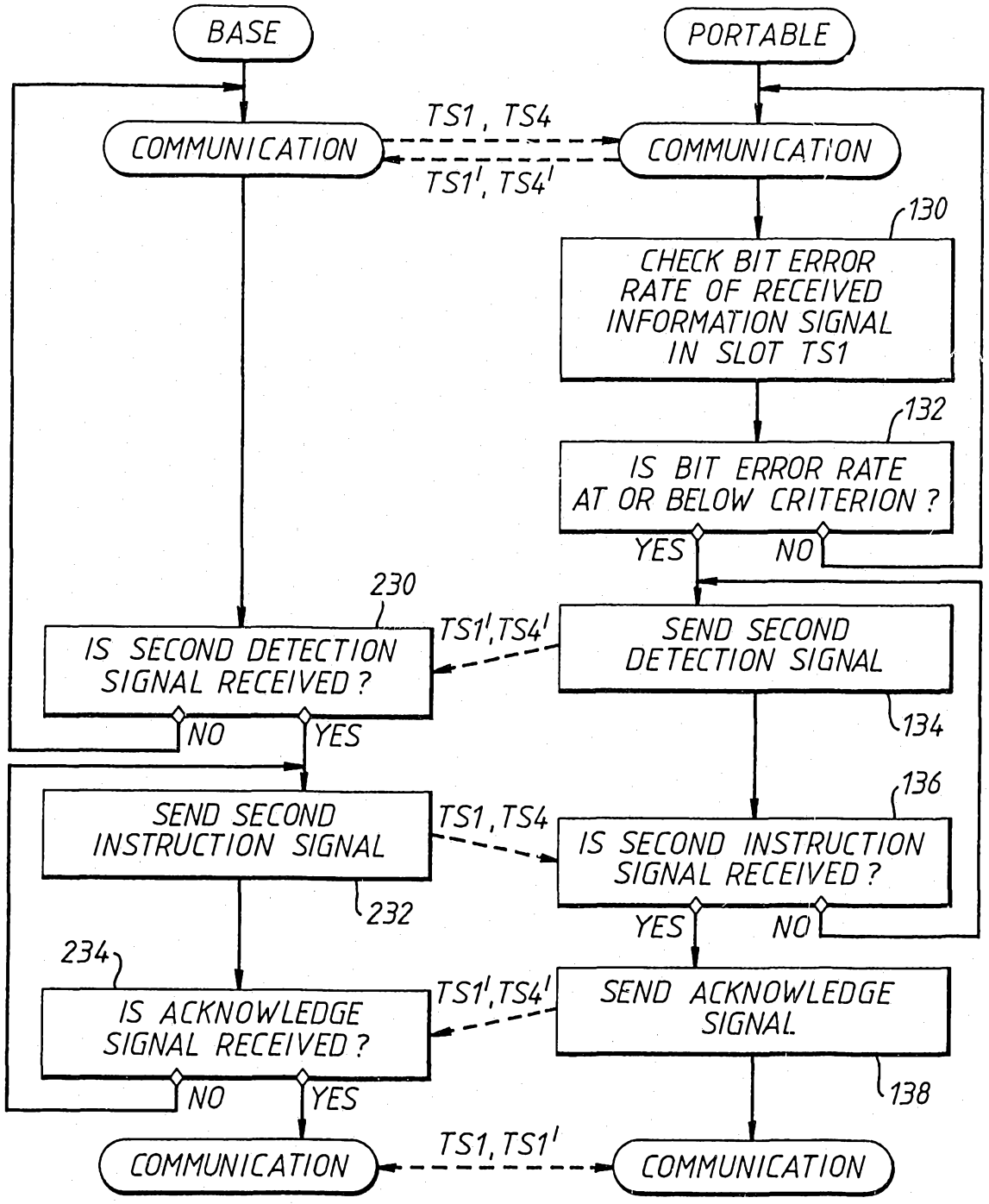
BASE
PORTABLE
COMMUNICATION
TS1 , TS4
TS1', TS4'
COMMUNICATION
130
CHECK BIT ERROR RATE OF RECEIVED INFORMATION SIGNAL IN SLOT TS1
132
IS BIT ERROR RATE AT OR BELOW CRITERION ?
YES
NO
230
IS SECOND DETECTION SIGNAL RECEIVED ?
TS1', TS4'
SEND SECOND DETECTION SIGNAL
134
NO
YES
SEND SECOND INSTRUCTION SIGNAL
TS1, TS4
136
IS SECOND INSTRUCTION SIGNAL RECEIVED ?
232
YES
NO
234
IS ACKNOWLEDGE SIGNAL RECEIVED ?
TS1', TS4'
SEND ACKNOWLEDGE SIGNAL
138
NO
YES
COMMUNICATION
TS1, TS1'
COMMUNICATION

Fig. 9

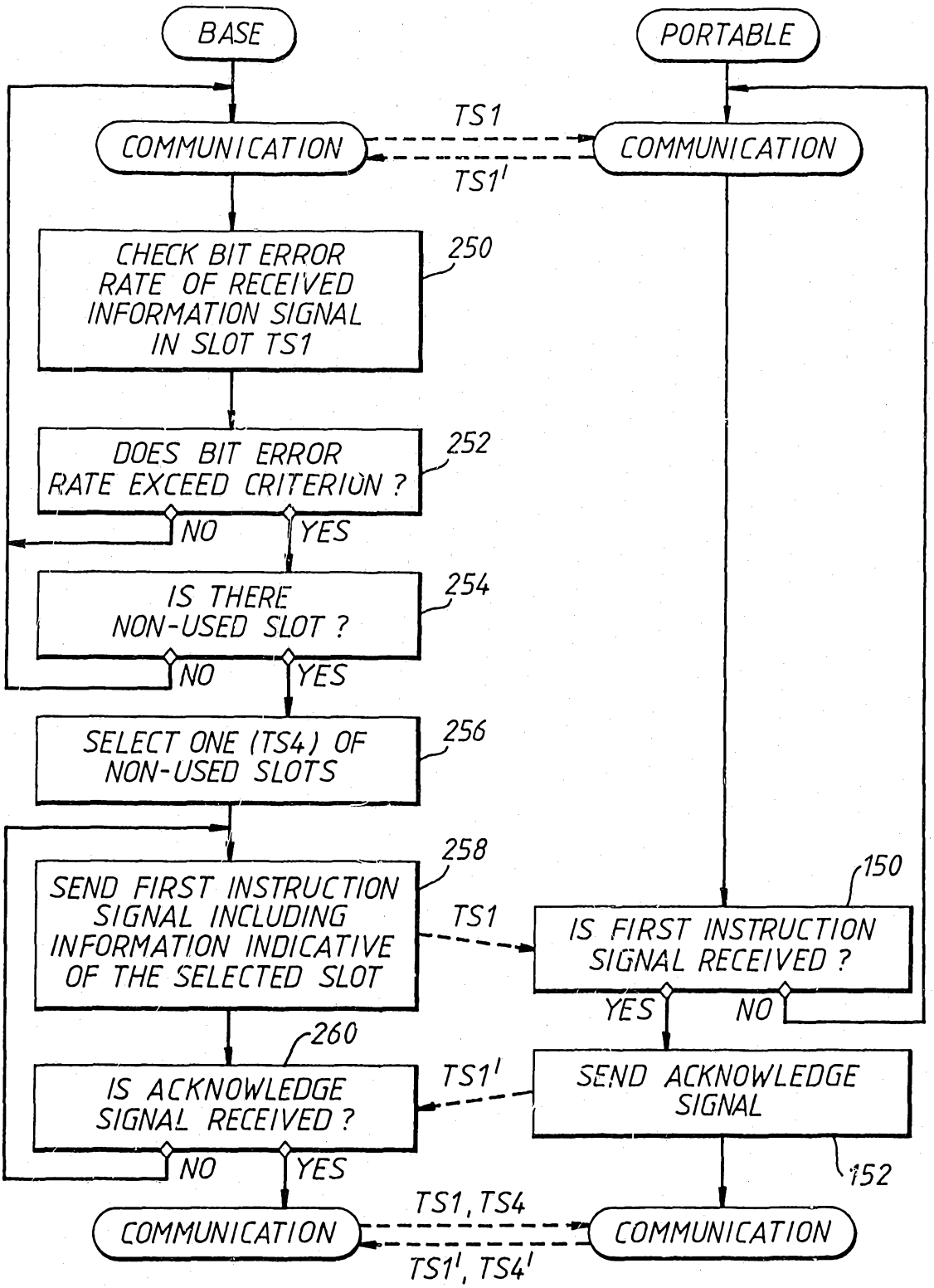
BASE
PORTABLE
COMMUNICATION
TS1
TS1'
COMMUNICATION
CHECK BIT ERROR RATE OF RECEIVED INFORMATION SIGNAL IN SLOT TS1
250
DOES BIT ERROR RATE EXCEED CRITERION ?
252
NO
YES
IS THERE NON-USED SLOT ?
254
NO
YES
SELECT ONE (TS4) OF NON-USED SLOTS
256
SEND FIRST INSTRUCTION SIGNAL INCLUDING INFORMATION INDICATIVE OF THE SELECTED SLOT
258
TS1
IS FIRST INSTRUCTION SIGNAL RECEIVED ?
150
YES
NO
IS ACKNOWLEDGE SIGNAL RECEIVED ?
260
TS1'
SEND ACKNOWLEDGE SIGNAL
152
NO
YES
COMMUNICATION
TS1, TS4
TS1', TS4'
COMMUNICATION

Fig. 10

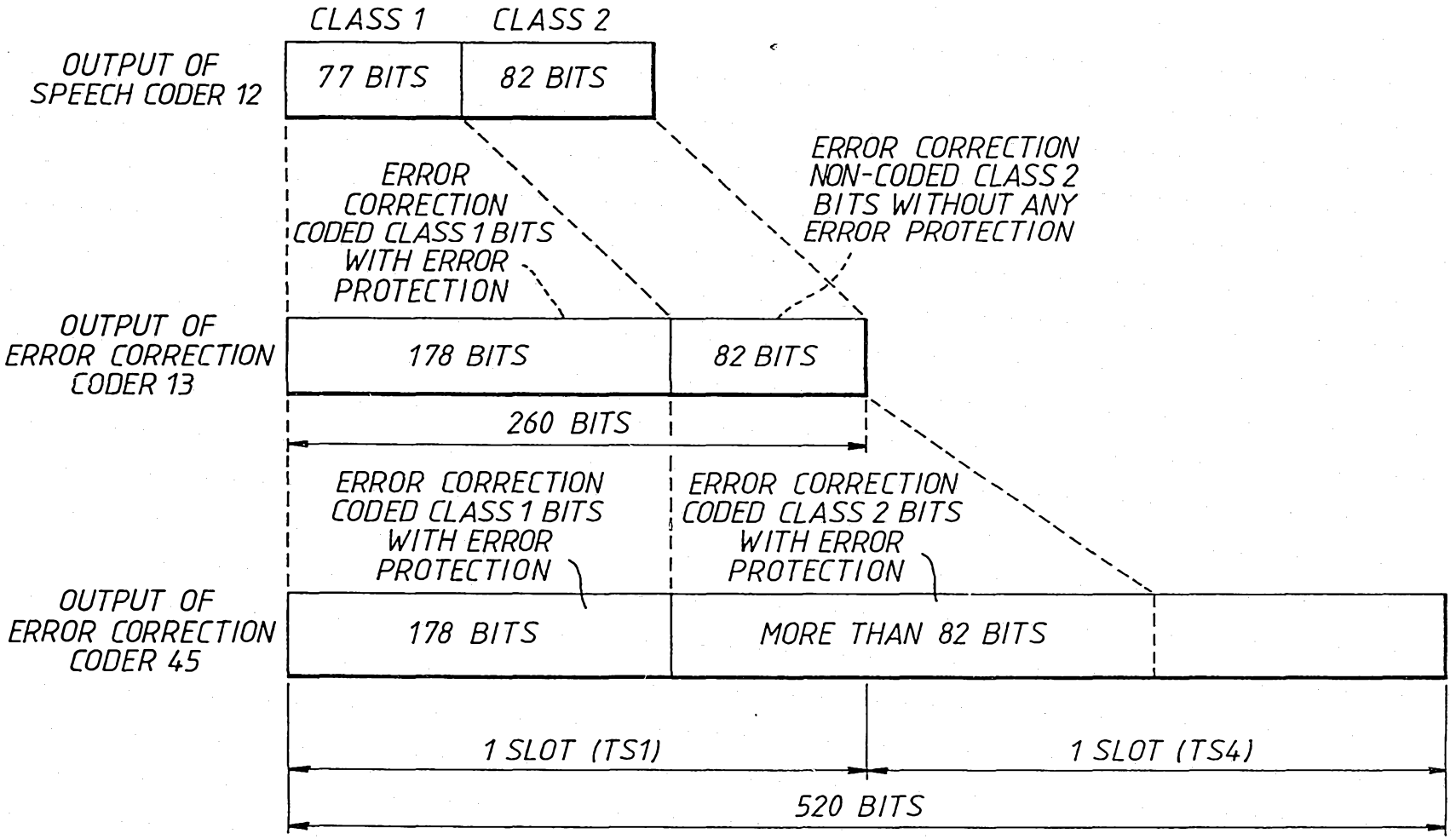
CLASS 1
CLASS 2
OUTPUT OF SPEECH CODER 12
77 BITS
82 BITS
ERROR CORRECTION CODED CLASS 1 BITS WITH ERROR PROTECTION
ERROR CORRECTION NON-CODED CLASS 2 BITS WITHOUT ANY ERROR PROTECTION
OUTPUT OF ERROR CORRECTION CODER 13
178 BITS
82 BITS
260 BITS
ERROR CORRECTION CODED CLASS 1 BITS WITH ERROR PROTECTION
ERROR CORRECTION CODED CLASS 2 BITS WITH ERROR PROTECTION
OUTPUT OF ERROR CORRECTION CODER 45
178 BITS
MORE THAN 82 BITS
1 SLOT (TS1)
1 SLOT (TS4)
520 BITS

Fig.11

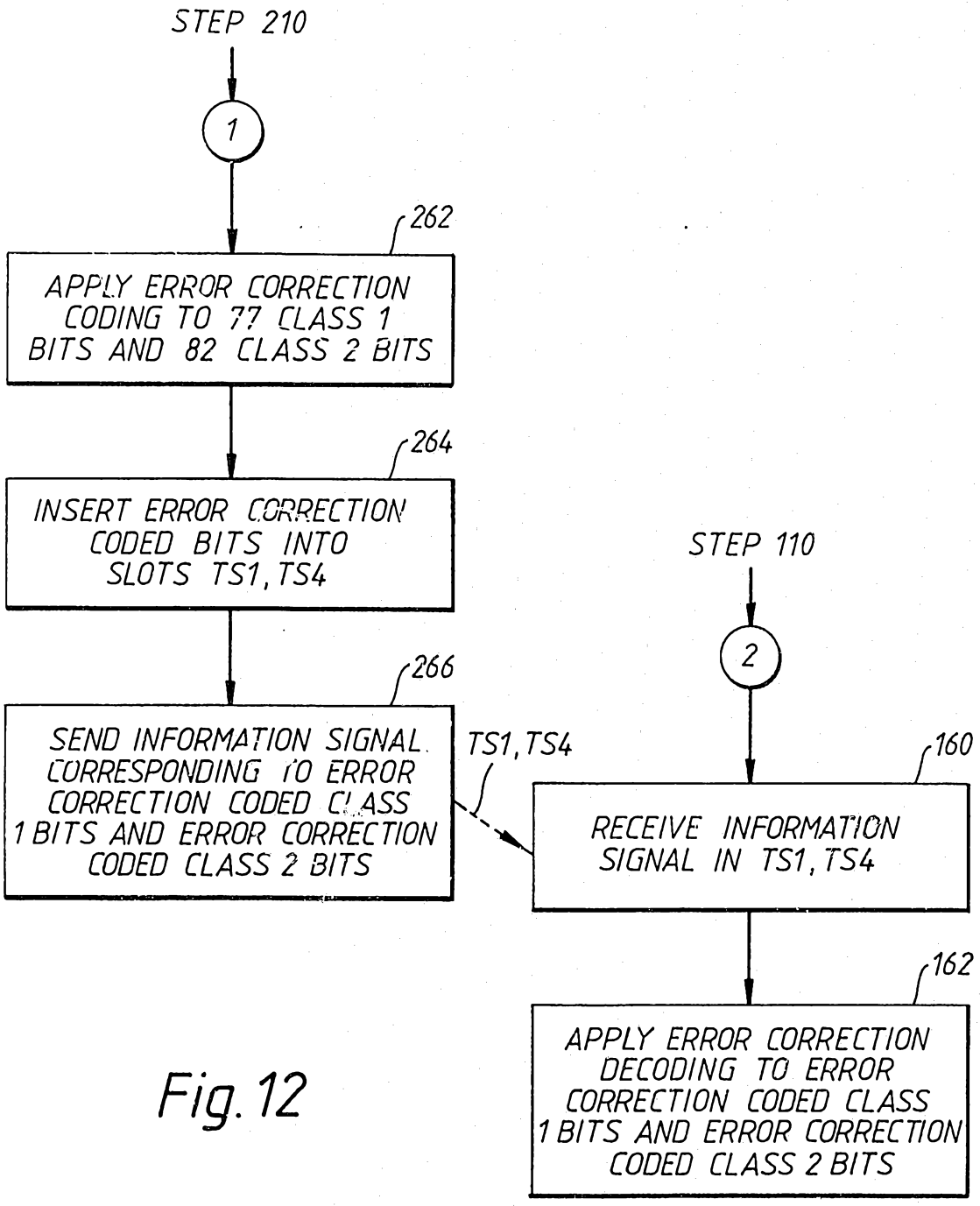
STEP 210
1
262
APPLY ERROR CORRECTION CODING TO 77 CLASS 1 BITS AND 82 CLASS 2 BITS
264
INSERT ERROR CORRECTION CODED BITS INTO SLOTS TS1, TS4
266
SEND INFORMATION SIGNAL CORRESPONDING TO ERROR CORRECTION CODED CLASS 1 BITS AND ERROR CORRECTION CODED CLASS 2 BITS
TS1, TS4
STEP 110
2
160
RECEIVE INFORMATION SIGNAL IN TS1, TS4
162
APPLY ERROR CORRECTION DECODING TO ERROR CORRECTION CODED CLASS 1 BITS AND ERROR CORRECTION CODED CLASS 2 BITS

Fig. 12

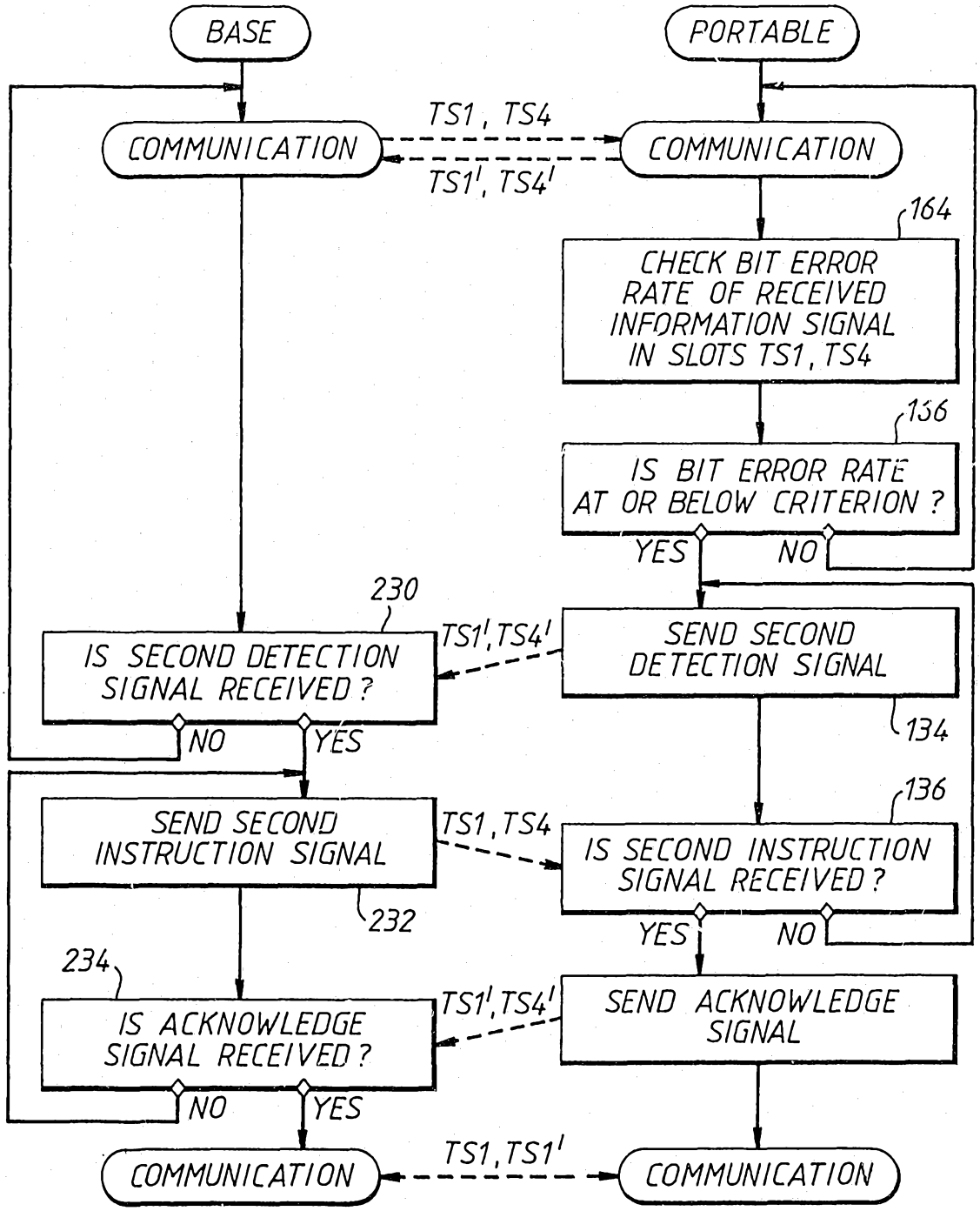
BASE
PORTABLE
TS1 , TS4
COMMUNICATION
COMMUNICATION
TS1', TS4'
164
CHECK BIT ERROR RATE OF RECEIVED INFORMATION SIGNAL IN SLOTS TS1, TS4
136
IS BIT ERROR RATE AT OR BELOW CRITERION ?
YES
NO
230
IS SECOND DETECTION SIGNAL RECEIVED ?
TS1', TS4'
SEND SECOND DETECTION SIGNAL
134
NO
YES
136
SEND SECOND INSTRUCTION SIGNAL
TS1, TS4
IS SECOND INSTRUCTION SIGNAL RECEIVED ?
232
YES
NO
234
IS ACKNOWLEDGE SIGNAL RECEIVED ?
TS1', TS4'
SEND ACKNOWLEDGE SIGNAL
NO
YES
COMMUNICATION
TS1, TS1'
COMMUNICATION

Fig.13

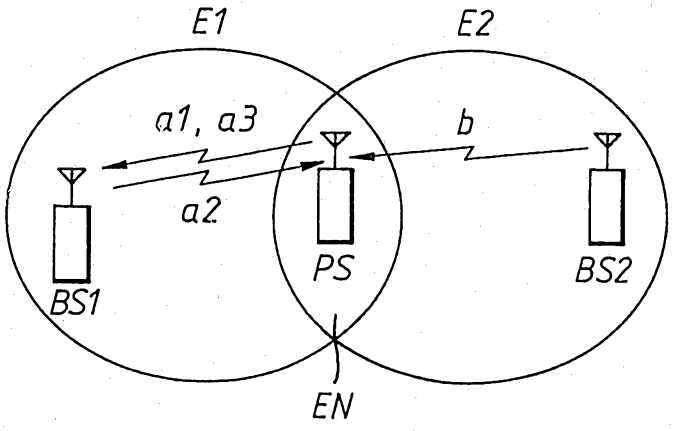
E1
E2
a1, a3
a2
b
BS1
PS
BS2
EN

Fig. 14

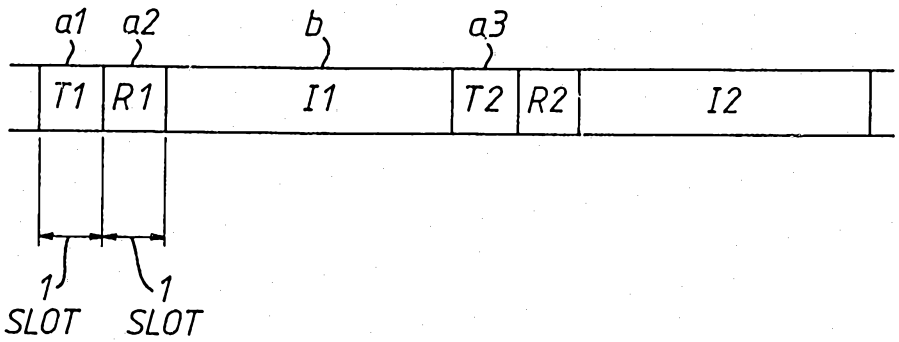
a1
a2
b
a3
T1
R1
I1
T2
R2
I2
1 SLOT
1 SLOT

Fig. 15

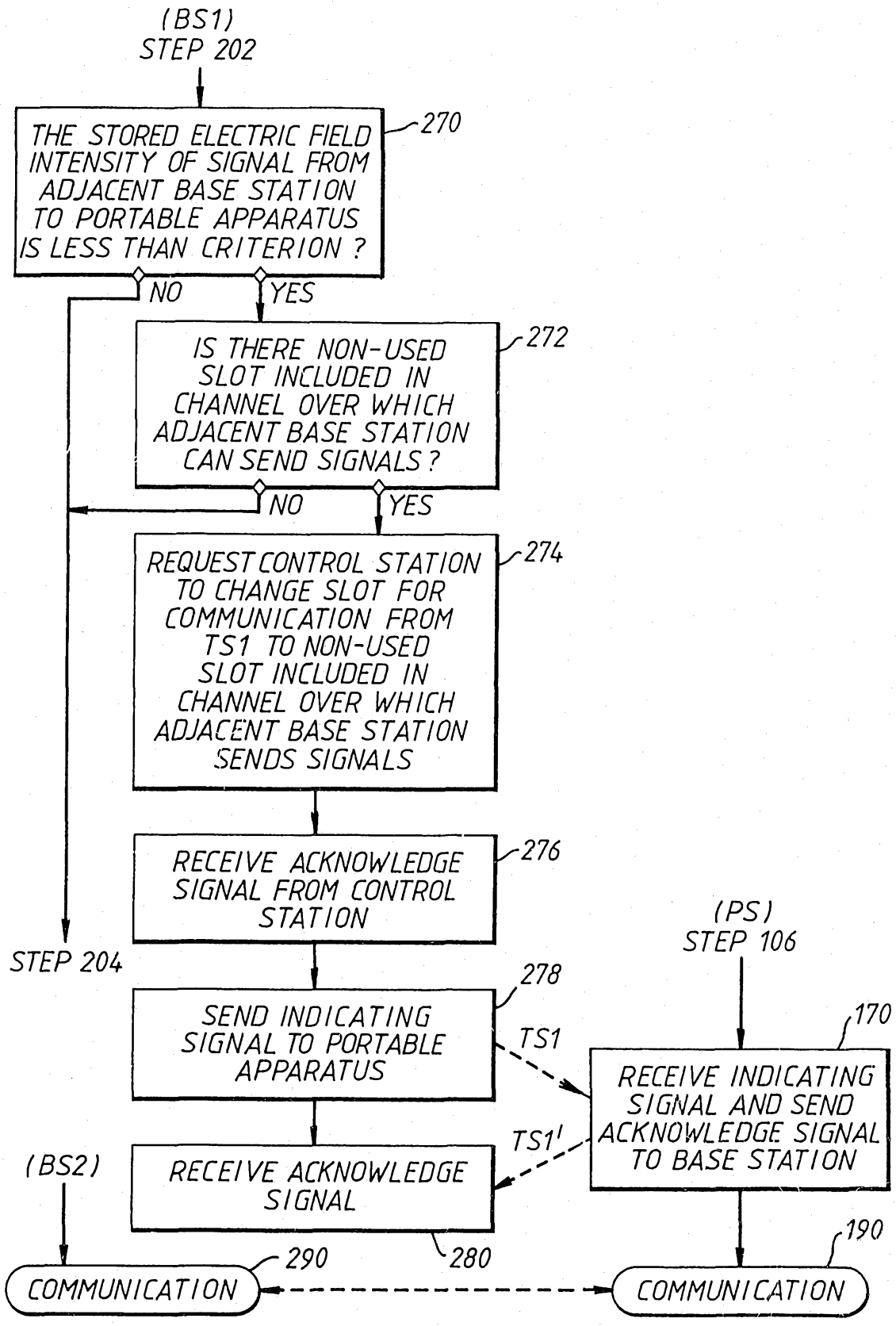
(BS1)
STEP 202
THE STORED ELECTRIC FIELD INTENSITY OF SIGNAL FROM ADJACENT BASE STATION TO PORTABLE APPARATUS IS LESS THAN CRITERION ?
270
NO
YES
IS THERE NON-USED SLOT INCLUDED IN CHANNEL OVER WHICH ADJACENT BASE STATION CAN SEND SIGNALS ?
272
NO
YES
REQUEST CONTROL STATION TO CHANGE SLOT FOR COMMUNICATION FROM TS1 TO NON-USED SLOT INCLUDED IN CHANNEL OVER WHICH ADJACENT BASE STATION SENDS SIGNALS
274
RECEIVE ACKNOWLEDGE SIGNAL FROM CONTROL STATION
276
STEP 204
(PS)
STEP 106
SEND INDICATING SIGNAL TO PORTABLE APPARATUS
278
TS1
170
RECEIVE INDICATING SIGNAL AND SEND ACKNOWLEDGE SIGNAL TO BASE STATION
TS1'
(BS2)
RECEIVE ACKNOWLEDGE SIGNAL
280
190
290
COMMUNICATION
COMMUNICATION

Fig. 16

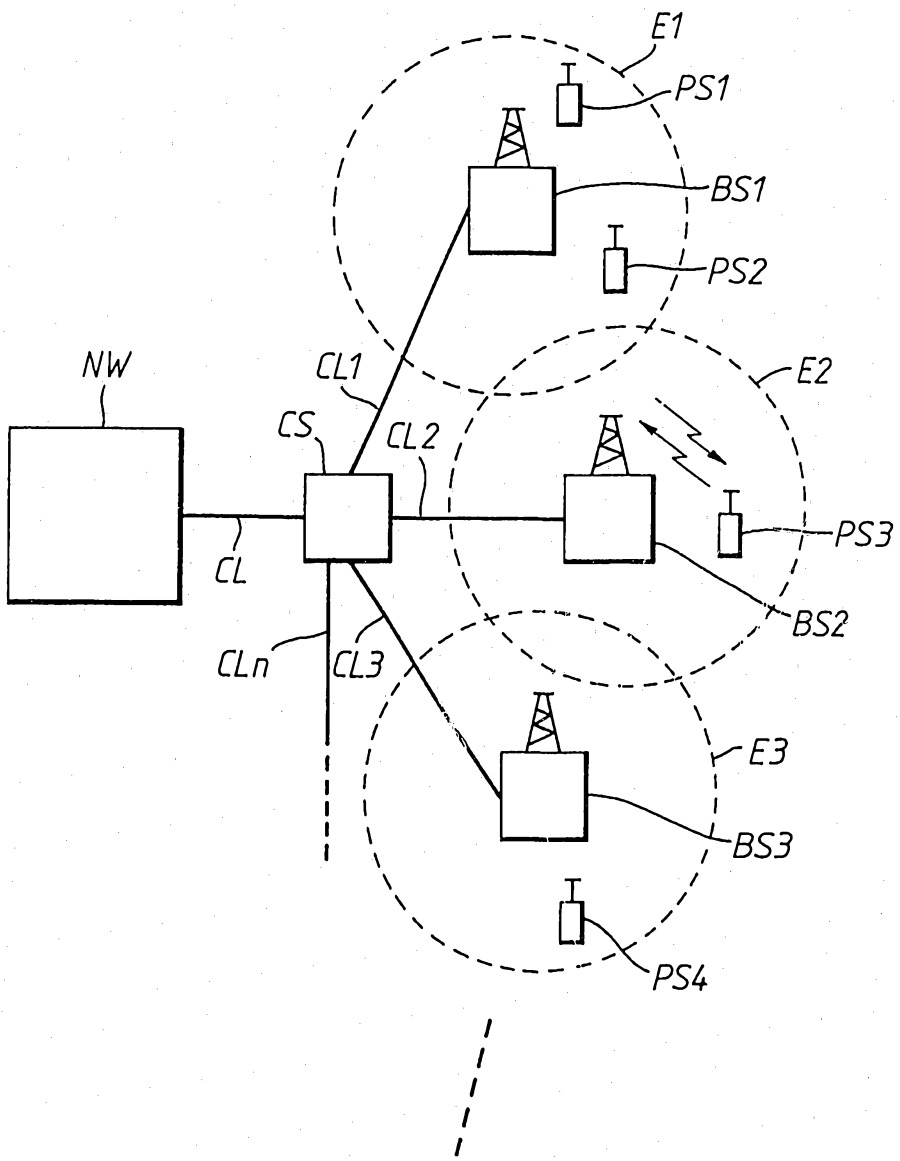

Fig. 18

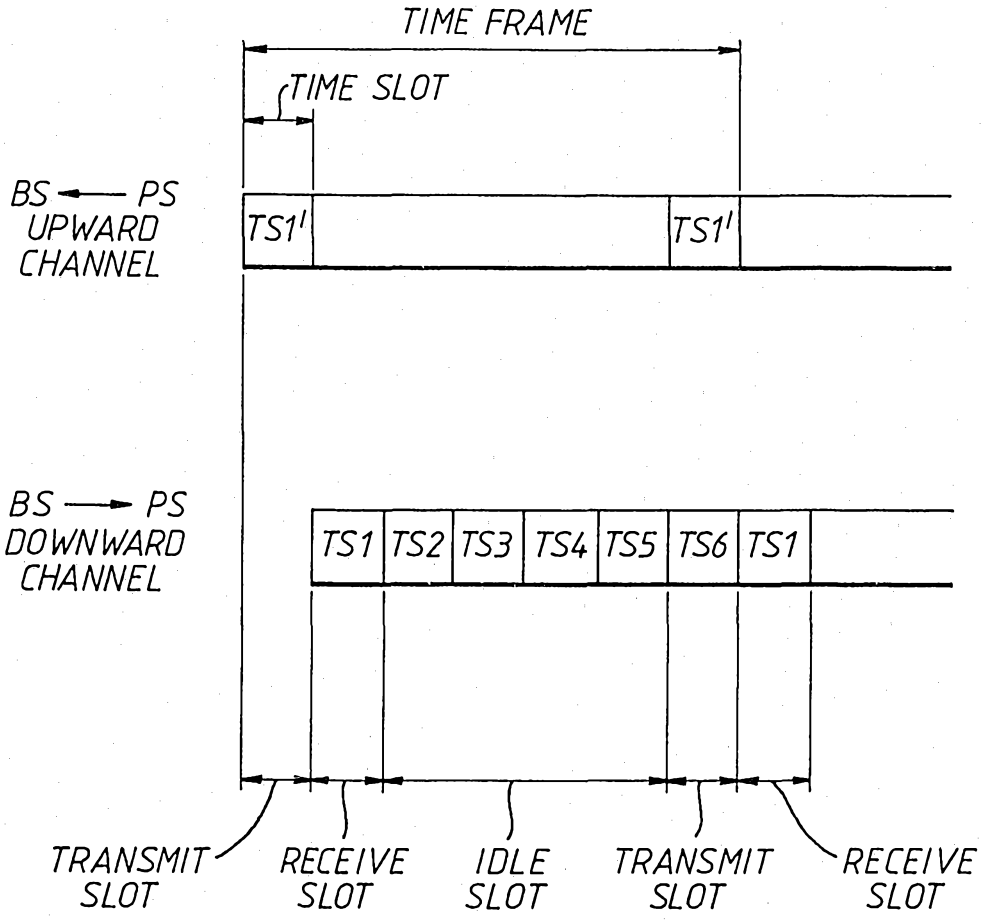
TIME FRAME
TIME SLOT
BS ← PS
UPWARD
CHANNEL
TS1'
TS1'
BS → PS
DOWNWARD
CHANNEL
TS1
TS2
TS3
TS4
TS5
TS6
TS1
TRANSMIT
SLOT
RECEIVE
SLOT
IDLE
SLOT
TRANSMIT
SLOT
RECEIVE
SLOT

Fig. 19