(12) PATENT
(19) AUSTRALIAN PATENT OFFICE

(11) Application No. **AU 199530315 B2**
(10) Patent No. **700092**

(54) Title
Multilayer cellular radio network

(51)[6] International Patent Classification(s)
H04Q 007/36

(21) Application No: 199530315

(22) Application Date: 1995 .08 .28

(30) Priority Data

(31) Number	(32) Date	(33) Country
94 10972	1994 .09 .14	FR

(43) Publication Date : 1996 .03 .28
(43) Publication Journal Date : 1996 .03 .28
(44) Accepted Journal Date : 1998 .12 .24

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(56) Related Art
WO 93/12589
EP 504122

AU9530315

(12) PATENT ABSTRACT (11) Document No. AU-A-30315/95
(19) AUSTRALIAN PATENT OFFICE

(54) Title
MULTILAYER CELLULAR RADIO NETWORK

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(21) Application No. : **30315/95** (22) Application Date : **28.08.95**

(30) Priority Data

(31) Number	(32) Date	(33) Country
94 10972	**14.09.94**	**FR FRANCE**

(43) Publication Date : **28.03.96**

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(57)

The invention provides a method of setting up a dedicated channel (TCH, SDCCH) between a mobile (M) and a base station (Si) in a multilayer cellular radiocommunications system with mobiles. The method includes the following steps:

- a reception step (E1) in which each base station (S1, ..., S13) receives an access message (AB) transmitted by the mobile over the said beacon frequency (BCCH),

- a selection step (E2) in which one (Si) of the said base stations is selected as defining radio coverage for the mobile (M), as a function of measurements of reception level of the said access message (AB), and

- a transmission step (E3) in which an allocation message ([SDCCH]; [TCH]) is transmitted by the said base station (SP) of the umbrella cell (CP) on the said beacon frequency (BCCH) to the said mobile (M), the said allocation message identifying the dedicated channel ([SDCCH]; [TCH] which is available in the selected base station (Si, SP).

ABSTRACT

The invention provides a method of setting up a dedicated channel (TCH, SDCCH) between a mobile (M) and a base station (Si) in a multilayer cellular radiocommunications system with mobiles. The method includes the following steps:

- a reception step (E1) in which each base station (S1, ..., S13) receives an access message (AB) transmitted by the mobile over the said beacon frequency (BCCH),

- a selection step (E2) in which one (Si) of the said base stations is selected as defining radio coverage for the mobile (M), as a function of measurements of reception level of the said access message (AB), and

- a transmission step (E3) in which an allocation message ([SDCCH]; [TCH]) is transmitted by the said base station (SP) of the umbrella cell (CP) on the said beacon frequency (BCCH) to the said mobile (M), the said allocation message identifying the dedicated channel ([SDCCH]; [TCH] which is available in the selected base station (Si, SP).

Figure to be published: FIG. 2

P/00/011 28/5/91
Regulation 3.2

AUSTRALIA

Patents Act 1990

ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT

Invention Title:

"MULTILAYER CELLULAR RADIO NETWORK"

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

This invention generally relates to a cellular radiocommunications network, or system, with mobiles and more particularly a multilayer cellular system composed firstly of a plurality of microcells, and secondly an umbrella cell with radio coverage covering the plurality of microcells. The invention in particular aims at providing a method of setting up a call with a mobile, and a method of transferring from microcell to microcell the call set up in this way in such a multilayer cellular system within which no microcell uses a beacon frequency. The invention finds application in particular in the G.S.M. (Global System for Mobile Communications) digital cellular network.

The American Patent US-A-4 723 266 (Perry) describes a multilayer cellular system in which the phases of call setup with a mobile are managed by the umbrella cell, with the objective of reducing the number of control channels in each microcell.

A call setup request message transmitted by a mobile is received, in the control channel, by a base station associated with the umbrella cell. In response to the receipt of this message, the umbrella cell base station allocates to the mobile, through the control channel, a temporary traffic channel for the requested call. The temporary traffic channel is set up between the umbrella cell base station and the mobile, and the setup requested call is temporarily conveyed through this traffic channel. Each microcell includes an additional receiver to receive and measure a power level in the temporary traffic channel conveying the call. Measurements are therefore returned by all microcells to the infrastructure equipment of the network. The infrastructure equipment selects those microcells which receive the signal of the call, conveyed in the temporary traffic channel, with the greatest power. The microcell selected is the microcell closest to the mobile, and the call is switched from the temporary traffic channel to a current traffic channel associated with the selected microcell. The switching, or cell to cell transfer, or handover, of the call is preceded by a message transfer phase of signalling with the mobile through the temporary traffic channel in order to indicate to the mobile the new channel, referred to as the current channel, which is allocated to the call.

Within the scope of a GSM network in particular, the above-mentioned patent has two main deficiencies.

With regard to the first deficiency, the document does not deal with inter-

microcell handover. It will be recalled that a beacon frequency in the GSM is transmitted continuously by a given cell and carries the channels BCCH (BroadCast CHannel) and CCCH (Common Control CHannel). The BCCH channel carries, in particular, frequency and time synchronisation bursts. The BCCH is used in addition during a preparation phase for a cell handover, with the purpose of determining, through measurement of power by the mobile, the cell to which it belongs. The CCCH channel, which is a two-way channel, includes an up-channel in the mobile-to-network direction which is intended to receive call messages from mobiles, and a down-channel in the network-to-mobile direction which is intended to transmit call messages to mobiles. It appears preferable to eliminate all microcell beacon frequencies and to use a single umbrella coverage beacon frequency. Such action infers a considerable gain in terms of frequency reuse. In effect, use of a continuously generated beacon frequency in a microcell prevents the same frequency being used in a neighbouring microcell. On the other hand, the technique of frequency hopping permits use of the same frequency which is generated sporadically in neighbouring cells, since this technique gives a significant statistical gain in accordance with the principal referred to as interference diversity, as explained in the document "The GSM-Global System for Mobile Communications" produced and published by M. MOULY and M. B. Pautet, 1992 Edition, pages 218-233. The sequences of frequency hopping lead to a low probability of interference in same frequency channels in neighbouring cells.

With regard to the second deficiency, the previously-mentioned American patent proposes a non-optimum technical solution according to which the call is conveyed temporarily in a channel associated with the umbrella cell, prior to its transfer onto a microcell traffic channel. It appears more advisable, insofar as all conditions are fulfilled, to directly set up a call in a channel associated with the microcell to which a mobile belongs rather than temporarily use an umbrella cell traffic channel as described in the studied American patent.

The invention aims to eliminate these two deficiencies.

According to the present invention, there is provided a method of setting up a dedicated channel between a mobile and a base station in a multilayer cellular

radiocommunications system with mobiles in the form of a plurality of microcells and an umbrella cell having radio coverage which covers the said plurality of microcells, the said microcells and umbrella cell being associated with respective base stations, is characterised according to the invention in that a single beacon frequency is defined and associated with the umbrella cell base station, and in that the said method includes the following steps:

- each base station receiving an access message transmitted by the mobile over the said beacon frequency,

- selecting one of the said base stations as defining radio coverage for the mobile, the selection being made as a function of measurements of reception level of the said access message, and

- transmitting an allocation message by the said umbrella cell base station on the said beacon frequency to the said mobile, the said allocation message identifying the dedicated channel which is available in the selected base station.

The invention also provides that a call with a mobile can be set up in a channel of the umbrella cell, for example in the case where the mobile is part of a coverage zone of the umbrella cell not covered by a microcell. For this purpose, the said selection step, in addition to being a function of the respective measurements of reception level at which the access message is received by the microcell base stations, is also a function of a reception level measurement of the said access message by the said umbrella cell base station.

The invention also provides a method of transfer from cell to cell in such a multilayer network. According to the invention, such a method of transferring a call from a first microcell base station to a second base station, which call is set up with a mobile in a multilayer cellular radiocommunications system with mobiles in the form of a plurality of microcells and an umbrella cell having a radio coverage which covers the said plurality of microcells, the said microcells and umbrella cell being associated with respective base stations, is characterised in that a single beacon frequency is defined and associated with the base station in the umbrella cell, and in that it includes the following steps:

- each microcell base station, which is adjacent to the said first microcell base

station and associated with the respective one of the plurality of microcells, receiving an up-channel signal of the call set up between the mobile and the first microcell base station,

- selecting, in the said second base station, one of the said base stations as defining radio coverage for the mobile, the selection being made as a function of respective measurements of the reception level of the said up-channel signal, and

- transmitting an allocation message by the said first microcell base station to the said mobile in a down-channel corresponding to the said up-channel, the said allocation message identifying an available channel in the said second base station.

The invention also provides that a call with a mobile can be transferred to a channel of the umbrella cell, for example in the case where the mobile moves to a coverage zone of the umbrella cell not covered by a microcell. To this end, the selection step is, in addition to the said respective measurements of reception level of the said access message, a function of a measurement of the reception level at which the mobile receives a signal transmitted at the said beacon frequency by the said umbrella cell base station.

A base station is also provided by the invention. The base station is characterised in that it does not transmit a beacon frequency and in that it includes, in addition a receiver to receive signals transmitted, firstly between mobiles and the umbrella cell base station in a beacon channel, and secondly between mobiles and microcell base stations in traffic channels.

Infrastructure equipment for implementing the method of setting up a dedicated channel includes selection means for selecting a base station with which a call with a mobile has to be set up, the selection being performed as a function of measurements of reception level, by the microcell base stations, of an access message transmitted by the mobile, and, possibly, a measurement of the reception level of the said access message by the said umbrella cell base station.

Infrastructure equipment for implementing the transfer method includes selection means for selecting a second base station, to which a call set up with a first microcell base station has to be handed over, the selection being performed as a function of measurements of reception level at which the microcell base stations

adjoining the said first base station receive the traffic channel set up with the said first base station, and, possibly, as a function of a measurement of the reception level at which the mobile receives a signal transmitted at the said beacon frequency by the said umbrella cell base station.

Other features and advantages of this invention will appear more clearly with reading of the following description and reference to the corresponding annexed drawings in which:

- Figure 1 represents schematically an umbrella cell microcell network;
- Figure 2 shows steps suitable for implementing a method according to the invention for setting up a traffic channel between a mobile and a microcell base station in a network of the type shown in Figure 1; and
- Figure 3 shows steps suitable for implementing a method according to the invention for handing over a call, set up between a mobile and a microcell base station, from microcell to microcell in a network of the type shown in Figure 1.

As mentioned in the preamble to the description, the prior art does not provide an umbrella cell microcell network allowing the handover from microcell to microcell combined with the lack of a beacon frequency for each microcell.

A carrier frequency, transmitted continuously and intended to convey common control channels, is referred to as a beacon frequency. These common control channels are by definition intended to receive signal messages from or to not just the one and only mobile. They are referred to as BCCH and CCCH in the GSM. By the technique of frequency hopping the lack of a beacon frequency, or BCCH frequency in GSM terminology, in each microcell avoids systematically redefining, for each addition of a new microcell base station, new planning of frequency reuse which aims to eliminate interference between identical beacon frequencies in the neighbouring cells. A beacon frequency is nevertheless provided, according to the invention, in the umbrella cell.

With reference to Figure 1, an umbrella cell microcell network, or system, includes a plurality of microcells C1, C2, C3, ..., C12 and C13 and an umbrella cell CP whose radio coverage covers each of the said plurality of microcells. The coverage of the umbrella cell CP is represented by a broken line [sic] in Figure 1. The microcells

C1 to C13 and umbrella cell CP are each associated with a base station S1 to S13 and SP. In practice, geographic zones can be covered by the umbrella cell CP without being covered by a microcell. Microcells therefore are not necessarily contiguous, and between two microcells a zone may not be covered by any microcell.

With reference to Figure 2, steps of a method according to the invention for setting up a traffic channel between a mobile M and a microcell base station Sj are now described. By contrast with the American patent quoted in the preamble to the description, the traffic channel is preferably set up directly between the microcell base station Sj and the mobile M, and no traffic channel is temporarily set up beforehand between the said mobile and the base station SP of the umbrella cell CP. The steps represented in Figure 2 involve both an incoming call and an outgoing call for the mobile M. It should be remembered that, in the case of an incoming call, the mobile receives a call message in a call channel conveyed by the CCCH and transmitted by the umbrella cell base station SP. The call channel is marked PCH for Paging CHannel.

Following reception of the call message in the case of an incoming call, or on the initiative of the mobile M in the case of an outgoing call, the mobile transmits, as shown by step E1, an access message, or burst, AB to the umbrella cell base station SP over an up-channel carried by the beacon frequency, or BCCH frequency. As represented schematically by the step E1, the access message AB transmitted by the mobile M to the station SP is received as well by the J=13 microcell base stations S1 to S13. The microcell base stations S1 to S13 each include an additional receiver intended to "listen" to the access messages transmitted by the mobiles on the beacon frequency of the umbrella cell base station SP. For each of the J=13 respective signals originating from the 13 additional receivers of the microcell base stations S1 to S13, a reception power level of the access message AB received by each microcell base station S1 to S13 can be measured. Reception power levels may be measured as zero for certain microcell base stations. Step E2 shows a Cartesian diagram of the reception power level P of the access message AB as a function of the base station Sj, j varying from 1 to 13.

According to the example in Figure 2, the station Sj has the greatest reception

power level marked Pmax. In order to confirm the presence of the mobile M in the coverage of the microcell Sj, or a variant of it, the level of reception quality of the message AB received by the microcell Sj can be measured.

By using measurements of reception power level and reception quality level of the message AB received by the various base stations S1 to S13, the step E2 aims to select Sj, one of these stations S1 to S13, as defining the microcell Cj to which the mobile M belongs at the instant of transmission of the access message AB by the mobile. The identity of the selected microcell base station Sj is then transmitted to the umbrella cell base station SP.

In accordance with the step marked E3, the umbrella cell base station SP then transmits an allocation message [SDCCH] or [TCH] to the mobile M in an up-channel of the beacon frequency BCCH. This message [SDCCH] or [TCH] identifies a dedicated channel which is available in the selected microcell base station Sj. A dedicated channel is a channel allocated for data exchange between a single mobile M and a base station.

As shown by step E4, a traffic channel TCH (Traffic CHannel) or a low rate signalling channel SDCCH (Stand-Alone Dedicated Control CHannel) is then set up between the selected station Sj and the mobile M.

In this way the dedicated channel TCH, or SDCCH, is set up directly between the mobile M and the microcell base station Sj without a channel being temporarily set up beforehand between the said mobile and the umbrella cell base station. It will become obvious to the expert that the access message AB can be replaced by any message transmitted by the mobile during the call setup phase, for listening by the microcell base stations with a view to determining the microcell to which the mobile M belongs.

The invention also provides that a call with a mobile can be set up in a channel of the umbrella cell, for example in the case where the mobile belongs to a coverage zone of the umbrella cell not covered by a microcell. In that case, selection according to step E2 of the base station with which the call is set up, in addition to being a function of the respective measurements of reception level of the access message AB received by the microcell base stations, is also a function of a measurement of

reception level of the access message received by the said umbrella cell base station. The message AB is received by the umbrella cell base station on the beacon frequency and more precisely, in the context of GSM, in the CCCH channel carried by the beacon frequency. Among all the microcell base stations and umbrella cell, the one which receives the access message AB with the greatest reception level is the one which is selected.

With reference to Figure 3, steps according to the invention are represented for handover, or transfer, from microcell to microcell, of a call set up with a mobile in a multilayer network of the type shown in Figure 1.

Initially, as represented by step E1', a traffic channel marked TCH is set up between the mobile M and a microcell base station marked Si. Each of the microcell base stations Sj adjacent or next to the base station Si include an additional receiver intended for listening to the up-component of such a traffic channel TCH set up between the mobile M and the station Si. From each of the respective signals originating from the additional receivers in the adjacent microcell base stations Sj, a reception power level of the TCH traffic up-channel received by each microcell base station Sj can be measured.

The step E2' shows a Cartesian diagram of the level of reception power P of the TCH channel as a function of the base station Sj, j defining the suffix of the neighbouring microcell base stations of the base station Si. According to the example shown in Figure 3, the station Sj' has the greatest reception power level. In order to validate the presence of the mobile M in the radio coverage of the microcell Sj', the level of reception quality of the TCH channel set up between the mobile M and the station Si can be measured by the station Sj'. Furthermore, the distinction between two channels using the same frequency in distinct cells results from the differentiation which is made, for example in the GSM, between the two channels by means of two respective distinct sequences (training sequence) carried by the bursts in the two channels. Thus according to step E2', by using measurements of power level and/or quality level of reception of the setup traffic channel TCH received by the various base stations Sj, one station, Sj', of the stations Sj, is selected as defining the microcell Cj' to which the mobile belongs and towards which the setup call has to be handed over.

The identity of the selected microcell base station Sj' is then transmitted to the microcell base station Si with which the call over the current TCH channel is set up.

As shown by step E3', the station Si then transmits an activation message in a known way in the TCH traffic down-channel, the said activation message handing over the call, marked HO[TCH], from microcell to microcell. The HO[TCH] message includes in addition the identity of a channel available in the selected microcell base station Sj'. In response to this handover phase, and as schematised by step E4', a new TCH traffic channel is set up between the mobile M and the station Sj'. This traffic channel is then listened to by the receivers in the microcell base stations Sj, distinct from and adjacent to the station Sj'. In what has been written before concerning the cell-to-cell handover, the TCH channel can be replaced by a SDCCH channel.

The invention also provides that a call with a mobile can be handed over in a channel of the umbrella cell, for example in the case where the mobile progresses towards a coverage zone in the umbrella cell not covered by a microcell. In that case, the selection according to step E2' of the base station to which the call is handed over, in addition to being a function of the respective measurements of reception level of the TCH up-channel received by the microcell base stations, is also a function of a power level of the beacon frequency signal measured by the mobile M and retransmitted to the mobile network. It should be recalled that in GSM, a mobile retransmits power measurement messages to the base station with which it is connected, in a "slow" channel SACCH which is associated with a dedicated channel, typically a traffic channel. According to the invention, in the case where a call is set up with the mobile via a microcell base station, the power measurement information sent by the mobile to the network, via the said microcell base station, relates to the power level of the beacon frequency signal transmitted by the umbrella cell base station. This power measurement information retransmitted by the mobile to the network, and the respective measurements of reception level of the TCH up-channel received by the microcell base stations, allow selection of that one of the microcell base stations and umbrella cell to which the setup call has to be handed over.

As shown by the steps E3 and E3' in Figures 2 and 3, a microcell base station or umbrella cell for implementing the method according to the invention must include

means for receiving from infrastructure equipment in the mobile network a message identifying a channel [SDCCH], [TCH], HO[TCH]. The information in the message identifying this channel is retransmitted to the mobile M in a setup channel. In the case of setting up a call, the setup channel is the BCCH. In the case of a handover, the setup channel is the TCH traffic channel in which the call is at present transmitted. In addition, a microcell base station according to the invention includes a receiver for receiving the transmitted signals, on the one hand between mobiles M and the umbrella base station SP in a beacon channel, or BCCH channel so as to receive the bursts AB, and on the other hand between the mobiles and the other microcell base stations in order to listen to the TCH traffic channels in expectation of cell handovers.

The specialist will acknowledge the fact that handover of a call set up with a mobile can be effected from the umbrella cell CP to a microcell. The solution provided is as follows. Each microcell includes an additional receiver to receive and measure a power level in the traffic channel set up between the mobile and the umbrella cell. Measurements of power and/or quality levels of the traffic channel can thus be returned by all the microcells to infrastructure equipment in the network. The infrastructure equipment selects that one of the microcells which receives the call signal with the greatest power conveyed in the umbrella cell traffic channel. The selected microcell is the closest microcell to the mobile, and the call is switched from the traffic channel of the umbrella cell to a traffic channel associated with this selected microcell. The handover of the call from umbrella cell to microcell is preceded by a phase of signal message transfer between the umbrella cell base station and the mobile by means of the traffic channel in order to signal to the mobile the new microcell channel which is allocated to the call.

Furthermore, the specialist will appreciate that, in accordance with the GSM, cell-to-cell handover can be implemented conventionally in the case where a mobile leaves the coverage of the umbrella cell CP. The handover is the result of listening by the said mobile to the beacon frequencies of the umbrella cell and neighbouring cell(s) (not shown). In addition, it should be noted that infrastructure equipment, which can be a base station controller, plays an important role in the context of the invention. Firstly, the infrastructure equipment includes means for selecting a base

station with which a call with a mobile has to be set up, as a function of measurements of reception level at which the microcell base stations receive an access message transmitted by the mobile. According to the variant of the method of the invention, which provides that a call may be set up in a channel of the umbrella cell base station, the selection means select the base station with which a call with a mobile has to be set up, as a function not only of measurements of reception level at which the microcell base stations receive an access message transmitted by the mobile, but also as a function of a measurement of reception level at which the said umbrella cell base station receives the said access message.

Secondly, the infrastructure equipment includes means for selecting a second base station to which a call set up with a first microcell base station has to be transferred, as a function of measurements of reception levels at which the microcell base stations next to the said first base

station receive the traffic channel set up with the said first base station. In the case of the variant which allows that the call may be transferred to a channel of the umbrella cell, the selection means select the second base station as a function not only of measurements of reception level at which the microcell base stations next to the said first base station receive the traffic channel set up with the said first base station, but also as a function of a measurement of reception level at which the mobile receives a signal transmitted on the said beacon frequency by the said umbrella cell base station.

The claims defining the invention are as follows:

1. A method of handing over to a second base station a call between a mobile and a first base station, the call being set up in a multilayer cellular radiocommunications system with mobiles, the system being in the form of a plurality of microcells and an umbrella cell having radio coverage covering the plurality of microcells, the microcells and umbrella cell being associated with respective base stations, wherein, in accordance wih the method, a single beacon frequency is defined and associated with the base station of the umbrella cell, and wherein the method includes the following steps:

- a reception step in which each microcell base station, which is adjacent to the first microcell base station and associated with the respective one of the plurality of microcells, receives an up-channel signal of the call set up between the mobile and the first microcell base station;

- a selection step in which one of the base stations having radio coverage for the mobile is selected as the second base station as a function of respective measurements of reception level of the up-channel signal; and

- a transmission step in which an allocation message is transmitted by the first microcell base station to the mobile in a down-channel corresponding to the up-channel, the allocation message identifying an available channel in the second base station.

2. A method as claimed in Claim 1, in which the base station selected as the second base station may include the umbrella cell base station, wherein the selection step, in addition to being a function of the respective measures of reception level at which the access message is received, is also a function of a measurement of reception level at which the mobile receives a signal transmitted at the beacon frequency by the base station of the umbrella cell.

3. A method of setting up communication between a mobile and a base station in a multilayer cellular radiocommunications system with mobiles, and hnding over the communication to another base station within the system, the system being in the form of a plurality of microcells and umbrella cell having radio coverage covering the plurality of microcells, the microcells and umbrella being associated with respective base stations, wherein a single beacon frequency is defined and associated with the

base station of the umbrella cell, and in that the method includes the following steps:

- a reception step in which each base station receives an access message transmitted by the mobile over the beacon frequency,

- a selection step in which a first base station is selected as defining radio coverage for the mobile, as a function of measurements of reception level of the access message,

- a transmission step in which an allocation message is transmitted by the base station of the umbrella cell on the beacon frequency to the mobile, the allocation message identifying a dedicated channel,

- the communication being handed over to a second base station by the method of claim 1 or claim 2.

4. A method as claimed in Claim 3, in which the selected base station may be the umbrella cell base station, wherein the selection step, in addition to being a function of respective measurements of reception level at which the access message is received by the microcell base stations, is also a function of a measurement of reception level at which the access message is received by the umbrella cell base station.

5. A microcell base station in a cellular radiocommunications network with mobiles for implementing the method as claimed in any one of Claims 1 to 4, wherein the base station does not transmit a beacon frequency, and wherein the base station further includes:

a receiver for receiving signals transmitted, firstly between mobiles and the umbrella cell base station in a beacon channel, and secondly between mobiles and microcell base stations in the traffic channels.

6. Control equipment for implementing the method as claimed in any one of claims 1 to 4, including selection means for selecting a base station with which a call with a mobile has to be set up, selection criteria including a function of respective measurements of reception level at which the microcell base stations receive an access message transmitted by the mobile.

7. Control equipment as claimed in Claim 6 for implementing the method as claimed in Claim 2, wherein the selection means, includes in the selection criteria a function of a measurement of reception level at which the umbrella cell base station receives the access message.

8. Control equipment for implementing the method as claimed in any one of Claims 1 to 4, including selection means for selecting a second base station to which a call set up with a first microcell base station has to be handed over, the selection being made as a function of measurements of reception level at which the microcell base stations next to the first base station receive the traffic channel set up with the first base station.

9. Control equipment as claimed in Claim 8, wherein the selection means select the second base station as a function furthermore of a measurement of reception level at which the mobile receives a signal transmitted at the beacon frequency by the umbrella cell base station.

10. A method of establishing and handing-over a call substantially as herein described with reference to Figures 1 - 2 of the accompanying drawings.

11. *Control equipment* substantially as herein described with reference to Figures 1 - 2 of the accompanying drawings.

DATED THIS *TWENTY-NINTH* DAY OF OCTOBER 1998

ALCATEL N.V.

FIG.1

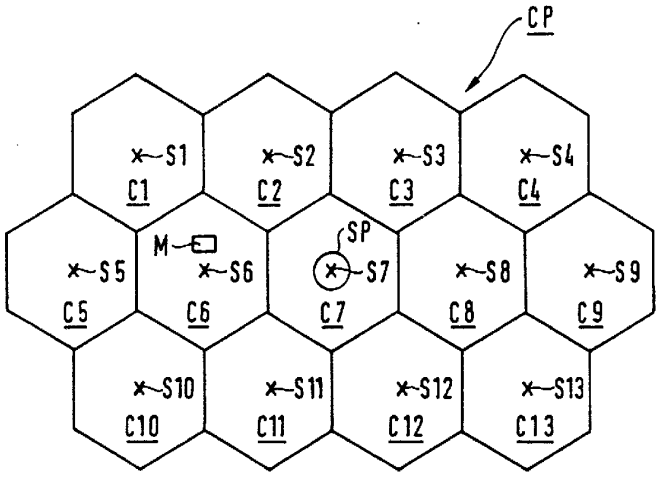
CP
S1
S2
S3
S4
C1
C2
C3
C4
M
SP
S5
S6
S7
S8
S9
C5
C6
C7
C8
C9
S10
S11
S12
S13
C10
C11
C12
C13

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FIG. 2

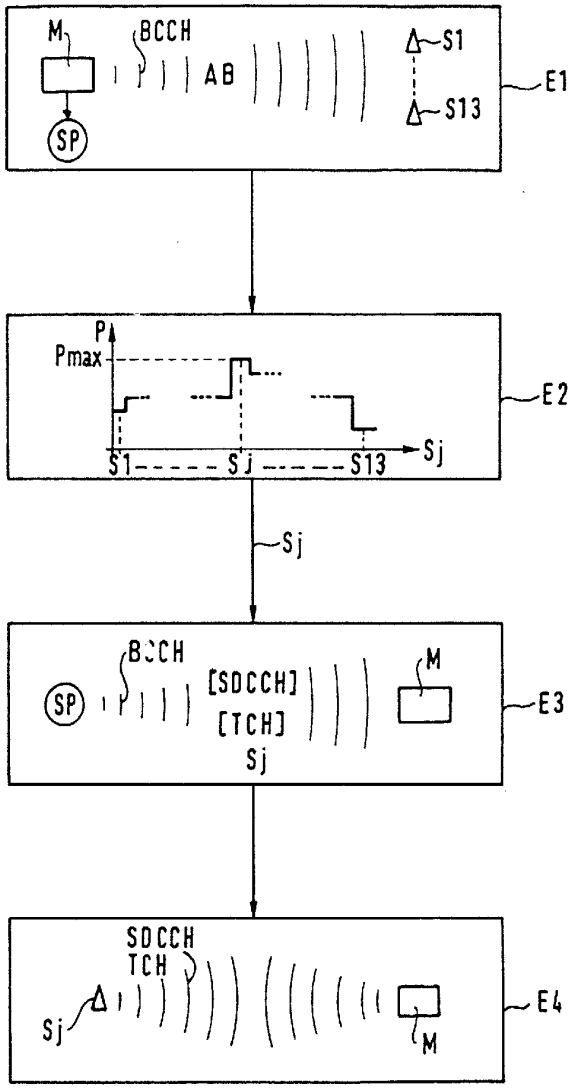

FIG. 3