(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 061 752 B9**

(12) **CORRECTED EUROPEAN PATENT SPECIFICATION**

(15) Correction information:
**Corrected version no 1 (W1 B1)**
**Corrections, see**
**Description Paragraph(s) 1, 19**
**Claims EN 8, 10**

(48) Corrigendum issued on:
**22.02.2012 Bulletin 2012/08**

(45) Date of publication and mention of the grant of the patent:
**17.08.2011 Bulletin 2011/33**

(21) Application number: **00900392.2**

(22) Date of filing: **14.01.2000**

(51) Int Cl.:
***H04W 48/16*** *(2009.01)*

(86) International application number:
**PCT/JP2000/000152**

(87) International publication number:
**WO 2000/042788 (20.07.2000 Gazette 2000/29)**

# (54) Mobile communication terminal having base station search function

Mobiles Kommunikationsendgerät mit einer Suchfunktion für Basisstationen

Terminal de télécommunication mobile comportant une fonction de recherche de station de base

(84) Designated Contracting States:
**DE FR**

(30) Priority: **14.01.1999 JP 813499**

(43) Date of publication of application:
**20.12.2000 Bulletin 2000/51**

(73) Proprietor: **Fujitsu Toshiba Mobile Communications Limited**
**Nakahara-ku**
**Kawasaki-shi**
**Kanagawa 211-8588 (JP)**

(72) Inventor: **IIMORI, Eiji,**
**Hino Operations-Digital Media Equip.**
**Hino-shi,**
**Tokyo 191-8555 (JP)**

(74) Representative: **Kramer - Barske - Schmidtchen**
**Landsberger Strasse 300**
**80687 München (DE)**

(56) References cited:
**EP-A- 0 812 119**
**EP-A- 0 859 476**
**WO-A-97/03531**
**GB-A- 2 314 435**
**JP-A- 1 303 817**
**JP-A- 5 063 636**
**JP-A- 7 312 771**
**JP-A- 8 154 265**
**JP-A- 8 331 628**
**US-A- 5 642 398**

- **CHIANG K-H ET AL: "INTELLIGENT HANDOVER AND LOCATION UPDATING CONTROL FOR A THIRD GENERATION MOBILE NETWORK" , IEEE GLOBECOM 1998. GLOBECOM '98. THE BRIDGE TO GLOBAL INTEGRATION. SYDNEY, NOV. 8 - 12, 1998, IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE, NEW YORK, NY: IEEE, US, VOL. VOL. 4, PAGE(S) 1963-1969 XP000894393 ISBN: 0-7803-4985-7**



EP 1 061 752 B9

## Description

**[0001]** This invention relates to a mobile radio communication terminal device used in a cellular radio communication system according to claim 1.

**[0002]** In recent years, cellular radio communication systems have been popularized. In the cellular radio communication system, base stations are distributed over a service area, each base station forms a radio zone called a cell, and a base station and a mobile station are connected by radio in each cell. In this type of system, when the power supply of a mobile station is turned on, the mobile station is first synchronized with the nearest base station and then connected to the latter. Thereafter, the process of switching the base station to which the mobile station is connected, what is called handover, is carried out as the mobile station moves.

**[0003]** For example, in a cellular radio communication system using a CDMA (Code Division Multiple Access) scheme complying with the U.S. TIA standard (IS-95A), when the power supply is turned on at a mobile station, the mobile station tries to pick up the pilot signal broadcast from a base station. It takes about one to two seconds to pick up the pilot signal. This is where the time is required most in the sequence for establishing the system synchronization between the mobile station and base station. After the pilot signal has been picked up, the mobile station establishes the PN code synchronization with the base station and then switches the Walsh code, orthogonal code, thereby receiving a sync channel transmitted from the base station. After receiving the message transmitted through the sync channel, the mobile station demodulates it and stores the received message. The message includes inherent information about the base station and network.

**[0004]** After having completed the synchronization establishing sequence, the mobile station goes into the wait state. In the wait state, the mobile station causes the radio communication circuit section to operate only in the receiving period for a slot where the base station will possibly send a page message to the mobile station and prevents the main clock from being generated in the remaining period to disable the radio communication circuit section. The disabled state is called a sleep state. Such a battery saving operation is called the slot mode operation, whereby the average drawn current of the mobile station is reduced to lengthen the battery service life.

**[0005]** In the wait state, the mobile station not only receives the page message transmitted through the paging channel from the base station to which the mobile station is now being connected, in every receiving period for a slot where the mobile station should receive, but also searches for neighboring base stations in preparation for handover. The base station now being connected reports information about the neighboring base stations to be searched for in the form of a neighbor list message. The neighbor list message is such that the PN offset values of the neighboring base stations are arranged in the order in which they are closer to the base station that transmits the neighbor list message. On the basis of the neighbor list message, the mobile station chooses, for example, three stations in each receiving period for a slot where the mobile station should receive, thereby searching for neighboring base stations.

**[0006]** When neighboring base stations are searched for while the slop mode operation is being carried out, it takes a very long time to complete the search of all the neighboring base stations, because the number of neighboring base stations that can be searched for in a single slot receiving period is as small as about three. Therefore, of the results of searching for all the neighboring base stations, the oldest one is most likely to be unsuitable for the state of the present mobile station. For this reason, if handover were executed with the result of the search being regarded as reliable, the recapture or handover of the pilot signal would fail and the system lost might occur. If the system lost has occurred once, the mobile station starts the operation of establishing the synchronization of the PN code again from scratch as described above. As a result, it takes a very long time for the mobile station to go into the wait state again. In the meantime, the operating current flows in full, thus impairing the battery saving effect in the slot mode operation.

**[0007]** To overcome this problem, when a conventional mobile station has determined that handover is needed, it searches for all the neighboring base stations specified by the neighbor list message again at that time. Then, on the basis of the result of the search, the mobile station chooses the best handover destination and effects handover. It takes as a long time as about several hundred milliseconds to search for all the neighboring base stations again from scratch. Moreover, in the cellular mobile radio communication system, to connect a mobile station to the best base station at all times, the mobile station is generally designed to determine that handover is necessary even when the reception level from the base station now being connected drops slightly. Each time such a determination is made, the mobile station searches for all the neighboring base stations. As a result, the drawn current is still large in the wait state, which makes it difficult to lengthen the continuously using time of the mobile station.

**[0008]** US-A-5 642 398 discloses a comprehensive method for mobile station registration in a cellular communication system wherein registrations are made due to multiple stimulus.

**[0009]** Furthermore, EP-A-0 812 119 discloses a mobile radio communication terminal device which stores historical data and uses this data to control cell reselection.

**[0010]** Additionally, "Intelligent Handover and Location Updating Control for Third Generation Mobile Network", of Chiang K.-H. et al., IEEE Globecom 1998, IEEE, US-Vol. 4, pages 1963 to 1969, XP-000894393, ISBN 8-7803-4985-7, discloses a definition for the term "handover" which differs from that used in this applica-

tion.

**[0011]** EP-A-0 859 476 discloses a mobile computer system which performs a handover operation with high-reliability while the system can flexibly cope with various circumstances in which a mobile station is used.

**[0012]** It is therefore an object of the invention to provide a new advantageous information suitable for the usage in a mobile radio communication terminal device.

**[0013]** The above object of the present invention is achieved by a device as set out in claims 1. Further refinements are given in the dependent claims.

**[0014]** It is an advantageous aspect of the present invention to provide a mobile radio communication terminal device capable of determining accurately whether a mobile station in the wait state is in a steady state or a moving state.

**[0015]** A further advantageous aspect of the present invention is to provide a mobile radio communication terminal device which enables the best base station to be searched for according to the state of a mobile station and thereby reduces the drawn current in the wait state to lengthen the battery service life.

**[0016]** In a cellular mobile radio communication system where base stations are distributed over a service area, the base stations form their respective radio areas, and a radio channel connects a mobile station and a base station in each of the radio areas, a mobile radio communication terminal device used as the mobile station characterized by comprising: history information storage means for storing information relating to past handovers representing base stations connected to the mobile radio communication terminal device as handover history information; update means for updating the handover history information stored in the history information storage means each time handover is performed; and state determining means for determining whether the mobile radio communication terminal device is in a steady state or a moving state, on the basis of the handover history information stored in the history information storage means.

**[0017]** A concrete configuration of the state determining means is as follows. Each time handover is effected, the state determining means determines whether any of the base stations to which a specific number of past consecutive handovers including the present handover were connected became a handover destination base station in the past, on the basis of the handover history information stored in the history information storage means. When determining that any of the base stations became a handover destination base station, the state determining means recognizes its own mobile radio communication terminal device to be in the steady state. In contrast, when determining that at least one of the base station did not become a handover destination base station, the state determining means recognizes its own mobile radio communication terminal

**[0018]** With a mobile radio communication terminal device of the present invention, since the present state of its own station is determined by tracing the history of past handovers, it is possible to determine accurately with relative ease whether its own station is now in the moving state or is now stationary or in a limited range even when moving, or in what is called a steady state.

**[0019]** With a mobile radio communication terminal device of the present invention, use of a search algorithm suitable for the characteristic in each of the steady state and moving state enables a base station to be searched for efficiently.

**[0020]** For example, because in the steady state, the mobile station is either stationary or moving slowly in a limited range, the number of base stations that will possibly become handover destinations is about three to four at most. Therefore, in the steady state, just searching for a limited number of base stations during handover enables a suitable base station to be found as the handover destination. Consequently, as compared with the case where a large number of neighboring base stations are searched for unconditionally, a suitable handover destination can be found in a shorter search time. This shortens the search time, reducing the power consumption that much, which lengthens the battery service life.

**[0021]** In contrast, in the moving state, the base station most suitable for the handover destination changes dynamically. Because of this, in the moving state, neighboring base stations are searched for over a relatively wide range during handover according to the neighbor list message reported from the base station now being connected, thereby making it possible to find a suitable base station as the handover destination with a high probability.

**[0022]** With a configuration according to claim 3 or 9, in each reception slot, not only each base stations in the first or third search group but also each base stations in the second or fourth search group can be searched for. This prevents the result of searching for the base stations in the second or fourth search group from becoming too old. Thus, when handover is needed, a suitable handover destination can be found with a relatively high probability.

**[0023]** With a configuration according to claim 4 or 10, when a suitable base station has been found as the handover destination as the result of searching for base station belonging to the first or third search group, the second or fourth search group need not be searched. Therefore, as compared with the case where all the search groups are searched unconditionally, the average search time is shortened, making shorter the time required for the handover process. This reduces the power consumption that much, which lengthens the battery service life.

**[0024]** With a configuration according to claim 5 or 11, when it is determined whether the quality of the reception from the base station now being connected is restored, after the search of the first or third search group, and handover is no longer needed because of the restoration of the reception quality, the mobile station can return to the sleep state without searching the second or fourth

search group. Therefore, as compared with the case where the search of all the search groups is continued unconditionally, a useless search operation is eliminated, thus reducing the power consumption that much, which lengthens the battery service life.

**[0025]** With a configuration according to claim 7 or 13, when a possibility of handover is checked excessively because the condition for determining whether handover is needed has not been optimized, the handover determination condition can be corrected automatically to the optimum condition. As a result, a base station is searched for only when handover is really needed, reducing the power consumption, which lengthens the battery service life.

FIG. 1 shows an embodiment of the cell configuration of a cellular mobile radio communication system according to the present invention;

FIG. 2 is a circuit block diagram of an embodiment of a mobile radio communication terminal device according to the present invention;

FIG. 3 is a timing diagram to help explain the operation of searching for a base station in the slot mode;

FIG. 4 is a diagram to help explain the operation of determining the state of a mobile station on the basis of the history of handover;

FIG. 5A shows an example of the structure of a first memory used in determining the state of a mobile station;

FIG. 5B shows an example of the structure of a second memory used in determining the state of a mobile station;

FIG. 6 shows an example of a neighbor list message;

FIG. 7 is a diagram to help explain the operation of searching for a base station in the steady state;

FIG. 8 is a diagram to help explain the operation of searching for a base station in the moving state;

FIG. 9 is a flowchart to help explain the first half of the procedure for searching for a base station in the mobile radio communication terminal device of FIG. 2; and

FIG. 10 is a flowchart to help explain the second half of the procedure for searching for a base station in the mobile radio communication terminal device of FIG. 2.

**[0026]** Hereinafter, referring to the accompanying drawings, embodiments of the present invention will be explained in detail.

**[0027]** FIG. 1 shows a cell configuration of a CDMA cellular mobile radio communication system according to an embodiment of the present invention.

**[0028]** In the system, a large number of cells Ea, Eb, Ec, Ed, ... are formed in a service area. In these cells Ea, Eb, Ec, Ed, ..., six base stations BSa1 to BSa6, BSb1 to BSb6, BSc1 to BSc6, BSd1 to BSd6, ... are provided respectively. Each of the six base stations has directivity in the direction of transmission and reception of radiowaves and covers a respective one of the six sectors formed by dividing each cell.

**[0029]** PN offsets (76), (80), (84), ... differing from each other are given to the base stations BSa1 to BSa6, BSb1 to BSb6, BSc1 to BSc6, BSd1 to BSd6, .... A mobile radio communication terminal device (hereinafter, referred to as a mobile station) MS synchronizes the generation start timing of its own PN code with the PN offset given to the base station in the sector where the mobile station exists, thereby enabling CDMA communication with the base station.

**[0030]** On the other hand, the mobile station MS is constructed as follows. FIG. 2 is a circuit block diagram showing the configuration of the mobile station.

**[0031]** In the figure, after the radio frequency signals transmitted from the base stations BSa1 to BSa6, BSb1 to BSb6, BSc1 to BSc6, BSd1 to BSd6, ... are received by an antenna 1, they are inputted via an antenna duplexer (DUP) 2 to a reception circuit (RX) 3. In the reception circuit 3, the radio frequency signal is mixed with the reception local oscillating signal outputted from a frequency synthesizer (SYN) 4 and frequency-converted into an intermediate frequency signal. The reception circuit 3 is provided with a reception electric-field strength sensor. The data RC on the reception electric-field strength sensed by the reception electric-field strength sensor is inputted to an input/output interface (I/F) 42. The input/output interface 42 inputs the data RC via a bus 43 to a controller 40.

**[0032]** The controller 40 specifies the frequency of the reception local oscillating signal generated by the frequency synthesizer 4. Specifically, the frequency control signal SC outputted from the controller 40 is transferred via the bus 43 to the input/output interface 42. The input/output interface 42 then supplies the frequency control signal to the frequency synthesizer 4.

**[0033]** In a CDMA signal processing section 6, the reception intermediate frequency signal is subjected to orthogonal demodulation and then to inverse diffusion using the diffusion code (PN code) allocated to the reception channel, thereby converting the reception intermediate frequency signal into the demodulation data in a specific format according to the data rate. The converted demodulation data is inputted to a speech coding section 7. Of the reception data, the control data representing the data rate is inputted as the reception data rate to the controller 40.

**[0034]** The speech, coding section 7 subjects the demodulation data outputted from the CDMA signal processing section 6 to an expanding process according to the reception data rate reported from the controller 40 and then to a decoding process using Viterbi decoding or the like and an error corrective decoding process, thereby reproducing the reception digital data in the base band.

**[0035]** A PCM coding section 8 carries out a different signal process, depending on the type of communication outputted from the controller 40, for example, whether

the type of communication is audio communication or data communication.

**[0036]** Specifically, in audio communication, the reception digital data outputted from a speech coding section 7 is PCM-decoded, thereby outputting an analog receive signal. The analog receive signal is amplified by a receive amplifier 9 and then converted by a speaker 10 into greater sound energy, enabling the sound output to be audible over a large area.

**[0037]** In contrast, when information data, such as computer data or video data, is communicated, the receive digital data outputted from the speech coding section 7 is inputted via the bus 43 to the controller 40. The controller 40 outputs the receive digital data via the input/output interface 42 and further external interfaces 48 and 49 to a personal computer PC. The personal computer PC is composed of, for example, a Personal Digital Assistance (PDA) or a notebook-size personal computer.

**[0038]** Each of the external interfaces 48, 49 includes a connector mechanism for mechanically connecting the personal computer PC to the mobile radio communication terminal device and a modem for performing data transfer.

**[0039]** On the other hand, in audio communication, the voice inputted by the talker passes through a microphone 11, which converts it into an analog transmit signal and inputs this signal. The analog transmit signal is amplified by a transmit amplifier 12 to a suitable level and then subjected to PCM coding at the PCM coding section 8, which then inputs the coded signal as transmit data to the speech coding section 7.

**[0040]** In contrast, information data, such as computer data or video data, outputted from the personal computer PC is inputted via the external interfaces 49, 48 and the input/output interface 42 to the controller 40. The controller 40 then supplies the data via the PCM coding section 8 to the speech coding section 7.

**[0041]** In audio communication, the speech coding section 7 senses the amount of energy of the inputted sound from the transmitted audio data outputted from the PCM coding section 8 and, on the basis of the result of the sense, determines the data rate. Then, the transmitted data is compressed into a burst signal in the format according to the data rate. The burst signal is subjected to an error-correcting coding process and the resulting signal is outputted to the CDMA signal processing section 6. In data communication, the transmitted data outputted from the PCM coding section 8 is compressed into a burst signal in the format according to a preset data rate. The burst signal is further subjected to an error-correcting coding process and the resulting signal is outputted to the CDMA signal processing section 6. In both audio communication and data communication, any data rate is notified as transmission data rate to the controller 40.

**[0042]** Using the PN code allocated to the transmission channel, the CDMA signal processing section 6 performs a diffusion process on the burst signal compressed at the speech coding section 7. The transmission signal diffusion-coded is further subjected to an orthogonal modulation process. The orthogonal modulation signal is outputted to a transmission circuit (TX) 5.

**[0043]** The transmission circuit 5 combines the orthogonal modulation signal with the transmission local oscillation signal generated by a frequency synthesizer 4, thereby converting the orthogonal modulation signal into a radio frequency signal. Then, the transmission circuit 5 high-frequency amplifies only the effective part of the radio frequency signal on the basis of the transmission data rate TC specified by the controller 40 and outputs the amplified signal as a transmission radio-frequency signal. The transmission radio-frequency signal outputted from the transmission circuit 5 is supplied via the antenna duplexer 2 to the antenna 1. The antenna 1 transmits the transmission radio-frequency signal toward the base station.

**[0044]** The controller 40 is composed of, for example, a microcomputer and includes not only an ordinary control function of performing radio connection control or communication control with the base station but also a state determining function 40a of determining the state of its own station and base-station searching control means 40b for controlling the operation of searching for the base station on the basis of the result of the determination at the state determining function 40a.

**[0045]** The storage section 41 attached to the controller 40 is provided with a handover history storage section 41a. The handover history storage section 41a is composed of a first memory and a second memory. In the first memory, up to five pieces of information about handover destination base stations are stored, starting with the newest one, each time a new handover is effected. In the second memory, pieces of information about past five consecutive handover destinations are stored.

**[0046]** On the basis of the handover history information stored in the handover history storage section 41a, the state determining means 40a determines whether any of the base stations to which a specific number of past consecutive handovers including the present handover were connected has become a handover connection destination once or more. On the basis of the result of the determination, it is determined whether the present station is in the steady state or in the moving state.

**[0047]** A basic station search control means 41b chooses a different search algorithm according to either the steady state or the moving state, depending on the result of the determination by the state determining means 41a, thereby searching for a base station.

**[0048]** Specifically, in the steady state, four base stations whose histories have been stored as handover destinations in the handover history storage section 41a are put together into a first search group acting as a priority search object. The other individual base stations are put together into a second search group acting as an ordinary search object. The first search group is searched for more frequently than the second search group.

**[0049]** The reason why the number of base stations in

the first search group acting as the priority search object is four is that the number of base stations most likely to hand over to mobile stations in the steady state is generally about four.

**[0050]** In the moving state, on the basis of the neighbor list message reported from the base station to which the present station is now being connected, or the base station in the active set state, eight neighboring base stations closer in distance to the base station now being connected are put together into a third search group acting as a priority search object. The remaining neighboring base stations in the list are put together into a fourth search group. The third search group is searched for more frequently than the fourth search group.

**[0051]** The reason why the number of neighboring base stations in the third search group acting as a priority search object is eight is that selection of eight neighboring base stations in the neighbor list message in the order of description generally enables a total of three cells including the cell in which the present station exists to be included in the search object.

**[0052]** Numeral 44 indicates a key unit. In the key unit 44, a key group, including a dial key, a call originating key, a power key, a communication end key, a volume control key, and a mode specify key are provided. Numeral 45 is an LCD display. On the LCD display, the telephone number of the called party's terminal, various operating states of the device, and information data to be transmitted and received, and others are displayed. After a ringing signal outputted from the input/output interface 42 is amplified by an amplifier 46 and supplied to a sounder 47, which outputs call incoming sound.

**[0053]** Numeral 31 indicates a power supply circuit. The power supply circuit 31 generates a specific operating power-supply voltage Vcc on the basis of the output of a battery 30 and supplies the voltage to each circuit section.

**[0054]** Next, the way a mobile station MS constructed as described above searches for a base station will be explained. FIGS. 9 and 10 are flowcharts to help explain the procedure and contents of control.

**[0055]** When the power switch (not shown) is turned on, the mobile station MS first executes the process of establishing initial synchronization at step 9a. Specifically, first, the mobile station picks up the pilot signal broadcast by a base station and then establishes PN coding synchronization with the base station. Then, the mobile station changes the Walsh code, thereby receiving the sync channel transmitted by the base station. The mobile station then receives and demodulates the message transmitted through the sync channel and stores the resulting information. The message includes the information inherent to the base station and network. In establishing the initial synchronization, the mobile station assumes itself to be in the moving state as shown in FIG. 4.

**[0056]** After finishing the synchronization establishing sequence, the mobile station MS goes into the wait state. In the wait state, the mobile station MS carries out a slot mode operation. Specifically, at step 9b, the mobile station MS monitors the slot period it should receive. Then, when the reception slot period has been reached, the mobile station proceeds to step 9c, where it monitors the arrival of the page massage addressed to itself and then searches for neighboring base stations.

**[0057]** FIG. 3 is a timing chart showing an example of the slot mode operation. In the figure, the reception slot period lasts 100 milliseconds. In the reception slot period, the monitoring of the arrival of the page message addressed to the present mobile station and the searching of three neighboring base stations are done. The interval between reception slot periods, or the sleep period, is 5 seconds long.

**[0058]** After having searched for base stations in one reception slot period, the mobile station MS moves from step 9d to step 9e, where it is determined whether handover is needed. The determination whether or not handover is needed is made as follows. The reception electric-field strength level of the radio frequency signal arriving from the base station now being connected is sensed. The reception electric-field strength level sensed is compared with a preset determination level. If the reception electric field strength level sensed is equal to or higher than the determination level, handover is determined not to be needed. If the reception electric-field strength level sensed is lower than the determination level, handover is determined to be needed.

**[0059]** Now, it is assumed that the reception electric field strength level of the radio frequency signal arriving from the base station now being connected is high and the controller 40 has determined that handover is not needed. In this case, the mobile station MS, at step 9f, selects the base station with the best handover condition, on the basis of the result of searching for base stations in the preceding reception slot period. Then, the mobile station compares the condition of the selected base station with that of the base station now being connected and determines at step 9g whether handover is possible, or whether handover should be effected. Then, the condition of the reception from the base station now being connected is better, the mobile station determines that handover is not needed and goes to step 9m, where it goes into the sleep state.

**[0060]** In contrast, when the neighboring base station is better in the reception condition than the base station now being connected, the mobile station determines that handover should be effected and goes to step 9h, where the mobile station executes the handover process. In the handover process, the controller 40 determines whether information about the base station at the handover destination has been stored in the first memory of the handover history storage section 41a. The first memory is a memory for storing only information on new handover destinations.

**[0061]** If information on the base station at the handover destination has not been stored in the first memory, the controller 40 regards the base station as a new

handover destination and additionally stores the information in the first memory. Information about the handover destination is stored as it is in the second memory that stores past five handover destinations in sequence. FIGS. 5A and 5B show examples of pieces of information stored in the first memory and second memory, respectively.

**[0062]** After having finished the handover process, the mobile station MS proceeds to step 9i, where it determines whether it is in the moving or steady state. The determination of the state is made on the basis of the pieces of information stored in the first and second memories of the handover history storage section 41a. Specifically, the mobile station determines whether the destination to which handover was just connected has not been registered in the first memory and is new. If it is new, the mobile station determines that it is in the moving state. On the other hand, if the destination to which handover was just connected has been already registered in the first memory, the mobile station determines whether the destinations to which the past five consecutive handovers were connected have all been registered in the first memory. If they have been registered, the mobile station determines that it is in the steady state.

**[0063]** For example, it is assumed that the handover history information about the mobile station MS is as shown in FIGS. 5A and 5B. In this situation, the mobile station determines that it is changed from the moving state to the steady state at the time when handover is effected to the base station with PN offset (236) as shown in FIG. 4. Furthermore, the mobile station returns from the steady state to the moving state at the time when handover is effected to the base station with PN offset (176) at a new handover destination.

**[0064]** On the basis of the result of determining the state, the search algorithm according to the moving state and the search algorithm according to the steady state are set at step 9j and step 9k, respectively. Thereafter, the mobile station MS executes the process of searching base stations according to the set search algorithms.

**[0065]** Specifically, in the steady state, four handover destinations of those already registered in the first memory are selected and put together into a first search group acting as a priority search object. The other base stations not included in the first search group are put together into a second search group.

**[0066]** For example, it is assumed that the mobile station MS is connected to base station BSa3 and the handover destination information shown in FIG. 5A has been registered in the first memory. In this situation, the mobile station MS selects four base stations with PN offsets (80), (88), (236), and (172) as the first search group and the other base stations with PN offsets (76), (92), ... as the second search group.

**[0067]** The number of base stations constituting the first search group and the number of base stations constituting the second search group are arbitrary, provided that the number of base stations in the second search group is larger than the number of base stations in the first search group.

**[0068]** Thereafter, the base stations included in the first search group and the base stations included in the second group are searched for one by one alternately in the order of the circled numbers ①, ②, ③, ... in FIG. 7 each time its own reception slot period is reached. The first search group is searched for earlier than the second search group and the number of base stations included in the first search group is smaller than the number of base stations included in the second search group. As a result, the base stations in the first search group are given priority in search over the base stations in the second search group and are searched more frequently than the latter.

**[0069]** Consequently, a sector with a strong possibility that the mobile station MS exists is mainly searched for, which makes it possible to find the best handover destination with a high probability in effecting handover. Although the first search group is given priority in search over the second search group, the base stations in the second search group never fail to be searched for once each time a reception slot is reached, because the base stations in the first search group and those in the second search group are searched for one by one alternately. This prevents the result of searching for the base stations in the second search group from becoming too old, which makes it possible to find a suitable handover destination with a relatively high probability, when handover is needed in the mobile station MS.

**[0070]** On the other hand, in the moving state, the mobile station selects eight base stations in the order in which they are closer to the present base station, on the basis of the neighbor list message reported by the base station now being connected. These eight base stations are put together into a third search group acting as a priority search object. Of the base stations whose PN offsets are written in the neighbor list message, all the base stations not included into the third search group are put together into a fourth search group.

**[0071]** For example, it is assumed that the mobile station MS is connected to base station BSa3 given PN offset (84) and the base station BSa3 notifies a neighbor message as shown in FIG. 6. In this situation, the mobile station MS as shown in FIG. 8 selects eight base stations with PN offsets (80), (88), (76), (92), (236), (232), (172), and (176) in the neighbor list and classifies them into the third search group and the other base stations in the neighbor list into the fourth search group.

**[0072]** The number of base stations constituting the third search group and the number of base stations constituting the fourth search group are arbitrary, provided that the number of base stations in the fourth search group is larger than the number of base stations in the third search group.

**[0073]** Thereafter, all the base stations included in the third search group and each base station included in the fourth group are searched for one by one alternately in

the order of the circled numbers ①, ②, ③, ... in FIG. 8 each time its own reception slot period is reached. As a result, each base station in the third group is given priority in search over the base stations in the fourth search group and is searched for more frequently than the latter. In addition, the third search group is searched for intensively. Consequently, search information about a base station most likely to become the destination to which the mobile station MS moves can be acquired in a relatively short time. As a result, when handover is needed, the best handover destination can be found with a high probability.

**[0074]** The number of base stations selected from the fourth search group is not necessarily limited to one and may be set to any number, provided that it is smaller than the number of base stations in the third search group.

**[0075]** Next, the search operation when it has been determined at step 9e that handover is needed will be described.

**[0076]** It is assumed that the reception electric-field strength sense level of the radio frequency signal coming from the base station now being connected has dropped below a determination level and therefore the controller 40 has determined that handover is needed. In this situation, the mobile station MS continues the search without going into the sleep state as shown in FIG. 3.

**[0077]** Specifically, as shown in FIG. 10, at step 10a, the priority search group is searched according to the state of the mobile station at that time.

**[0078]** For example, when the mobile station MS is in the steady state, each of the four base stations in the first search group is searched for. In contrast, when the mobile station MS is in the moving state, each of the eight stations in the third search group of FIG. 8 is searched for.

**[0079]** After having searched the first or third search group acting as the priority search group, the mobile station MS moves from step 10b to step 10c, where it determines whether there is a base station that fulfills the condition for the handover destination, on the basis of the latest result of searching the priority search group. Then, if there is a base station that fulfills the condition, the mobile station returns to step 9h, where it executes the handover process.

**[0080]** In contrast, if no base station that fulfills the condition has been found from the priority search group, the mobile station MS senses the reception electric-field strength of the radio frequency signal coming from the base station now being connected and checks again to see if the sense level is still below the determination level. If it is still below the determination level, the mobile station proceeds to step 10e, where it searches the second or fourth search group acting as the ordinary search group.

**[0081]** On the other hand, for example, when the result of the determination at step 9e is caused by a temporary drop in the reception electric-field strength and the determination at step 10d has shown that the reception electric-field strength sense level is restored to the determination level or above, the mobile station proceeds to step 9f without searching the ordinary search group. As a result, when the reception quality of the signal from the base station now being connected is restored, the ordinary search group is prevented from being searched wastefully, reducing the power consumption that much, which lengthens the battery service life.

**[0082]** After having searched the ordinary search group, the mobile station MS moves from step 10f to step 10g, where it determines whether there is any base station that fulfills the condition for the handover destination, on the basis of the latest result of searching the ordinary search group. Then, if there is a base station that fulfills the condition, the mobile station returns to step 9h of FIG. 9 and executes the handover process.

**[0083]** In contrast, if no base station that fulfills the condition has been found in the ordinary search group, the mobile station MS, at step 10h, senses the reception electric-field strength of the radio frequency signal coming from the base station now being connected and checks again to see if the sense level is still below the determination level. If the reception electric-field strength sense level remains below the determination level, the mobile station returns to step 10a, where it searches the priority search group and the ordinary search group repeatedly.

**[0084]** In returning to the act of searching the priority search group, the mobile station, at step 10k, counts up the number of times the search is repeated and, at step 10i, determines the number of searches repeated. Then, when the number of repeats becomes, for example, three or more, the mobile station, at step 10j, performs control in such a manner that the determination level of the handover is decreased by, for example, 1 dB each time the search is repeated.

**[0085]** The alleviated handover determination condition is returned to the original determination condition before the alleviation, after the handover has failed and the system lost has occurred.

**[0086]** Now, it is assumed that the reception quality of the signal from the base station now being connected has been restored in the middle of the repetitive search. In this situation, the mobile station MS returns from step 10h to step 9h of FIG. 9.

**[0087]** As described above, with the present invention, the history of the handover destinations is stored in the handover history storage section 41a. Each time handover is effected, the history of past five consecutive handover destinations including the present one is determined on the basis of the handover history storage section 41a. When all the handover destinations have been stored in the handover history storage section 41a, the mobile station recognizes its state to be in the steady state. In the other cases, the mobile station recognizes its state to be in the moving state. On the basis of the recognition, the mobile station selects a search algorithm suitable for each state and searches for a base station.

**[0088]** Since the state of the present station is determined by tracing the history of past handovers, it is possible to determine accurately whether the present station

is in the moving state or in the steady state and further to carry out the operation of searching for the best base station in each state.

**[0089]** Specifically, in the steady state, the five handover destinations stored in the handover history storage section 41a are classified into the first search group and the other stations are classified into the second search group. The first search group is searched more frequently than the second search group.

**[0090]** On the other hand, in the moving state, on the basis of the neighbor list message reported from the base station to which the present station is now being connected, eight neighboring base stations closer in distance to the base station now being connected are classified into the third search group. The remaining neighboring base stations in the list are classified into the four search group. The third search group is searched more frequently than the fourth search group.

**[0091]** With this approach, for example, in the steady state, since the mobile station MS is stationary or moving slowly in a limited range, it can find the suitable base station as the handover destination by just searching for a limited number of base stations, such as three or four base stations. Therefore, as compared with the case where a large number of neighboring base stations are searched for unconditionally, a suitable handover destination can be found in a shorter search time. This shortens the search time, reducing the power consumption that much, which lengthens the battery service life.

**[0092]** In the moving state, the best base station for the handover destination changes dynamically. Because of this, in the moving state, neighboring base stations are searched for over a relatively wide range according to the neighbor list message reported from the base station now being connected, which makes it possible to find a suitable base station as the handover destination with a high probability.

**[0093]** Since the base stations in the first search group and those in the second search group are searched for one by one alternately, the base stations in the second search group never fail to be searched for once each time reception slot is reached. This prevents the result of searching for the base stations in the second search group from becoming too old, which makes it possible to find a suitable handover destination with a relatively high probability, even when the mobile station MS moves suddenly.

**[0094]** Furthermore, when a suitable base station could not be found as the handover destination as the result of searching the first search group and second search group, a determination whether or not handover is needed is made again. Only when the result of the determination has shown that handover is needed, the second search group and fourth search group are searched.

**[0095]** Therefore, when the reception quality has been restored and handover is not needed, the mobile station can return to the sleep state without searching the second search group. Therefore, as compared with the case where the search of the first and second search groups is continued unconditionally, a useless search is eliminated, thus reducing the power consumption that much, which lengthens the battery service life.

**[0096]** Furthermore, in a case where a suitable base station could not be found as the handover destination as the result of searching the first or third search group and the second or fourth search group, the first or third search group and the second or fourth search group are searched repeatedly and, when handover becomes unnecessary in the course of repeating the search three times or more, control is performed in such a manner that the handover determination condition is alleviated.

**[0097]** Therefore, when a possibility of handover is checked excessively because the handover determination condition has not been optimized, the handover determination condition can be corrected automatically to the optimum condition. As a result, a base station is searched for only when handover is really needed, reducing the power consumption, which lengthens the battery service life.

**[0098]** While explanation has been given using the CDMA cellular radio communication system, the means for determining whether the mobile station is in the steady state or the moving state may also be applied to a TDMA cellular radio communication system or a cellular radio communication system of the analog type, such as the AMPS scheme.

## Claims

**1.** A mobile radio communication terminal device used as a mobile station (MS) in a cellular mobile radio communication system where base stations (BSa1 to BSd6) are distributed over a service area, the base stations form their respective radio areas (Ea, Eb, Ec, Ed), and a radio channel connects the mobile station and a base station in each of the radio areas, comprising:

history information storage means (41a) for storing information relating to past handovers representing base stations connected to the mobile radio communication terminal device as handover history information;

update means (40a, 41a) for updating the handover history information stored in said history information storage means each time handover is performed; and

state determining means (40a) for determining whether the mobile radio communication terminal device is in a steady state or a moving state, on the basis of the handover history information stored in said history information storage means, wherein

each time handover is performed, said state de-

termining means (40b) is suitable for determining whether any of the base stations connected to the mobile station (MS) by a specific number of past successive handovers including the present handover became a destination base station connected to the mobile station in the past, on the basis of the handover history information stored in said history information storage means (41a), and when determining that any of the base stations became the handover destination base station, for recognizing the mobile radio communication terminal device to be in the steady state and, in contrast, when determining that at least one of the base stations, did not become the handover destination base station, for recognizing its own mobile radio communication terminal device to be in the moving state; further comprising base station searching means (40b) for selecting a search algorithm, depending on either the steady state or the moving state, according to the result of the determination by said state determining means (40b) and for searching for a base station (BSa1 to BSd6) according to the selected search algorithm.

2. The mobile radio communication terminal device according to claim 1, **characterized in that** said base station searching means (40b), in the steady state, is suitable for classifying a first number of base stations in the handover destination base stations stored in said history information storage means (41a) into a first search group and a second number of the other base stations larger than said first number into a second search group and that the first search group is given priority in search over the second search group.

3. The mobile radio communication terminal device according to claim 2, **characterized in that** said base station searching means (40b) includes necessity determining means for determining whether handover is needed, and when the necessity determining means determines that handover is not needed, is suitable for searching for each base station belonging to said first search group and each base station belonging to said second search group alternately.

4. The mobile radio communication terminal device according to claim 2 or 3, **characterized in that** said base station searching means (40b) includes necessity determining means for determining whether handover is needed and when the necessity determining means determines that handover is needed, is suitable for searching for all the base stations belonging to the first search group and, when a suitable base station is not be found as the result of the search, is suitable for searching for each base station belonging to the second search group

5. The mobile radio communication terminal device according to claim 4, **characterized in that**, when a suitable base station is not be found as the handover destination as the result of the search of the first search group, said base station searching means (40b) is suitable for causing said necessity determining means to determine again whether handover is needed and, only when the determination determines that handover is needed, for searching the second search group.

6. The mobile radio communication terminal device according to claim 4 or 5, **characterized in that**, when a suitable base station is not be found as the handover destination as the result of searching the first search group and the second search group, said base station searching means (40b) is suitable for searching the first search group and the second search group repeatedly.

7. The mobile radio communication terminal device according to claim 6, **characterized in that** said base station searching means (40b) is suitable for counting the number of times the first search group and the second search group are searched repeatedly and, when the number of repetitions becomes a predetermined number of times, for performing variable control of the determination conditions of said necessity determining means.

8. The mobile radio communication terminal device according to any one of claims 1 to 7, **characterized in that** said base station searching means (40b), in the moving state, is suitable for selecting a third number of neighboring base stations closer in distance to the base station connected to the mobile radio communication terminal device, on the basis of a list of neighboring base stations reported from the connected base station, for classifing these neighboring base stations into a third search group and the other neighboring base stations in said list into a fourth search group, and for giving priority in search to the third search group over the fourth search group.

9. The mobile radio communication terminal device according to claim 8, **characterized in that** said base station searching means (40b) includes necessity determining means for determining whether handover is needed and when the necessity determining means determines that handover is not needed, is suitable for searching for the third number of neighboring base stations belonging to said third search group and the fourth number of neighboring base stations smaller than said third number selected from said fourth search group alternately.

**10.** The mobile radio communication terminal device according to claim 8 or 9 **characterized in that** said base station searching means (40b) includes necessity determining means for determining whether handover is needed, and when the necessity determining means determines that handover is needed, is suitable for searching for all the base stations belonging to the third search group and, when a suitable base station is not be found as the result of the search, is suitable for searching for each base station belonging to the fourth search group

**11.** The mobile radio communication terminal device according to claim 10, **characterized in that**, when a suitable base station is not be found as the handover destination as the result of the search of the third search group, said base station searching means (40b) is suitable for causing said necessity determining means to determine again whether handover is needed and, only when the determination determines that handover is needed, for searching for one base station of the fourth search group.

**12.** The mobile radio communication terminal device according to claim 10 or 11, **characterized in that**, when a suitable base station is not be found as the handover destination as the result of searching the third search group and the fourth search group, said base station searching means (40b) is suitable for searching the third search group and the fourth search group repeatedly.

**13.** The mobile radio communication terminal device according to claim 12, **characterized in that** said base station searching means (40b) is suitable for counting the number of times the third search group and the fourth search group are searched repeatedly and, when the number of repetitions becomes a predetermined number of times, for performing variable control of the determination conditions of said necessity determining means.

**14.** A mobile radio communication terminal device according to any one of claims 1 to 13 comprising:

base station search control means (40b) for controlling the operation of searching for said base stations on the basis of the handover history information stored in said history information storage means.

**Patentansprüche**

**1.** Mobilfunkkommunikationsendgerätevorrichtung, die als eine Mobilstation (MS) verwendet wird, in einem zellularen Mobilfunkkommunikationssystem, wo Basisstationen (BSa1 bis BSd6) über einen Dienstbereich verteilt sind, wobei die Basisstationen ihre jeweiligen Funkbereiche (Ea, Eb, Ec, Ed) bilden, und ein Funkkanal die Mobilstation und eine Basisstation in jedem der Funkbereiche verbindet, enthaltend:

ein Historieinformationsspeichermittel (41a) zum Speichern von Information, die die vergangenen Verbindungsübergaben betrifft, die Basisstationen darstellen, die mit der Mobilfunkkommunikationsendgerätevorrichtung verbunden waren, als Verbindungsübergabehistorieinformation;
ein Aktualisierungsmittel (40a, 41a) zum Aktualisieren der Verbindungsübergabehistorieinformation, die in dem Historieinformationsspeichermittel gespeichert wird, jedes Mal wenn eine Verbindungsübergabe erfolgt; und
ein Zustandbestimmungsmittel (40b) zum Bestimmen, ob die Mobilfunkkommunikationsendgerätevorrichtung in einem Ruhezustand oder einem Bewegungszustand ist, basierend auf der Verbindungsübergabehistorieinformation, die in dem Historieinformationsspeichermittel gespeichert ist, wobei
jedes Mal wenn eine Verbindungsübergabe erfolgt, das Zustandsbestimmungsmittel (40b) geeignet ist zum Bestimmen, ob irgendeine der Basisstationen, die mit der Mobilstation (MS) eine bestimmte Anzahl von vergangenen aufeinanderfolgenden Übergängen, einschließlich der gegenwärtigen Verbindungsübergabe, oft verbunden war, eine Zielbasisstation wird, die mit der Mobilstation in der Vergangenheit verbunden war, basierend auf der Verbindungsübergabehistorieinformation, die in dem Historieninformationsspeichermittel (41a) gespeichert ist, und wenn bestimmt wird, dass eine der Basisstationen die Verbindungsübergabezielbasisstation wurde, zum Erkennen, dass die Mobilfunkkommunikationsendgerätevorrichtung in dem Ruhezustand ist, und im Gegensatz dazu, wenn bestimmt wurde, dass mindestens eine der Basisstationen nicht die Verbindungsübergabezielbasisstation wird, zum Erkennen, dass sein eigenes Mobilfunkkommunikationsendgerätevorrichtung in dem Bewegungszustand ist;
ferner enthaltend ein Basisstationssuchmittel (40b) zum Auswählen eines Suchalgorithmus in Abhängigkeit von entweder dem Ruhezustand oder dem Bewegungszustand, gemäß dem Ergebnis der Bestimmung durch das Zustandsbestimmungsmittel (40b), und zum Suchen nach einer Basisstation (BSa1 bis BSd6) gemäß dem ausgewählten Suchalgorithmus.

**2.** Mobilfunkkommunikationsendgerätevorrichtung

nach Anspruch 1, **dadurch gekennzeichnet, dass** in dem Ruhezustand das Basisstationssuchmittel (40b) geeignet ist zum Klassifizieren einer ersten Anzahl von Basisstationen in den Verbindungsübergabezielbasisstationen, die in dem Historieinformationsspeichermittel (41 a) gespeichert sind, in eine erste Suchgruppe, und einer zweiten Anzahl der anderen Basisstationen, die größer als die erste Anzahl ist, in eine zweite Suchgruppe, und dass der ersten Suchgruppe gegenüber der zweiten Suchgruppe eine Priorität bei der Suche gegeben ist.

**3.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 2, **dadurch gekennzeichnet, dass** das Basisstationssuchmittel (40b) ein Notwendigkeitsbestimmungsmittel enthält, zum Bestimmen, ob eine Verbindungsübergabe notwendig ist, und wenn das Notwendigkeitsbestimmungsmittel bestimmt, dass eine Verbindungsübergabe nicht notwendig ist, geeignet ist zum abwechselnden Suchen nach jeder Basisstation, die zu der ersten Suchgruppe gehört, und nach jeder Basisstation, die zu der zweiten Suchgruppe gehört.

**4.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 2 oder 3, **dadurch gekennzeichnet, dass** das Basisstationssuchmittel (40b) ein Notwendigkeitsbestimmungsmittel enthält zum Bestimmen, ob eine Verbindungsübergabe notwendig ist, und wenn das Notwendigkeitsbestimmungsmittel bestimmt, dass die Verbindungsübergabe notwendig ist, geeignet ist zum Suchen nach allen Basisstationen, die zu der ersten Suchgruppe gehören, und wenn als Ergebnis der Suche eine geeignete Basisstation nicht gefunden wird, geeignet ist zum Suchen jeder Basisstation, die zu der zweiten Suchgruppe gehört.

**5.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 4, **dadurch gekennzeichnet, dass** wenn als Ergebnis der Suche in der ersten Suchgruppe eine geeignete Basisstation nicht als Verbindungsübergabeziel gefunden wird, das Basisstationssuchmittel (40b) geeignet ist das Notwendigkeitsbestimmungsmittel zu veranlassen erneut zu bestimmen, ob eine Verbindungsübergabe notwendig ist, und nur wenn die Bestimmung bestimmt, dass die Verbindungsübergabe notwendig ist, zum Suchen in der zweiten Suchgruppe.

**6.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass**, wenn als Ergebnis der Suche in der ersten Suchgruppe und der zweiten Suchgruppe eine geeignete Basisstation nicht als Verbindungsübergabeziel gefunden wird, das Basisstationssuchmittel (40b) geeignet ist zum wiederholten Absuchen der ersten Suchgruppe und der zweiten Suchgruppe.

**7.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass** das Basisstationssuchmittel (40b) geeignet ist zum Zählen, wie oft die erste Suchgruppe und die zweite Suchgruppe wiederholt abgesucht worden sind, und wenn die Anzahl von Wiederholungen eine vorbestimmte Anzahl wird, zum Durchführen einer variablen Steuerung der Bestimmungsbedingungen des Notwendigkeitsbestimmungsmittels.

**8.** Mobilfunkkommunikationsendgerätevorrichtung nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** in dem Bewegungszustand das Basisstationssuchmittel (40b) geeignet ist zum Auswählen einer dritten Anzahl von Nachbarbasisstationen, die näher zu der Basisstation sind, die mit der Mobilfunkkommunikationsendgerätevorrichtung verbunden ist, basierend auf einer Liste von Nachbarbasisstationen, die von der verbundenen Basisstation berichtet wird, zum Klassifizieren dieser Nachbarbasisstationen in eine dritte Suchgruppe und der anderen Nachbarbasisstationen in dieser Liste in eine vierte Suchgruppe, und zum Vergeben einer Priorität für die dritte Suchgruppe gegenüber der vierten Suchgruppe bei der Suche.

**9.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 8, **dadurch gekennzeichnet, dass** das Basisstationssuchmittel (40b) ein Notwendigkeitsbestimmungsmittel enthält zum Bestimmen, ob eine Verbindungsübergabe notwendig ist, und wenn das Notwendigkeitsbestimmungsmittel bestimmt, dass die Verbindungsübergabe nicht notwendig ist, geeignet ist zum abwechselnden Suchen nach der dritten Anzahl von Nachbarbasisstationen, die zu der dritten Suchgruppe gehören, und der vierten Anzahl von Nachbarbasisstationen, die kleiner ist als die dritte Anzahl, die aus der vierten Suchgruppe ausgewählt werden.

**10.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 8 oder 9, **dadurch gekennzeichnet, dass** das Basisstationssuchmittel (40b) ein Notwendigkeitsbestimmungsmittel enthält zum Bestimmen, ob eine Verbindungsübergabe notwendig ist, und wenn das Notwendigkeitsbestimmungsmittel bestimmt, dass die Verbindungsübergabe notwendig ist, geeignet ist zum Suchen nach allen Basisstationen, die zu der dritten Suchgruppe gehören, und wenn als Ergebnis einer Suche eine geeignete Basisstation nicht gefunden wird, geeignet ist zum Suchen nach jeder Basisstation, die zu der vierten Suchgruppe gehört.

**11.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 10, **dadurch gekennzeichnet, dass**, wenn als Ergebnis der Suche in der dritten Suchgruppe eine geeignete Basisstation nicht als

Verbindungsübergabeziel gefunden wird, das Basisstationssuchmittel (40b) geeignet ist zum Veranlassen des Notwendigkeitsbestimmungsmittels erneut zu bestimmen, ob eine Verbindungsübergabe notwendig ist, und nur wenn die Bestimmung bestimmt, dass die Verbindungsübergabe notwendig ist, zum Suchen nach einer Basisstation der vierten Suchgruppe.

**12.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 10 oder 11, **dadurch gekennzeichnet, dass**, wenn als Ergebnis der Suche in der dritten Suchgruppe und der vierten Suchgruppe eine geeignete Basisstation nicht als Verbindungsübergabeziel gefunden wird, das Basisstationssuchmittel (40b) geeignet ist zum wiederholten Suchen in der dritten Suchgruppe und der vierten Suchgruppe.

**13.** Mobilfunkkommunikationsendgerätevorrichtung nach Anspruch 12, **dadurch gekennzeichnet, dass** das Basisstationssuchmittel (40b) geeignet ist zum Zählen, wie oft die dritte Suchgruppe und vierte Suchgruppe wiederholt abgesucht worden sind, und wenn die Anzahl von Wiederholungen gleich einer vorbestimmten Anzahl wird, zum Durchführen einer variablen Steuerung der Bestimmungsbedingungen des Notwendigkeitsbestimmungsmittels.

**14.** Mobilfunkkommunikationsendgerätevorrichtung nach einem der Ansprüche 1 bis 13, enthaltend:

ein Basisstationssuchsteuerungsmittel (40b) zum Steuern des Suchvorgangs nach Basisstationen basierend auf der Verbindungsübergabehistorieinformation, die in dem Historieinformationsspeichermittel gespeichert ist.

**Revendications**

**1.** Terminal de radiocommunications mobiles utilisé comme station mobile (MS) dans un système de radiocommunications mobiles cellulaire où des stations de base (BSa1 à BSd6) sont réparties sur une zone de service, les stations de base formant leurs zones radio respectives (Ea, Eb, Ec, Ed), et un canal radio reliant la station mobile et une station de base dans chacune des zones radio, comportant :

un moyen de stockage d'informations d'historique (41a) pour mémoriser des informations ayant trait à des transferts passés représentant des stations de base reliées au terminal de radiocommunications mobiles en tant qu'informations d'historique de transfert ;
un moyen de mise à jour (40a, 41a) pour mettre à jour les informations d'historique de transfert mémorisées dans ledit moyen de stockage d'informations d'historique à chaque fois qu'un transfert est effectué ; et
un moyen de détermination d'état (40a) pour déterminer si le terminal de radiocommunications mobiles se trouve dans un état d'arrêt ou dans un état de déplacement, en fonction des informations d'historique de transfert mémorisées dans ledit moyen de stockage d'informations d'historique, dans lequel
chaque fois qu'un transfert est effectué, ledit moyen de détermination d'état (40b) est adapté pour déterminer si l'une quelconque des stations de base reliées à la station mobile (MS) par un nombre spécifique de transferts successifs passés comprenant le transfert présent est devenue une station de base de destination reliée à la station mobile dans le passé, en fonction des informations d'historique de transfert mémorisées dans ledit moyen de stockage d'informations d'historique (41a), et lorsqu'il détermine que l'une quelconque des stations de base est devenue la station de base de destination de transfert, il est adapté pour reconnaître le terminal de radiocommunications mobiles comme se trouvant dans un état d'arrêt et, au contraire, lorsqu'il détermine qu'au moins une des stations de base n'est pas devenue la station de base de destination de transfert, il est adapté pour reconnaître son propre terminal de radiocommunications mobiles comme se trouvant dans un état de déplacement ;
comportant en outre un moyen de recherche de station de base (40b) pour sélectionner un algorithme de recherche, selon qu'il se trouve soit dans l'état d'arrêt soit dans l'état de déplacement, conformément au résultat de la détermination par ledit moyen de détermination d'état (40b) et pour rechercher une station de base (BSa1 à BSd6) selon l'algorithme de recherche sélectionné.

**2.** Terminal de radiocommunications mobiles selon la revendication 1, **caractérisé en ce que** ledit moyen de recherche de station de base (40b), dans l'état d'arrêt, est adapté pour classifier un premier nombre de stations de base parmi les stations de base de destination de transfert mémorisées dans ledit moyen de stockage d'informations d'historique (41a) en un premier groupe de recherche et un second nombre d'autres stations de base plus grand que ledit premier nombre en un second groupe de recherche et en que l'on donne priorité pour la recherche au premier groupe de recherche par rapport au second groupe de recherche.

**3.** Terminal de radiocommunications mobiles selon la revendication 2, **caractérisé en ce que** ledit moyen de recherche de station de base (40b) comprend un

moyen de détermination de nécessité pour déterminer si un transfert est nécessaire, et lorsque le moyen de détermination de nécessité détermine qu'un transfert n'est pas nécessaire, il est adapté pour rechercher alternativement chaque station de base appartenant audit premier groupe de recherche et chaque station de base appartenant audit second groupe de recherche.

**4.** Terminal de radiocommunications mobiles selon la revendication 2 ou 3, **caractérisé en ce que** le moyen de recherche de station de base (40b) comprend un moyen de détermination de nécessité pour déterminer si un transfert est nécessaire et lorsque le moyen de détermination de nécessité détermine qu'un transfert est nécessaire, il est adapté pour rechercher les stations de base appartenant au premier groupe de recherche et, lorsqu'une station de base adaptée n'est pas trouvée en tant que résultat de la recherche, il est adapté pour rechercher chaque station de base appartenant au second groupe de recherche.

**5.** Terminal de radiocommunications mobiles selon la revendication 4, **caractérisé en ce que**, lorsqu'une station de base adaptée n'est pas trouvée comme destination de transfert en tant que résultat de la recherche du premier groupe de recherche, ledit moyen de recherche de station de base (40b) est adapté pour amener ledit moyen de détermination de nécessité à déterminer de nouveau si un transfert est nécessaire et, seulement si la détermination détermine qu'un transfert est nécessaire, pour rechercher le second groupe de recherche.

**6.** Terminal de radiocommunications mobiles selon la revendication 4 ou 5, **caractérisé en ce que**, lorsqu'une station de base adaptée n'est pas trouvée comme destination de transfert en tant que résultat de la recherche du premier groupe de recherche et du second groupe de recherche, ledit moyen de recherche de station de base (40b) est adapté pour rechercher de façon répétée le premier groupe de recherche et le second groupe de recherche.

**7.** Terminal de radiocommunications mobiles selon la revendication 6, **caractérisé en ce que** ledit moyen de recherche de station de base (40b) est adapté pour compter le nombre de fois que le premier groupe de recherche et le second de recherche sont recherchés de façon répétée et, lorsque le nombre de répétitions devient un nombre prédéterminé de fois, pour effectuer un contrôle variable des conditions de détermination dudit moyen de détermination de nécessité.

**8.** Terminal de radiocommunications mobiles selon l'une quelconque revendication 1 à 7, **caractérisé en ce que** ledit moyen de recherche de station de base (40b), dans l'état de déplacement, est adapté pour sélectionner un troisième nombre de stations de base voisines plus proches de la station de base reliée au terminal de radiocommunications mobiles, en fonction d'une liste de stations de base voisines indiquée par la station de base reliée, pour classifier ces stations de base voisines en un troisième groupe de recherche et les autres stations de base voisines dans ladite liste en un quatrième groupe de recherche, et pour donner la priorité concernant la recherche au troisième groupe de recherche par rapport au quatrième groupe de recherche.

**9.** Terminal de radiocommunications mobiles selon la revendication 8, **caractérisé en ce que** ledit moyen de recherche de station de base (40b) comprend un moyen de détermination de nécessité pour déterminer si un transfert est nécessaire et lorsque le moyen de détermination de nécessité détermine qu'un transfert n'est pas nécessaire, il est adapté pour rechercher alternativement le troisième nombre de stations de base voisines appartenant audit troisième groupe de recherche et le quatrième nombre de stations de base voisines plus petit que ledit troisième nombre sélectionné parmi ledit quatrième groupe de recherche.

**10.** Terminal de radiocommunications mobiles selon la revendication 8 ou 9, **caractérisé en ce que** ledit moyen de recherche de station de base (40b) comprend un moyen de détermination de nécessité pour déterminer si un transfert est nécessaire, et lorsque le moyen de détermination de nécessité détermine qu'un transfert est nécessaire, il est adapté pour rechercher toutes les stations de base appartenant au troisième groupe de recherche et, lorsqu'une station de base adaptée n'est pas trouvée en tant que résultat de la recherche, il est adapté pour rechercher chaque station de base appartenant au quatrième groupe de recherche.

**11.** Terminal de radiocommunications mobiles selon la revendication 10, **caractérisé en ce que** lorsqu'une station de base adaptée n'est pas trouvée comme destination de transfert en tant que résultat de la recherche du troisième groupe de recherche, ledit moyen de recherche de station de base (40b) est adapté pour amener ledit moyen de détermination de nécessité à déterminer de nouveau si un transfert est nécessaire et, seulement si la détermination détermine qu'un transfert est nécessaire, il est adapté pour rechercher une station de base du quatrième groupe de recherche.

**12.** Terminal de radiocommunications mobiles selon la revendication 10 ou 11, **caractérisé en ce que**, lorsqu'une station de base adaptée n'est pas trouvée

comme destination de transfert en tant que résultat de la recherche du troisième groupe de recherche et du quatrième groupe de recherche, ledit moyen de recherche de station de base (40b) est adapté pour rechercher le troisième groupe de recherche et le quatrième groupe de recherche de façon répétée.

**13.** Terminal de radiocommunications mobiles selon la revendication 12, **caractérisé en ce que** ledit moyen de recherche de station de base (40b) est adapté pour compter le nombre de fois que le troisième groupe de recherche et le quatrième groupe de recherche sont recherchés de façon répétée et, lorsque le nombre de répétitions devient un nombre prédéterminé de fois, pour effectuer un contrôle variable des conditions de détermination dudit moyen de détermination de nécessité.

**14.** Terminal de radiocommunications mobiles selon l'une quelconque des revendications 1 à 13, comportant :

un moyen de contrôle de recherche de station de base (40b) pour contrôler l'opération de recherche desdites stations de base en fonction des informations d'historique de transfert mémorisées dans ledit moyen de stockage d'informations d'historique.

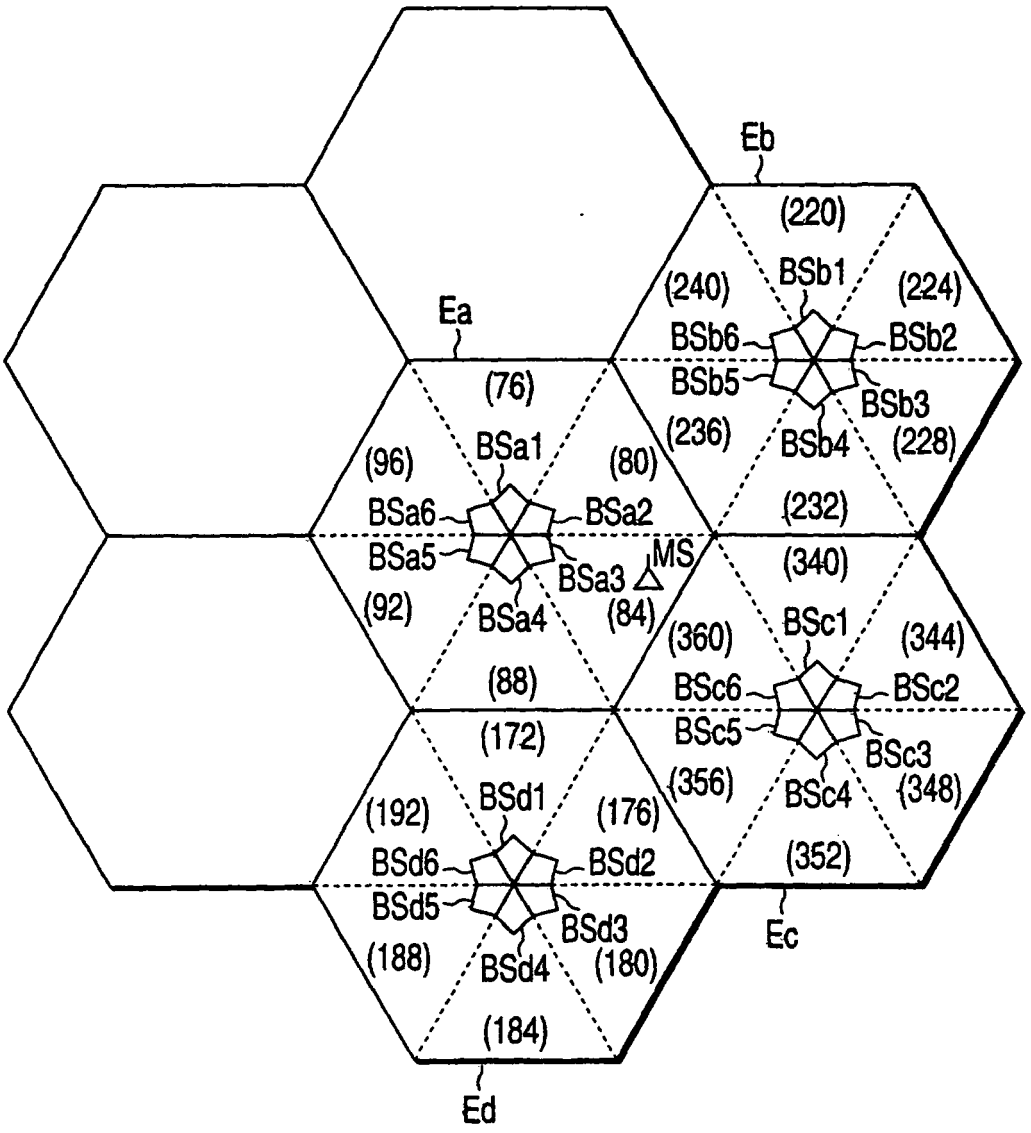
Eb
(220)
(240)
BSb1
(224)
Ea
BSb6
BSb2
(76)
BSb5
BSb3
(236)
BSb4
(228)
(96)
BSa1
(80)
BSa6
BSa2
(232)
BSa5
MS
BSa3
(340)
(92)
BSa4
(84)
(360)
BSc1
(344)
(88)
BSc6
BSc2
(172)
BSc5
BSc3
(356)
BSc4
(348)
(192)
BSd1
(176)
BSd6
BSd2
(352)
BSd5
BSd3
Ec
(188)
BSd4
(180)
(184)
Ed

FIG. 1

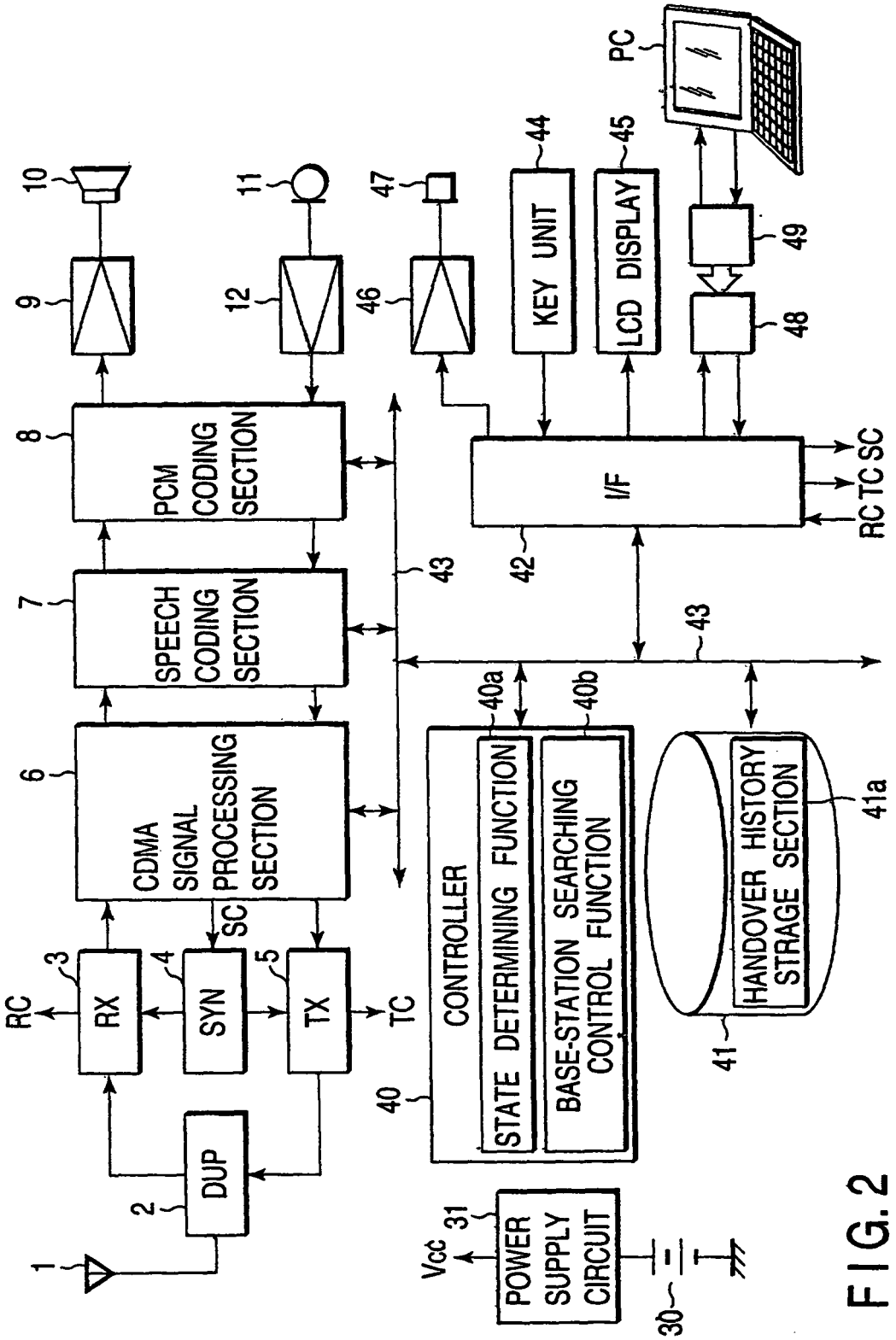
1
2
DUP
3
RX
RC
4
SYN
5
TX
TC
SC
6
CDMA SIGNAL PROCESSING SECTION
7
SPEECH CODING SECTION
8
PCM CODING SECTION
9
10
11
12
43
40
CONTROLLER
40a
STATE DETERMINING FUNCTION
40b
BASE-STATION SEARCHING CONTROL FUNCTION
41
41a
HANDOVER HISTORY STRAGE SECTION
42
I/F
RC TC SC
44
KEY UNIT
45
LCD DISPLAY
46
47
48
49
PC
Vcc
31
POWER SUPPLY CIRCUIT
30

FIG. 2

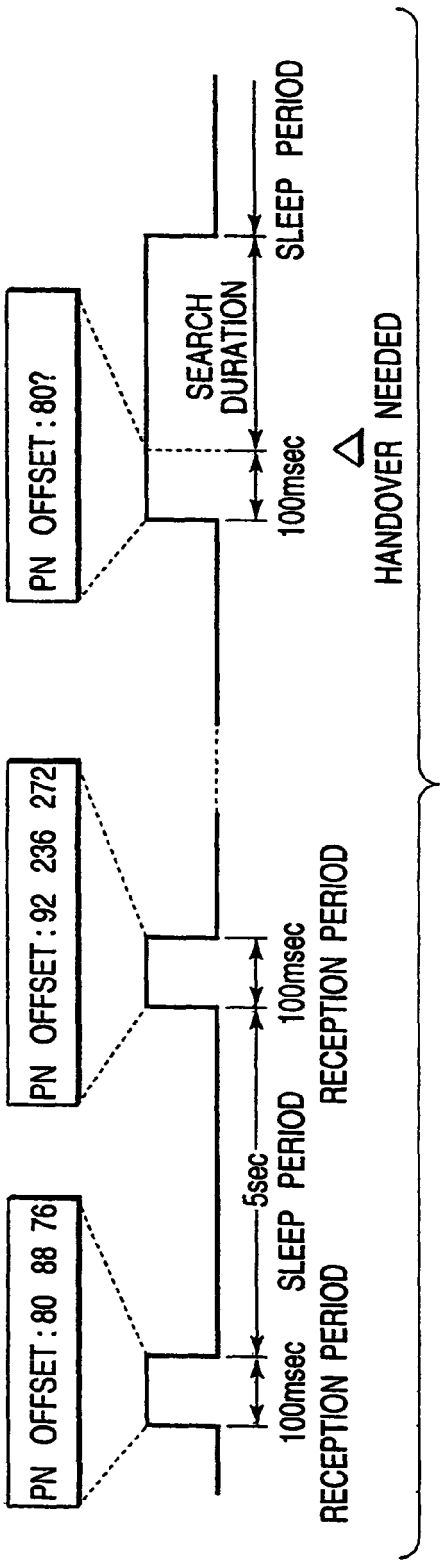
PN OFFSET : 80 88 76
PN OFFSET : 92 236 272
PN OFFSET : 80?
100msec
SLEEP PERIOD
5sec
100msec
RECEPTION PERIOD
100msec
SEARCH DURATION
SLEEP PERIOD
RECEPTION PERIOD
HANDOVER NEEDED

FIG. 3

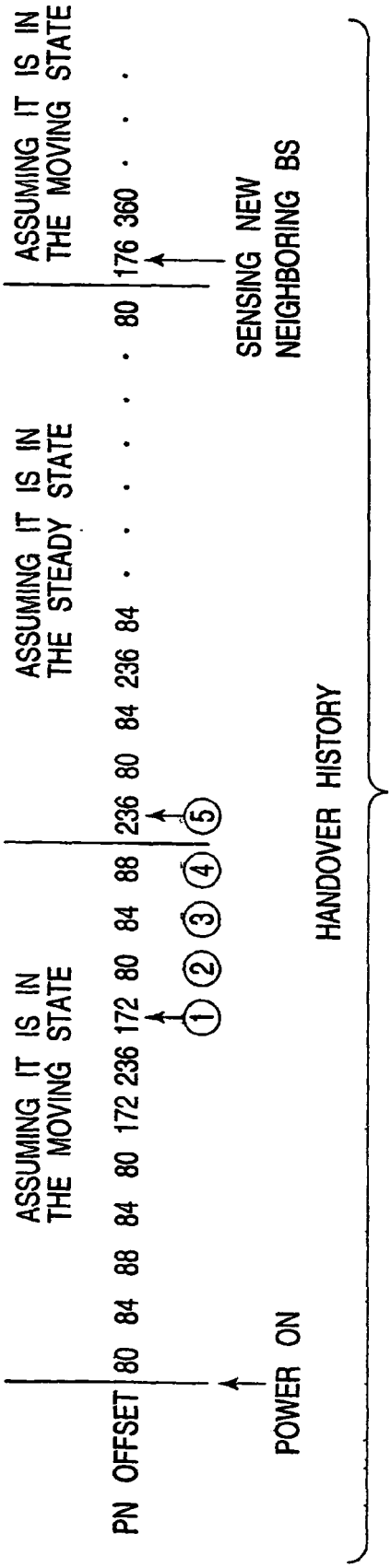
PN OFFSET
80 84 88 80 84 80 172 236 172 80 84 88 236 80 84 236 84 . . . . . 80 176 360 . . .
ASSUMING IT IS IN THE MOVING STATE
ASSUMING IT IS IN THE STEADY STATE
ASSUMING IT IS IN THE MOVING STATE
① ② ③ ④ ⑤
POWER ON
SENSING NEW NEIGHBORING BS
HANDOVER HISTORY

FIG. 4

| FIRST MEMORY PN OFFSET |
|---|
| 80 |
| 84 |
| 88 |
| 172 |
| 236 |

FIG. 5A

| SECOND MEMORY PN OFFSET |
|---|
| 172 |
| 80 |
| 84 |
| 88 |
| 236 |

FIG. 5B

EXAMPLE OF NEIGHBOR LIST MESSAGE

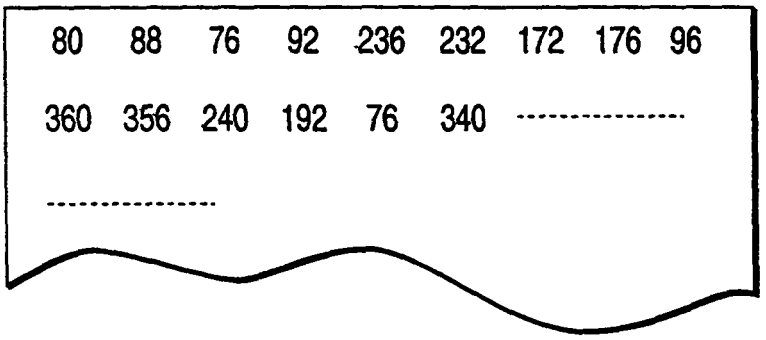


FIG. 6

SEARCH IN THE STEADY STATE :
Active:84

DETERMINATION (IDLE HANDOVER OR SLEEP?)

| | FIRST SEARCH GROUP | SECOND SEARCH GROUP |
|---|---|---|
| PN OFFSET | 80 88 236172 | 78 92 232 176 96 360 356 240 192 340 ···· |
| SEARCH SEQUENCE | ①③⑤⑦ ⑨⑪⑬⑮ ⑰⑲ | ② ④ ⑥ ⑧ ⑩ ⑫ ⑭ ⑯ ⑱ ⑳ |

FIG. 7

SEARCH IN THE MOVING STATE :
Active:84

DETERMINATION (IDLE HANDOVER OR SLEEP?)

| | THIRD SEARCH GROUP | FOURTH SEARCH GROUP |
|---|---|---|
| PN OFFSET | 80 88 76 92 236 232 172 176 | 92 96 360 356 240 192 76 340 ···· |
| SEARCH SEQUENCE | ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑩ ⑪ ⑫ ⑬ ⑭ ⑮ ⑯ ⑰ | ⑨ ⑱ · · · |

FIG. 8

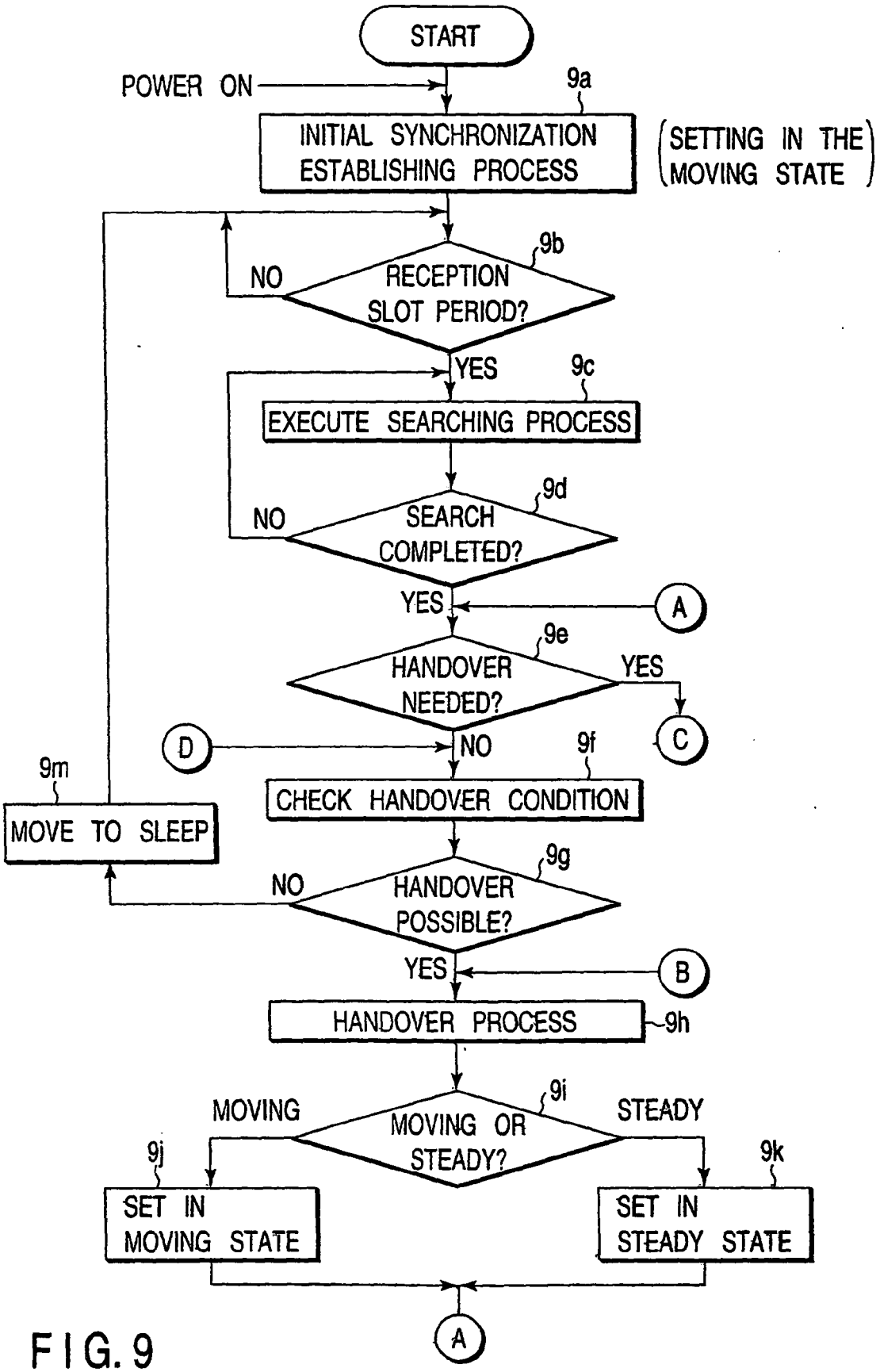
START
POWER ON
9a
INITIAL SYNCHRONIZATION ESTABLISHING PROCESS
(SETTING IN THE MOVING STATE)
9b
NO
RECEPTION SLOT PERIOD?
YES
9c
EXECUTE SEARCHING PROCESS
9d
NO
SEARCH COMPLETED?
YES
A
9e
HANDOVER NEEDED?
YES
C
D
NO
9f
CHECK HANDOVER CONDITION
9m
MOVE TO SLEEP
9g
NO
HANDOVER POSSIBLE?
YES
B
HANDOVER PROCESS
9h
9i
MOVING
MOVING OR STEADY?
STEADY
9j
9k
SET IN MOVING STATE
SET IN STEADY STATE
A

FIG. 9

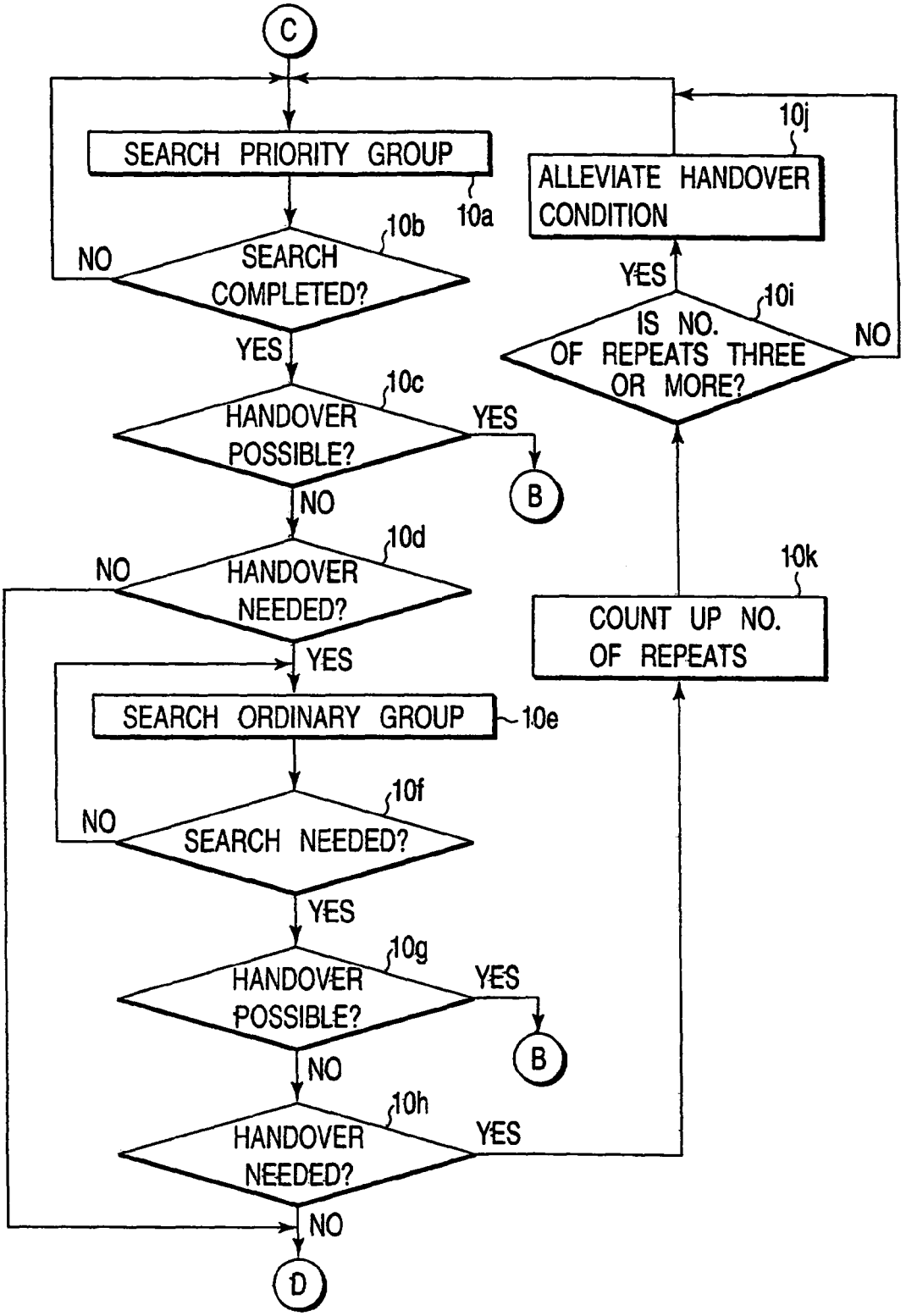
C
SEARCH PRIORITY GROUP
10a
10b
SEARCH COMPLETED?
NO
YES
10c
HANDOVER POSSIBLE?
YES
B
NO
10d
HANDOVER NEEDED?
NO
YES
SEARCH ORDINARY GROUP
10e
10f
SEARCH NEEDED?
NO
YES
10g
HANDOVER POSSIBLE?
YES
B
NO
10h
HANDOVER NEEDED?
YES
NO
D
10j
ALLEVIATE HANDOVER CONDITION
YES
10i
IS NO. OF REPEATS THREE OR MORE?
NO
10k
COUNT UP NO. OF REPEATS

FIG. 10

## REFERENCES CITED IN THE DESCRIPTION

*This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.*

### Patent documents cited in the description


- US 5642398 A **[0008]**
- EP 0812119 A **[0009]**
- EP 0859476 A **[0011]**


### Non-patent literature cited in the description


- **Chiang K.-H. et al.** Intelligent Handover and Location Updating Control for Third Generation Mobile Network. *IEEE Globecom 1998,* 1998, vol. 4, ISBN 8-7803-4985-7, 1963-1969 **[0010]**