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(54) **TWO-WAY PAGING SYSTEM HAVING RANDOM REVERSE CHANNEL SLOT SCHEDULING**

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(58) Field of Search 455/31.1, 31.2, 455/31.3, 458; 370/336; 340/825.44

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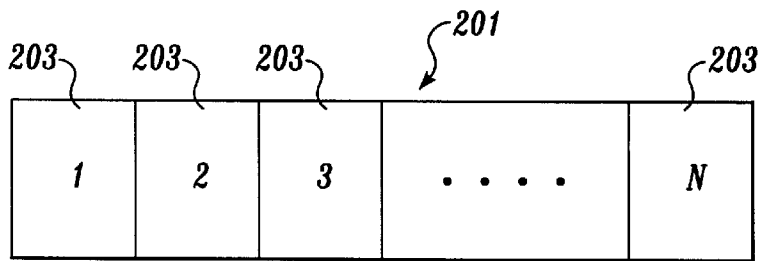
(57) **ABSTRACT**

In a two-way paging system including a paging terminal, a plurality of paging transmitters, a plurality of paging receivers, and a plurality of two-way paging units, the plurality of two-way paging units transmitting reverse channel messages to the paging receivers in a time division multiplexed protocol, the protocol including a frame with a plurality of reverse channel time slots, a method of assigning reverse channel time slots to the paging units is disclosed. The method comprises: (a) determining a set of transmitting paging units from the plurality of two-way paging units, the set of transmitting paging units being those of the plurality of two-way paging units that are to transmit a reverse channel message; and (b) randomly assigning each of the transmitting paging units in the set of transmitting paging units one of the reverse channel time slots in the frame.
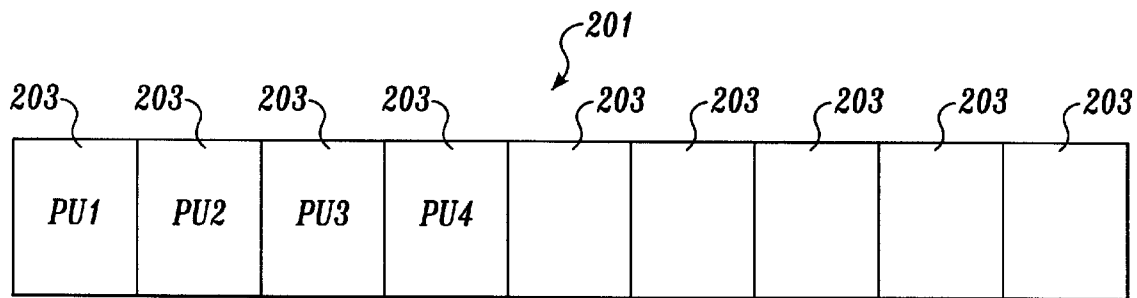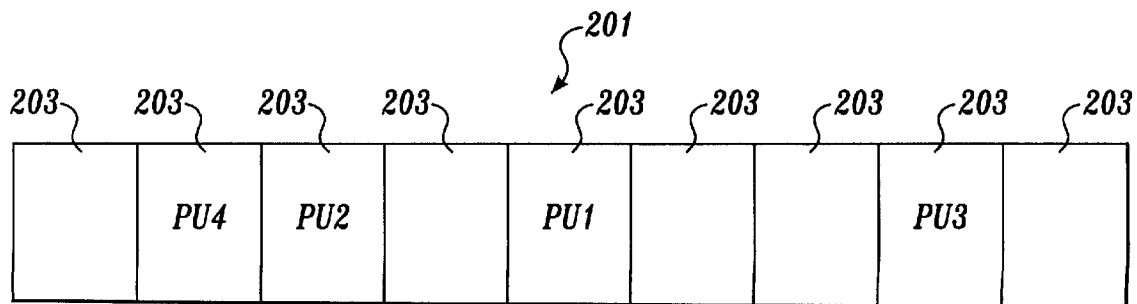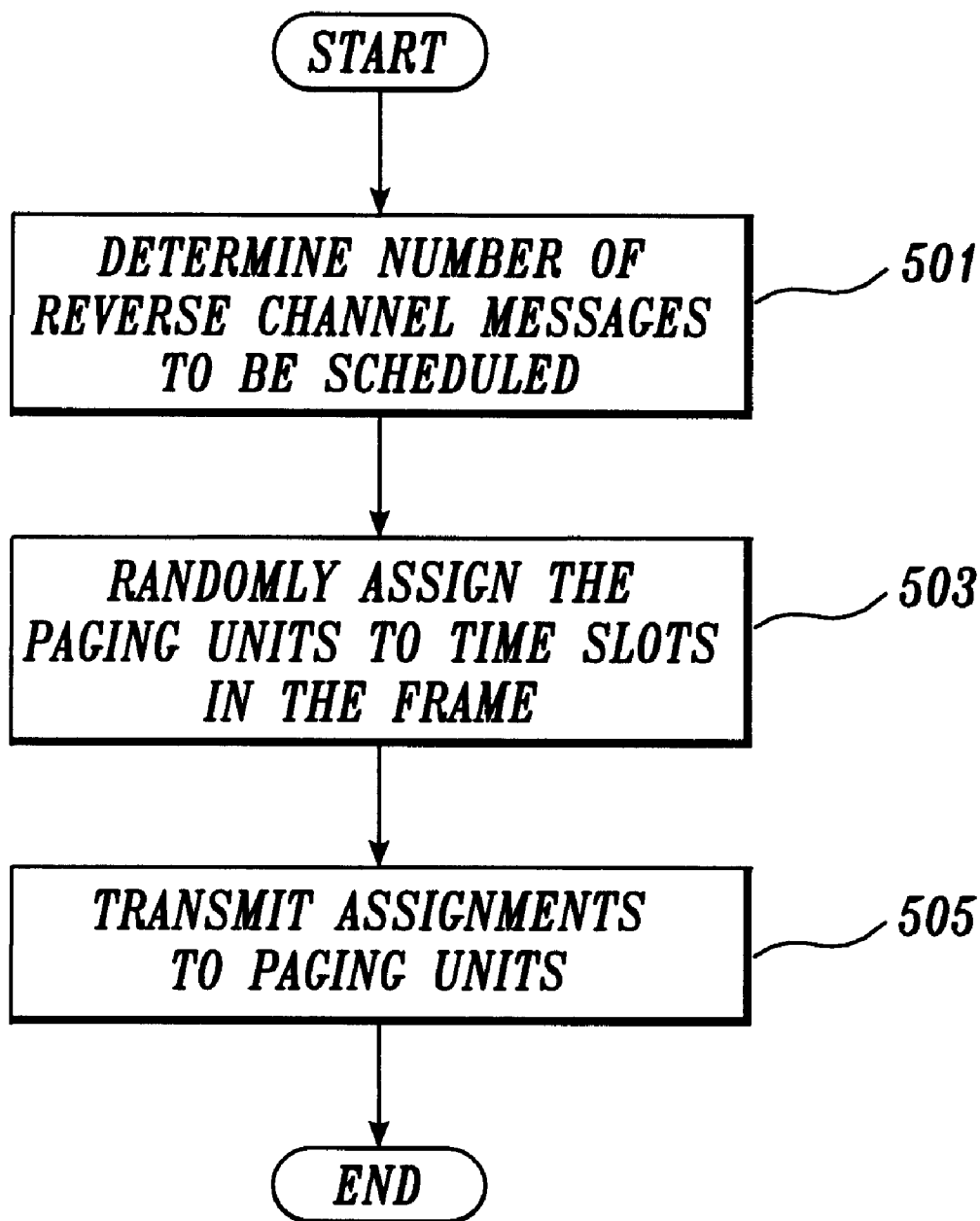
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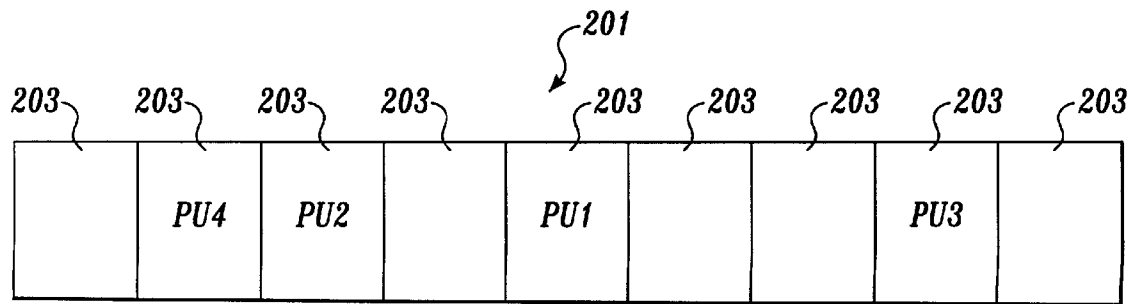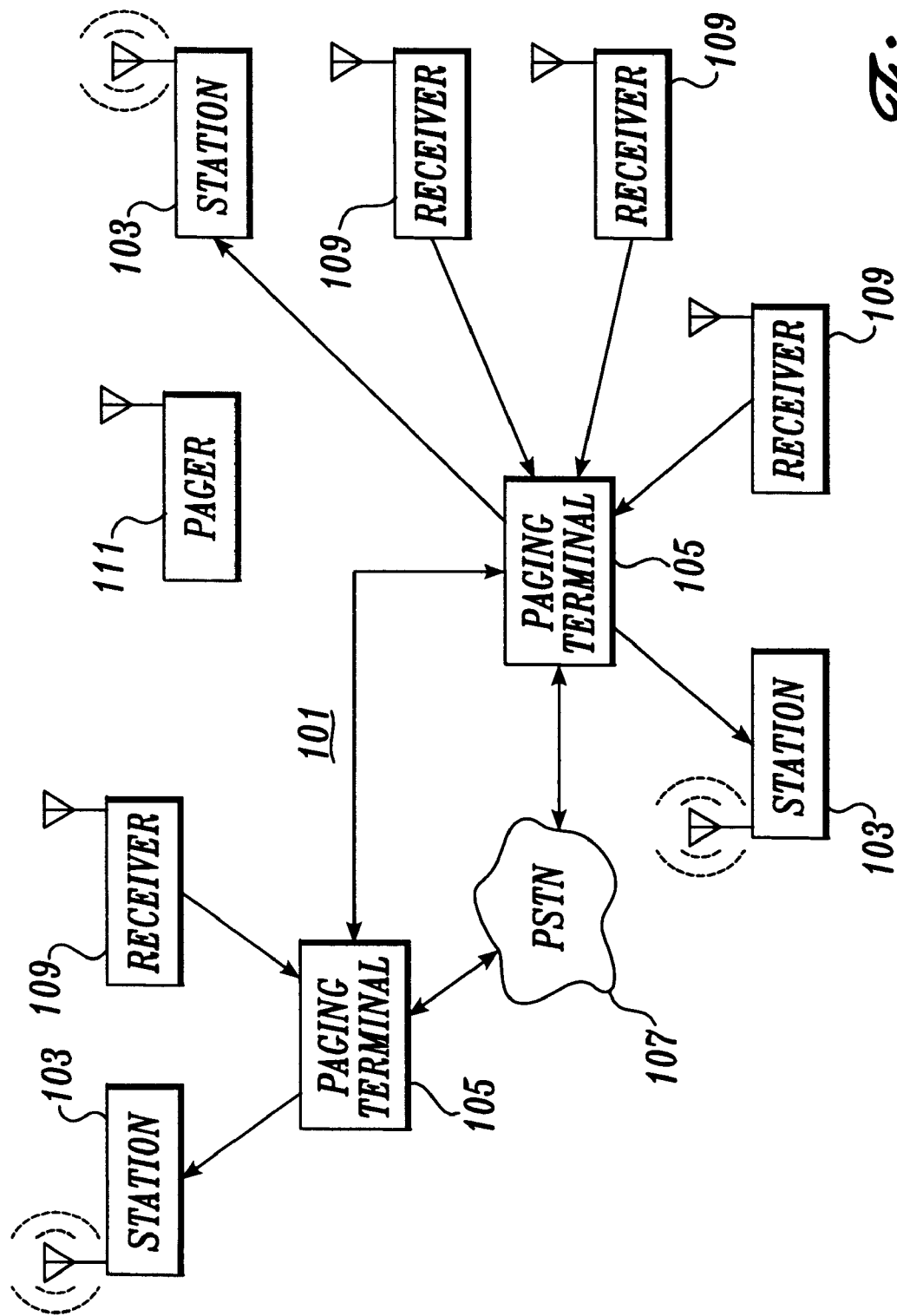
Fig. 1.

Fig. 2.

Fig. 3.
(PRIOR ART)

Fig. 4.

```
        ┌──────────────┐
        │    START     │
        └──────┬───────┘
               │
               ▼
   ┌───────────────────────────┐
   │   DETERMINE NUMBER OF      │──────  501
   │  REVERSE CHANNEL MESSAGES  │
   │     TO BE SCHEDULED        │
   └─────────────┬─────────────┘
                 │
                 ▼
   ┌───────────────────────────┐
   │    RANDOMLY ASSIGN THE     │──────  503
   │  PAGING UNITS TO TIME SLOTS│
   │        IN THE FRAME        │
   └─────────────┬─────────────┘
                 │
                 ▼
   ┌───────────────────────────┐
   │   TRANSMIT ASSIGNMENTS     │──────  505
   │     TO PAGING UNITS        │
   └─────────────┬─────────────┘
                 │
                 ▼
        ┌──────────────┐
        │     END      │
        └──────────────┘
```

Fig. 5

TWO-WAY PAGING SYSTEM HAVING RANDOM REVERSE CHANNEL SLOT SCHEDULING

FIELD OF THE INVENTION

The present invention relates to two-way paging systems, and more particularly, to a two-way paging system that randomly schedules reverse channel transmissions to minimize co-channel, time slot, and adjacent channel interference.

BACKGROUND OF THE INVENTION

A paging system might support millions of pagers using a network of thousands of paging transmitters in fixed locations nationwide. The paging transmitters are also supported by a control system and at least one paging terminal. The paging terminal operates to supply the pages to be broadcast to each of the paging transmitters. The combination of paging transmitters, control systems, and paging terminals, is collectively known as the paging infrastructure of the paging system.

For modern two-way paging systems where the pagers can send as well as receive information, the paging infrastructure will also have a large number of paging receivers in fixed locations. The frequency band at which the pagers transmit to the paging system is referred to as the "reverse channel". Similarly, messages from the pagers to the paging system are referred to as "reverse channel messages".

In a two-way paging system, the paging infrastructure tracks the location of the pagers in order to deliver messages to the pagers using only a subset of the fixed location transmitters, thus allowing reuse of the frequency in geographically separate locations. One prior art method of tracking pagers requires the pagers to transmit a registration message when the pager enters a new geographic "area". An "area" is specified by the paging system and indicated to the pagers by periodically broadcasted system wide informational messages.

The registration message, and indeed all reverse channel messages, are transmitted by the pager on a predefined or otherwise dictated frequency. In order to prevent two paging units from transmitting on the reverse channel simultaneously, the paging system provides an indication to a paging unit of the time period at which to transmit the reverse channel message. Thus, the reverse channel messages are transmitted in a time division multiplexed manner.

More specifically, in most prior art two-way paging systems, the reverse channel is divided into discrete time intervals referred to as frames. The frames are further divided into individual time slots that accommodate the reverse channel messages broadcast by the paging units. Additionally, other portions of the frames are reserved for synchronization and other "overhead" requirements. An example of such a two-way paging protocol is the ReFLEX™ family of paging protocols that is widely used in the industry.

Because of the time division multiplexed protocol used in reverse channel messages, it is crucial for the paging units to be synchronized with a master clocking scheme, such as the Global Positioning System (GPS). For further information regarding a two-way paging system, the reader is directed to U.S. Pat. No. 5,663,715 entitled "Synchronized Paging System" to Godoroja assigned to the same assignee as the present invention and herein incorporated by reference.

Typically, in the prior art, reverse channel transmissions are scheduled to occur sequentially at the beginning of each frame, for as many time slots as are required in order for all paging units that need to transmit have the opportunity to do so. Further, in most commercially operated systems, not all of the time slots in a given frame are required to fully service the paging units.

For a multitude of reasons, it is not always possible for all of the paging units to be perfectly synchronized in time to each other and to the paging system. This results in some paging units transmitting outside of their assigned time slot and possibly spilling over into other adjacent time slots. Because the paging units are assigned time slots in a sequential manner in the prior art, this will result in what is termed "adjacent time slot interference". For example, if two paging units transmitting in adjacent time slots have timing errors such that a first transmission is late and the following transmission is early, the transmissions may interfere with each other.

Furthermore, the transmitters located in the paging units used to transmit the back channel messages, for reasons of economy, are generally spectrally imperfect. This results in reverse channel messages not only being transmitted in the desired frequency channel, but also in nearby frequency channels. These reverse channel messages in nearby frequency channels are referred to as "image" messages. This results in what is termed adjacent channel interference. Adjacent channel interference is undesirable in locations where multiple two-way paging systems are operating. For example, in large metropolitan areas, two or more separate two-way paging systems in operation are not uncommon. In addition, it is typical for the paging systems to be assigned reverse channel frequency bands that are close to or adjacent to each other. Thus, the image messages transmitted by a paging unit for a first paging system may interfere with the authentic reverse channel messages transmitted on a second paging system.

In addition, because radio frequency channels are scarce resources, the same radio frequency channel may be re-used in a cellular system. Even though these cellular systems are designed such that units using the same radio frequency channel are geographically separate, the units may still interfere with each other. This is termed co-channel interference.

Therefore, there is a need for implementing reverse channel transmissions so as to minimize interference. The present invention addresses these and other problems of the prior art.

SUMMARY OF THE INVENTION

In a two-way paging system including a paging terminal, a plurality of paging transmitters, a plurality of paging receivers, and a plurality of two-way paging units, said plurality of two-way paging units transmitting reverse channel messages to said paging receivers in a time division multiplexed protocol, said protocol including a frame with a plurality of reverse channel time slots, a method of assigning reverse channel time slots to said paging units is disclosed. The method comprises: (a) determining a set of transmitting paging units from said plurality of two-way paging units, said set of transmitting paging units being those of said plurality of two-way paging units that are to transmit a reverse channel message; and (b) randomly assigning each of the transmitting paging units in said set of transmitting paging units one of said reverse channel time slots in said frame.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated

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