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(54) Title: METHODS OF RADIO COMMUNICATION INVOLVING MULTIPLE RADIO CHANNELS, AND RADIO SIGNAL
REPEATER AND MOBILE STATION APPARATUSES IMPLEMENTING SAME

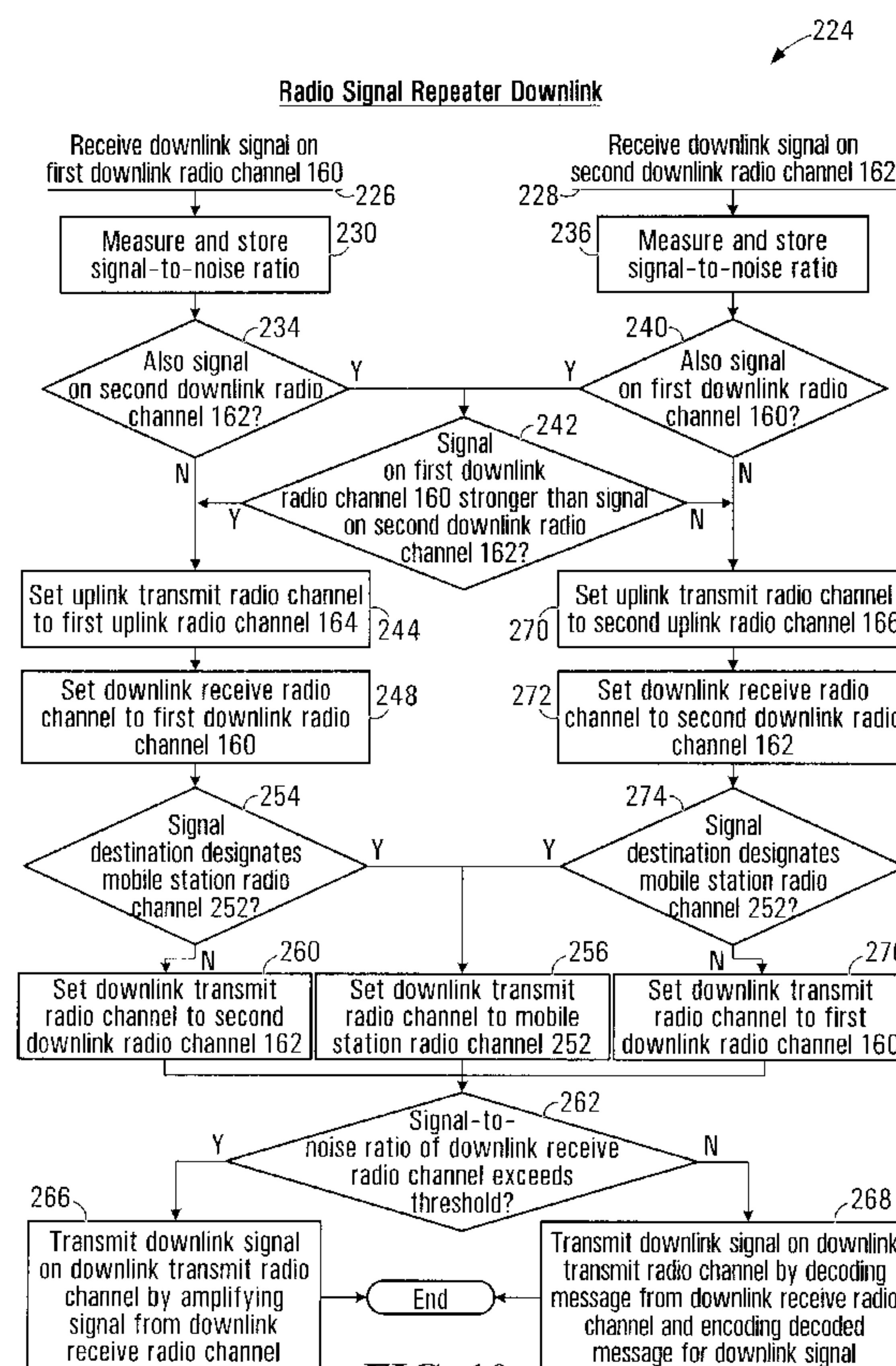


FIG. 10

(57) Abrégé/Abstract:

A method of facilitating radio communications involves receiving a first message from a first remote radio station on a first radio channel, transmitting the first message to a second remote radio station on a second radio channel, receiving a second message

(57) **Abrégé(suite)/Abstract(continued):**

from the second remote radio station on a third radio channel, and transmitting the second message to the first remote radio station on a fourth radio channel. A method of radio communication involves receiving a first radio signal from a first remote radio station on a first radio channel, transmitting a second radio signal to the first remote radio station on a second radio channel, receiving a third radio signal from a second remote radio station on a third radio channel, and transmitting a fourth radio signal to the second remote radio station on a fourth radio channel. Radio signal repeater and mobile station apparatuses are also disclosed.

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(54) Title: METHODS OF RADIO COMMUNICATION INVOLVING MULTIPLE RADIO CHANNELS, AND RADIO SIG-
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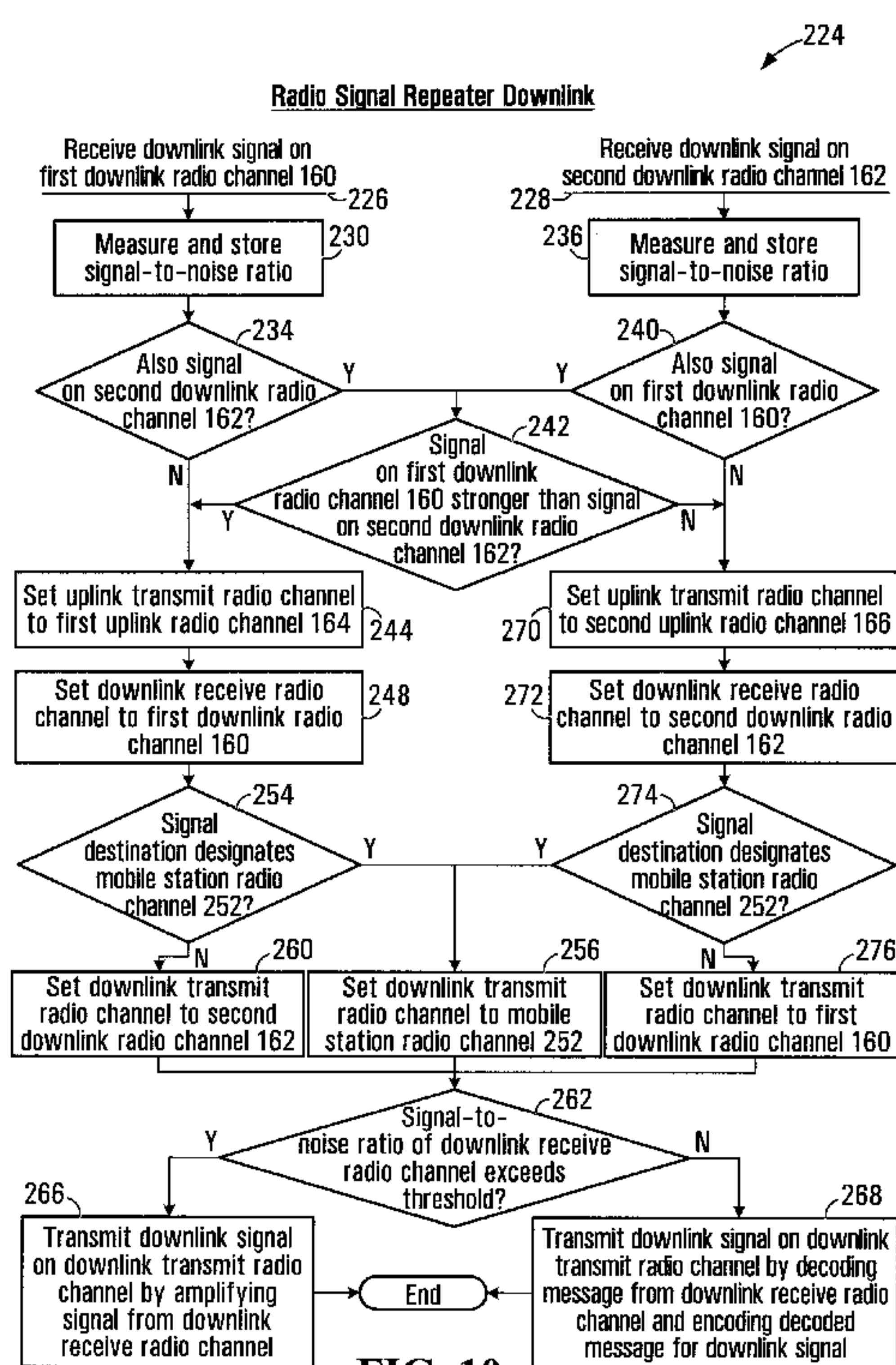


FIG. 10

(57) Abstract: A method of facilitating radio communications involves receiving a first message from a first remote radio station on a first radio channel, transmitting the first message to a second remote radio station on a second radio channel, receiving a second message from the second remote radio station on a third radio channel, and transmitting the second message to the first remote radio station on a fourth radio channel. A method of radio communication involves receiving a first radio signal from a first remote radio station on a first radio channel, transmitting a second radio signal to the first remote radio station on a second radio channel, receiving a third radio signal from a second remote radio station on a third radio channel, and transmitting a fourth radio signal to the second remote radio station on a fourth radio channel. Radio signal repeater and mobile station apparatuses are also disclosed.

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**METHODS OF RADIO COMMUNICATION INVOLVING MULTIPLE RADIO
CHANNELS, AND RADIO SIGNAL REPEATER AND MOBILE STATION
APPARATUSES IMPLEMENTING SAME**

CROSS-REFERENCE TO RELATED APPLICATION

5 This application claims the benefit of United States provisional patent application no. 61/245,349 filed September 24, 2009, which is incorporated by reference herein in its entirety.

BACKGROUND

1. Field of Invention

10 The invention relates generally to radio communication, and more particularly to methods of radio communication involving multiple radio channels and to apparatuses implementing the same.

2. Description of Related Art

15 Numerous standards for radio communication are known. For example, the Global System for Mobile Communications ("GSM") standard is a radio communication standard for mobile telephones, and prescribes radio frequencies ranging from about 380 MHz to about 2 GHz. Other radio communication standards for mobile telephones include the Time Division Multiple Access ("TDMA") standard and the Code Division Multiple Access
20 ("CDMA") standard, and these standards also generally prescribe radio frequencies less than about 2.5 GHz. The Institute of Electrical and Electronics Engineers ("IEEE") 802.11 and 802.16 standards are other radio communication standards that prescribe radio signals having frequencies less than about 5 GHz.

25 These standards generally prescribe radio signals at relatively low radio frequencies, and generally lower radio frequencies permit lower operating bandwidth than higher radio frequencies. However, higher radio frequencies generally have shorter range and generally are more sensitive to

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environmental interference (such as rain and oxygen absorption, for example) than lower radio frequencies. Such shorter range may require radio frequency repeaters that are closer together, but positioning known repeaters closer together may cause disadvantageously cause interference between the signals of the repeaters. Therefore, many known standards for radio communication prescribe radio signals at relatively low radio frequencies to avoid such disadvantages of higher radio frequencies and to use commercially wireless hardware, but disadvantageously provide lower bandwidths because of the relatively low radio frequencies, and are disadvantageously limited to available radio frequency bands at such relatively low radio frequencies.

SUMMARY

In accordance with one illustrative embodiment, there is provided a method of facilitating radio communications. The method involves: receiving, at a radio signal repeater from a first remote radio station on a first radio channel, a first radio signal encoded with a first message; after receiving the first radio signal, transmitting, from the radio signal repeater to a second remote radio station on a second radio channel different from the first radio channel, a second radio signal encoded with the first message; receiving, at the radio signal repeater from the second remote radio station on a third radio channel different from the first and second radio channels, a third radio signal encoded with a second message; and after receiving the third radio signal, transmitting, from the radio signal repeater to the first remote radio station on a fourth radio channel different from the first, second, and third radio channels, a fourth radio signal encoded with the second message.

The first, second, third, and fourth radio channels may be frequency-division multiplexed on first, second, third, and fourth different radio frequency bands respectively.

The first and fourth radio channels may time-division multiplexed on a first radio frequency band, and the second and third radio channels may be time-division

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multiplexed on a second radio frequency band different from the first radio frequency band.

5 The method may further involve receiving, at the radio signal repeater, configuration information encoded in a configuration information signal in a configuration radio frequency band different from respective radio frequency bands of the first, second, third, and fourth radio channels.

The configuration radio frequency band may be between about 57 GHz and about 64 GHz.

10 The first, second, third, and fourth radio channels may have respective radio frequencies between about 57 GHz and about 64 GHz.

Transmitting the second radio signal may involve amplifying the first radio signal, and transmitting the fourth radio signal may involve amplifying the third radio signal.

15 Transmitting the second radio signal may involve digitally decoding the first message from the first radio signal and encoding the decoded first message for the second radio signal, and transmitting the fourth radio signal may involve digitally decoding the second message from the third radio signal and encoding the decoded second message for the fourth radio signal.

20 The method may further involve determining a first signal-to-noise ratio representing a ratio of strength of the first radio signal to noise in the first radio signal at the radio signal repeater, and determining a second signal-to-noise ratio representing a ratio of strength of the third radio signal to noise in the third radio signal at the radio signal repeater. If the first signal-to-noise ratio satisfies a first criterion, transmitting the second radio signal may involve amplifying the first
25 radio signal. If the first signal-to-noise ratio does not satisfy the first criterion, transmitting the second radio signal may involve digitally decoding the first message from the first radio signal and encoding the decoded first message for the second radio signal. If the second signal-to-noise ratio satisfies a second criterion, transmitting the fourth radio signal may involve amplifying the third

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radio signal. If the second signal-to-noise ratio does not satisfy the second criterion, transmitting the fourth radio signal may involve digitally decoding the second message from the third radio signal and encoding the decoded second message for the fourth radio signal.

- 5 The first signal-to-noise ratio may satisfy the first criterion if the first signal-to-noise ratio exceeds a first threshold, and the first signal-to-noise ratio may not satisfy the first criterion if the first signal-to-noise ratio does not exceed the first threshold. The second signal-to-noise ratio may satisfy the second criterion if the second signal-to-noise ratio exceeds a second threshold, and the second signal-to-noise ratio may not satisfy the second criterion if the second signal-to-noise ratio does not exceed the second threshold.
- 10

- The method may further involve: before transmitting the second radio signal, receiving, at the radio signal repeater from the first remote radio station on the second radio channel, a fifth radio signal encoded with the first message, the first radio signal being stronger than the fifth radio signal; and comparing respective signal strengths of the first and fifth radio signals to determine that the first radio signal is stronger than the fifth radio signal. Transmitting the second radio signal may involve selecting the second radio channel instead of the first radio channel for the second radio signal in response to determining that the first radio signal is stronger than the fifth radio signal.
- 15
- 20

- The method may further involve: receiving, at the radio signal repeater from the first remote radio station on the first radio channel, a sixth radio signal encoded with a third message; after receiving the sixth radio signal, transmitting, to a third remote radio station on a fifth radio channel different from the first, second, third, and fourth radio channels, a seventh radio signal encoded with the third message; receiving, at the radio signal repeater from the third remote radio station on the fifth radio channel, an eighth radio signal encoded with a fourth message; and after receiving the eighth radio signal, transmitting, to the first remote radio station on the fourth radio channel, a ninth radio signal encoded with the fourth message.
- 25
- 30

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The fifth radio channel may have a radio frequency less than about 5 GHz.

Receiving the sixth radio signal may involve receiving the sixth radio signal on a subchannel of the first radio channel associated with the third remote radio station. Transmitting the seventh radio signal may involve transmitting the seventh radio signal on a subchannel of the fifth radio channel associated with the third remote radio station. Receiving the eighth radio signal may involve receiving the eighth radio signal on the subchannel of the fifth radio channel associated with the third remote radio station. Transmitting the ninth radio signal may involve transmitting the ninth radio signal on a subchannel of the fourth radio channel associated with the third remote radio station.

The sixth radio signal may include a destination field including destination data designating the third remote radio station.

The method may further involve: receiving the second radio signal at the second remote radio station from the radio signal repeater; and after receiving the second radio signal, transmitting, from the second remote radio station to a fourth remote radio station on the first radio channel, a tenth radio signal encoded with the first message.

The method may further involve, before transmitting the third radio signal, receiving, at the second remote station from the fourth remote station on the fourth radio channel, an eleventh radio signal encoded with the second message.

In accordance with another illustrative embodiment, there is provided a radio signal repeater apparatus including: provisions for receiving, from a first remote radio station on a first radio channel, a first radio signal encoded with a first message; provisions for transmitting, after receiving the first radio signal, a second radio signal to a second remote radio station on a second radio channel different from the first radio channel, the second radio signal encoded with the first message; provisions for receiving, from the second remote radio station on a third radio channel different from the first and second radio channels, a third radio signal encoded with a second message; and provisions for transmitting,

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after receiving the third radio signal, a fourth radio signal to the first remote radio station on a fourth radio channel different from the first, second, and third radio channels, the fourth radio signal encoded with the second message.

5 In accordance with another illustrative embodiment, there is provided a radio signal repeater apparatus including: an interface for facilitating radio communication with first and second remote radio stations on first, second, third, and fourth different radio channels; and a processor in communication with the interface. The processor is operably configured to: receive, from the interface, a first radio signal from the first remote radio station on the first radio channel, the first radio signal encoded with a first message; cause the interface to transmit, 10 after receiving the first radio signal, a second radio signal to the second remote radio station on the second radio channel, the second radio signal encoded with the first message; receive, from the interface, a third radio signal from the second remote radio station on the third radio channel, the third radio signal encoded with a second message; and cause the interface to transmit, after receiving the third radio signal, a fourth radio signal to the first remote radio station on the fourth radio channel, the fourth radio signal encoded with the second message. 15

20 The first, second, third, and fourth radio channels may be frequency-division multiplexed on first, second, third, and fourth different radio frequency bands respectively.

25 The first and fourth radio channels may be time-division multiplexed on a first radio frequency band, and the second and third radio channels may be time-division multiplexed on a second radio frequency band different from the first radio frequency band.

The processor may be further operably configured to receive, from the interface, configuration information encoded in a configuration information signal in a configuration radio frequency band different from respective radio frequency bands of the first, second, third, and fourth radio channels.

30 The configuration radio frequency band may be between about 57 GHz and

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about 64 GHz.

The first, second, third, and fourth radio channels may have respective radio frequencies between about 57 GHz and about 64 GHz.

5 The processor may be operably configured to cause the interface to transmit the second radio signal by amplifying the first radio signal, and the processor may be operably configured to cause the interface to transmit the fourth radio signal by amplifying the third radio signal.

10 The processor may be operably configured to cause the interface to transmit the second radio signal by digitally decoding the first message from the first radio signal and by encoding the decoded first message for the second radio signal, and the processor may be operably configured to cause the interface to transmit the fourth radio signal by digitally decoding the second message from the third radio signal and by encoding the decoded second message for the fourth radio signal.

15 The processor may be further operably configured to determine a first signal-to-noise ratio representing a ratio of strength of the first radio signal to noise in the first radio signal at the interface. The processor may be operably configured to cause the interface to transmit the second radio signal by amplifying the first radio signal if the first signal-to-noise ratio satisfies a first criterion. The
20 processor may be operably configured to cause the interface to transmit the second radio signal by digitally decoding the first message from the first radio signal and by encoding the decoded first message for the second radio signal if the first signal-to-noise ratio does not satisfy the first criterion. The processor may be further operably configured to determine a second signal-to-noise ratio
25 representing a ratio of strength of the third radio signal to noise in the third radio signal at the interface. The processor may be operably configured to cause the interface to transmit the fourth radio signal by amplifying the third radio signal if the second signal-to-noise ratio satisfies a second criterion. The processor may be operably configured to cause the interface to transmit the fourth radio signal
30 by digitally decoding the second message from the third radio signal and by

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encoding the decoded second message for the fourth radio signal if the second signal-to-noise ratio does not satisfy the second criterion.

The first signal-to-noise ratio may satisfy the first criterion if the first signal-to-noise ratio exceeds a first threshold, and the first signal-to-noise ratio may not satisfy the first criterion if the first signal-to-noise ratio does not exceed the first threshold. The second signal-to-noise ratio may satisfy the second criterion if the second signal-to-noise ratio exceeds a second threshold, and the second signal-to-noise ratio may not satisfy the second criterion if the second signal-to-noise ratio does not exceed the second threshold.

The processor may be further operably configured to: receive from the interface, before transmitting the second radio signal, a fifth radio signal from the first remote radio station on the second radio channel, the fifth radio signal encoded with the first message and not as strong as the first radio signal; compare respective signal strengths of the first and fifth radio signals; and select the second radio channel instead of the first radio channel for the second radio signal if the first radio signal is stronger than the fifth radio signal.

The processor may be further operably configured to: receive, from the interface, a sixth radio signal from the first remote radio station on the first radio channel, the sixth radio signal encoded with a third message; after receiving the sixth radio signal, cause the interface to transmit, to a third remote radio station on a fifth radio channel different from the first, second, third, and fourth radio channels, a seventh radio signal encoded with the third message; receive, from the interface, an eighth radio signal from the third remote radio station on the fifth radio channel, the eighth radio signal encoded with a fourth message; and after receiving the eighth radio signal, cause the interface to transmit, to the first remote radio station on the fourth radio channel, a ninth radio signal encoded with the fourth message.

The fifth radio channel may have a radio frequency less than about 5 GHz.

The processor may be operably configured to receive the sixth radio signal on a subchannel of the first radio channel associated with the third remote radio

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station. The processor may be operably configured to transmit the seventh radio signal on a subchannel of the fifth radio channel associated with the third remote radio station. The processor may be operably configured to receive the eighth radio signal on the subchannel of the fifth radio channel associated with the third remote radio station. The processor may be operably configured to transmit the ninth radio signal on a subchannel of the fourth radio channel associated with the third remote radio station.

The sixth radio signal may include a destination field including destination data, and the processor may be operably configured to cause the interface to transmit the seventh radio signal in response to receiving the sixth radio signal when the destination field of the sixth radio signal includes destination data designating the third remote radio station.

In accordance with another illustrative embodiment, there is provided a method of radio communication. The method involves: receiving a first radio signal at a mobile station from a first remote radio station on a first radio channel; transmitting a second radio signal from the mobile station to the first remote radio station on a second radio channel associated with the first radio channel and different from the first radio channel; receiving a third radio signal at the mobile station from a second remote radio station on a third radio channel different from the first and second radio channels; and transmitting a fourth radio signal from the mobile station to the second remote radio station on a fourth radio channel associated with the third radio channel and different from the first, second, and third radio channels.

The first, second, third, and fourth radio channels may be frequency-division multiplexed on first, second, third, and fourth different radio frequency bands respectively.

The first and second radio channels may be time-division multiplexed on a first radio frequency band, and the third and fourth radio channels may be time-division multiplexed on a second radio frequency band different from the first radio frequency band.

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The method may further involve receiving, at the mobile station, configuration information encoded in a configuration information signal in a configuration radio frequency band different from respective radio frequency bands of the first, second, third, and fourth radio channels.

5 The configuration radio frequency band may be between about 57 GHz and about 64 GHz.

The first, second, third, and fourth radio channels may have respective radio frequencies between about 57 GHz and about 64 GHz.

10 In accordance with another illustrative embodiment, there is provided a mobile station apparatus including: provisions for receiving a first radio signal from a first remote radio station on a first radio channel; provisions for transmitting a second radio signal to the first remote radio station on a second radio channel associated with the first radio channel and different from the first radio channel; provisions for receiving a third radio signal from a second remote radio station
15 on a third radio channel different from the first and second radio channels; and provisions for transmitting a fourth radio signal to the second remote radio station on a fourth radio channel associated with the third radio channel and different from the first, second, and third radio channels.

20 In accordance with another illustrative embodiment, there is provided a mobile station apparatus including: an interface for facilitating radio communication with first and second remote radio stations on first, second, third, and fourth different radio channels; and a processor in communication with the interface. The processor is operably configured to: receive, from the interface, a first radio signal from a first remote radio station on a first radio channel; cause the
25 interface to transmit a second radio signal to the first remote radio station on a second radio channel associated with the first radio channel and different from the first radio channel; receive, from the interface, a third radio signal from a second remote radio station on a third radio channel different from the first and second radio channels; and cause the interface to transmit a fourth radio signal
30 to the second remote radio station on a fourth radio channel associated with the

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third radio channel and different from the first, second, and third radio channels.

The first, second, third, and fourth radio channels may be frequency-division multiplexed on first, second, third, and fourth different radio frequency bands respectively.

- 5 The first and second radio channels may be time-division multiplexed on a first radio frequency band, and the third and fourth radio channels may be time-division multiplexed on a second radio frequency band different from the first radio frequency band.

- 10 The processor may be further operably configured to receive, from the interface, configuration information encoded in a configuration information signal in a configuration radio frequency band different from respective radio frequency bands of the first, second, third, and fourth radio channels.

The configuration radio frequency band may be between about 57 GHz and about 64 GHz.

- 15 The first, second, third, and fourth radio channels may have respective radio frequencies between about 57 GHz and about 64 GHz.

Other aspects and features will become apparent to those ordinarily skilled in the art upon review of the following description of illustrative embodiments in conjunction with the accompanying figures.

20 **BRIEF DESCRIPTION OF THE DRAWINGS**

In drawings of various illustrative embodiments:

Figure 1 is a top-view schematic representation of an illustrative radio communication system;

- 25 Figure 2 is a schematic representation of a base station of the radio communication system of Figure 1;

Figure 3 is a schematic representation of downlink codes of the base station of Figure 2;

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Figure 4 is a schematic representation of a downlink signal transmitted by a radio communication interface of the base station of Figure 2;

Figure 5 is a schematic representation of uplink codes of the base station of Figure 2;

5 Figure 6 is a schematic representation of an uplink signal received at the radio communication interface of the base station of Figure 2;

Figure 7 is a schematic representation of configuration codes of the base station of Figure 2;

10 Figure 8 is a schematic representation of a configuration signal transmitted by the radio communication interface of the base station of Figure 2;

Figure 9 is a schematic representation of a radio signal repeater of the radio communication system of Figure 1;

15 Figure 10 is a schematic representation of downlink codes of the radio signal repeater of Figure 9;

Figure 11 is a schematic representation of uplink codes of the radio signal repeater of Figure 9;

Figure 12 is a schematic representation of configuration codes of the radio signal repeater of Figure 9;

20 Figure 13 is a schematic representation of a mobile station of the radio communication system of Figure 1;

Figure 14 is a schematic representation of downlink codes of the mobile station of Figure 13;

25 Figure 15 is a schematic representation of uplink codes of the mobile station of Figure 13;

Figure 16 is a schematic representation of configuration codes of the mobile

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station of Figure 13;

Figure 17 is a schematic representation of illustrative signals transmitted and received in the radio communication system of Figure 1;

5 Figure 18 is a schematic representation of other illustrative signals transmitted and received in the radio communication system of Figure 1;

Figure 19 is a schematic representation of other illustrative signals transmitted and received in the radio communication system of Figure 1; and

10 Figure 20 is a schematic representation of other illustrative signals transmitted and received in the radio communication system of Figure 1.

DETAILED DESCRIPTION

Referring to Figure 1, an exemplary radio communication system is shown generally at 100 and includes a base station 102, radio signal repeaters 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, and 132, and mobile stations 134, 136, 138, and 140. In the embodiment shown, the mobile station 134 is in radio communication with the radio signal repeater 106, the mobile station 136 is in radio communication with the radio signal repeaters 106 and 120, and the mobile station 140 is in radio communication with the radio signal repeater 118. Generally, the base station 102 and the radio signal repeaters 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, and 132 have respective radio communication ranges that overlap and collectively communicate by radio with mobile stations such as the mobile stations 134, 136, 138, and 140 in a coverage area 142 surrounding the base station 102. The base station 102, the radio signal repeaters 104, 106, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, and 132, and the mobile stations 134, 136, 138, and 140 may be referred to simply as radio stations.

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Referring to Figure 2, the base station **102** (also shown in Figure 1) is illustrated schematically, and in the embodiment shown includes a microprocessor **144** and program memory **146**, an input/output (“I/O”) module **148**, and configuration memory **150**. The program memory **146** in the embodiment shown includes random-access memory (“RAM”) encoded with codes generally for directing the microprocessor **144** to carry out functions of the base station **102**. The I/O module **148** includes a radio communication port **152** in communication with a radio antenna **154**. The I/O module **148** also includes a backhaul port **156** for communicating with a backhaul **158** of the base station **102**. The backhaul **158** connects the base station **102** to other base stations in a radio communication network and to other communication networks, such as telephone networks and the internet for example, to facilitate communication between mobile stations in the coverage area **142** (shown in Figure 1) with mobile stations (not shown) outside of the coverage area (**142**) and with other telephones and computers on the internet (not shown), for example. The configuration memory **150** in the embodiment shown is also a RAM, and generally stores data for configuring the base station **102**. Although the base station **102** in the embodiment shown includes the microprocessor **144**, the program memory **146**, the I/O module **148**, and the configuration memory **150**, alternative base stations may include additional or alternative components such as hard drives and application-specific integrated circuits (“ASICs”), for example.

Referring to Figures 1 and 2, the radio antenna **154** in the embodiment shown facilitates radio communication with the radio signal repeaters **104**, **106**, **108**, **110**, and **112** on at least five different radio channels, namely first and second downlink radio channels **160** and **162**, first and second uplink radio channels **164** and **166**, and a configuration and control radio channel **204**. Although for simplicity the radio channels **160**, **162**, **164**, **166**, and **204** are illustrated in Figure 1 only between the base station **102** and the radio signal repeater **106** and between the radio signal repeaters **106** and **120**, in the embodiment shown the base station **102** is also in radio communication with the radio signal repeaters **106**, **108**, **110**, and **112**, the radio signal repeater **104** is in

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radio communication with the radio signal repeaters **114** and **116**, the radio signal repeater **106** is in radio communication with the radio signal repeaters **118** and **120**, the radio signal repeater **108** is in radio communication with the radio signal repeaters **122** and **124**, the radio signal repeater **110** is in radio communication with the radio signal repeaters **126** and **128**, and the radio signal repeater **112** is in radio communication with the radio signal repeaters **130** and **132**, all on the radio channels **160**, **162**, **164**, **166**, and **204**. The radio antenna **154** thus functions as a radio communication interface, or simply as an interface, to the radio signal repeaters **104**, **106**, **108**, **110**, and **112** in the embodiment shown.

Herein, "radio channel" refers to a multiplexed communication channel in one or more radio or other electromagnetic frequency bands. In the embodiment shown, the base station **102** is configurable to multiplex the radio channels **160**, **162**, **164**, and **166** using frequency-division multiplexing, in which case the radio channels **160**, **162**, **164**, and **166** are multiplexed onto respective different radio frequency bands. The base station **102** in the embodiment shown is also configurable to multiplex the radio channels **160**, **162**, **164**, and **166** using time-division multiplexing, in which case the first downlink radio channel **160** and the first uplink radio channel **164** are time-division multiplexed in a first radio frequency band, and the second downlink radio channel **162** and the second uplink radio channel **166** are time-division multiplexed in a second radio frequency band different from the first radio frequency band. However, in any case in the embodiment shown, the configuration and control radio channel **204** is multiplexed in a frequency band different from frequency bands of the radio channels **160**, **162**, **164**, and **166**. Alternative base stations may multiplex the radio channels **160**, **162**, **164**, **166**, and **204** using different multiplexing techniques, and the configuration memory **150** in the embodiment shown stores configuration data specifying a particular multiplexing technique for the base station **102**.

In the embodiment shown, the radio channels **160**, **162**, **164**, **166**, and **204** are in respective radio frequency bands in a radio frequency band between

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about 57 GHz and about 64 GHz, which may be referred to for simplicity as the “60 GHz” band and which is unlicensed in the United States. In alternative embodiments, the radio channels **160**, **162**, **164**, **166**, and **204** may have other radio frequencies, such as other radio frequencies known as Extremely High Frequencies (“EHF”) between about 30 GHz and 300 GHz, for example. The respective radio frequency bands of the radio channels **160**, **162**, **164**, **166**, and **204** are also specified in the configuration memory **150** in the embodiment shown.

Referring back to Figure 2, the program memory **146** includes downlink codes **168** that include blocks of code for directing the microprocessor **144** to transmit a downlink signal. Referring to Figure 3, the downlink codes **168** are illustrated schematically and begin at **170** in response to receiving a downlink message from the backhaul **158** (shown in Figure 2). A downlink message received at **170** from the backhaul (**158**) may include any message directed to a mobile station in the coverage area **142** (such as the mobile stations **134**, **136**, **138** and **140** shown in Figure 1), and may include a voice message, a data message, or a configuration message, for example. The downlink codes **168** continue at block **172**, which directs the microprocessor (**144**) to cause the radio antenna **154** to transmit a downlink signal encoded with the downlink message received at **170** on the first downlink radio channel **160**. The downlink codes **168** continue at block **174**, which directs the microprocessor (**144**) to transmit a downlink signal encoded with the downlink message received at **170** on the second downlink radio channel **162**. The downlink codes **168** then end.

Therefore, in the embodiment shown, the base station (**102**) receives a downlink message from the backhaul (**158**), and the base station (**102**) transmits downlink signals including that message on both the first and second downlink radio channels **160** and **162**. Alternative base stations may transmit a signal on only one of the first and second downlink radio channels **160** and **162**, in which case one of the blocks **172** and **174** may be omitted. Still other alternative base stations may select one of the first and second

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downlink radio channels **160** and **162** for downlink signals directed to particular radio signal repeaters in radio communication with the base station.

Referring to Figure 4, an exemplary downlink signal transmitted in response to the codes in block **172** or **174** (shown in Figure 3) is shown generally at **176**, and includes a destination identifier field **178** for storing an identifier of a destination for the downlink signal, and a message field **180** storing the message received at **170** (shown in Figure 3). Downlink signals in the embodiment shown are therefore digital data packets. However, in alternate embodiments, downlink signals may be analog signals or digital data stream signals that are not transmitted as digital data packets, for example.

Referring back to Figure 2, the program memory **146** also includes uplink codes **182** for directing the microprocessor **144** (shown in Figure 2) to receive an uplink signal from one of the radio signal repeaters **104**, **106**, **108**, **110**, and **112** (shown in Figure 1) in the embodiment shown. Referring to Figure 5, the uplink codes **182** are illustrated schematically and begin either at **184** in response to an uplink signal received on the first uplink radio channel **164** at the radio antenna **154** (shown in Figure 2) or at **186** in response to an uplink signal received on the second uplink radio channel **166** at the radio antenna (**154**). In either case, the uplink codes **182** continue at block **188**, which directs the microprocessor (**144**) to transmit the message encoded in the signal that was received at either **184** or **186** to the backhaul **158** (shown in Figure 2). Therefore, referring back to Figure 1, in the embodiment shown the base station **102** receives uplink signals on the first and second uplink radio channels **164** and **166** from the radio signal repeaters **104**, **106**, **108**, **110**, and **112**, and transmits messages encoded in those uplink signals to the backhaul **158** (shown in Figure 2).

Referring to Figure 6, an exemplary uplink signal received at **184** or **186** (shown in Figure 5) is shown generally at **190**, and includes a source identifier field **192** for storing an identifier of a source (such as one of the mobile stations **134**, **136**, **138**, and **140** shown in Figure 1, for example) of an uplink message, and a message field **194** for storing the message. An uplink

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message in the uplink message field **194** may include data for voice communication or other data, for example. Also, in the embodiment shown, the uplink signal **190** is a digital packet, but in alternative embodiments, uplink signals may include analog signals or digital data stream signals that are not divided into packets, for example.

Referring back to Figure 2, the program memory **146** also includes configuration codes **196** for directing the microprocessor **144** (shown in Figure 2) to receive and transmit configuration information. Herein, "configuration information" may also refer to control information, and a "configuration signal" may also refer to a signal including control information. Referring to Figure 7, the configuration codes **196** in the embodiment shown begin at **198** in response to receiving configuration information from the backhaul **158** (shown in Figure 2). Configuration information received at **198** may include configuration information specifying multiplexing techniques, frequency bands for the radio channels **160**, **162**, **164**, **166**, and **204**, and generally other configuration information for the radio communication system **100** (shown in Figure 1), for example. The configuration codes **196** continue at block **200**, which directs the microprocessor **144** (shown in Figure 1) to store the configuration information received at **198** in the configuration memory **150** (shown in Figure 2). The configuration codes **196** continue at block **202**, which directs the microprocessor (**144**) to transmit a configuration signal encoded with the configuration information on the configuration and control radio channel **204**.

As indicated above, the configuration and control radio channel **204** in the embodiment shown is also between about 57 GHz and about 64 GHz, but is in a frequency band different from frequency bands of the radio channels **160**, **162**, **164**, and **166**. Therefore, in the embodiment shown, configuration information is sent in a different radio frequency band from uplink and downlink signals, which may advantageously permit greater flexibility for timing configuration signals in some embodiments. Alternatively, the configuration and control radio channel **204** could be multiplexed in the same

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radio frequency bands as the radio channels **160**, **162**, **164**, and **166**, for example.

Referring to Figure **8**, an exemplary configuration signal transmitted at block **202** (shown in Figure **7**) is shown generally at **326**, and includes a configuration information field **208** for storing configuration information such as the configuration information received at **198** (shown in Figure **7**).

Referring to Figure **9**, the radio signal repeater **106** (also shown in Figure **1**) is shown schematically and in the embodiment shown includes a microprocessor **210** and configuration memory **212**, program memory **214**, temporary memory **216**, and an I/O module **218** all in communication with the microprocessor **210**. The configuration memory **212** in the embodiment shown includes RAM and stores information for configuring the radio signal repeater **106** such as configuration information received in the configuration signal **206** (shown in Figure **8**), for example. The program memory **214** in the embodiment shown also includes RAM and stores codes generally for directing the microprocessor **210** to carry out functions of the radio signal repeater **106**. The temporary memory **216** in the embodiment shown includes RAM and stores various data that are generated and accessed during operation of the radio signal repeater **106**. The I/O module **218** includes a radio antenna port **220** in communication with a radio antenna **222**, and in the embodiment shown the radio antenna **222** facilitates radio communication with the base station **102** and with the radio signal repeaters **118** and **120** (shown in Figure **1**) over the radio channels **160**, **162**, **164**, **166**, and **204**. The radio antenna **222** thus functions as a radio communications interface, or simply as an interface, for radio communication with the base station (**102**) and with the radio signal repeaters (**118** and **120**). Although the radio signal repeater **106** is illustrated in the embodiment shown with the microprocessor **210**, the configuration memory **212**, the program memory **214**, the temporary memory **216**, and the I/O module **218**, alternative radio signal repeaters may include different components such as hard drives and ASICs, for example.

The program memory **214** includes downlink codes **224** generally for directing

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the microprocessor **210** to respond to a downlink signal transmitted by the base station **102** (shown in Figure 1) at block **172** or **174** (shown in Figure 3) in the embodiment shown.

Referring to Figure 10, the downlink codes **224** are illustrated schematically and begin either at **226** in response to receiving a downlink signal **176** (shown in Figure 4) at the radio antenna **222** (shown in Figure 9) on the first downlink radio channel **160** in response to the codes at block **172** (shown in Figure 3), or at **228** in response to receiving a downlink signal (**176**) on the second downlink radio channel **162** in response to the codes at block **174** (shown in Figure 3).

If the downlink codes **224** begin at **226**, then the downlink codes **224** continue at block **230**, which directs the microprocessor **210** (shown in Figure 9) to measure a signal-to-noise ratio of the signal received on the first downlink radio channel **160**, and to store the signal-to-noise ratio in a first signal-to-noise ratio store **232** in the temporary memory **216** (shown in Figure 9). The downlink codes **224** continue at block **234**, which directs the microprocessor (**210**) to determine whether a signal encoded with the same data was also received on the second downlink radio channel **162**. A signal encoded with the same data may also be received on the second downlink radio channel **162** in response to the codes at block **174** (shown in Figure 3).

If at block **234** a signal encoded with the same data was also received on the second downlink radio channel **162**, then the downlink codes **224** also begin at **228** and continue at block **236**, which directs the microprocessor (**210**) to measure a signal-to-noise ratio of the signal on the second downlink radio channel **162**, and to store the signal-to-noise ratio in a second signal-to-noise ratio store **238** in the temporary memory **216** (shown in Figure 9). The downlink codes **224** continue from block **236** to block **240**, which directs the microprocessor (**210**) to determine whether a signal encoded with the same data was also received on the first downlink radio channel **160**.

If at block **234** a signal encoded with the same data was also received on the

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second downlink radio channel **162**, or if at block **240** a signal encoded with the same data was also received on the first downlink radio channel **160**, then the downlink codes **224** continue at block **242**, which directs the microprocessor (**210**) to determine whether the signal on the first downlink radio channel **160** was stronger than the signal on the second downlink radio channel **162**. In the embodiment shown, the codes at block **242** direct the microprocessor (**210**) to compare the signal-to-noise ratios stored in the first and second signal-to-noise ratio stores **232** and **238** (shown in Figure 9), and the microprocessor (**210**) determines that the signal on the first downlink radio channel **160** is stronger than the signal on the second downlink radio channel **162** if the first signal-to-noise ratio store (**232**) stores a greater signal-to-noise ratio than the second signal-to-noise ratio store (**238**).

If at block **242** the signal on the first downlink radio channel **160** is stronger than the signal on the second downlink radio channel **162**, or if at block **234** there is no signal encoded with the same data on the second downlink radio channel **162**, then the downlink codes **224** continue at block **244**, which directs the microprocessor (**210**) to configure an uplink transmit radio channel store **246** in the temporary memory **216** (shown in Figure 9) to set the first uplink radio channel **164** as the uplink transmit radio channel. The downlink codes **224** continue at block **248**, which directs the microprocessor (**210**) to configure a downlink receive radio channel store **250** in the temporary memory **216** (shown in Figure 9) to set the first downlink radio channel **160** as the downlink receive radio channel.

Referring back to Figure 1, in the embodiment shown the radio signal repeater **106** is in radio communication with the mobile station **134** on a mobile station radio channel **252**. In the embodiment shown, the radio channels **160**, **162**, **164**, **166**, and **204** are in the 60 GHz band, whereas the mobile station radio channel **252** is in a GSM radio band at about 2 GHz. In alternative embodiments, radio signal repeaters may communicate with mobile stations in various radio frequency bands such as radio frequency bands for GSM, CDMA, TDMA, and IEEE 802.11 or 802.16, for example, and such mobile

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station radio channels will generally be in lower radio frequencies than the radio frequencies of the radio channels **160**, **162**, **164**, **166**, and **204** in the embodiment shown.

Referring back to Figure **10**, the downlink codes **224** continue from block **248** to block **254**, which directs the microprocessor (**210**) to determine whether the destination identifier in the destination identifier field **178** (shown in Figure **4**) of the signal received at **226** designates a downlink radio channel in the mobile station radio channel **252**. In the embodiment shown, the destination identifier in the destination identifier field (**178**) designates a downlink radio channel in the mobile station radio channel **252** if the destination identifier in the destination identifier field (**178**) designates a mobile station in radio communication with the radio signal repeater (**106**) on the mobile station radio channel **252**, such as the mobile station **134** shown in Figure **1** in the embodiment shown. If at block **254** the destination identifier in the destination identifier field (**178**) designates a downlink radio channel in the mobile station radio channel **252**, then the downlink codes **224** continue at block **256**, which directs the microprocessor (**210**) to configure a downlink transmit radio channel store **258** in the temporary memory **216** (shown in Figure **9**) to set the mobile station radio channel **252** as the downlink transmit radio channel. Otherwise, the downlink codes **224** continue at block **260**, which directs the microprocessor (**210**) to configure the downlink transmit radio channel store (**258**) to set the second downlink radio channel **162** as the downlink transmit radio channel.

After either block **256** or **260**, the downlink codes **224** continue at block **262**, which directs the microprocessor (**210**) to determine whether the signal-to-noise ratio of the downlink receive radio channel exceeds a threshold stored in a threshold store **264** in the configuration memory **212** (shown in Figure **9**). If the downlink receive radio channel was set as the first downlink radio channel **160** at block **248**, then the codes at block **262** compare the signal-to-noise ratio stored in the first signal-to-noise ratio store **232** to the threshold stored in the threshold store **264**. If at block **262** the signal-to-noise ratio of the

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downlink receive radio channel exceeds the threshold, then the downlink codes **224** continue at block **266**, which directs the microprocessor **210** to cause the radio antenna **222** (shown in Figure **9**) to transmit a downlink signal on the downlink transmit radio channel (specified by the downlink transmit radio channel store **258** shown in Figure **9**) by amplifying the signal received from the downlink receive radio channel (specified by the downlink receive radio channel store **250**). However, if at block **262** the signal-to-noise ratio of the downlink receive radio channel does not exceed the threshold, then the downlink codes **224** continue at block **268**, which directs the microprocessor (**210**) to cause the radio antenna (**222**) to transmit a downlink signal (**176**) on the downlink transmit radio channel (specified by the downlink transmit radio channel store **258** shown in Figure **9**) by digitally decoding the message received from the downlink receive radio channel (specified by the downlink receive radio channel store **250**) and encoding the decoded message for the downlink signal. After either block **266** or block **268**, the downlink codes **224** end.

Therefore, in the embodiment shown, the radio signal repeater (**106**) can repeat a received message either by simply amplifying the received uplink signal (as at block **266**), or by digitally decoding and then encoding the received message (as at block **268**). Where the signal-to-noise ratio of the received signal is above a threshold, the radio signal repeater (**106**) may simply amplify the signal, as a signal with a higher signal-to-noise ratio may be expected to have fewer errors. However, where the signal-to-noise ratio is below the threshold, then the signal is more likely to include errors, and digitally decoding and encoding the message may advantageously enhance the quality of the repeated signal, particularly if the signal includes redundant data-correction information, for example. In alternative embodiments, the codes at block **262** may be omitted, and the downlink codes **224** may proceed directly to either the codes at block **266** or to the codes at block **268**, for example. In still other embodiments, the configuration memory **212** (shown in Figure **9**) may include configuration information determining whether to execute the codes at block **266** or the codes at block **268**. Further, in

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embodiments where the downlink and uplink signals are purely analog, then the codes of blocks **262** and **268** may be omitted such that the downlink codes **224** proceed directly to the codes at block **266**.

Still referring to Figure **10**, if at block **240** a signal encoded with the same data was not also received on the first downlink radio channel **160**, or if at block **242** the signal on the first downlink radio channel **160** was not stronger than the signal on the second downlink radio channel **162**, then the downlink codes **224** continue at block **270**, which directs the microprocessor (**210**) to configure the uplink transmit radio channel store **246** (shown in Figure **9**) to set the second uplink radio channel **166** as the uplink transmit radio channel. The downlink codes **224** continue at block **272**, which directs the microprocessor (**210**) to configure the downlink receive radio channel store **250** (shown in Figure **9**) to set the second downlink radio channel **162** as the downlink receive radio channel.

The downlink codes **224** continue at block **274**, which directs the microprocessor (**210**) to determine whether the destination identifier in the destination identifier field **178** of the downlink signal **176** (shown in Figure **4**) received at **228** designates a downlink radio channel in the mobile station radio channel **252**. The codes at block **274** are therefore substantially the same as the codes at block **254**, except that the codes at block **254** direct the microprocessor (**210**) to respond to the destination identifier in the destination identifier field (**178**) of a downlink signal (**176**) received at **226**, and the codes at block **274** direct the microprocessor (**210**) to respond to the destination identifier in the destination identifier field (**178**) of a downlink signal (**176**) received at **228**. If at block **274** the destination identifier in the destination identifier field (**178**) designates a downlink radio channel in the mobile station radio channel **252**, then the downlink codes **224** continue at block **256** as discussed above. Otherwise, the downlink codes **224** continue at block **276**, which directs the microprocessor (**210**) to configure the downlink transmit radio channel store **258** (shown in Figure **9**) to set the first downlink radio channel **160** as the downlink transmit radio channel. The downlink codes **224**

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then continue at block **262** as described above, except that if the downlink receive radio channel was set as the second downlink radio channel **162** at block **272**, then the codes at block **262** compare the signal-to-noise ratio stored in the second signal-to-noise ratio store **238** (shown in Figure 9) to the threshold stored in the threshold store **264** (shown in Figure 9).

Referring back to Figure 1, the radio signal repeater **106** in the embodiment shown may also receive uplink signals from the radio signal repeaters **118** and **120** or from the mobile stations **134** and **136**. Referring to Figures 1 and 9, the program memory **214** also includes uplink codes **278** generally for directing the microprocessor **210** to respond to an uplink signal **190** (shown in Figure 6) from one of the radio signal repeaters **118** and **120** or from one of the mobile stations **134** and **136** in the embodiment shown. Referring to Figure 11, the uplink codes **278** are illustrated schematically and begin at one of: **280** in response to receiving an uplink signal (**190**) at the radio antenna **222** (shown in Figure 9) on the first uplink radio channel **164**; **282** in response to receiving an uplink signal (**190**) at the radio antenna (**222**) on the second uplink radio channel **166**; and **284** in response to receiving an uplink signal (**190**) at the radio antenna (**222**) on the mobile station radio channel **252**.

After either **280**, **282**, or **284**, the uplink codes **278** continue at block **288**, which directs the microprocessor (**210**) to measure a signal-to-noise ratio of the uplink signal received at **280**, **282**, or **284**. The uplink codes **278** continue at block **290**, which directs the microprocessor (**210**) to determine whether the signal-to-noise ratio determined that block **288** exceeds the threshold stored in the threshold store **264** (shown in Figure 9). If at block **290** the signal-to-noise ratio exceeds the threshold, then the uplink codes **278** continue at block **292**, which directs the microprocessor (**210**) to transmit an uplink signal **190** (shown in Figure 6) on the uplink transmit radio channel (specified by the uplink transmit radio channel store **246** shown in Figure 9) by amplifying the signal received at **280**, **282**, or **284**. Otherwise, the uplink codes **278** continue at block **294**, which directs the microprocessor (**210**) to transmit an uplink signal (**190**) on the uplink transmit radio channel (specified by the uplink

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transmit radio channel store **246**) by digitally decoding the message received at **280**, **282**, or **284**, and then encoding the decoded message.

Therefore, as discussed above with respect to blocks **262**, **266**, and **268** (shown in Figure **10**), the codes at blocks **290**, **292**, and **294** cause the microprocessor (**210**) simply to amplify a received uplink signal if the signal-to-noise ratio of the received uplink signal exceeds a threshold, but to digitally decode and encode the received message if the signal-to-noise ratio of the received uplink signal is less than the threshold, as a signal received with a lower signal-to-noise ratio is likely to have additional errors that may be removed by digitally decoding and encoding the message. Again, in alternative embodiments, the codes at block **290** may be omitted, and the uplink codes **278** may proceed directly to either the codes at block **292** or to the codes at block **294**, for example. In still other embodiments, the configuration memory **212** (shown in Figure **9**) may include configuration information determining whether to execute the codes at block **292** or the codes at block **294**. Further, in embodiments where the downlink and uplink signals are purely analog, then the codes of blocks **290** and **294** may be omitted such that the uplink codes **278** proceed directly to the codes at block **292**.

Referring back to Figure **9**, the program memory **214** also includes configuration codes **296** generally for directing the microprocessor **210** to respond to a configuration signal **206** (shown in Figure **8**) transmitted in response of the codes at block **202** (shown in Figure **7**), for example. Referring to Figure **12**, the configuration codes **296** are illustrated schematically and begin at **298** in response to receiving a configuration signal (**206**) at the radio antenna **222** (shown in Figure **9**). The configuration codes **296** continue at block **300**, which direct the microprocessor **210** (shown in Figure **9**) to store the configuration information of the configuration information field **208** (shown in Figure **8**) of the configuration signal (**206**) received at **298** in the configuration memory **212** (shown in Figure **9**). The configuration codes **296** continue at block **302**, which directs the microprocessor (**210**) to cause

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the radio antenna (222) to transmit a configuration signal (206) on the configuration and control radio channel 204. In the embodiment shown, the codes at block 302 cause the radio signal repeater 106 to transmit the configuration signal (206) to the radio station repeaters 118 and 120 shown in Figure 1.

Referring back to Figure 1, the radio signal repeaters 104, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, and 132 are substantially the same as the radio signal repeater 106 in the embodiment shown. However, in operation, the radio signal repeaters 104, 108, 110, 112, 114, 116, 118, 120, 122, 124, 126, 128, 130, and 132 in the embodiment shown communicate by radio with other such radio stations as shown in Figure 1 and described above.

Referring to Figure 13, the mobile station 136 is illustrated schematically and in the embodiment shown includes a microprocessor 304 and configuration memory 306 for storing configuration information for the mobile station 136, program memory 308 generally for directing the microprocessor 304 to carry out functions of the mobile station 136, temporary memory 310 for storing data generated and accessed during operation of the mobile station 136, and an I/O module 312, all in communication with the microprocessor 304. The configuration memory 306, the program memory 308, and the temporary memory 310 in the embodiment shown are RAM, and the I/O module 312 includes a radio antenna port 314 for communicating with a radio antenna 316. The mobile station 136 also includes a user interface 317 in communication with the I/O module 312. The user interface 317 represents various I/O components for interacting with a user of the mobile station 136, and in the embodiment shown includes a screen, a microphone, a speaker, and a keypad (all not shown).

Referring to Figures 1 and 13, the radio antenna 316 in the embodiment shown facilitates radio communication with the radio signal repeaters 106 and 120. However, unlike the mobile station 134, the mobile station 136 is in radio communication with the radio signal repeaters 106 and 120 on the radio

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channels **160**, **162**, **164**, **166**, and **204**. In alternative embodiments, the mobile station **136** may be in radio communication with other radio signal repeaters or base stations, and more generally the radio antenna **316** functions as a radio communication interface, or simply an interface, for radio communication with radio signal repeaters such as the radio signal repeaters **106** and **120**.

Referring back to Figure **13**, the program memory **308** includes downlink codes **318** generally for directing the microprocessor **304** to respond to a downlink signal **176** (shown in Figure **4**) transmitted in response to the codes at block **266** or **268** (shown in Figure **10**) in the embodiment shown. Referring to Figure **14**, the downlink codes **318** are illustrated schematically and begin either at **320** in response to receiving a downlink signal (**176**) at the radio antenna **316** (shown in Figure **13**) on the first downlink radio channel **160**, or at **322** in response to receiving a downlink signal (**176**) at the radio antenna (**316**) on the second downlink radio channel **162**. If the downlink codes **318** begin at **320**, then the downlink codes **318** continue at block **324**, which directs the microprocessor **304** (shown in Figure **13**) to configure an uplink transmit radio channel store **326** in the temporary memory **310** (shown in Figure **13**) to set the first uplink radio channel **164** as the uplink transmit radio channel. The codes at block **324** direct the microprocessor (**304**) to set the first uplink radio channel **164** as the uplink transmit radio channel in response to a downlink signal received on the first downlink radio channel **160**, and the first uplink radio channel **164** is thus associated with the first downlink radio channel **160**.

The downlink codes **318** continue at block **328**, which directs the microprocessor (**304**) to respond to the downlink signal (**176**) received at **320** or **322**. For example the downlink signal (**176**) received at **320** or **322** may include a message for voice communication or for other data transmission, and the codes at block **328** generally direct the microprocessor (**304**) to respond to the message accordingly.

However, if the downlink codes **318** begin at **322**, then the downlink codes

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318 continue at block **330**, which directs the microprocessor (**304**) to configure the uplink transmit radio channel store (**326**) to set the second uplink radio channel **166** as the uplink transmit radio channel. The codes at block **330** direct the microprocessor (**304**) to set the second uplink radio channel **166** as the uplink transmit radio channel in response to a downlink signal received on the second downlink radio channel **162**, and the second uplink radio channel **166** is thus associated with the second downlink radio channel **162**. The downlink codes **318** then continue at block **328** as described above.

Referring back to Figure **13**, the program memory **308** also includes uplink codes **332** generally for directing the microprocessor **304** to transmit an uplink signal **190** (shown in Figure **6**). Referring to Figure **15**, the uplink codes **332** are illustrated schematically and begin at **334** in response to receiving an uplink message. The uplink message received at **334** may include uplink data for voice communication or other data communicated from the mobile station (**136**), for example. The uplink codes **332** continue at block **336**, which direct the microprocessor **304** (shown in Figure **13**) to transmit an uplink signal (**190**) including the uplink message received at **334** in the message field **194** (shown in Figure **6**) of the uplink signal (**190**) on the uplink transmit radio channel specified by the uplink transmit radio channel store **326** (shown in Figure **13**). The uplink codes **332** then end.

Referring back to Figure **13**, the program memory **308** also includes configuration codes **338** generally for directing the microprocessor **304** to respond to a configuration signal **206** (shown in Figure **8**) received at the radio antenna **316** on the configuration and control radio channel **204** in response to the codes at block **202** (shown in Figure **7**), for example. Referring to Figure **16**, the configuration codes **338** are illustrated schematically and begin at **340** in response to receiving the configuration signal (**206**) from the radio antenna (**316**). The configuration codes **338** continue at block **342**, which directs the microprocessor **304** (shown in Figure **13**) to store configuration information from the configuration information field **208** of the configuration

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signal **206** (shown in Figure **8**) received at **340** in the configuration memory **306** (shown in Figure **13**). The configuration codes **338** then end.

Referring to Figure **17**, an illustrative sequence of signals transmitted and received in the radio communication system **100** (shown in Figure **1**) is illustrated schematically and shown generally at **344**. The sequence of signals **344** begins when the base station **102** transmits a first downlink signal **346** on the first downlink radio channel **160** encoded with a first message **348** in response to the codes of block **172** of the downlink codes **168** (shown in Figure **3**). The radio signal repeater **106** receives the first downlink signal **346** and transmits a second downlink signal **350** on the second downlink radio channel **162** encoded with the first message **348** in response to the codes at blocks **230**, **234**, **244**, **248**, **254**, **260**, **262**, and either **266** or **268** of the downlink codes **224** (shown in Figure **10**). The mobile station **136** receives the second downlink signal **350** in response to the codes at blocks **330** and **328** of the downlink codes **318** (shown in Figure **14**). The mobile station **136** then transmits a first uplink signal **352** encoded with a second message **354** on the second uplink radio channel **166** in response to the codes at block **336** of the uplink codes **332** (shown in Figure **15**). Then the radio signal repeater **106** receives the first uplink signal **352** and transmits a second uplink signal **356** on the first uplink radio channel **164** encoded with the second message **354** in response to the uplink codes **278** (shown in Figure **11**). The base station **102** then receives the second uplink signal **356** in response to the uplink codes **182** (shown in Figure **5**).

In summary, in the sequence of signals **344**, the radio signal repeater **106**: receives, from the base station **102**, the first downlink signal **346** encoded with the first message **348** on the first downlink radio channel **160**; after receiving the first downlink signal **346**, transmits, to the mobile station **136**, the second downlink signal **350** encoded with the first message **348** on the second downlink radio channel **162**; receives, from the mobile station **136**, the first uplink signal **352** encoded with the second message **354** on the second uplink radio channel **166**; and after receiving the first uplink signal **352**, transmits, to

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the base station **102**, the second uplink signal **356** encoded with the second message **354** on the first uplink radio channel **164**.

In an alternative embodiment also shown on Figure 17, the base station **102** also transmits a third downlink signal **358** on the second downlink radio channel **162** and encoded with the first message **348**, and the radio signal repeater **106** receives the third downlink signal **358** before transmitting the second downlink signal **350**. However, in this alternative embodiment, the radio signal repeater **106** measures (at block **230** shown in Figure 10) a higher signal-to-noise ratio of the first downlink signal **346** than for the third downlink signal **358** (measured at block **236** shown in Figure 10). Therefore, at block **242** shown in Figure 10, the radio signal repeater **106** determines that the first downlink signal **346** on the first downlink radio channel **160** is stronger than the third downlink signal **358** on the second downlink radio channel **162**, and the downlink codes **224** therefore continue at blocks **244**, **248**, **254**, **260**, **262**, and **266** or **268** (shown in Figure 10) in this alternative embodiment. Therefore, in this alternative embodiment, the radio signal repeater **106** also receives, before transmitting the second radio signal (the second downlink signal **350**), a fifth radio signal (the third downlink signal **358**) encoded with the first message **348** on the second radio channel (the second downlink radio channel **162**), but because the first signal (the first downlink signal **346**) is stronger than the fifth signal (the third downlink signal **358**), the codes at block **242** (shown in Figure 10) cause the radio signal repeater **106** to select (at block **260** shown in Figure 10) the second radio channel (the second downlink radio channel **162**) instead of the first channel (the first downlink channel **160**) for the second radio signal (the second downlink signal **350**).

Referring back to Figure 1, the mobile station **136** is also in radio communication with the radio signal repeater **120** on the radio channels **160**, **162**, **164**, **166**, and **204**, and due to interference or other environmental conditions, for example, the mobile station **136** may lose radio communication with the radio signal repeater **106** and begin receiving downlink signals instead from the radio signal repeater **120**. Referring to Figure 18, another

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illustrative sequence of signals transmitted and received in the radio communication system **100** (shown in Figure 1), where the mobile station **136** receives downlink signals from the radio signal repeater **120** instead of from the radio signal repeater **106**, is illustrated schematically and shown generally at **374**. The sequence of signals **374** begins when the base station **102** transmits a first downlink signal **376** on the first downlink radio channel **160** encoded with a first message **378**. The radio signal repeater **106** receives the first downlink signal **346** and transmits a second downlink signal **380** on the second downlink radio channel **162** encoded with the first message **378**. The radio signal repeater **120** receives the second downlink signal **376** and transmits a third downlink signal **382** on the first downlink radio channel **160** encoded with the first message **378**. The mobile station **136** receives the third downlink signal **382** in response to the codes at blocks **324** and **328** of the downlink codes **318** (shown in Figure 14). The mobile station **136** then transmits a first uplink signal **384** encoded with a second message **386** on the first uplink radio channel **164** in response to the codes at block **336** of the uplink codes **332** (shown in Figure 15). Then the radio signal repeater **120** receives the first uplink signal **384** and transmits a second uplink signal **388** on the second uplink radio channel **166** encoded with the second message **386**. Then the radio signal repeater **106** receives the second uplink signal **388** and transmits a third uplink signal **390** on the first uplink radio channel **164** encoded with the second message **386**. The base station **102** then receives the third uplink signal **390**.

In summary, in the sequence of signals **374**, the radio signal repeater **120**: receives the second downlink signal **380** from the radio signal repeater **106**; after receiving the second downlink signal **380**, transmits the third downlink signal **382** encoded with the first message **378** to the mobile station **136** on the first downlink radio channel **160**; and before transmitting the second uplink signal **388**, receives the first uplink signal **384** encoded with the second message **386** from the mobile station **136**.

In summary, referring to Figures 17 and 18, in the sequences of signals **344**

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and **374**, the mobile station **136**: receives the second downlink signal **350** from the radio signal repeater **106** on the second downlink radio channel **162**; transmits the first uplink signal **352** to radio signal repeater **106** on the second uplink radio channel **166** associated (by the codes at block **330** shown in Figure **14**) with the second downlink radio channel **162**; receives the third downlink signal **382** from the radio signal repeater **120** on the first downlink radio channel **160**; and transmits the first uplink signal **384** to the radio signal repeater **120** on the first uplink radio channel **164** associated (by the codes at block **324** shown in Figure **14**) with the first downlink radio channel **160**.

In the illustrative embodiments shown in Figures **17** and **18**, the radio signal repeaters communicate only in the radio channels **160**, **162**, **164**, and **166**, and therefore in such embodiments need not be configured to communicate in the mobile station radio channel **252**. Therefore, in such embodiments, blocks **254**, **256**, and **274** (shown in Figure **10**) may be omitted.

Referring to Figure **19**, another illustrative sequence of signals transmitted and received in the radio communication system **100** (shown in Figure **1**) is illustrated schematically and shown generally at **360**. The sequence of signals **360** begins when the base station **102** transmits a first downlink signal **362** on the first downlink radio channel **160** and encoded with a first message **364**. In the embodiment shown, the destination identifier in the destination identifier field **178** (shown in Figure **4**) of the first downlink signal **362** designates the mobile station **134**, which is in radio communication with the radio signal repeater **106** over the mobile station radio channel **252** as shown in Figure **1**. Therefore, the radio signal repeater **106** receives the first downlink signal **362** and transmits a second downlink signal **366** encoded with the first message **364** on the mobile station radio channel **252** in response to the codes at block **254** shown in Figure **10**. The mobile station **134** receives the second downlink signal **366**, and later transmits a first uplink signal **368** encoded with a second message **370** on the mobile station radio channel **252**. The radio signal repeater **106** receives the first uplink signal **368** and transmits a second uplink signal **372** encoded with the second message **370** on the first uplink radio

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channel **164** in response to the uplink codes **278** (shown in Figure **11**). The base station **102** then receives the second uplink signal **372** in response to the uplink codes **182** (shown in Figure **5**).

In summary, in the illustrative sequence of signals **360**, the radio signal repeater **106**: receives the first downlink signal **362** encoded with the first message **364** on the first downlink radio channel **160**; after receiving the first downlink signal **362**, transmits, to the mobile station **134**, the second downlink signal **366** encoded with the first message **364** on the mobile station radio channel **252**; receives the first uplink signal **368** encoded with the second message **370** from the mobile station **134** on the mobile station radio channel **252**; and after receiving the first uplink signal **368**, transmits, to the base station **102**, the second uplink signal **372** encoded with the second message **370** on the first uplink radio channel **164**.

In the illustrative sequence of signals **360**, the mobile station **134** communicates on the mobile station radio channel **252** with the radio signal repeater **106**, and the mobile station **134** may thus be considered to be in a micro, pico, or femto cell of the radio signal repeater **106**. In the embodiment shown, one or more of the radio signal repeaters **104**, **106**, **108**, **110**, **112**, **114**, **116**, **118**, **120**, **122**, **124**, **126**, **128**, **130**, and **132** may establish respective such micro, pico, or femto cells.

Referring back to Figure **1**, the mobile station **140** is in radio communication with the radio signal repeater **118** on the mobile station radio channel **252**. In the embodiment shown, the configuration information received at **198** (shown in Figure **7**) and transmitted in the configuration information field **208** (shown in Figure **8**), for example, may configure the mobile stations **134** and **140** to be in radio communication with the radio signal repeaters **106** and **118** on respective different subchannels of the mobile station radio channel **252**. More generally, in the embodiment shown, the configuration information may associate various subchannels of the mobile station radio channel **252** with each of the radio signal repeaters **104**, **106**, **108**, **110**, **112**, **114**, **116**, **118**, **120**, **122**, **124**, **126**, **128**, **130**, and **132**, and one or more mobile stations in

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radio communication with one of those radio signal repeaters may also be associated with the subchannel associated with the radio signal repeater. These different subchannels may be advantageous to reduce interference in transmissions from adjacent radio signal repeaters on the mobile station radio channel **252**, for example.

The configuration information may also associate the subchannels of the mobile station radio channel **252** with respective subchannels in each of the radio channels **160**, **162**, **164**, and **166**. In such a configuration, the codes at blocks **172** and **174** (shown in Figure 3) and at blocks **266** and **268** (shown in Figure 10) transmit downlink signals **178** (shown in Figure 4) in respective subchannels of the first and second downlink radio channels **160** and **162** that are associated with the destination mobile station of the downlink signals, and the codes at blocks **292** and **294** (shown in Figure 11) and at block **336** (shown in Figure 15) transmit uplink signals **190** (shown in Figure 6) in respective subchannels of the first and second uplink radio channels **164** and **166** that are associated with the source mobile station of the uplink signals. Also in such a configuration, the destination identifier field **178** (shown in Figure 4) and the source identifier field **192** (shown in Figure 6) may be omitted because the destination or source of a signal may be identified by the subchannel of the downlink signal (**178**) or of the uplink signal (**190**), and the codes at blocks **254** and **274** (shown in Figure 10) may determine whether the signal is designated for the mobile station radio channel **252** by identifying the subchannel of the transmit downlink signal (**178**) received at **226** or **228** (also shown in Figure 10).

Referring to Figure 20, another illustrative sequence of signals transmitted and received in the radio communication system **100** (shown in Figure 1) is illustrated schematically and shown generally at **392**. The sequence of signals **392** begins when the base station **102** transmits a first downlink signal **394** in a subchannel of the first downlink radio channel **160** associated with the mobile station **134**. The radio signal repeater **106** receives the first downlink signal **394** and transmits a second downlink signal **396** to the mobile station

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134 on a subchannel of the mobile station radio channel **252** associated with the mobile station **134**. Later, the mobile station **134** transmits a first uplink signal **398** on the subchannel of the mobile station radio channel **252** associated with the mobile station **134**, and the radio signal repeater **106** receives the first uplink signal **398** and transmits a second uplink signal **400** to the base station **102** on a subchannel of the first uplink radio channel **162** associated with the mobile station **134**.

Later in the sequence of signals **392**, the base station **102** transmits a third downlink signal **402** on a subchannel of the first downlink radio channel **160** associated with the mobile station **140**. The radio signal repeater **106** receives the third downlink signal **402** and transmits a fourth downlink signal **404** on a subchannel of the second downlink radio channel **162** associated with the mobile station **140**. The radio signal repeater **118** receives the fourth downlink signal **404** and transmits a fifth downlink signal **406** to the mobile station **140** on a subchannel of the mobile station radio channel **252** associated with the mobile station **140**. Later, the mobile station **140** transmits a third uplink signal **408** on the subchannel of the mobile station radio channel **252** associated with the mobile station **140**. The radio signal repeater **118** receives the third uplink signal **408** and transmits a fourth uplink signal **410** on a subchannel of the second uplink radio channel **166** associated with the mobile station **140**. The radio signal repeater **106** receives the fourth uplink signal **410** and transmits a fifth uplink signal **412** on a subchannel of the first uplink radio channel **164** associated with the mobile station **140**.

The radio communication system **100** may enable communication at higher radio frequencies, such as EHF frequencies for example, advantageously enabling greater operating bandwidth available in such higher radio frequencies. In practice, the base station **102** of the radio communication system **100** may replace an existing base station using only lower radio frequencies to upgrade the existing base station and provide greater operating bandwidth. Further, the radio signal repeaters described above may advantageously be positioned closer together, as may be required to

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accommodate the shorter range of higher radio frequencies, as the at least two different channels for uplink signals and the at least two different channels downlink signals may advantageously reduce interference between the signals.

- 5 While various embodiments have been described and illustrated, such embodiments should be considered illustrative only and not as limiting the invention as construed in accordance with the accompanying claims.

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What is claimed is:

1. A method of facilitating radio communications, the method comprising:

receiving, at a radio signal repeater from a first remote radio station on a first radio channel, a first radio signal encoded with a first message;

after receiving the first radio signal, transmitting, from the radio signal repeater to a second remote radio station on a second radio channel different from the first radio channel, a second radio signal encoded with the first message;

receiving, at the radio signal repeater from the second remote radio station on a third radio channel different from the first and second radio channels, a third radio signal encoded with a second message; and

after receiving the third radio signal, transmitting, from the radio signal repeater to the first remote radio station on a fourth radio channel different from the first, second, and third radio channels, a fourth radio signal encoded with the second message.

2. The method of claim 1 wherein the first, second, third, and fourth radio channels are frequency-division multiplexed on first, second, third, and fourth different radio frequency bands respectively.

3. The method of claim 1 wherein the first and fourth radio channels are time-division multiplexed on a first radio frequency band, and wherein the second and third radio channels are time-division multiplexed on a second radio frequency band different from the first radio frequency band.

4. The method of claim 1, 2, or 3 further comprising receiving, at the radio signal repeater, configuration information encoded in a configuration information signal in a configuration radio frequency band different from

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respective radio frequency bands of the first, second, third, and fourth radio channels.

5. The method of claim 4 wherein the configuration radio frequency band is between about 57 GHz and about 64 GHz.

5 6. The method of any one of claims 1 to 5 wherein the first, second, third, and fourth radio channels have respective radio frequencies between about 57 GHz and about 64 GHz.

10 7. The method of any one of claims 1 to 6 wherein transmitting the second radio signal comprises amplifying the first radio signal, and wherein transmitting the fourth radio signal comprises amplifying the third radio signal.

15 8. The method of any one of claims 1 to 6 wherein transmitting the second radio signal comprises digitally decoding the first message from the first radio signal and encoding the decoded first message for the second radio signal, and wherein transmitting the fourth radio signal comprises digitally decoding the second message from the third radio signal and encoding the decoded second message for the fourth radio signal.

20 9. The method of any one of claims 1 to 6 further comprising:
determining a first signal-to-noise ratio representing a ratio of strength of the first radio signal to noise in the first radio signal at the radio signal repeater; and
determining a second signal-to-noise ratio representing a ratio of strength of the third radio signal to noise in the third radio signal at the radio signal repeater;
25 wherein if the first signal-to-noise ratio satisfies a first criterion, transmitting the second radio signal comprises amplifying the first radio signal;

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wherein if the first signal-to-noise ratio does not satisfy the first criterion, transmitting the second radio signal comprises digitally decoding the first message from the first radio signal and encoding the decoded first message for the second radio signal;

5 wherein if the second signal-to-noise ratio satisfies a second criterion, transmitting the fourth radio signal comprises amplifying the third radio signal; and

10 wherein if the second signal-to-noise ratio does not satisfy the second criterion, transmitting the fourth radio signal comprises digitally decoding the second message from the third radio signal and encoding the decoded second message for the fourth radio signal.

10. The method of claim **9** wherein:

15 the first signal-to-noise ratio satisfies the first criterion if the first signal-to-noise ratio exceeds a first threshold;

the first signal-to-noise ratio does not satisfy the first criterion if the first signal-to-noise ratio does not exceed the first threshold;

20 the second signal-to-noise ratio satisfies the second criterion if the second signal-to-noise ratio exceeds a second threshold; and

the second signal-to-noise ratio does not satisfy the second criterion if the second signal-to-noise ratio does not exceed the second threshold.

11. The method of any one of claims **1** to **10** further comprising:

25 before transmitting the second radio signal, receiving, at the radio signal repeater from the first remote radio station on the second radio channel, a fifth radio signal encoded with the first message, the first radio signal being stronger than the fifth radio

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signal; and

comparing respective signal strengths of the first and fifth radio signals to determine that the first radio signal is stronger than the fifth radio signal;

5 wherein transmitting the second radio signal comprises selecting the second radio channel instead of the first radio channel for the second radio signal in response to determining that the first radio signal is stronger than the fifth radio signal.

12. The method of any one of claims 1 to 11 further comprising:

10 receiving, at the radio signal repeater from the first remote radio station on the first radio channel, a sixth radio signal encoded with a third message;

15 after receiving the sixth radio signal, transmitting, to a third remote radio station on a fifth radio channel different from the first, second, third, and fourth radio channels, a seventh radio signal encoded with the third message;

receiving, at the radio signal repeater from the third remote radio station on the fifth radio channel, an eighth radio signal encoded with a fourth message; and

20 after receiving the eighth radio signal, transmitting, to the first remote radio station on the fourth radio channel, a ninth radio signal encoded with the fourth message.

13. The method of claim 12 wherein the fifth radio channel has a radio frequency less than about 5 GHz.

25 14. The method of claim 12 or 13 wherein:

receiving the sixth radio signal comprises receiving the sixth radio signal on a subchannel of the first radio channel

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associated with the third remote radio station;

transmitting the seventh radio signal comprises transmitting the seventh radio signal on a subchannel of the fifth radio channel associated with the third remote radio station;

5 receiving the eighth radio signal comprises receiving the eighth radio signal on the subchannel of the fifth radio channel associated with the third remote radio station; and

10 transmitting the ninth radio signal comprises transmitting the ninth radio signal on a subchannel of the fourth radio channel associated with the third remote radio station.

15. The method of claim **12** or **13** wherein the sixth radio signal includes a destination field including destination data designating the third remote radio station.

16. The method of any one of claims **1** to **15** further comprising:

15 receiving the second radio signal at the second remote radio station from the radio signal repeater; and

20 after receiving the second radio signal, transmitting, from the second remote radio station to a fourth remote radio station on the first radio channel, a tenth radio signal encoded with the first message.

17. The method of claim **16** further comprising, before transmitting the third radio signal, receiving, at the second remote station from the fourth remote station on the fourth radio channel, an eleventh radio signal encoded with the second message.

25 18. A radio signal repeater apparatus comprising:

means for receiving, from a first remote radio station on a first radio channel, a first radio signal encoded with a first message;

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means for transmitting, after receiving the first radio signal, a second radio signal to a second remote radio station on a second radio channel different from the first radio channel, the second radio signal encoded with the first message;

5 means for receiving, from the second remote radio station on a third radio channel different from the first and second radio channels, a third radio signal encoded with a second message; and

10 means for transmitting, after receiving the third radio signal, a fourth radio signal to the first remote radio station on a fourth radio channel different from the first, second, and third radio channels, the fourth radio signal encoded with the second message.

19. A radio signal repeater apparatus comprising:

15 an interface for facilitating radio communication with first and second remote radio stations on first, second, third, and fourth different radio channels; and

a processor in communication with the interface and operably configured to:

20 receive, from the interface, a first radio signal from the first remote radio station on the first radio channel, the first radio signal encoded with a first message;

25 cause the interface to transmit, after receiving the first radio signal, a second radio signal to the second remote radio station on the second radio channel, the second radio signal encoded with the first message;

receive, from the interface, a third radio signal from the second remote radio station on the third radio channel,

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the third radio signal encoded with a second message;
and

cause the interface to transmit, after receiving the third
radio signal, a fourth radio signal to the first remote radio
station on the fourth radio channel, the fourth radio signal
encoded with the second message.

20. The apparatus of claim **19** wherein the first, second, third, and fourth
radio channels are frequency-division multiplexed on first, second,
third, and fourth different radio frequency bands respectively.

21. The apparatus of claim **19** wherein the first and fourth radio channels
are time-division multiplexed on a first radio frequency band, and
wherein the second and third radio channels are time-division
multiplexed on a second radio frequency band different from the first
radio frequency band.

22. The apparatus of claim **19**, **20**, or **21** wherein the processor is further
operably configured to receive, from the interface, configuration
information encoded in a configuration information signal in a
configuration radio frequency band different from respective radio
frequency bands of the first, second, third, and fourth radio channels.

23. The apparatus of claim **22** wherein the configuration radio frequency
band is between about 57 GHz and about 64 GHz.

24. The apparatus of any one of claims **19** to **23** wherein the first, second,
third, and fourth radio channels have respective radio frequencies
between about 57 GHz and about 64 GHz.

25. The apparatus of any one of claims **19** to **24** wherein:

the processor is operably configured to cause the interface to
transmit the second radio signal by amplifying the first radio
signal; and

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the processor is operably configured to cause the interface to transmit the fourth radio signal by amplifying the third radio signal.

26. The apparatus of any one of claims **19** to **24** wherein:

5 the processor is operably configured to cause the interface to transmit the second radio signal by digitally decoding the first message from the first radio signal and by encoding the decoded first message for the second radio signal; and

10 the processor is operably configured to cause the interface to transmit the fourth radio signal by digitally decoding the second message from the third radio signal and by encoding the decoded second message for the fourth radio signal.

27. The apparatus of any one of claims **19** to **24** wherein:

15 the processor is further operably configured to determine a first signal-to-noise ratio representing a ratio of strength of the first radio signal to noise in the first radio signal at the interface;

the processor is operably configured to cause the interface to transmit the second radio signal by amplifying the first radio signal if the first signal-to-noise ratio satisfies a first criterion;

20 the processor is operably configured to cause the interface to transmit the second radio signal by digitally decoding the first message from the first radio signal and by encoding the decoded first message for the second radio signal if the first signal-to-noise ratio does not satisfy the first criterion;

25 the processor is further operably configured to determine a second signal-to-noise ratio representing a ratio of strength of the third radio signal to noise in the third radio signal at the interface;

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the processor is operably configured to cause the interface to transmit the fourth radio signal by amplifying the third radio signal if the second signal-to-noise ratio satisfies a second criterion; and

5 the processor is operably configured to cause the interface to transmit the fourth radio signal by digitally decoding the second message from the third radio signal and by encoding the decoded second message for the fourth radio signal if the second signal-to-noise ratio does not satisfy the second
10 criterion.

28. The apparatus of claim **27** wherein:

the first signal-to-noise ratio satisfies the first criterion if the first signal-to-noise ratio exceeds a first threshold;

15 the first signal-to-noise ratio does not satisfy the first criterion if the first signal-to-noise ratio does not exceed the first threshold;

the second signal-to-noise ratio satisfies the second criterion if the second signal-to-noise ratio exceeds a second threshold; and

20 the second signal-to-noise ratio does not satisfy the second criterion if the second signal-to-noise ratio does not exceed the second threshold.

29. The apparatus of any one of claims **19** to **28** wherein the processor is further operably configured to:

25 receive from the interface, before transmitting the second radio signal, a fifth radio signal from the first remote radio station on the second radio channel, the fifth radio signal encoded with the first message and not as strong as the first radio signal;

compare respective signal strengths of the first and fifth radio

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signals; and

select the second radio channel instead of the first radio channel for the second radio signal if the first radio signal is stronger than the fifth radio signal.

- 5 **30.** The apparatus of any one of claims **19** to **29** wherein the processor is further operably configured to:

receive, from the interface, a sixth radio signal from the first remote radio station on the first radio channel, the sixth radio signal encoded with a third message;

10 after receiving the sixth radio signal, cause the interface to transmit, to a third remote radio station on a fifth radio channel different from the first, second, third, and fourth radio channels, a seventh radio signal encoded with the third message;

15 receive, from the interface, an eighth radio signal from the third remote radio station on the fifth radio channel, the eighth radio signal encoded with a fourth message; and

after receiving the eighth radio signal, cause the interface to transmit, to the first remote radio station on the fourth radio channel, a ninth radio signal encoded with the fourth message.

- 20 **31.** The apparatus of claim **30** wherein the fifth radio channel has a radio frequency less than about 5 GHz.

- 32.** The apparatus of claim **30** or **31** wherein:

25 the processor is operably configured to receive the sixth radio signal on a subchannel of the first radio channel associated with the third remote radio station;

the processor is operably configured to transmit the seventh radio signal on a subchannel of the fifth radio channel

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associated with the third remote radio station;

the processor is operably configured to receive the eighth radio signal on the subchannel of the fifth radio channel associated with the third remote radio station; and

5 the processor is operably configured to transmit the ninth radio signal on a subchannel of the fourth radio channel associated with the third remote radio station.

33. The apparatus of claim **30** or **31** wherein:

10 the sixth radio signal includes a destination field including destination data; and

the processor is operably configured to cause the interface to transmit the seventh radio signal in response to receiving the sixth radio signal when the destination field of the sixth radio signal includes destination data designating the third remote radio station.

15

34. A method of radio communication, the method comprising:

receiving a first radio signal at a mobile station from a first remote radio station on a first radio channel;

20 transmitting a second radio signal from the mobile station to the first remote radio station on a second radio channel associated with the first radio channel and different from the first radio channel;

receiving a third radio signal at the mobile station from a second remote radio station on a third radio channel different from the first and second radio channels; and

25

transmitting a fourth radio signal from the mobile station to the second remote radio station on a fourth radio channel

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associated with the third radio channel and different from the first, second, and third radio channels.

5 **35.** The method of claim **34** wherein the first, second, third, and fourth radio channels are frequency-division multiplexed on first, second, third, and fourth different radio frequency bands respectively.

10 **36.** The method of claim **34** wherein the first and second radio channels are time-division multiplexed on a first radio frequency band, and wherein the third and fourth radio channels are time-division multiplexed on a second radio frequency band different from the first radio frequency band.

15 **37.** The method of claim **34**, **35**, or **36** further comprising receiving, at the mobile station, configuration information encoded in a configuration information signal in a configuration radio frequency band different from respective radio frequency bands of the first, second, third, and fourth radio channels.

38. The method of claim **37** wherein the configuration radio frequency band is between about 57 GHz and about 64 GHz.

20 **39.** The method of any one of claims **34** to **38** wherein the first, second, third, and fourth radio channels have respective radio frequencies between about 57 GHz and about 64 GHz.

40. A mobile station apparatus comprising:

 means for receiving a first radio signal from a first remote radio station on a first radio channel;

25 means for transmitting a second radio signal to the first remote radio station on a second radio channel associated with the first radio channel and different from the first radio channel;

 means for receiving a third radio signal from a second remote radio station on a third radio channel different from the first and

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second radio channels; and

means for transmitting a fourth radio signal to the second remote radio station on a fourth radio channel associated with the third radio channel and different from the first, second, and third radio channels.

5

41. A mobile station apparatus comprising:

an interface for facilitating radio communication with first and second remote radio stations on first, second, third, and fourth different radio channels; and

10

a processor in communication with the interface and operably configured to:

receive, from the interface, a first radio signal from a first remote radio station on a first radio channel;

15

cause the interface to transmit a second radio signal to the first remote radio station on a second radio channel associated with the first radio channel and different from the first radio channel;

20

receive, from the interface, a third radio signal from a second remote radio station on a third radio channel different from the first and second radio channels; and

cause the interface to transmit a fourth radio signal to the second remote radio station on a fourth radio channel associated with the third radio channel and different from the first, second, and third radio channels.

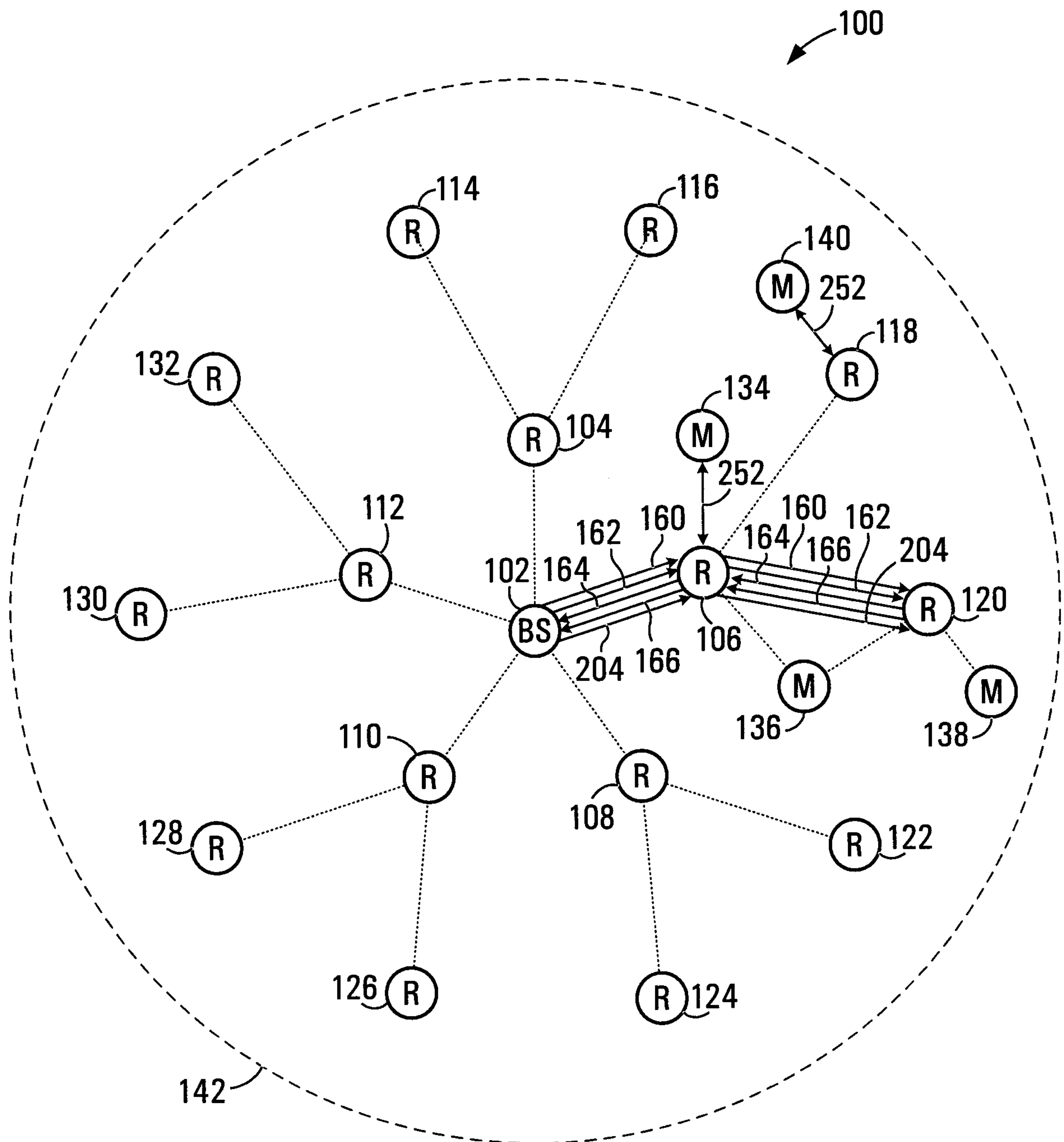
25

42. The apparatus of claim **41** wherein the first, second, third, and fourth radio channels are frequency-division multiplexed on first, second, third, and fourth different radio frequency bands respectively.

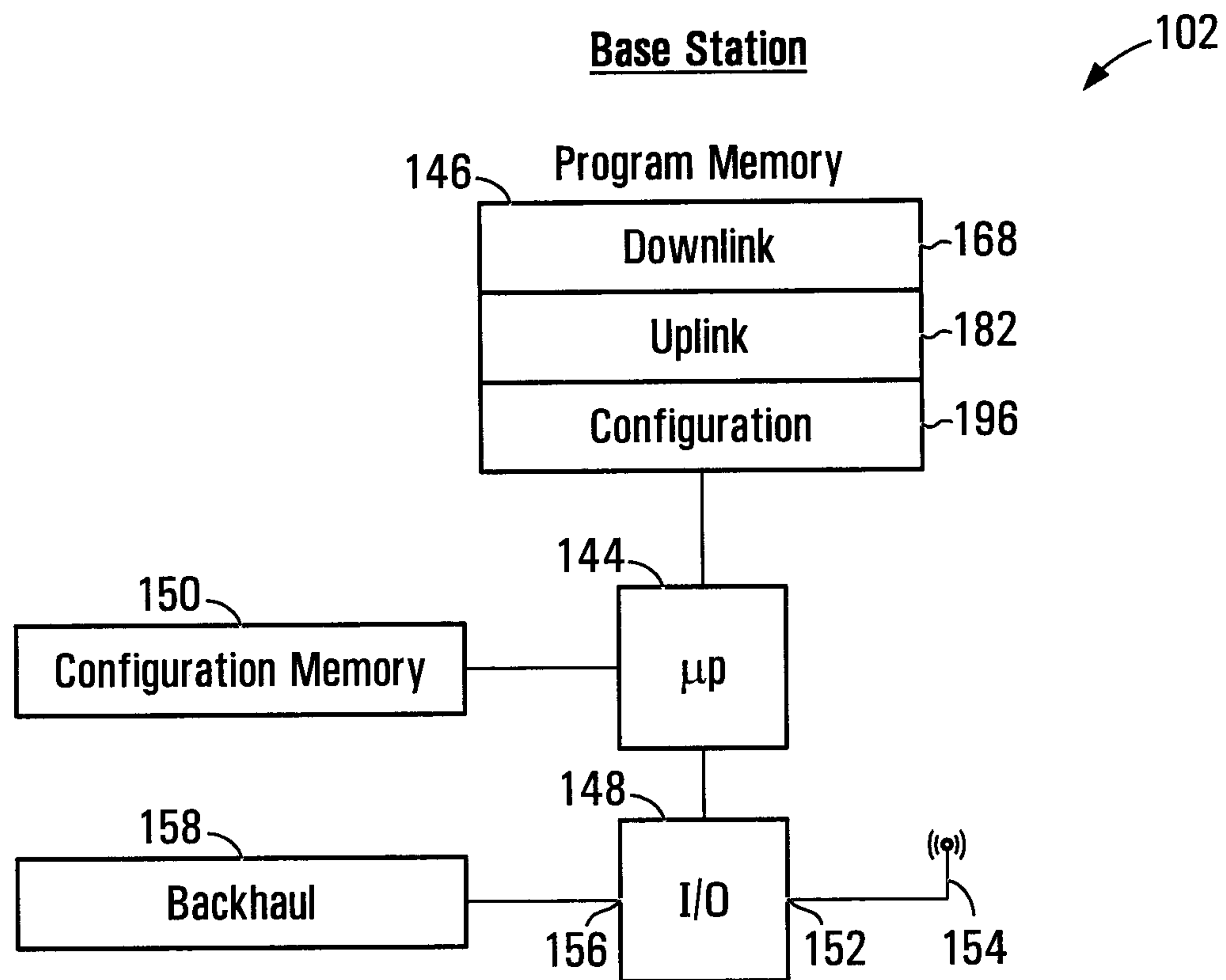
-51-

- 5 **43.** The apparatus of claim **41** wherein the first and second radio channels are time-division multiplexed on a first radio frequency band, and wherein the third and fourth radio channels are time-division multiplexed on a second radio frequency band different from the first radio frequency band.
- 10 **44.** The apparatus of claim **41**, **42**, or **43** wherein the processor is further operably configured to receive, from the interface, configuration information encoded in a configuration information signal in a configuration radio frequency band different from respective radio frequency bands of the first, second, third, and fourth radio channels.
- 45.** The apparatus of claim **44** wherein the configuration radio frequency band is between about 57 GHz and about 64 GHz.
- 15 **46.** The apparatus of any one of claims **41** to **45** wherein the first, second, third, and fourth radio channels have respective radio frequencies between about 57 GHz and about 64 GHz.

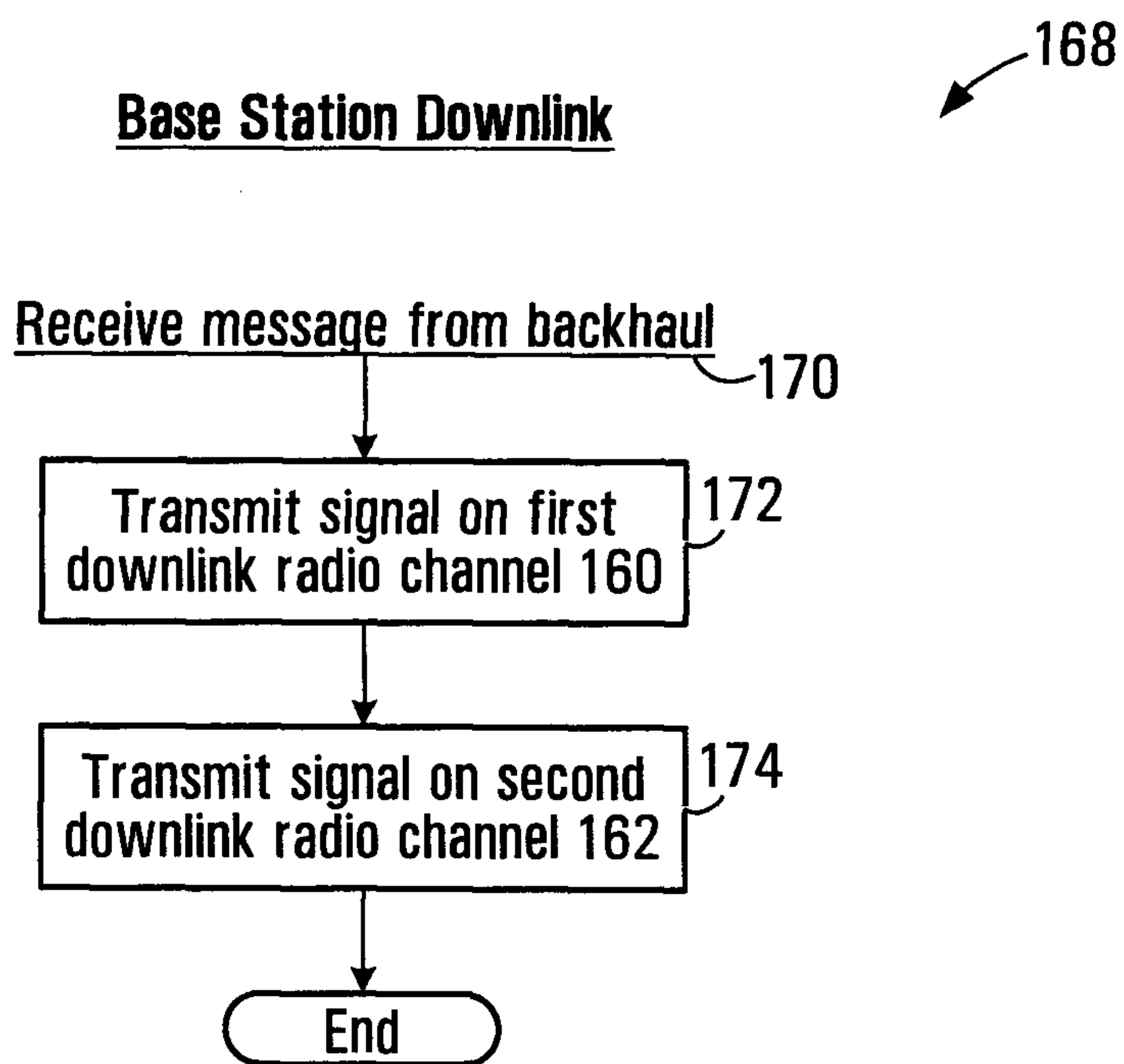
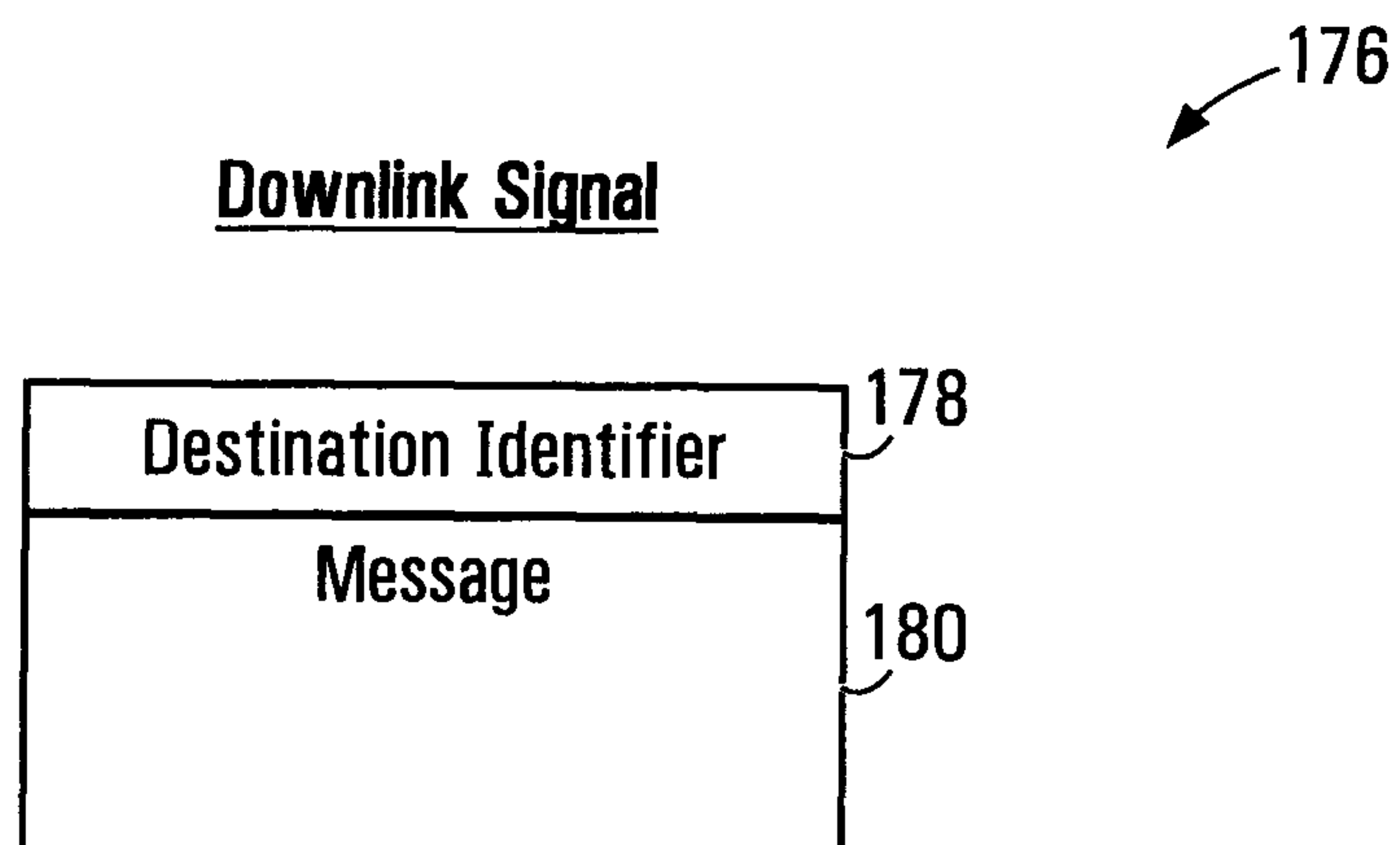
1/16



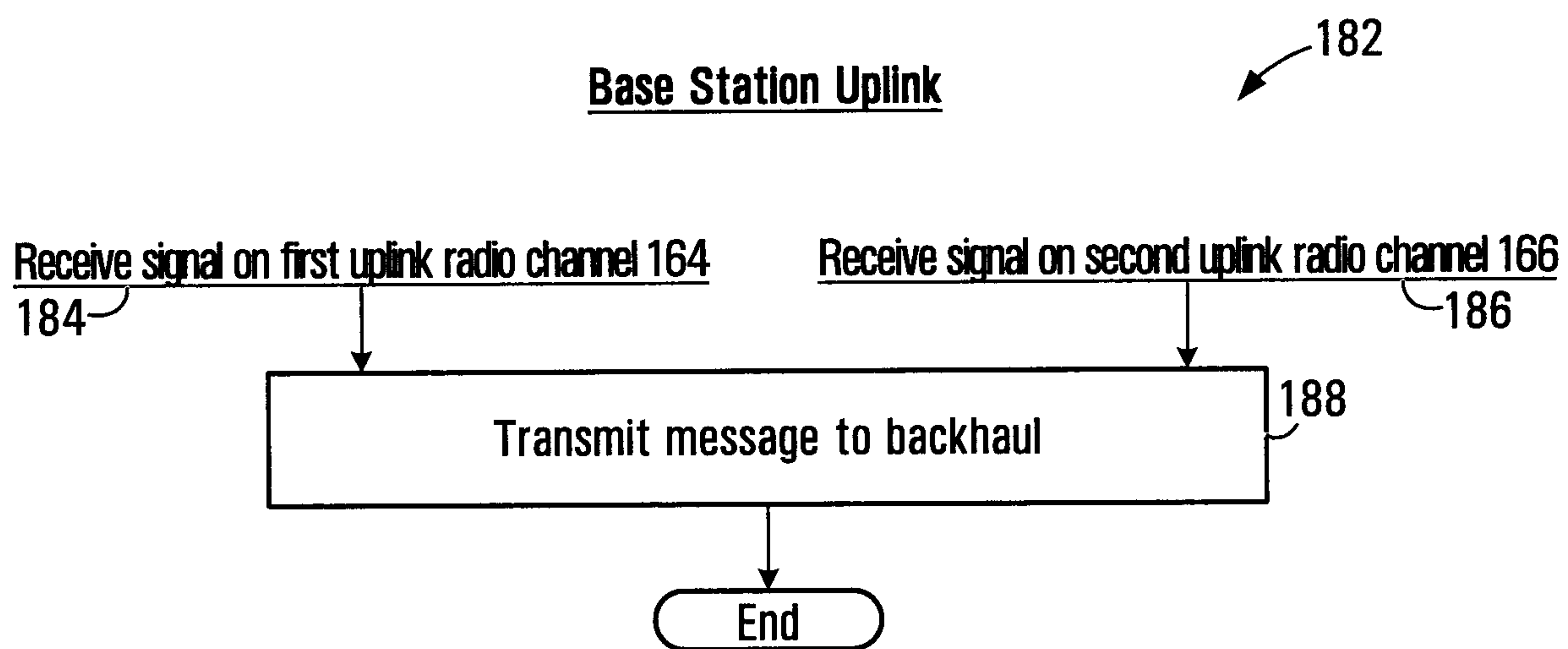
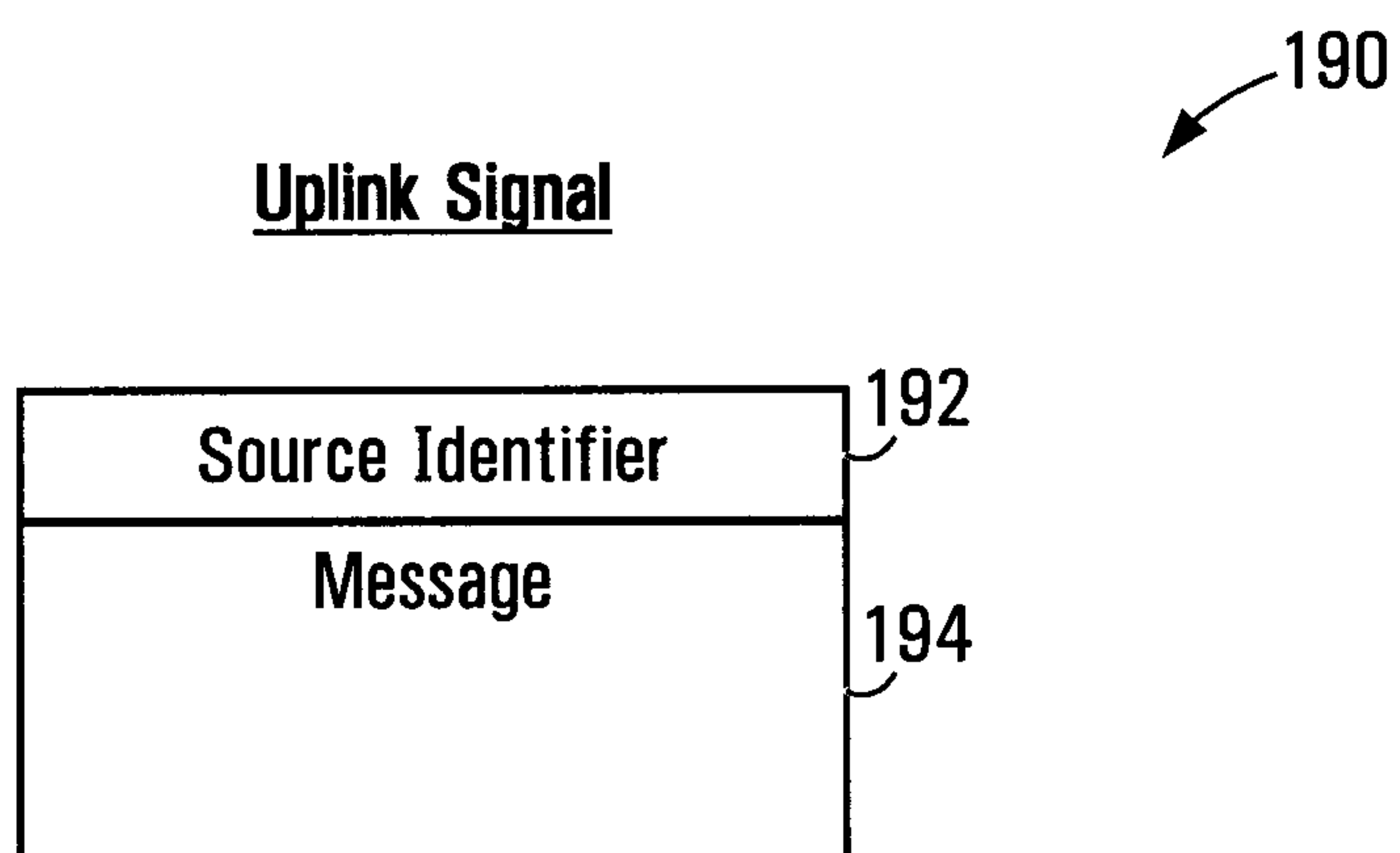
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**FIG. 2**

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**FIG. 3****FIG. 4**

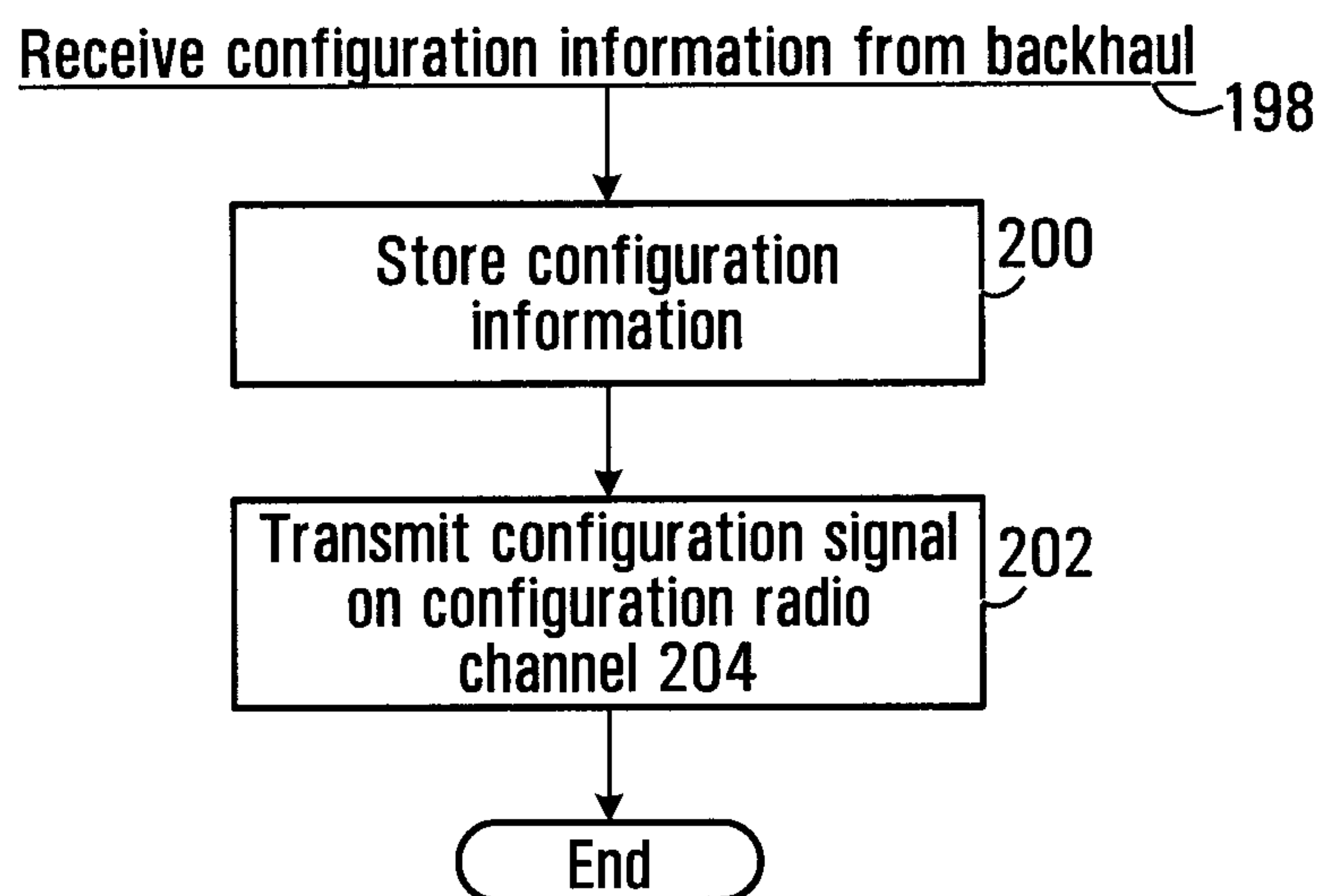
4/16

**FIG. 5****FIG. 6**

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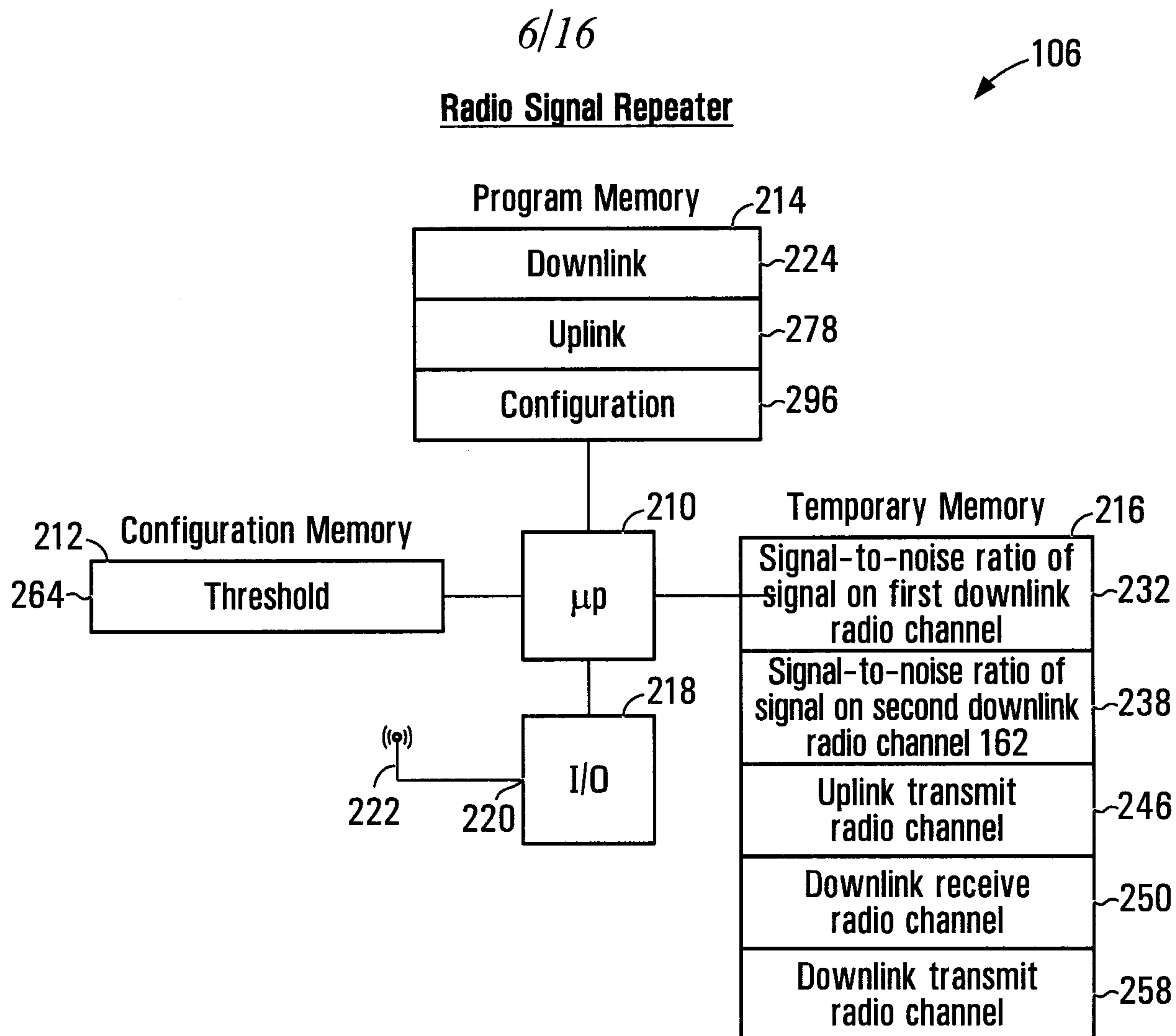
Base Station Configuration

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**FIG. 7**

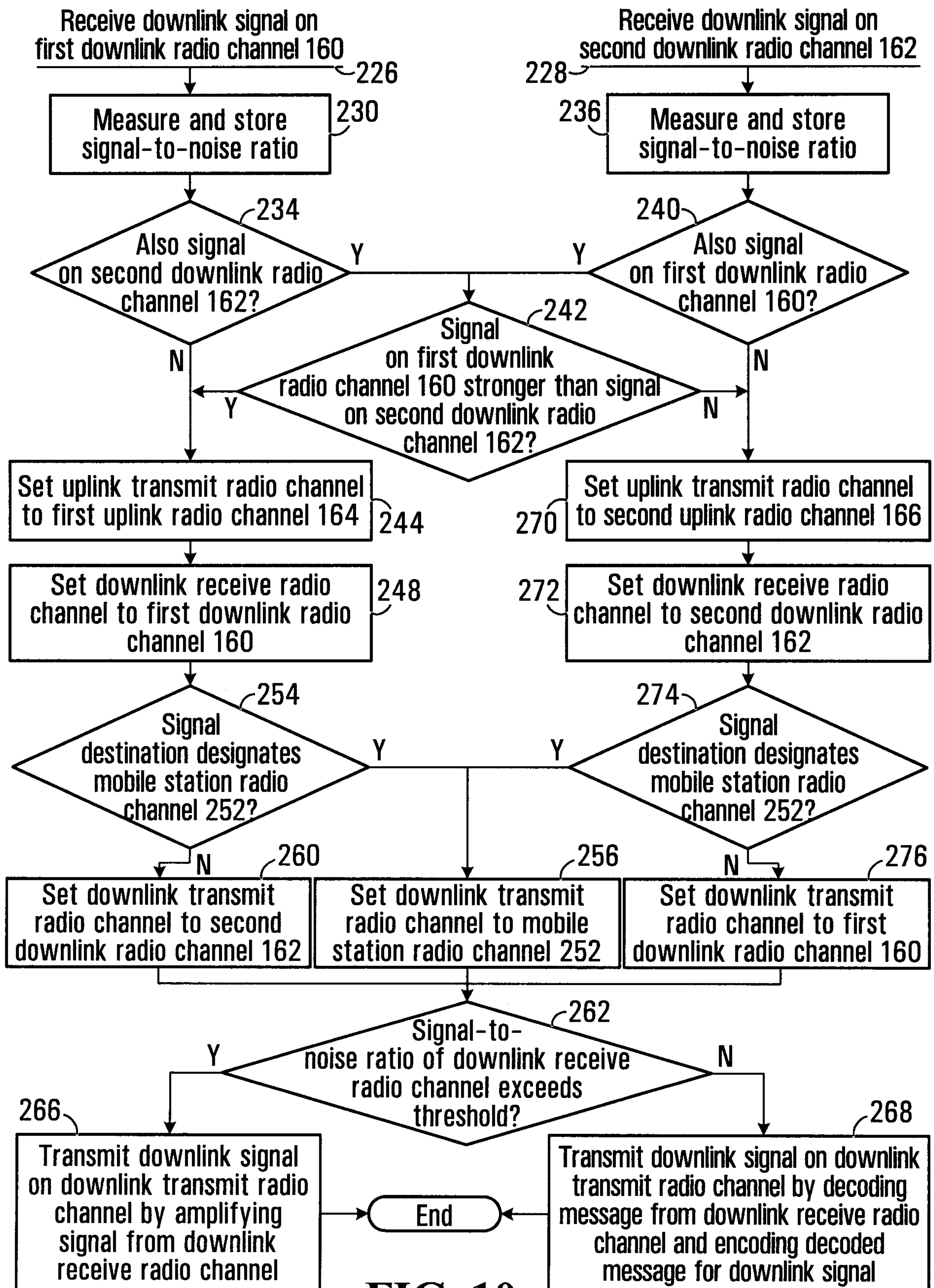
206

Configuration Signal**FIG. 8**

**FIG. 9**

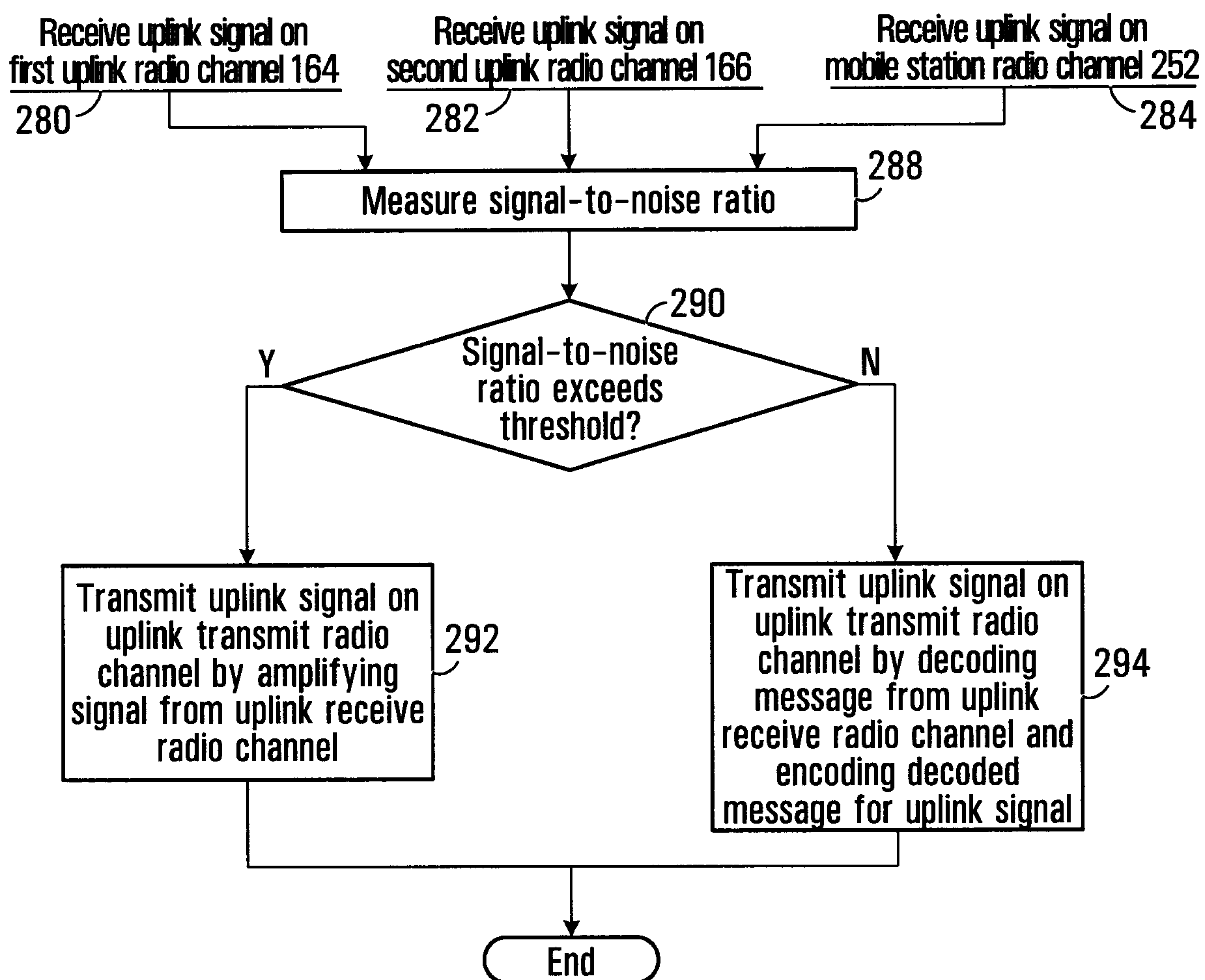
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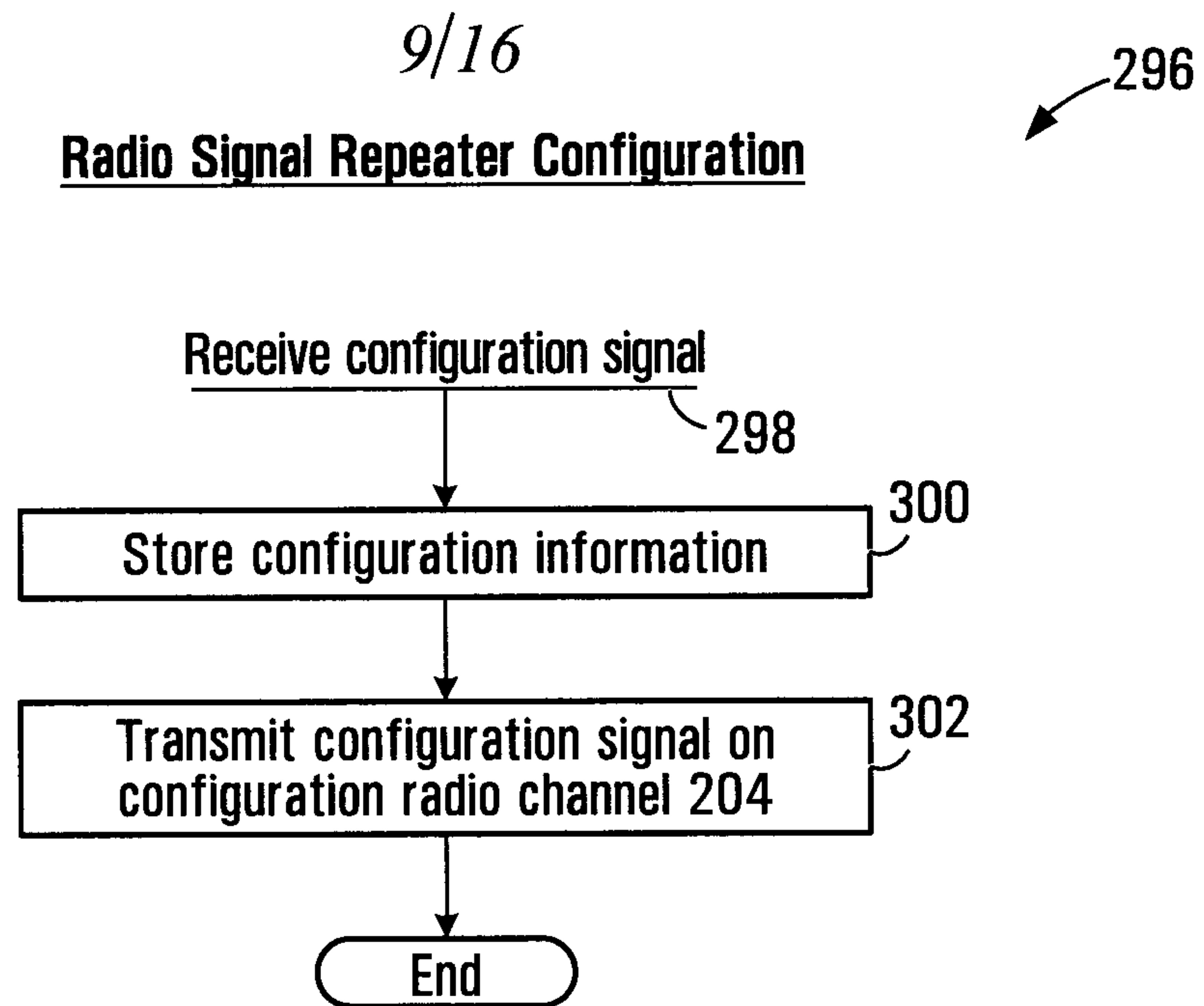
224

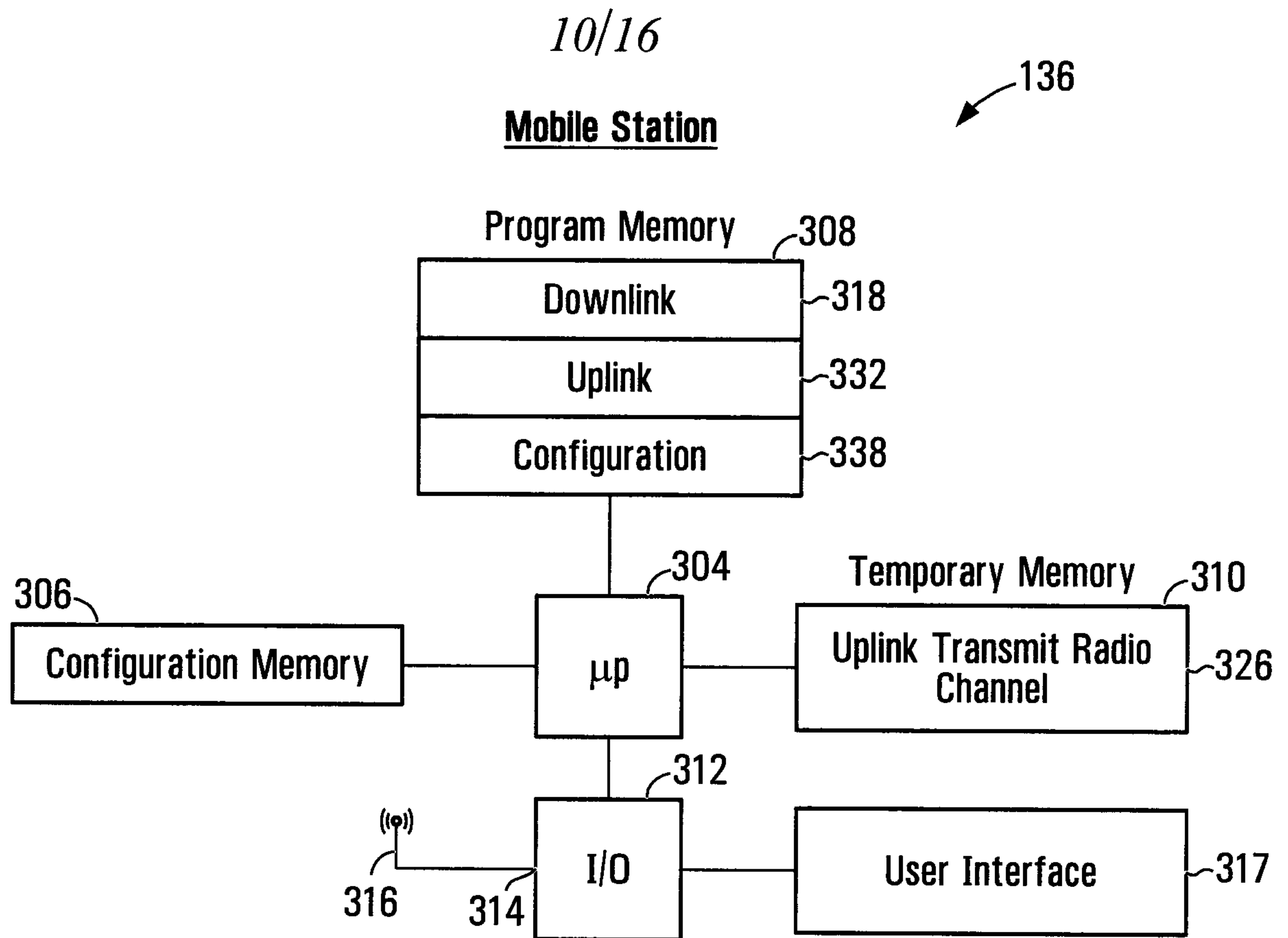
Radio Signal Repeater Downlink**FIG. 10**

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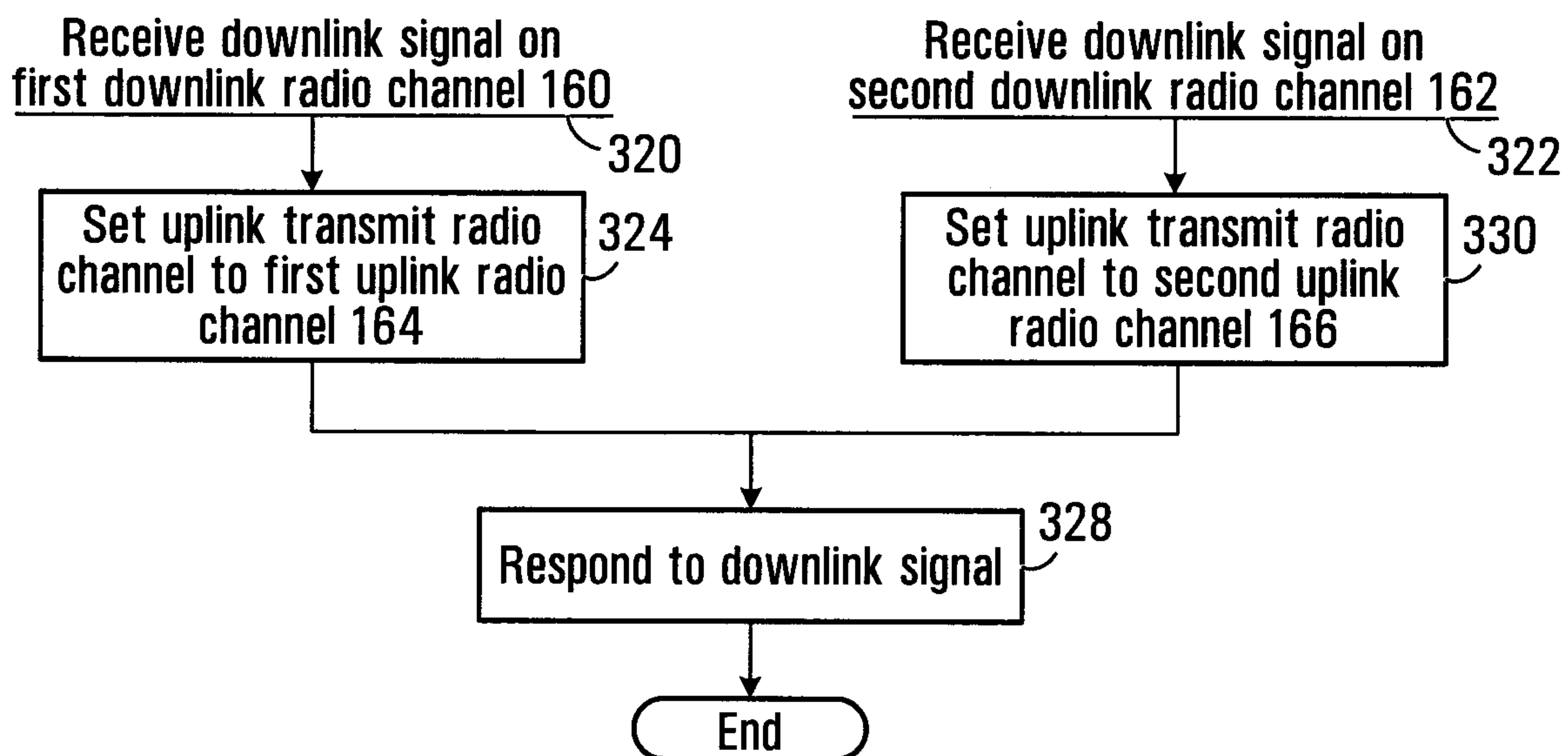
Radio Signal Repeater Uplink**FIG. 11**

**FIG. 12**

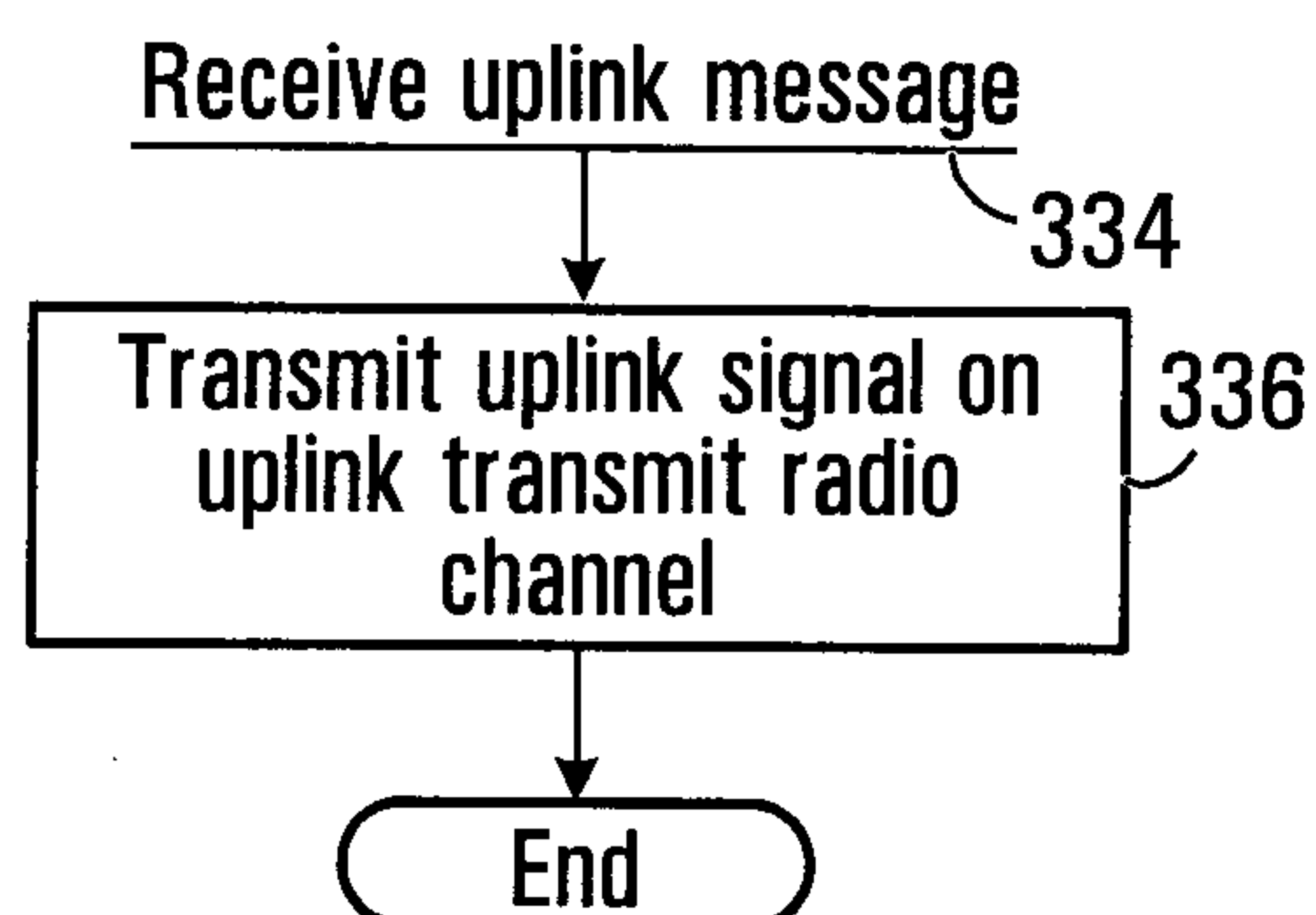
**FIG. 13**

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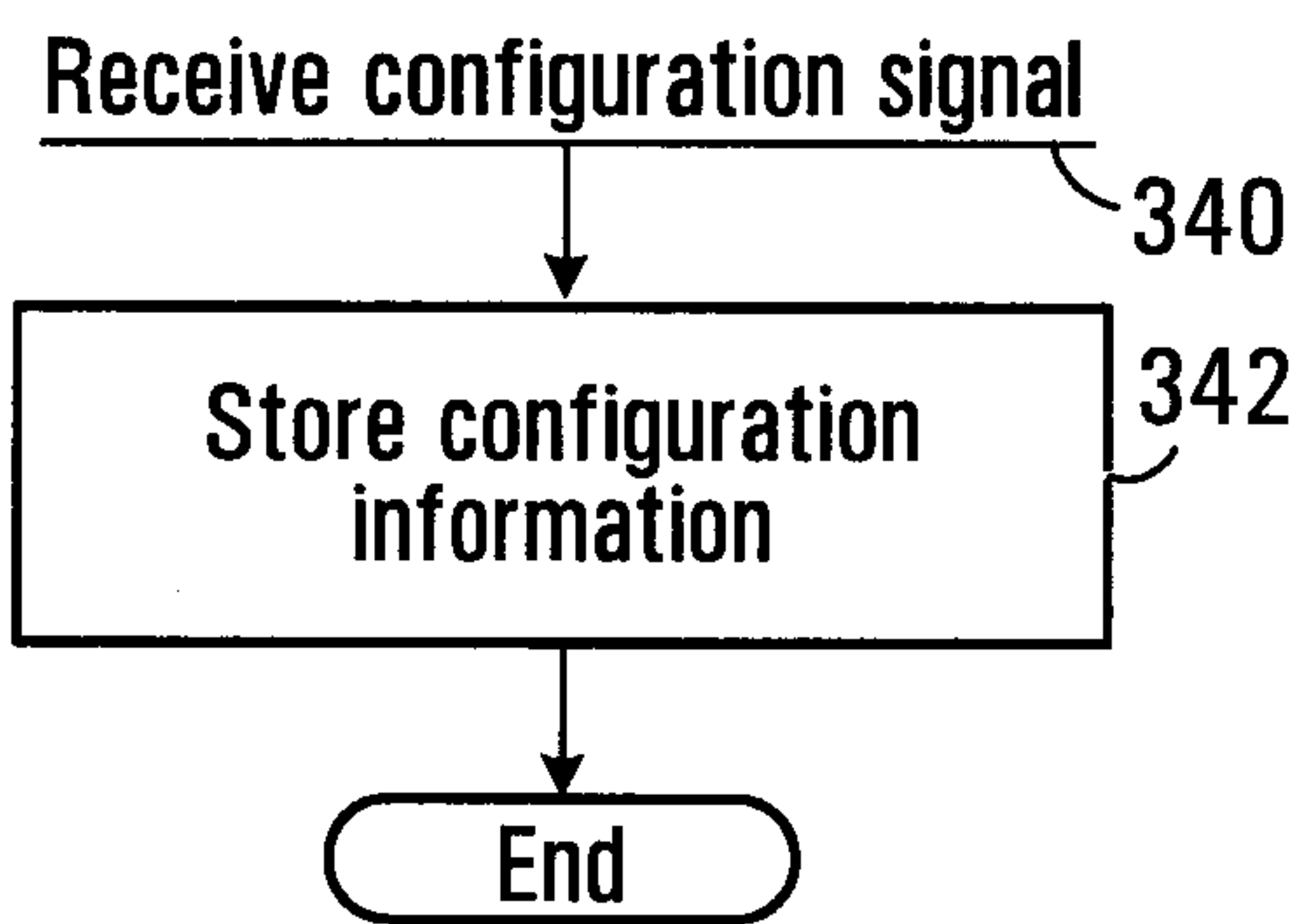
Mobile Station Downlink**FIG. 14**Mobile Station Uplink

332

**FIG. 15**

*12/16***Mobile Station Configuration**

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**FIG. 16**

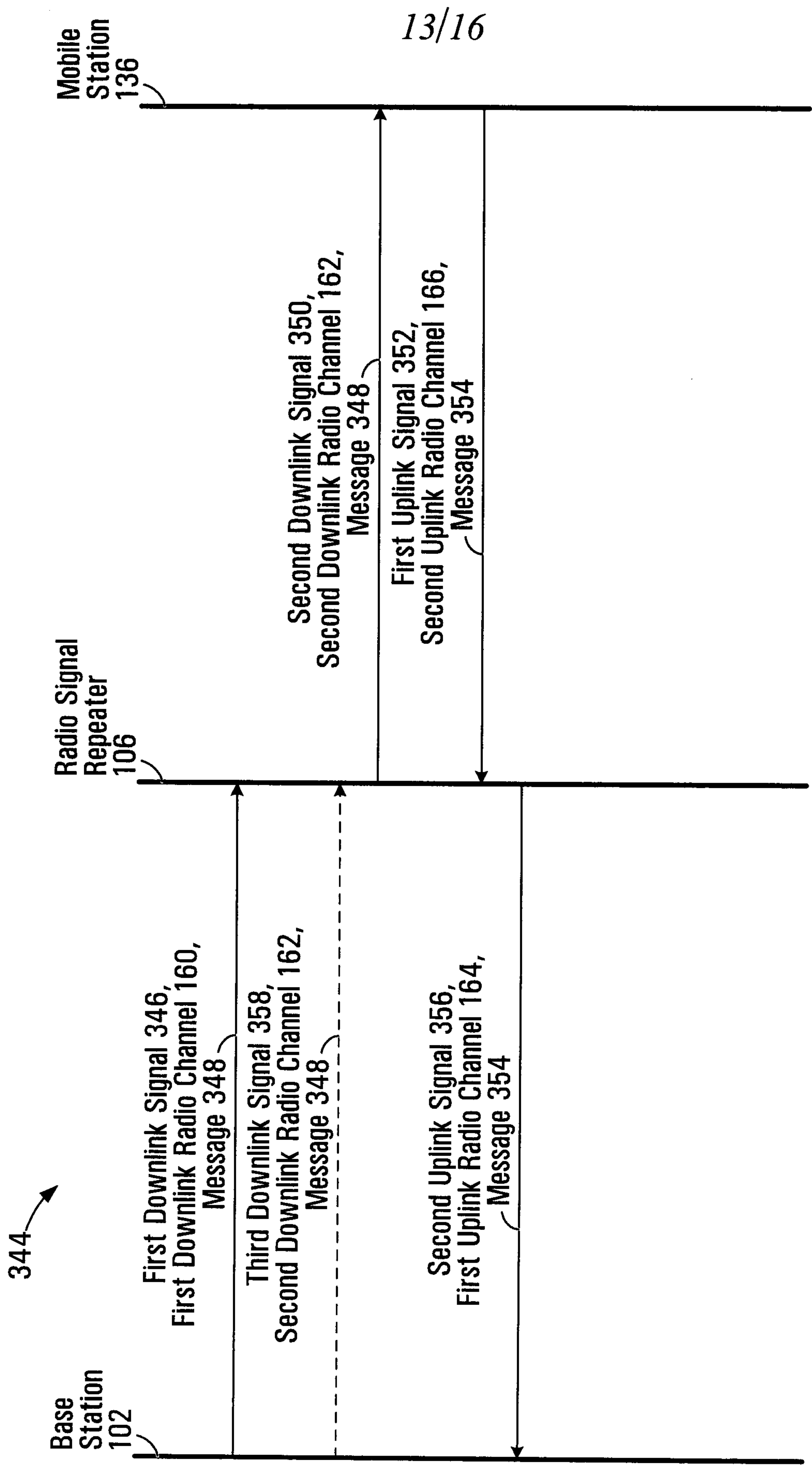


FIG. 17

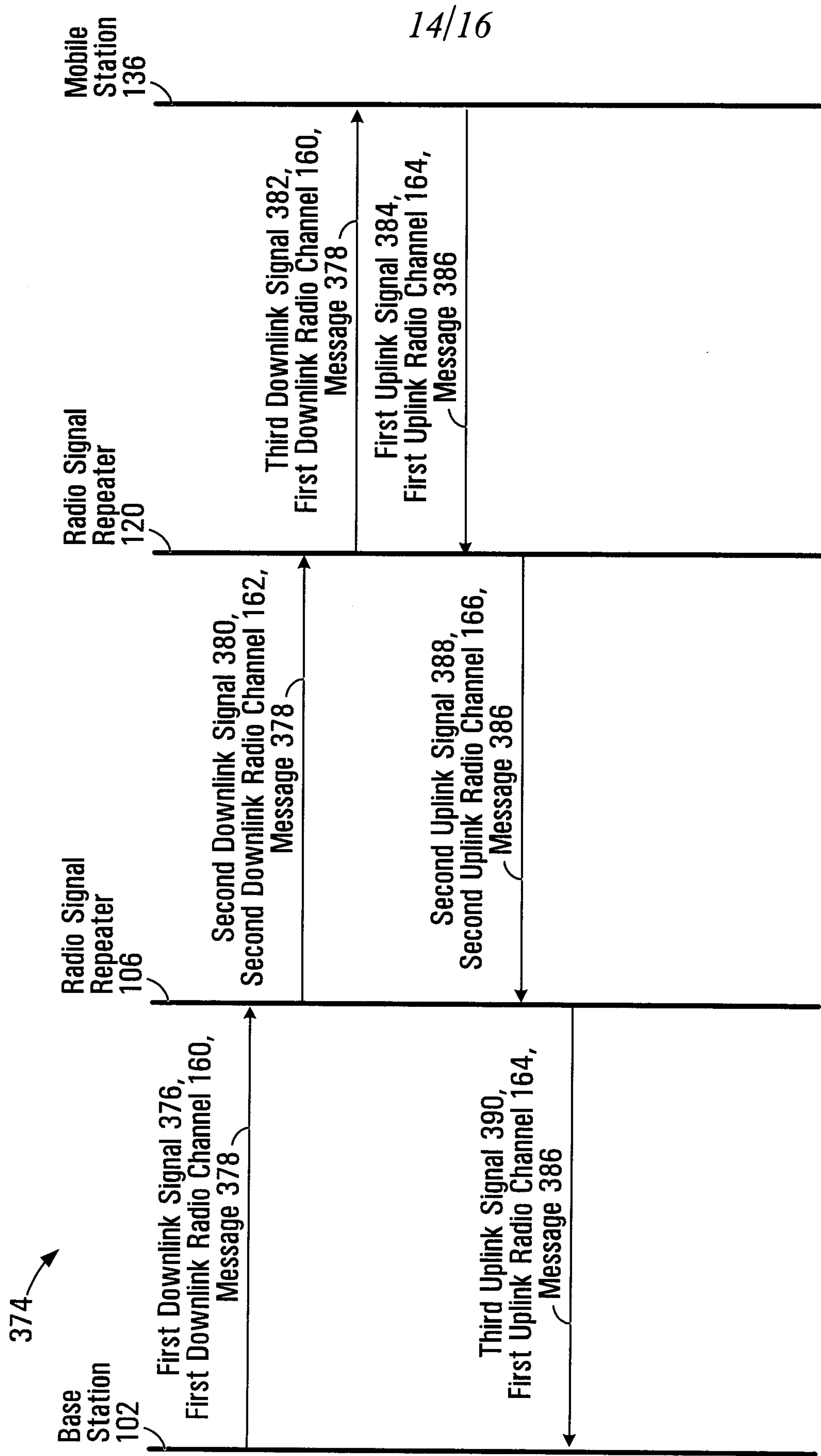


FIG. 18

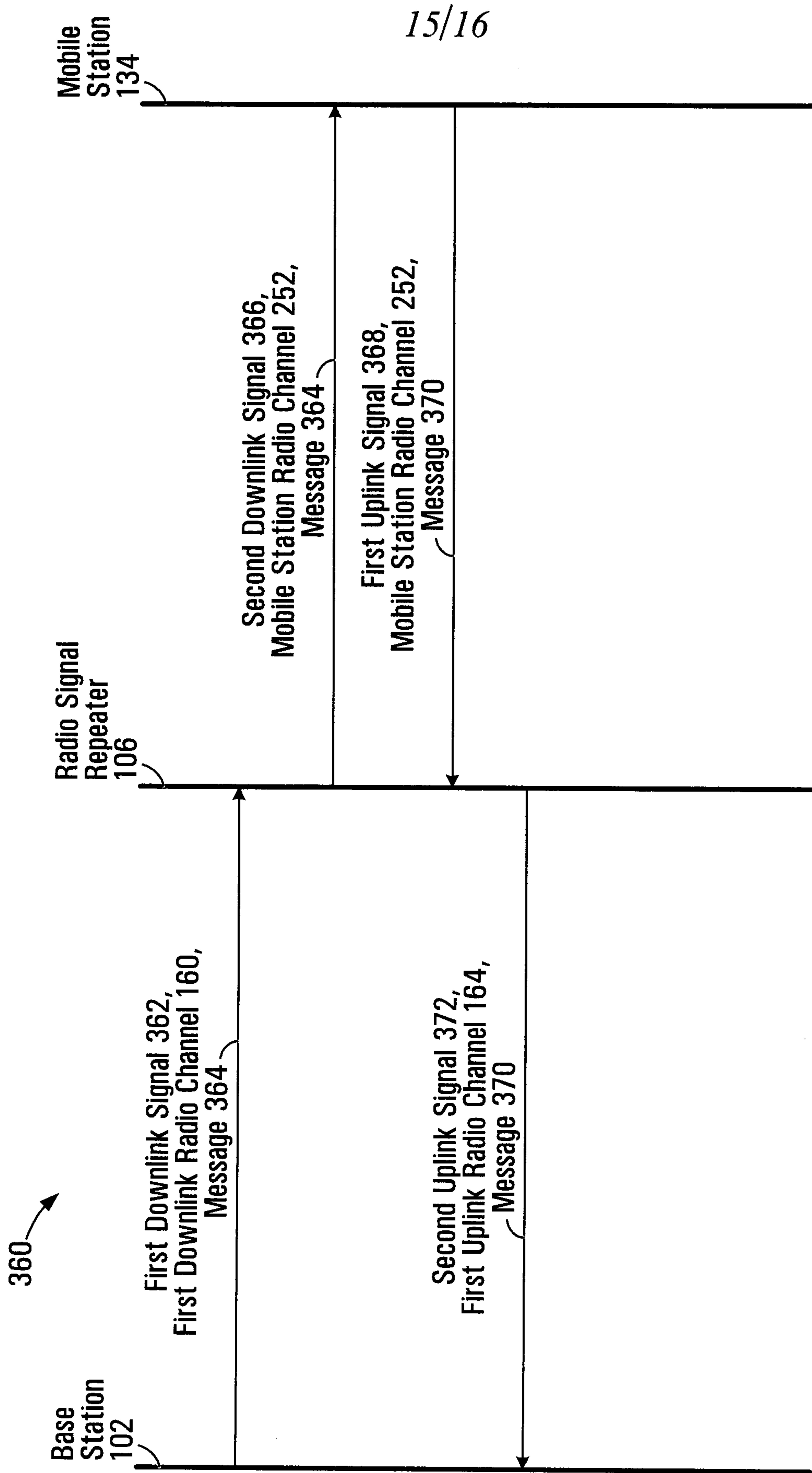


FIG. 19

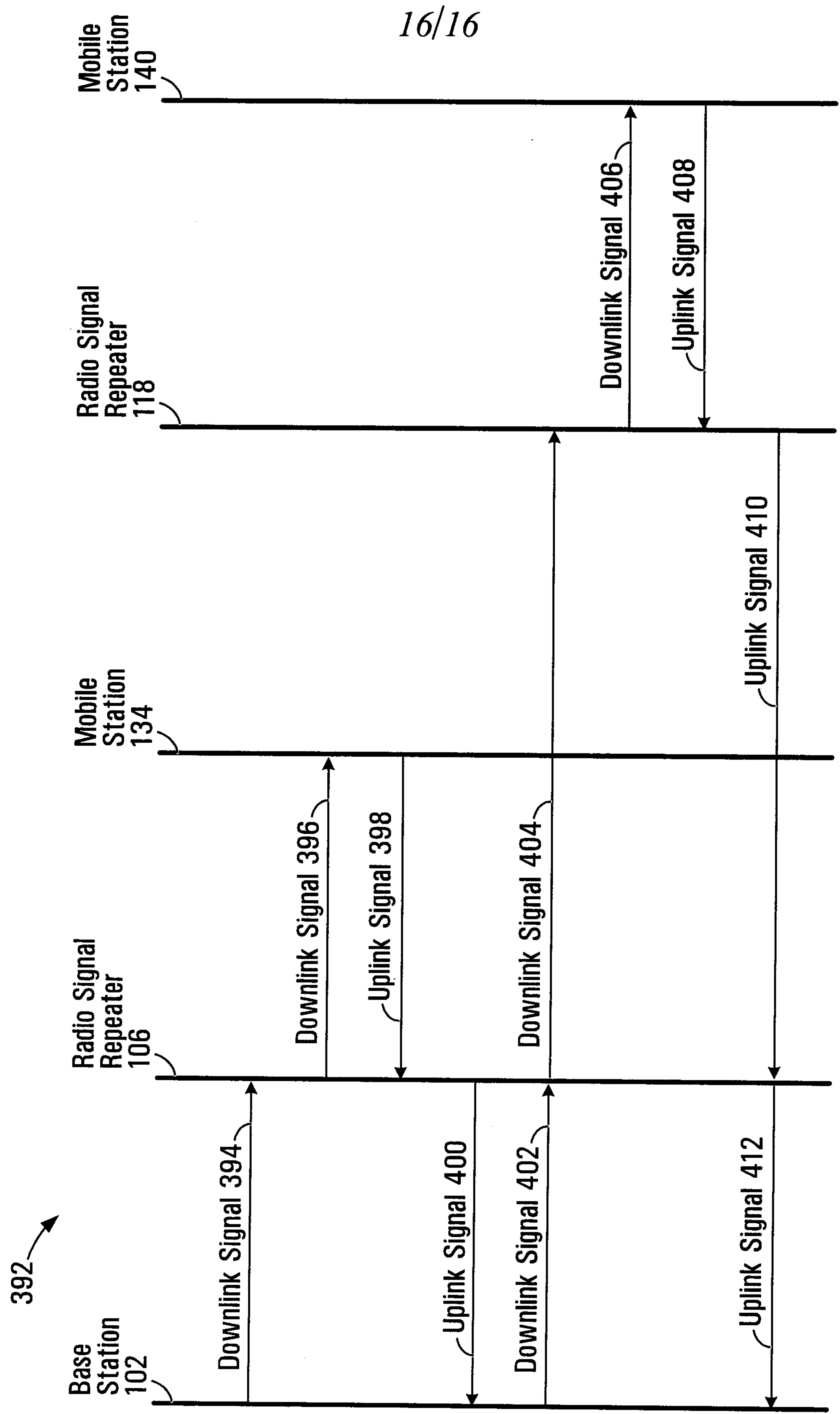


FIG. 20

Radio Signal Repeater Downlink

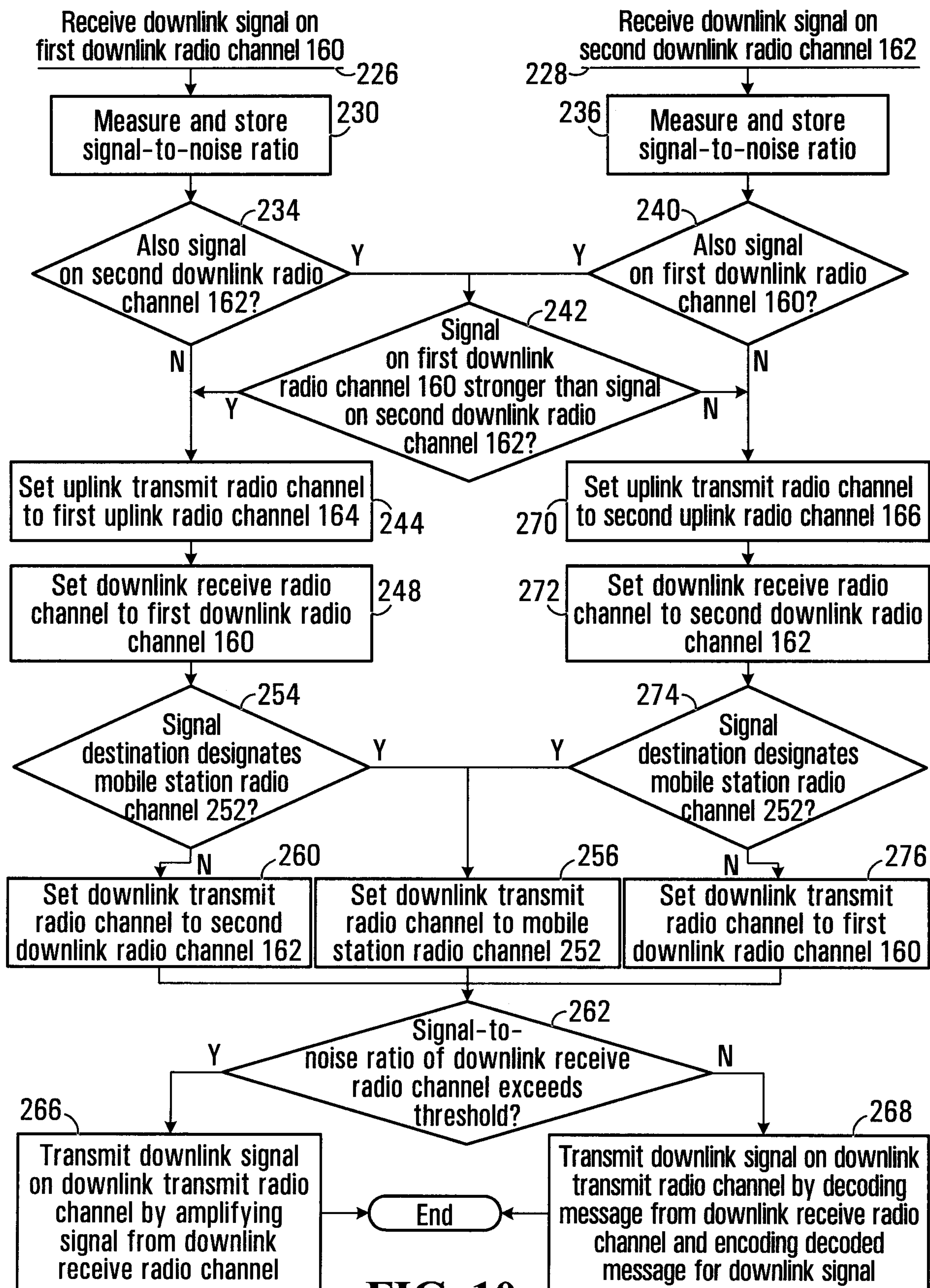


FIG. 10