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(54) Title: A REPEATER SYSTEM FOR EXTENDED CELL COVERAGE

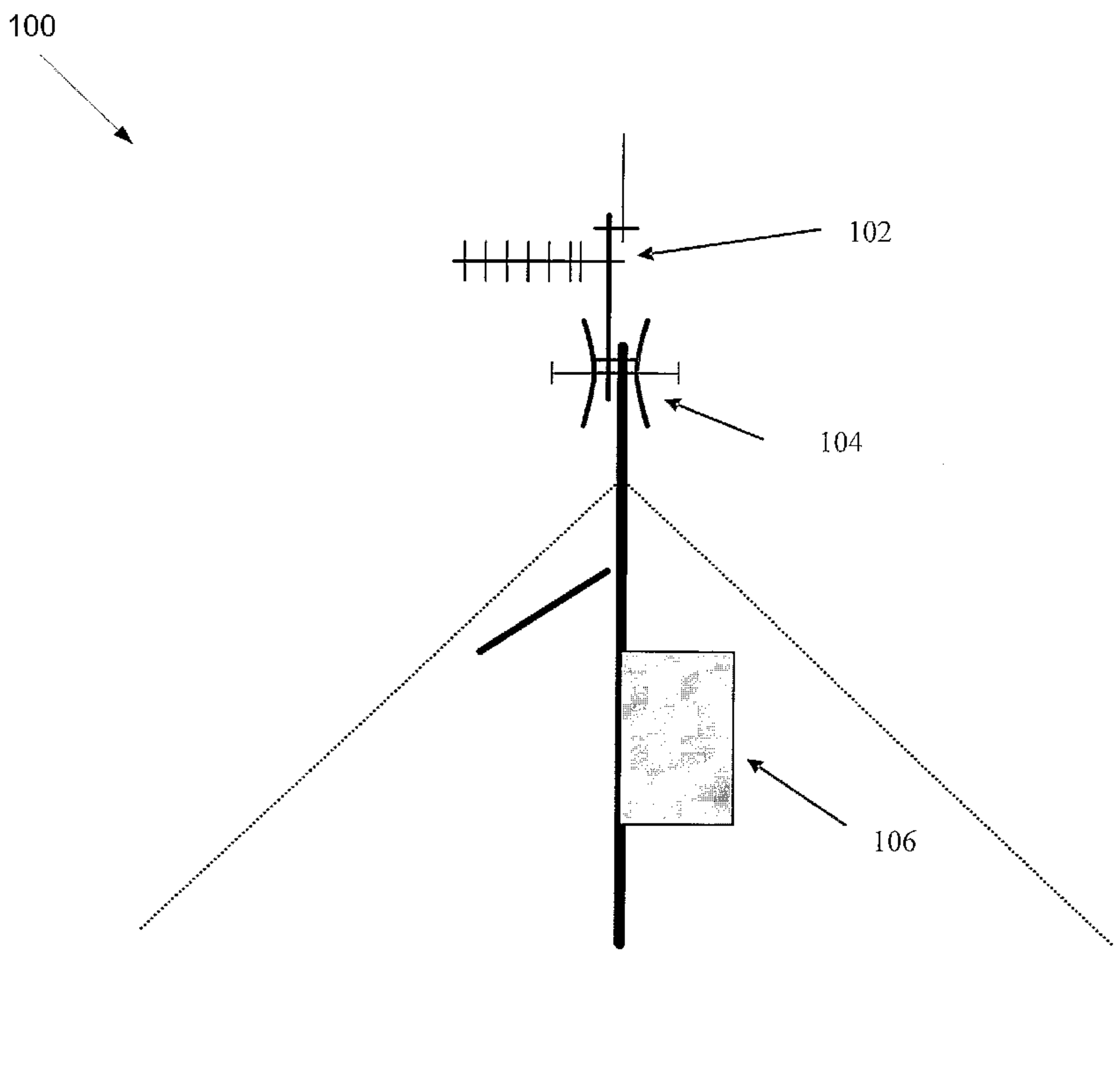

FIGURE 1

(57) Abrégé/Abstract:
A repeater system for extending cell coverage, including a frequency band translation repeater for transmitting radio frequency (RF) signals to and receiving RF signals from a base station and translating between the frequency band of THE RF signals and a different frequency band for RF transmission directly between the repeater and user equipment.

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(54) **Title:** A REPEATER SYSTEM FOR EXTENDED CELL COVERAGE

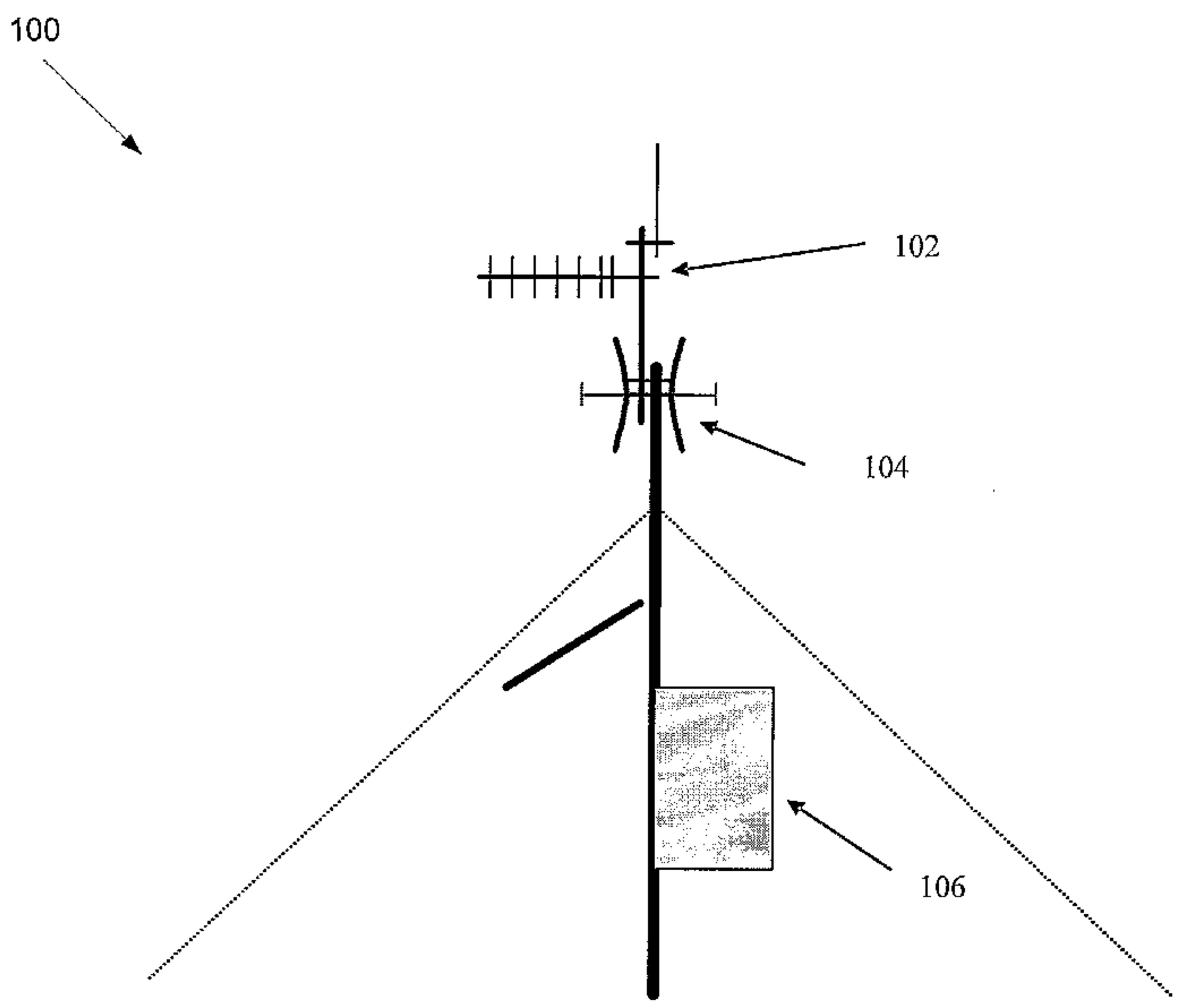

FIGURE 1

(57) **Abstract:** A repeater system for extending cell coverage, including a frequency band translation repeater for transmitting radio frequency (RF) signals to and receiving RF signals from a base station and translating between the frequency band of THE RF signals and a different frequency band for RF transmission directly between the repeater and user equipment.

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A REPEATER SYSTEM FOR EXTENDED CELL COVERAGE

FIELD

The present invention relates to a repeater system that can be used to extend cell coverage of a public land mobile telecommunications system.

BACKGROUND

The base stations of public land mobile telecommunications networks each have a radio range determined by the characteristics of their transmitting and receiving equipment and their location. The range determines the coverage area of the cell of the base station in which user equipment (UE), such as a telephone handset, is able to establish a communications channel with the base station. Accordingly, the coverage of the network is determined by both the selection and position of the base station of the network. Coverage in remote areas is always problematic, as it is generally cost prohibitive to install a base station in an area where usage of the network is very low. Accordingly, alternatives need to be adopted in order to extend network service to users in remote locations.

One alternative for remote locations is the use of satellite telecommunications infrastructure. Satellite telephones and access charges to satellite networks are however costly. Another alternative which has been used in Australia is to place mobile handset equipment at the edge of a mobile network's coverage, and then run a fixed copper line from the handset to terminal equipment at the remote location, e.g. the user's home. This gives rise to disadvantages associated with installation and maintenance of the copper lines for users, together with the cost of having the dedicated phones placed at the edge of the network.

Two other alternatives involve the use of radio frequency (RF) repeater systems. These are:

(i) a RF repeater at the edge of the coverage of the network so as to directly retransmit or relay the RF signals to and from the donor base station of the cell and the UE at a remote location outside of the coverage area. This, however, introduces the problem of feedback between the receiving and transmitting antennas of the repeater. Attempts have been made to reduce this feedback by introducing echo cancellers to remove the original signal at the repeater from the retransmitted signal, but this has proved expensive and feedback still occurs, such as from reflections from transport vehicles moving within the area.

(ii) a two stage RF translation system including a RF translator located at the donor base station of the cell to translate the RF signals from the donor base station to a different carrier frequency to that of the network for transmission to a RF repeater located on the edge of the coverage area. The repeater in turn then translates the received RF signals from the RF translator back to the original carrier frequency for transmission to the UE. RF transmission from the UE is similarly translated at the repeater site to communicate with the RF translator and hence to the donor base station. This however is a more expensive solution than (i) and suffers the disadvantage of having to install and maintain additional equipment at the base station as well infrastructure at the repeater site.

Accordingly, it is desired to address the above, or at least provide a useful alternative.

SUMMARY

In accordance with the present invention there is provided a repeater system for extending cell coverage, including a frequency band translation repeater for transmitting radio frequency (RF) signals to and receiving RF signals from a base station and translating between the frequency band of said RF signals and a different frequency band for RF transmission directly between the repeater and user equipment.

The present invention also provides a repeater system, including:

a donor port for a frequency band of a base station of a mobile telecommunications network;

a service port for a different frequency band, the different frequency band including a carrier frequency for communication with user equipment of the network; and

a repeater circuit for converting signals on the donor port and the service port between the bands.

The present invention also provides a method of extending cell coverage for a Universal Mobile Telecommunications System (UMTS) network, including:

retransmitting signals on the UMTS operating band of the network as signals on one or more different UMTS operating bands; and

retransmitting signals of the one or more different UMTS operating bands as signals on the operating band of the network.

DESCRIPTION OF DRAWINGS

Preferred embodiments of the present invention are hereinafter described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a diagram of a preferred embodiment of a repeater system in accordance with the present invention;

Figure 2 is a block circuit diagram of a repeater of the system;

Figure 3 is a flow diagram of a cell selection process performed by user equipment when using the system;

Figure 4 is a schematic illustration showing use of the system to extend cell coverage; and

Figure 5 is a schematic diagram illustrating use of two embodiments of the system to extend cell coverage.

DETAILED DESCRIPTION

A repeater system 100, as shown in Figure 1, can be placed within the area of coverage of an existing telecommunications network to extend the coverage of that network without requiring any modification to be made to the standard user equipment (UE) that is normally used for that network. Cell coverage can be considerably extended outside of and beyond the existing range of the network by placing the system 100 at the edge of coverage of a cell of the network. The system 100 includes a first antenna 102 for the carrier frequency of the network, a second antenna 104 for a different carrier frequency on which the user equipment can also operate, and a repeater 106 connected to the antennas 102 and 104 so as to translate between the frequency bands of the two carrier frequencies.

The repeater system 100 is a single stage translation system and is particularly applicable to Universal Mobile Telecommunications System (UMTS) networks, i.e. 3G Networks, which operate according to the standards of the 3rd Generation Partnership Project (3GPP). The 3GPP has established standard operating bands for all user equipment, i.e. mobile terminals. The operating bands are set out in the table below.

Operating Band	UL Frequencies UE transmit, Node B receive	DL frequencies UE receive, Node B transmit
I	1920 - 1980 MHz	2110 -2170 MHz
II	1850 -1910 MHz	1930 -1990 MHz
III	1710-1785 MHz	1805-1880 MHz
IV	1710-1755 MHz	2110-2155 MHz
V	824 - 849 MHz	869-894 MHz
VI	830-840 MHz	875-885 MHz
VII	2500-2570 MHz	2620-2690 MHz
VIII	880 - 915 MHz	925 - 960 MHz
IX	1749.9-1784.9 MHz	1844.9-1879.9 MHz
X	1710-1770 MHz	2110-2170 MHz

The radio access networks (RANs) provided by the base stations of UMTS mobile networks accordingly use a selected one of the operating bands that is normally determined by the telecommunications provider. For example, in Australia two networks provided by different service providers, e.g. carriers, are UMTS networks that operate using Band I. For these networks the carrier frequencies are referred to as being 2100 MHz. Another network provided in Australia, however, is a UMTS network that operates using Band V and is referred to as using a carrier frequency of 850 MHz. Operating on the 850 MHz band provides greater reach and penetration thereby extending the range for each base station on the network. For simplicity of description, the repeater system 100 is hereinafter described as operating between Bands I and V, although the repeater system could be used to translate between any two or more of the operating bands, provided the bands on one side (i.e. port 202) of the repeater 106 are different to those on the other side (i.e. port 204) of the repeater.

To shift between Band V and Band I, the first antenna 102 is configured to receive and transmit from a first band at 850 MHz, and is a standard base station antenna of the existing 850 MHz network. The first antenna 102 is placed within the range of coverage of a cell 404 of the 850 MHz network provided by an 850 MHz base station 402, as shown in Figure 4. The repeater 106 has one port 202 connected to the antenna 102 and is placed in a shelter at the base of the antenna structure. A second port 204 of the repeater 106 is connected to a 2100 MHz antenna 104 which is configured and positioned to establish a new and extended cell 406 operating on the 2100 MHz band. The second antenna 104 may be a Yagi or Omnidirectional antenna.

The repeater 106, as shown in Figure 2, has a donor port 202 that provides an 835 MHz uplink signal and an 880 MHz downlink signal for the first antenna 102. A service port 204 of the repeater 106 provides a 1950 MHz uplink signal and a 2140 MHz downlink signal for the second antenna 104.

The circuitry for the downlink part of the repeater 106 includes a duplexer for the donor port 202 that includes a downlink part 206 with an 880 MHz band pass filter. This is connected to a downlink low noise amplifier 208. The output of the amplifier 208 is connected to a variable gain amplifier 210 that can be adjusted by a gain control circuit 230. The gain control may be automatic based on the power level of the common pilot channel (CPICH) of the RAN signals. A first superheterodyne mixer 212 receives the output of the amplifier 210 and produces an intermediate frequency (IF). The intermediate frequency is selected by a first voltage controlled oscillator (VCO) 224, that in turn is controlled by a phase locked loop (PLL) circuit 226. The PLL circuit 226 is driven by a high stability reference oscillator 228. The PLL circuit 226 also includes a control microprocessor for controlling other circuit components of the repeater 106.

An intermediate frequency terminal filter 214 receives the output of the first mixer 212. The filter 214 is a SAW filter that is configured to provide filtering at the intermediate frequency to achieve single channel filtering, i.e. for a UMTS channel of 5 MHz. The bandwidth of the SAW filter 214 can be expanded by multiples of 5 MHz so as to allow additional channels to be retransmitted by the repeater 106, if desired. A second mixer 216 converts the filtered intermediate frequency signal to the downlink service port frequency of 2140 MHz. The output of the mixer 216 is connected to a power amplifier 218 which drives a duplexer for the service port 204 that includes a downlink part 220 with a 2140 MHz band pass filter. The second mixer 216 is driven by a second voltage controlled oscillator (VCO) 230 that is also controlled by the PLL 226. The output of the power amplifier 218 provides a feedback signal to the variable gain amplifier 210 for control purposes.

The circuitry is effectively repeated for the uplink part of the repeater 106. An uplink part 256 of the service port duplexer includes a band pass filter for 1950 MHz. The output of this filter is fed to a second low noise amplifier 258, which in turn is connected to a second variable gain amplifier 260. The output of the amplifier 260 is connected to a third mixer 262 which down converts the up link frequency of the service port 204 to the intermediate frequency. The mixer 262 is driven by a third VCO 280. The down converted signal is fed to a second intermediate frequency filter 264 that is the same as the first IF filter 214.

The output of the second filter 264 is passed to a fourth mixer 266 that is driven by a fourth VCO 274. The mixer 266 produces a signal at the 835 MHz uplink frequency. The signal is amplified by a second power amplifier 268, the output of which is fed to the uplink part 270 of the duplexer of the donor port 202. The gain control circuit 230 is also able to control the gain of the second variable gain amplifier 260 based on the level obtained from the CIPCH (the common pilot channel).

The user equipment 410 for a UMTS network is able to move between a cell 404 of the network, and the extended cell 406 by using the frequency and channel selection control logic that is built into the user equipment 410. For example, when a user terminal 410 of the network is switched on within the extended cell 406 (302), as shown in Figure 3, the UE 410 first searches for the common pilot channel (CIPCH) on the last stored carried frequency, i.e. a frequency of Band V of the network (304). If no suitable signal is found on that carrier frequency, the UE starts to search for other public land mobile networks at frequencies stored in the terminal's UMTS subscribed identity module (SIM) (306). If no suitable signal is found on other SIM frequencies, the UE begins to scan all of the UMTS operating bands (308). The UE locks onto the strongest carrier frequency found and reads information available from a broadcast control channel (BCCH) (310) of the UMTS network location. Accordingly, it will locate the repeated signal of the 850 MHz network on the 2100 MHz band and then using data available on the BCCH will seek to register with the network (312). The process looks for a match between the Mobile Network Code (MNC) and Mobile Country Code (MCC) of the PLMN received and that stored in the USIM. It also looks to determine if the Signal Quality Level (Squal) and Signal Receive Level (Srslev) received are sufficient before successfully registering with the PLMN. If registration is successful then the UE 410 will camp on the extended cell 406 at the 2100 MHz band which effectively means it is camping on the cell 404 (314). If registration is unsuccessful, then the UE 410 will record the LA (Location Area) of the rejected cell and simply move to the next strongest carrier frequency and attempt the registration process again.

A UE 410 can also move between the cells 404 and 406 by relying on the measurements the UE takes regarding the signals from neighbouring cells, notwithstanding that they are of different bands. Neighbouring cells are ranked on quality by the UE 410 based on data obtained from the CIPCH and the ranking can trigger re-selection to a different cell. When this occurs the UE 410 will move to the different cell.

In addition to extending cell coverage to one area, the repeater system 100 can also be used to extend the extended cell 406 to a further extended cell 502 at a different band. This can be done using another repeater system 504 that is essentially the same as the first repeater system 100 but which translates between the extended band of the cell 406 to another band for the further extended cell 502. This other band may be the same as the band of the network of the first cell 404.

In addition to extending cell coverage to a new location, the repeater system 100 can also be used to provide extended coverage within an existing cell 404 at different frequencies or a different operating band. For example, the repeater system 100 could be used at an airport to translate between the band of a network that covers the airport to the band of a visitor's UE that they use at home. The repeater system 100 could also be used to improve coverage in poor coverage areas, such as within a building. This can be done by mounting the system 100 within windows or specific areas to reduce black spots. Also, with interference that might be created by adjacent cells of a UMTS network, the repeater system 100 could be used to improve access to or performance of the High Speed Downlink Packet Access (HSDPA) system. The repeater system 100 could also be used to provide selective repeating for the bands of selected carriers (i.e. service providers) to certain locations in circumstances where a carrier only operates on one band. UEs could also be locked to a single band or a repeated band only and then coverage provided in an area by the repeater system 100 specifically for those UEs. This can be particularly useful for emergency services where quick and high reliability local coverage may be required and network capacity controlled. Coverage enhancement and signal quality enhancement can also be provided for particular hot spot areas with small coverage by installing the repeater system 100 at the hot spot.

Many modifications will be apparent to those skilled in the art without departing from the scope of the present invention herein described with reference to the accompanying drawings. For example, one antenna for two or more bands can be connected to both the donor port 202 and the service port 204 rather than having dedicated antennas for each port.

CLAIMS:

1. A repeater system for extending cell coverage, including a frequency band translation repeater for transmitting radio frequency (RF) signals to and receiving RF signals from a base station and translating between the frequency band of said RF signals and a different frequency band for RF transmission directly between the repeater and user equipment.

2. A repeater system as claimed in claim 1, wherein the system extends an area of said cell coverage of said base station to another area.

3. A repeater system as claimed in claim 2, including another frequency band translation repeater for transmitting and receiving said RF signals at said different frequency band and translating between said different frequency band and another frequency band for RF transmission directly between said another repeater and user equipment.

4. A repeater system as claimed in claim 3, wherein said another frequency band is the frequency band of said base station.

5. A repeater system as claimed in claim 1, wherein the system provides coverage at said different frequency band within an area of said cell coverage of said base station.

6. A repeater system as claimed in claim 5, wherein said coverage at said different frequency band is for said user equipment which does not operate at said frequency band of said base station.

7. A repeater system as claimed in any one of the preceding claims, wherein the frequency band and the different frequency band are bands of a Universal Mobile Telecommunications System (UMTS) network.

8. A repeater system as claimed in claim 7, wherein the user equipment is for a UMTS network and communicates at said different frequency band.

9. A repeater system including a repeater, including:

a donor port for a frequency band of a base station of a mobile telecommunications network;

a service port for a different frequency band, the different frequency band including a carrier frequency for communication with user equipment of the network; and

a repeater circuit for converting signals on the donor port and the service port between the bands.

10. A repeater system as claimed in claim 9, wherein the repeater circuit includes a downlink circuit for translation from the first band to the second band, and an uplink circuit for translation from the second band to the first band.

11. A repeater system as claimed in claim 10, wherein the downlink circuit and the uplink circuit include a gain amplifier controlled based on a power level determined from signals received on the donor port and the service port, respectively.

12. A repeater system as claimed in claim 9, wherein the system extends an area of cell coverage of said base station to another area.

13. A repeater system as claimed in claim 12, including another repeater for converting said signals at said different frequency band and to another frequency band for communication directly between the another repeater and user equipment.

14. A repeater system as claimed in claim 13, wherein said another frequency band is the frequency band of said base station.

15. A repeater system as claimed in claim 9, wherein the system provides coverage at said different frequency band within an area of cell coverage of said base station.

16. A repeater system as claimed in claim 15, wherein said coverage at said different frequency band is for said user equipment which does not operate at said frequency band of said base station.

17. A repeater system as claimed in any one of claims 9 to 16, wherein the frequency band and the different frequency band are bands of a Universal Mobile Telecommunications System (UMTS) network.

18. A repeater system as claimed in claim 17, wherein the user equipment is for a UMTS network and communicates at said different frequency band.

19. A method of extending cell coverage for a Universal Mobile Telecommunications System (UMTS) network, including:

retransmitting signals on the UMTS operating band of the network as signals on one or more different UMTS operating bands; and

retransmitting signals of the one or more different UMTS operating bands as signals on the operating band of the network.

20. A method as claimed in claim 19, wherein said method is performed at a site in the UMTS network by a frequency band translation repeater circuit.

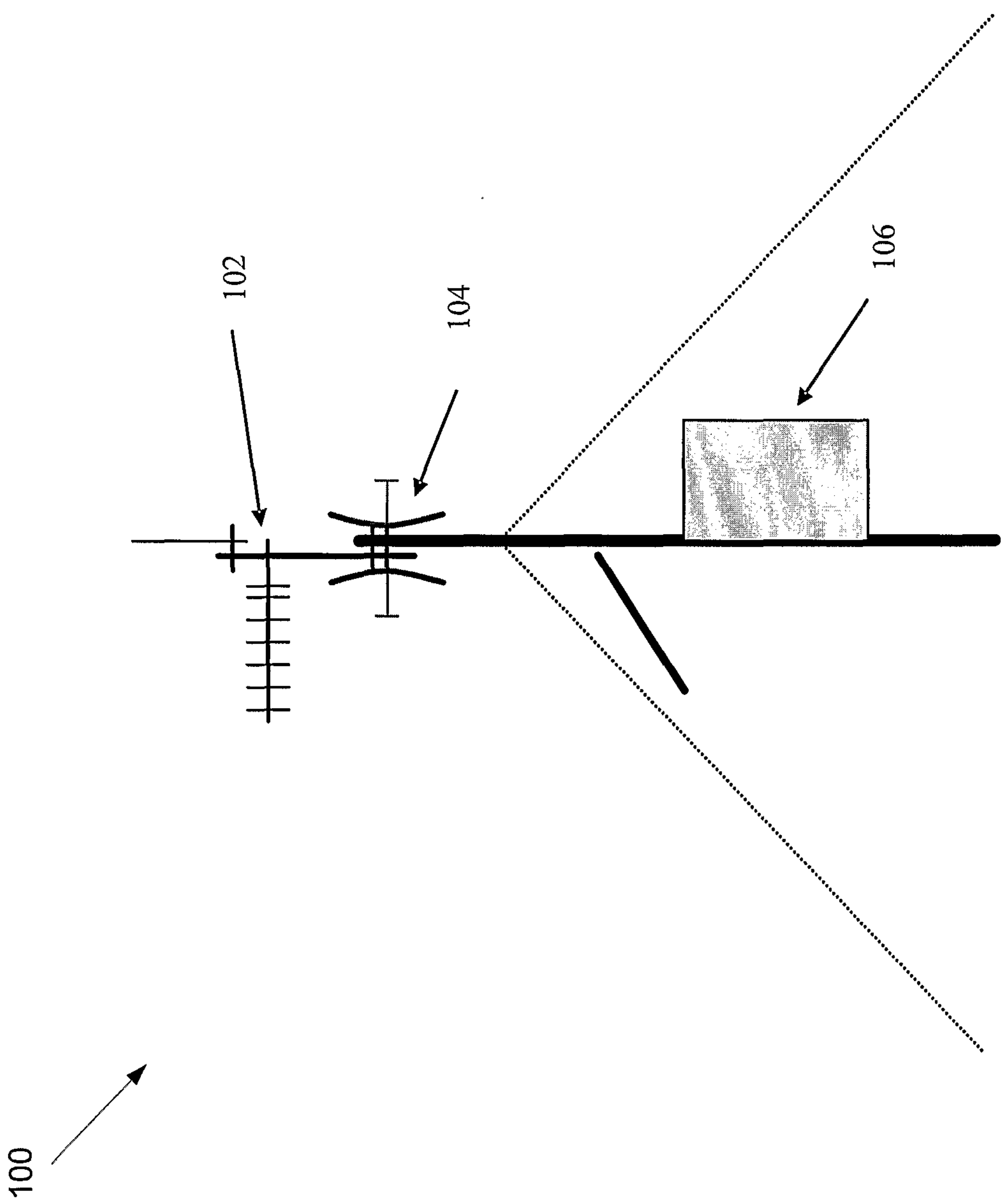

FIGURE 1

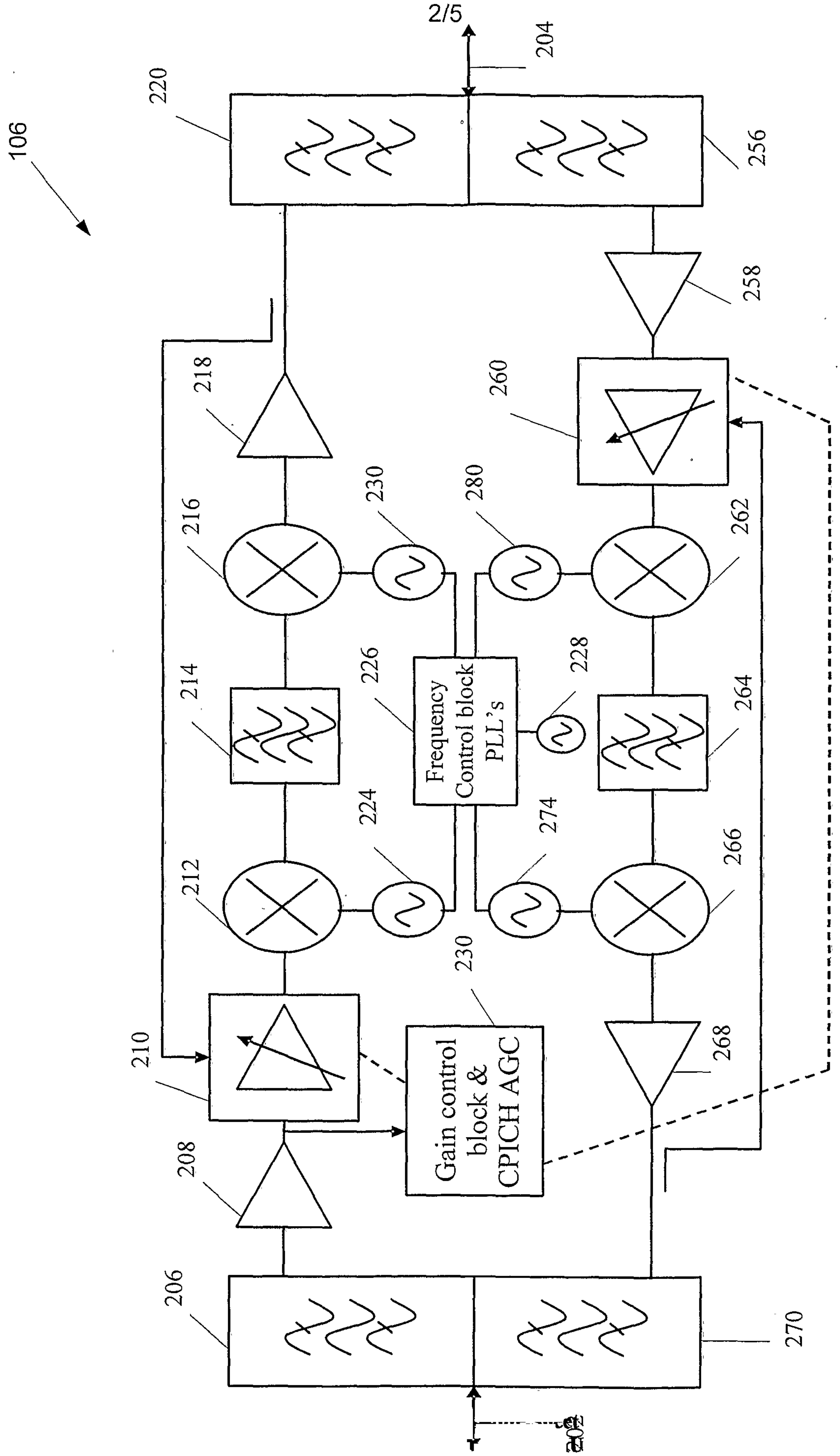
106
220
204
256
258
260
218
216
230
280
262
226
Frequency
Control block
PLL's
228
214
264
224
274
212
266
230
210
Gain control
block &
CPICH AGC
268
208
206
270
202

FIGURE 2

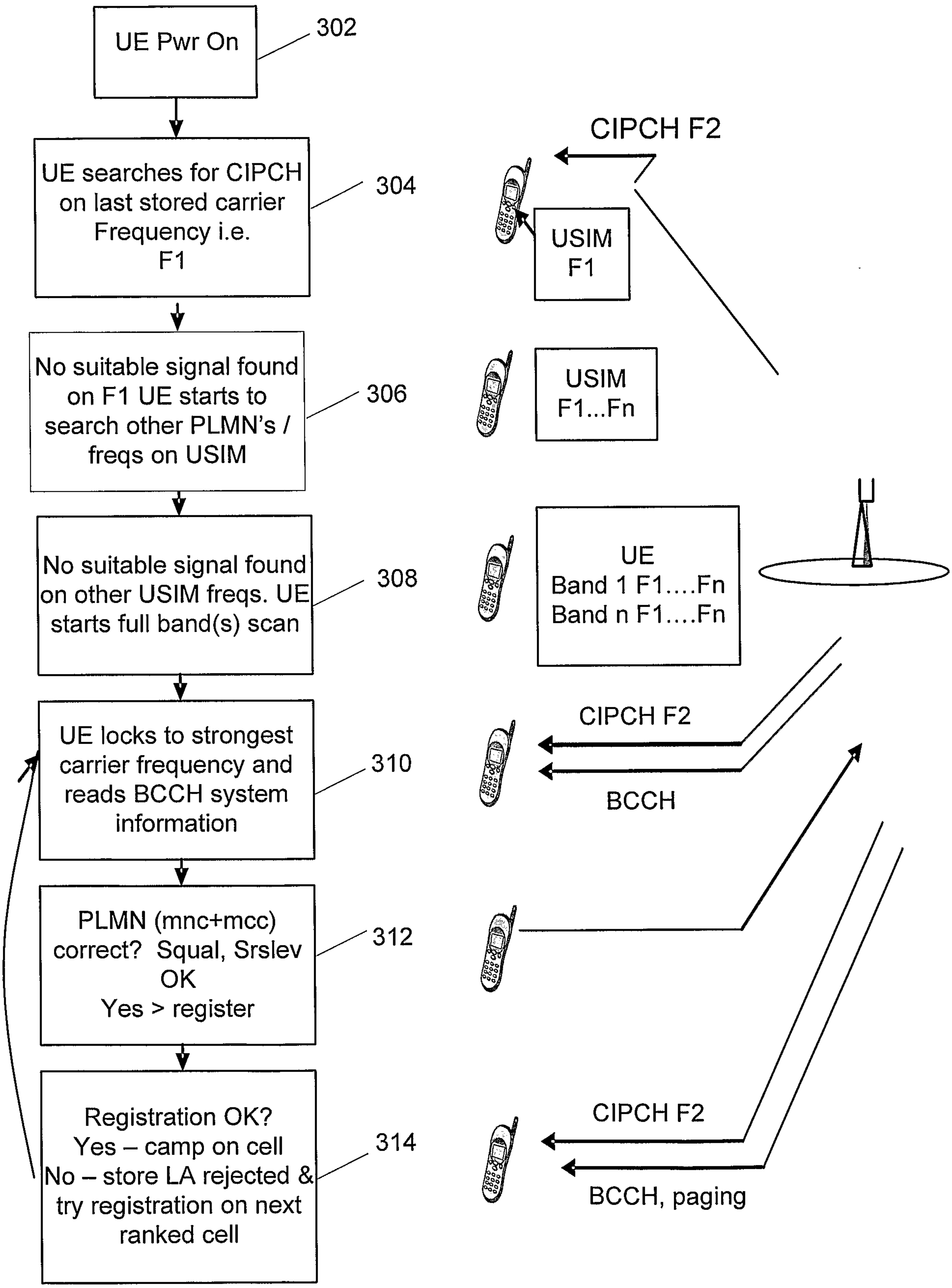
UE Pwr On
302
UE searches for CIPCH on last stored carrier Frequency i.e. F1
304
No suitable signal found on F1 UE starts to search other PLMN's / freqs on USIM
306
No suitable signal found on other USIM freqs. UE starts full band(s) scan
308
UE locks to strongest carrier frequency and reads BCCH system information
310
PLMN (mnc+mcc) correct? Squal, Srslev OK
Yes > register
312
Registration OK?
Yes – camp on cell
No – store LA rejected & try registration on next ranked cell
314
CIPCH F2
USIM
F1
USIM
F1...Fn
UE
Band 1 F1....Fn
Band n F1....Fn
CIPCH F2
BCCH
CIPCH F2
BCCH, paging

FIGURE 3

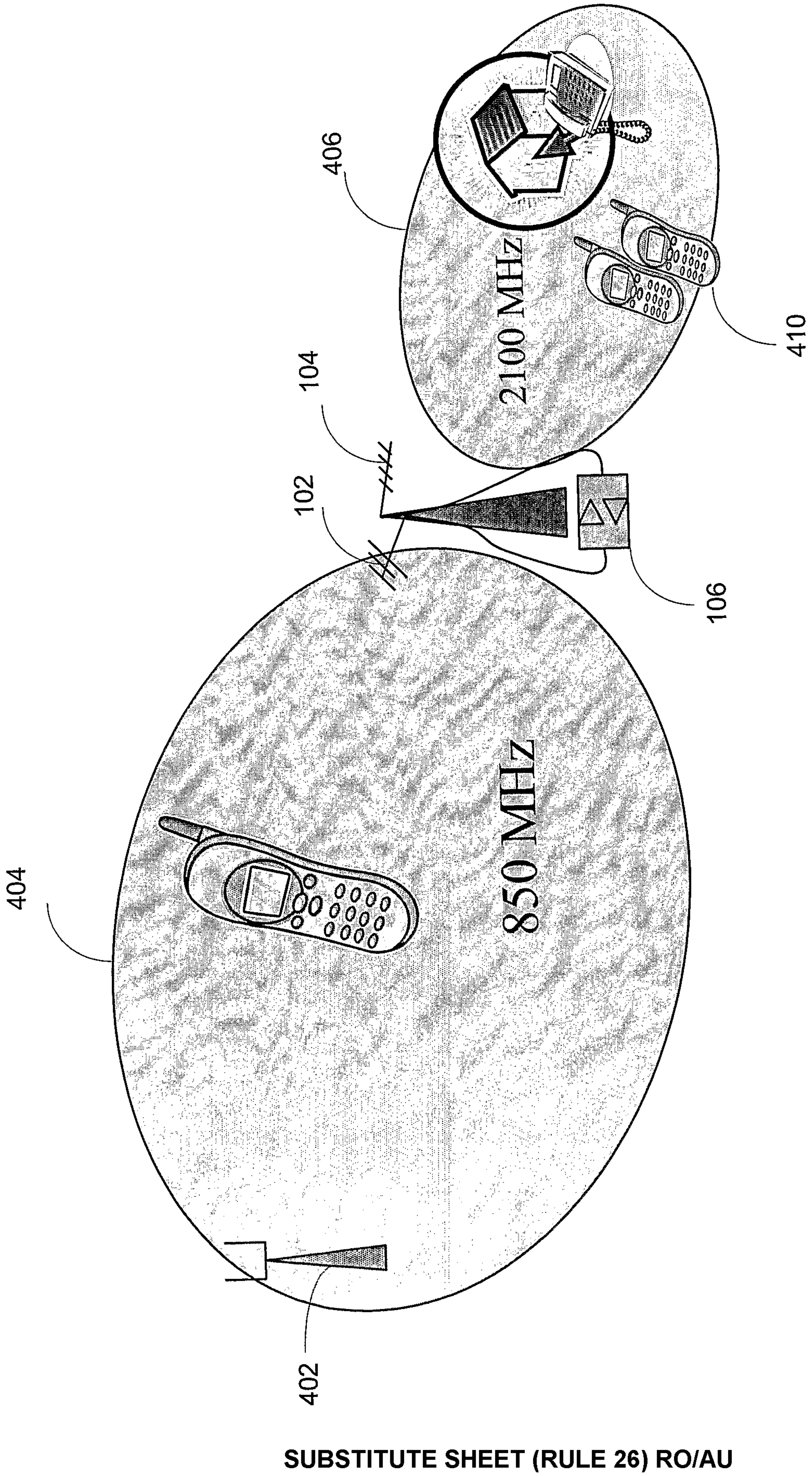

FIGURE 4

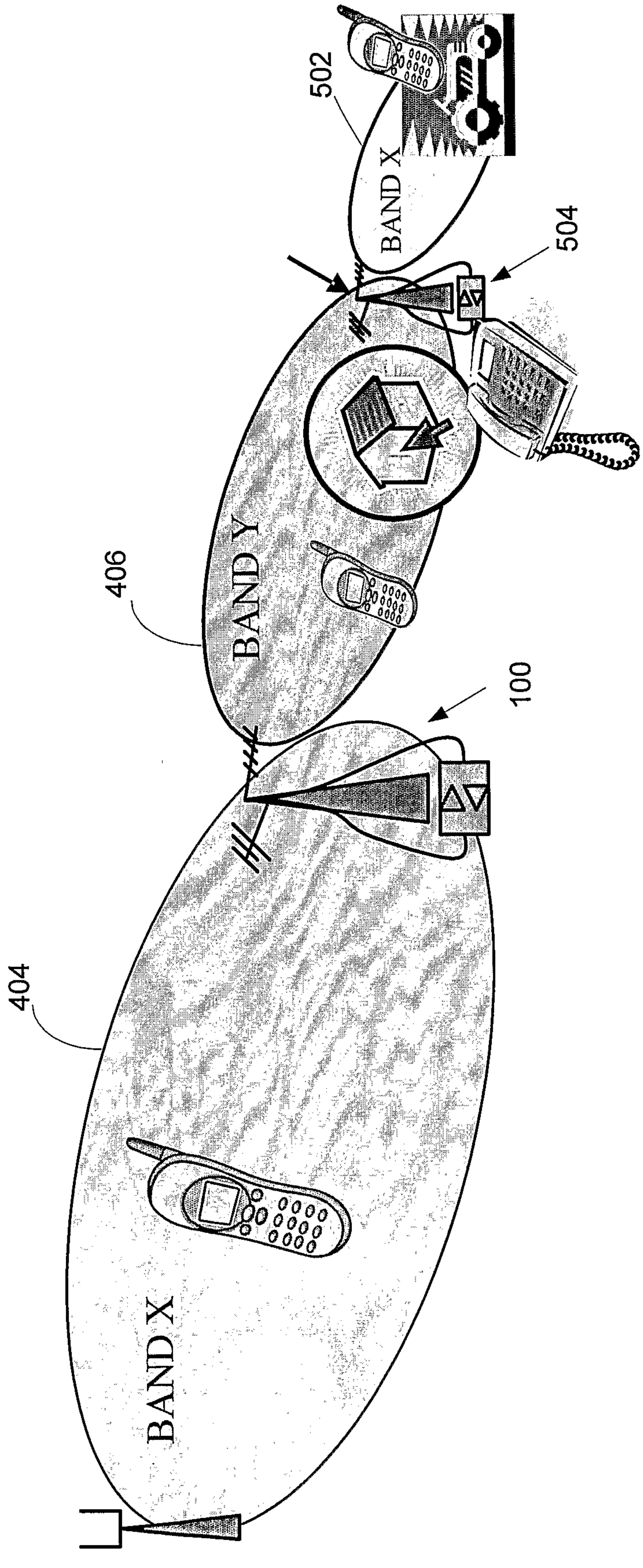

FIGURE 5

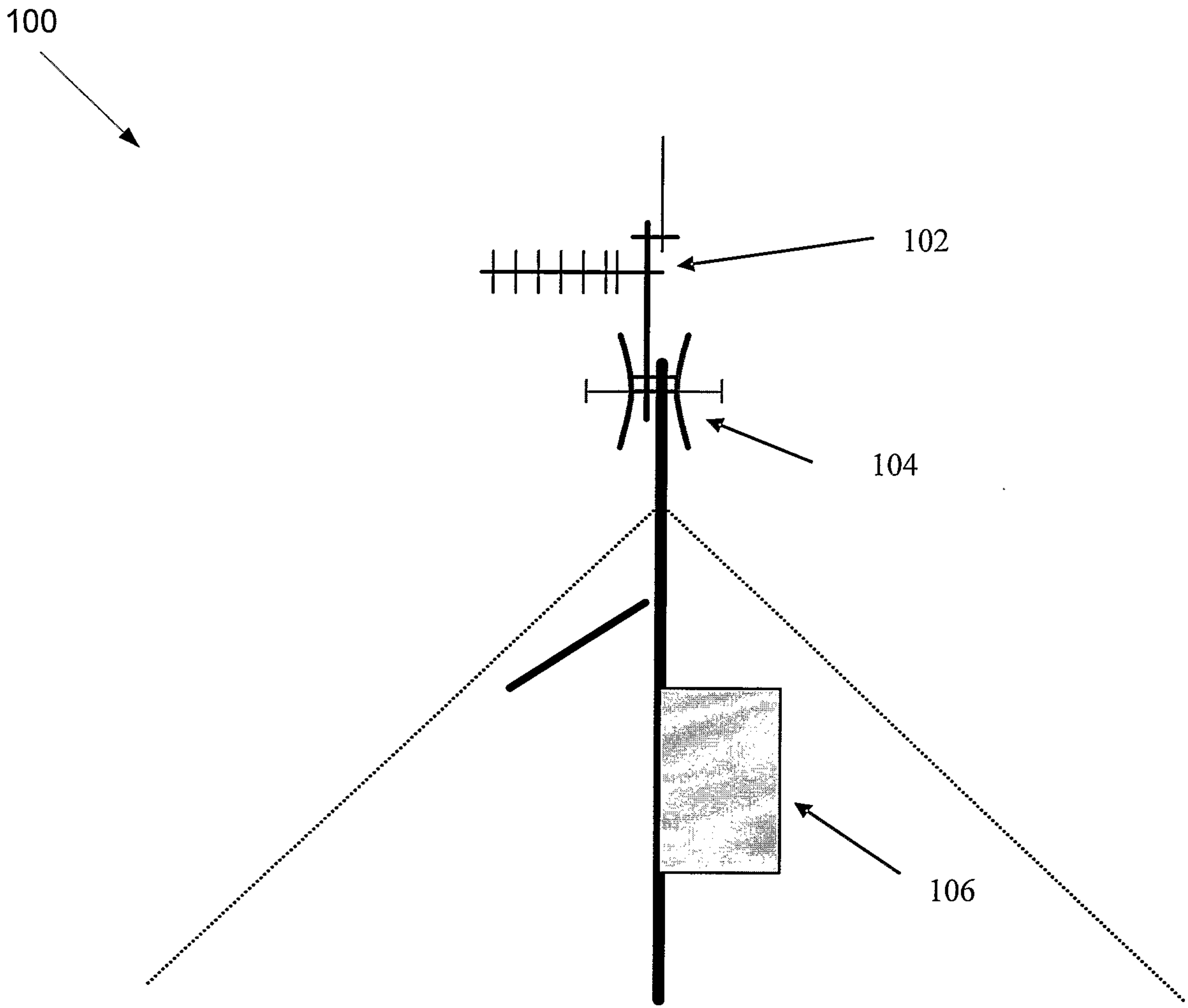

FIGURE 1