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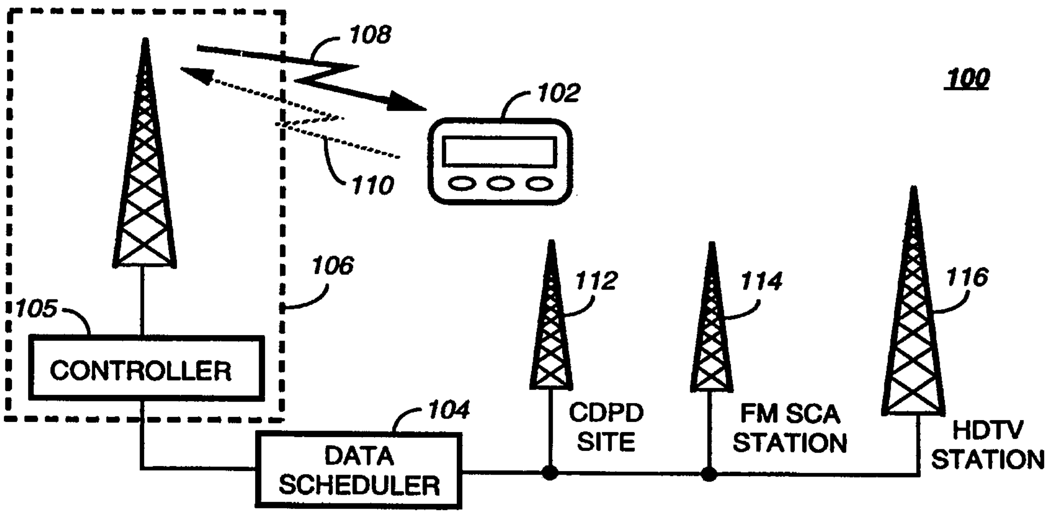

(57) Abstract

A communication system (100) that selects alternative data channels for communication including a cellular communication system (900) has a base station (106) coupled to a plurality of alternative data communication systems (112, 114, 116) that receive messages intended for a selective call device designated by an address. A data scheduler (104), coupled to the base station (106) and the plurality of alternative data communication systems (112, 114, 116), has a categorizer (404) for categorizing the message as being suitable for transmission on an alternative data channel, a controller (402) for coordinating a list of the alternative data communication systems suitable for transmitting the message and a selector (406) for selecting the alternative data channel for transmitting the message. A controller (105) encodes a selective call signal with the address and a vector and a transmitter transmits the selective call signal to the selective call device (102) on a control channel including the address for identifying the selective call device, the vector designating the alternative data channel.

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COMMUNICATION SYSTEM AND METHOD FOR SELECTING ALTERNATIVE FREQUENCIES

Field of the Invention

This invention relates in general to communication systems, and more specifically to a method and apparatus for selecting alternative frequencies of other transmission systems including a cellular communication system for transmitting selective call messages.

Background of the Invention

There are many communication systems in operation today, including virtually all of today's selective call systems, that utilize frequency modulation (FM) for addressing, and for data and voice transmission. The current communication subscriber units, e.g., selective call devices, utilize sophisticated receiver architectures, and today's selective call systems utilize well known and established signaling formats. The current receiver architectures and signaling formats have been optimized to provide both high receiver sensitivities and excellent battery saving capabilities.

In many metropolitan areas, many selective call systems are operated at, or near, the maximum system capacity, in both the number of subscribers that can be accommodated, and the message transmission time that is available. Such selective call system operation has resulted in reduced customer satisfaction due to extended times required to access the selective call system, and also due to extended delays in message delivery due to equally extended selective call system message transmission queues. At present, this need is being met by increasing the data rate of the protocol used or increasing the latency time by requiring the selective call devices to battery save longer.

To further aggravate the problem, the limited radio spectrum available worldwide or nationwide makes it challenging to provide seamless communication to and from the selective call devices. It has become necessary to equip the selective call devices with frequency synthesizers to enable them to scan or select among the frequencies within the available selective call spectrum when the selective call devices are roaming or has lost their signal. However, because there are a limited number of available selective call frequencies, no significant system expansions can be achieved or expected although there is a significant increase in the message length and the number of subscribers.

Thus, what is needed is a selective call system that can improve message delivery without the need for any addition of dedicated selective call frequency allocation or a selective call system that can improve message delivery by penetrating existing cellular communication systems without changing the paging protocol or cellular protocol and without requiring any more dedicated selective call frequency allocations.

Brief Description of the Drawings

FIGs. 1-3 are electrical block diagram of a communication system, in accordance with the preferred embodiment of the present invention.

FIG. 4 is an electrical block diagram of a data scheduler according to FIGs. 1-3

FIG. 5 is an electrical block diagram of a selective call device according to the preferred embodiment of the present invention.

FIG. 6 is a timing diagram illustrating the transmission format of the Grand Alliance High Definition Television (HDTV) in accordance with the preferred embodiment of the present invention.

FIG. 7 is a flow diagram illustrating a method for determining and coordinating alternative frequencies for communication in accordance with the preferred embodiment of the present invention.

FIG. 8 is a flow diagram illustrating the method for determining and coordinating alternative frequencies of the data scheduler according the preferred embodiment of the present invention.

FIG. 9 is a pictorial block diagram of a combined paging communication system and cellular communication system in accordance with a preferred embodiment of the present invention.

FIG. 10 is an electrical block diagram of a cellular switch in accordance with the preferred embodiment of the present invention.

FIG. 11 is an electrical block diagram of a paging terminal in accordance with the preferred embodiment of the present invention.

FIG. 12 is an electrical block diagram of the paging terminal controller in accordance with the preferred embodiment of the present invention.

FIG. 13 is an electrical block diagram of the portable communication unit in accordance with the preferred embodiment of the present invention.

FIG. 14-17 are timing diagrams of a synchronous signal for transmitting and receiving selective call messages in accordance with the preferred protocol.

FIGs. 18 and 19 are flow diagrams illustrating the operation of a base station during a base station originated message in accordance with the preferred embodiment of the present invention.

FIGs. 20 and 21 are flow diagrams illustrating the operation of the selective call device when the base station originates a message in accordance with the preferred embodiment of the present invention.

FIG. 22 is a flow diagram of a selective call device originated message protocol in accordance with the preferred embodiment of the present invention.

FIG. 23 is a flow diagram illustration of the base station operation when the portable communication unit originates a message in accordance with the preferred embodiment of the present invention.

FIG. 24 is a flow diagram illustration of the selective call device originated registration procedure in accordance with the preferred embodiment of the present invention.

Description of a Preferred Embodiment

Referring to FIGs. 1-3, electrical block diagrams of a communication system coupled with other alternative data communication systems are shown in accordance with the preferred embodiment of the present invention. Referring specifically to FIG. 1, the communication system 100 preferably comprises a selective call communication system (a base station controller 105 and antenna) 106 coupled to a data scheduler 104. The data scheduler 104 is coupled to a plurality of other alternative wireless data communication systems, e.g., Cellular Digital Packet Data (CDPD) communication system 112, FM Sub-Carrier Authorized (FM SCA) Station 114, and Grand Alliance High Definition Television (HDTV) Station 116. A selective call device (or portable communication unit) 102 is wirelessly coupled to the selective call communication system 106 and communicates with the selective call communication system 106, preferably, on the InFLEXion™ protocol. The timing and data structures of the InFLEXion protocol are well know to those skilled in the art of selective call communication systems. Those skilled in the art understand that the InFLEXion protocol is designed to accommodate voice communication.

Operationally, the selective call communication system 106, upon receipt of a message for a designated selective call device 102, transmits preferably a selective call signal 108 to the selective call device 102. The selective call signal comprises the address for identifying the selective call device and the vector designating a frequency of an alternative data communication system. In addition, the vector of the selective call signal can include a protocol for identifying a data structure, a time designation for informing the selective call device when the message will be transmitted and a message packet identification code for identifying the message to be received. The selective call device 102 receives and decodes the address and the vector. The vector can direct the selective call device 102 to another or alternative frequency or channel that is not within the set of channels allocated to the selective call spectrum and can identify the message to be received with a message or the packet identification. Therefore, after decoding its correct address, the selective call device 102 decodes the alternative frequency assignment and switches to that channel (or frequency) and loads the appropriate protocol decoder; the protocol decoder identifies or defines how the message or information is to be received and decoded. The details of switching the frequency and selecting the protocol decoder will be discussed in details below. With a two-way selective call device 102, the selective call device 102 will or can acknowledge 110 its receipt of its address and vector assignment 110 on the control channel, preferably the InFLEXion protocol, which acts as the preassigned control (or default) channel.

Referring to FIG. 2, after the selective call device 102 has switched to the alternative data communication frequency and the protocol decoder designated by the vector assignment has been loaded, it begins to listen on the alternative data channel, which, e.g., could be a frequency on the set of frequencies allocated for transmission by the HDTV stations. It is understood that the selective call device 102 will switch and remain on the alternative channel to receive its message, preferably for a predetermined time period. The HDTV transmission system 116 will transmit 202 the message to the selective call device 102 during the designated or available time and on the correct frequency. After a predetermined time has expired, the selective call device 102 will switch back to the InFLEXion control channel and inform the selective call communication system 106 whether or not the message was received by acknowledging 302 the status to the selective call system 106 as shown in FIG. 3.

Although not shown, the selective call communication system, as is well known, is coupled to a communication link, e.g., a public switched telephone network (PSTN) for receiving requests to transmit messages or information to a subscribing selective call device 102. The selective call communication system 106 can be wirelessly coupled to other data providers, like the stock market and other information services. When a request is received, particularly, a request to transmit a long message, e.g., data or information service type message, during, e.g., the peak hours of the selective call communication system 106, the data scheduler 104 will poll (or initiate a request to) the alternative data systems to select the best (or available) candidate to use to transmit the message to the designated selective call device 102. The selection can be based on a list of criteria including but not limited to the type of system protocol, the frequency, the cost and the ease of the selective call device to decode the message on the alternative frequency with the alternative protocol. Alternatively, the alternative data systems 112, 114, 116 can provide to the data scheduler 104, before hand, a list of times when they will be available for transmission of selective call messages.

The data scheduler 104 will have all the specification on all the alternative data systems, including, e.g., the channels (frequencies) and protocols which stipulate the data structures. This information is preprogrammed into the selective call devices 102. Therefore, for example, by using a code, e.g., the vector, the selective call device 102 would know the channel (frequency) to switch to, the data structures and the time that it has to remained tuned to that channel to receive its message. All the alternative data systems can have different wait times because of the protocol difference and the system loading.

It should be noted that the data scheduler 104 is capable of operating in a distributed transmission control environment (wired and wireless) that allows mixing conventional cellular, simulcast, satellite, or other coverage schemes involving a plurality of radio frequency transmitter/receivers and conventional antennas for providing reliable radio signals within a geographic area as large as a worldwide network.

Referring to FIG. 4, an electrical block diagram of the data scheduler is shown. The data scheduler 104 preferably comprises a controller 402 for coordinating a list of the alternative data communication systems suitable for transmitting the selective call message or information. The controller 402 creates and retrieves information on the alternative communication system in memory, preferably a random-access-memory (RAM), e.g., the alternative system information 408. The alternative system information 408 can include information such as the availability of the each alternative system, its loading, latency, the cost for transmitting a message during different periods of time, etc. A categorizer 404 coupled to the controller 402 categorizes the message as a candidate for transmission on an alternative frequency channel. The categorizer 404, e.g., measures or count the number characters in a message and when the number exceeds a predetermined number (threshold), e.g., 50 to 100 characters, the message is characterized as a long message which is suitable for transmission by an alternative data system. A channel selector 406 selects the alternative data channel suitable for transmitting the message and retrieves the frequency, protocol and wait time from memory 412. It is understood that any changes in the alternative data system can be wirelessly communicated to the selective call devices by over-the-air (OTA) updates. The data scheduler 104 is shown coupled to an antenna 416 and a communication link, for example a public switch telephone network (PSTN), 414 which will enable the data scheduler 104 to communicate, e.g., with the selective call devices 102 and send OTA updates. The PSTN 414 enables the data scheduler 104 to continually receive information from the alternative data communication system. A transceiver 410, the operation of which is well known to those skilled in the art, enables the receipt and transmission of information to and from the data scheduler 104. The data scheduler 104 comprises a memory, preferably an erasable memory, 412 that stores information about the alternative data systems, e.g., the frequencies, the protocol, the wait times, etc. An initiator 418 initiates a retransmission of the message when the selective call device has indicated that the message was not received by either selecting another or the same alternative data channel for retransmitting the message.

Referring to FIG. 5, an electrical block diagram of the selective call device 102 according to the preferred embodiment of the invention. It is understood by one skilled in the art that since the invention uses alternative channels of other communication systems, the operating bandwidth of the selective call device 102 is increased. A selective call device 102 that is able to operate and receive information on the alternative data systems should be able to receive information on a frequency band of approximately 54 MegaHertz (MHz) to about 941 MHz. The receiver portion preferably has an antenna 502 that is adjustable to receive information over the entire bandwidth. The antenna 502 is coupled to a radio frequency (RF) amplifier 504. A first mixer 506 mixes the received frequency up to 1030 MHz which is provided to a bandpass filter 508, a second mixer 510 and an intermediate frequency (IF) amplifier 512 coupled in series to an Analog-to-Digital-Converter (ADC) 514. A first synthesizer 516 and a first local oscillator (LO) 518 are coupled to the first mixer 506, a second synthesizer 520 and a second local oscillator 522 are coupled to the second mixer 510 while a third synthesizer 524 and a third local oscillator 526 are coupled to the ADC 514. A reference oscillator 528 controls the first, second, and third synthesizer and oscillator pairs. The receiver employs a high first IF, above the receive band (1030 MHz for example) which moves the first image and the first IF spurs very far from the receive band eliminating the need for a tunable preselector. After a second conversion to a lower IF, the desired signal is passed through the ADC 514 then to a programmable digital channel filter 530 and then to a reconfigurable protocol handler 532 for demodulation and further processing. The reconfigurable protocol handler 532 is coupled to the controller 540 which is coupled to the protocol Read-Only-Memory (ROM) 542 which stores a plurality of protocols associated with the plurality of alternative data communication systems 112, 114, 116. The controller 540 is also coupled to the codeplug read-only-memory (ROM) 544 which stores the addresses of the selective call devices 102. A message RAM 546 coupled to the controller 540 stores the messages that are received and a display 548 displays or presents the messages to the user.

The antenna 502 and RF amplifier 504 are tunable across the receive band. The first mixer 506 receives the desired 54-to-941 MHz signal from the RF amplifier 504, and mixes it with the 1084-to-1971 MHz LO to produce the

1030 MHz first IF frequency. This IF signal is sent to the first IF filter 508, preferably a Surface Acoustic Wave (SAW) filter, wide enough to handle the widest expected signal deviation, e.g., 6 MHz. The signal is then sent to the second mixer 510, which mixes it with a 984.9 MHz second LO signal to produce the 45.1 MHz second IF signal. The second LO frequency may be varied +/- 3 MHz to receive any single signal within the 6 MHz first IF passband. The second IF signal is amplified and passed to the ADC 514.

Operationally, when the selective call device 102 receives its address, it checks the vector associated with the address to determine if the message will be transmitted on an alternative communication system. It is possible, e.g., to encode two or more bits to designate the alternative communication system's frequency and protocol. Therefore, when the selective call device 102 receives the encoded vector, it retrieves the information including the frequency and data structures from the protocol ROM 542. Alternatively, the frequency of the alternative communication systems may be explicitly included in the vector associated with the message. The receive filters and frequency synthesizers will be set to switch to and receive the message on the alternative data communication system.

Referring to FIG. 6, a timing diagram of the Grand Alliance HDTV protocol is shown illustrating the transmission format of one of the alternative data HDTV communication station 116. The data structure or packet formation 600 of the HDTV comprises a link header 602 of 4 bytes, an adaptation header 604 which can have a variable length. The data 606 is appended to the variable length header resulting in a 188 byte total length. There is a 3 bits-per-symbol rate.

Referring to FIG. 7, a method for determining and coordinating alternative frequencies for communication. When a user enters an address and a message via the PSTN for example, the selective call base station receives it, step 702, and determines if the message is a short message, step 704. A short message can be designated as having fewer than a predetermined number of alphanumeric characters, e.g., 50 or 100, depending on the selective call system's capacity or latency. If it is a short message, it is transmitted on the preassigned control channel of the InFLEXion protocol, i.e., the selective call device is not directed to switch to any alternative data channel, step 706. When a long message is received, a list of the alternative data systems are retrieved or generated to determine which alternative data system is more suited to carry the message, step 708.

The selective call system selects the alternative data system based on some predetermined criteria, e.g., the cost of transmission, the length of the message to be transmitted, the latency of the alternative data system, and the type of message carrier, step 710. The type of carrier can be ranked depending on the protocol, its frequency or its latency, etc. The selective call system estimates the latency of the selected alternative data systems, step 712, and determine which of the alternative data systems are suitable, step 714. If none of the alternative data system has acceptable latency, step 714, the selective call system can select the alternative data system with the shortest latency, step 716. On the other hand, if all or more than one of the alternative data system have acceptable latency 714, the selective call system preferably selects the alternative data system with the lowest cost for transmission of the message with the desired latency, step 718. The message from either steps 716 and 726 is then encoded according to the protocol of the alternative data system and passed to the alternative data system to transmitted in at designated time, step 720. The address and the vector is transmitted to the selective call device 102 to enable the selective call device 102 to switch to the alternative data system identified by the vector, step 722. The selective call system waits to receive a status report from the selective call device 102 to determine whether the message was received or not, step 724. An affirmative report ends the transmission sequence for that message, step 728. When the selective call device 102 reports that it failed to receive the message, the selective call system retransmits the message more times within a predetermined time, step 726. If the time expires and the selective call device 102 fails to receive the message, step 726, the selective call system can select another alternative data system to transmit the message, step 716.

Referring to FIG. 8, upon the input of the address and message, step 802, the data scheduler checks the system memory for the list of allowable transmission channels for that selective call device assigned to the received address, step 804. The transmission channel or alternative data system is chosen and the time for retransmission is selected based upon the message length, the destination selective call model, alternative data system availability, loading, and previous message channel success, etc., step 806. Based on the criteria of step 806, if the InFLEXion channel (control channel) is selected, the message is appended to the address and vector according to the InFLEXion data structure which is well know in the art and is transmitted to the selective call device, step 810.

On the other hand, when the message is chosen for transmission on an alternative data channel (not the InFLEXion control channel), the address of the selective call device 102, the vector identifying message channel, protocol, and the time when the message will be transmitted is determined, step 812. The message, the transmission time, and the selective call address is transferred to the data scheduler 104, step 814. It is understood that the data scheduler 104 can contact the alternative data system to determine the times that are available for transmission of the selective call message. The data scheduler 104 waits for a response from the selective call device 102 via the selective call base station 106, step 816. The data scheduler determines from the status report if the message was received or not, step 818. If the message was received, the process ends, step 820, otherwise process transfers to step 804 to check for allowable channels.

In this way, a selective call communication system is able to coordinate and select alternative channels from other communication or transmission systems when these other systems have available resources. This technique allows for efficient low-cost communication, because the selective call device can decide on a case-by-case basis which messages are to be transmitted on the outside or alternative transmission resources. With this invention, the selective call system can designate other transmission systems that are apt to transmit longer messages to a selective call device thereby improving the latency time of the selective call system. There message delivery is improved without the necessity of expanding the dedicated selective call frequencies.

In summary, a selective call communication system that coordinates and selects alternative data channels for communication comprises a base station coupled to a plurality of alternative data communication systems which receive messages intended for a selective call device designated by an address. A data scheduler coupled to the base station and the plurality of alternative data communication systems comprises a categorizer for categorizing the message as a candidate for transmission on an alternative data channel. The categorizer determines if a length of the message is greater than a threshold, a controller coordinates a list of the alternative data communication systems suitable for transmitting the message, a selector selects the alternative data channel suitable for transmitting the message and creates and stores a list of alternative data channels, and an initiator initiates a retransmission of the message when the selective call device has indicated that the message was not received. The initiator selects another alternative data channel for retransmitting the message. An encoder encodes a selective call signal including the address and a vector wherein the vector includes a delay for designating a time period for waiting for a response from the selective call device to determine if the message was received on the alternative data system. A transmitter transmits the selective call signal to the selective call device on a control channel wherein the selective call signal comprises the address for identifying the selective call device. The vector designates a frequency of the alternative data system. A protocol identifies the data structure and a time designation for informing the selective call device when the message will be transmitted and an PSTN for transferring the message to an alternative data communication system for transmission during a specified time. The selective call signal comprises the address for identifying the selective call device and the vector designating a frequency of an alternative data communication system, a protocol for identifying a data structure, a time designation for informing the selective call device when the message will be transmitted, and a time delay for waiting for a response from the selective call device to determine if the message was received on the alternative data communication system.

Referring to FIG. 9, a pictorial diagram of an integrated or combined paging communication system and cellular communication system 100 in accordance with a preferred embodiment of the present invention. The integrated communication system 900 includes a plurality of cellular transmission regions 902 each of which includes an antenna tower and a base station 904 utilized in the transmission of calls to portable communication units, e.g., cellular telephones 920, selective call receivers 940, or other personal communication transceivers. It will be appreciated that the antenna tower and base stations 904 are associated with each of the plurality of cellular transmission regions 902, although only four are being shown for illustration and simplicity. The transmission of calls to the cellular telephones 920 from the antenna and base stations 904 within each cellular transmission region 902 is well known in the art.

Also shown in FIG. 9 are a number of paging transmission regions 906, two of which are being shown. Each paging transmission region 906 overlaps a number of the cellular transmission regions 902. In the example shown, each paging transmission region 906 overlaps over ten cellular transmission regions 902; although it will be appreciated that the actual number of regions that are overlapped is dependent on the actual size of each cellular transmission region 902 relative to each overlapping paging transmission region 906. Each paging transmission region 906 includes an antenna and base station 908 that are located substantially within the center of the transmission region.

Calls placed by callers using the telephone system are directed to the cellular telephone portion of the portable communication device 920, which includes a callers' telephone 922 that couples through the public switched telephone network (PSTN) to the telephone company central office 924. From the telephone company central office 924, the calls are coupled via telephone lines preferably to a service center (SC) 932 then to a cellular switch 926. The service center 932 couples the cellular system, preferably, the Global System for Mobile Communication (GSM) protocol networks and the paging system, preferably, the FLEX™ paging protocol networks, by a dual mode control protocol. Using existing protocols within the GSM infrastructure, the service center 932 interrogates entities within the GSM system such as the Home Location Register (HLR) and the Visitor Location Register (VLR) to obtain location update and status information, the details of the HLR and VLR will be described in further detail below. The service center 932 also decides which system will be used to transmit an incoming message. The service center 932 communicates with both the FLEX paging network and the GSM cellular network via the telephone lines and transfers status information between the paging networks and the cellular networks. Think of the service center 932 as the "middleman" between callers and the FLEX/GSM networks. The cellular switch 926 selectively couples the calls via the telephones lines, or link transmitters and receivers (not shown), to the appropriate antenna tower and cellular base station 904 within the cellular transmission region 902 in which a cellular telephone 920 is located for which the call is directed. The operation of a cellular system for the transmission of calls between a land line based telephone and a portable cellular telephone is well known in the art. One such cellular system is described in U.S. Patent No. 3,906,166 to Cooper et al, entitled "Radio Telephone System" which is assigned to the assignee of the present invention and which is hereby incorporated by reference herein.

Paging messages directed to the selective call devices 940, or the pager portion, of the portable communication device 920 are placed by callers also using the telephone system that includes the callers' telephone 922 which couples through the public switched telephone network (PSTN) to the telephone company central office 924. From the PSTN 924, the paging messages are coupled via the service center 932 and the telephone lines to a paging terminal 928 that processes the paging messages for transmission. After the paging messages have been processed for transmission, the processed paging messages are coupled via the telephone lines, or link transmitters and receivers (not shown), to the antenna and base stations 908 in each paging transmission region 906. The paging messages can be transmitted, generally, in a simulcast fashion from each of the antenna and paging base stations 908 throughout the region covered by the paging system.

Although paging communication systems and cellular communication systems have operated independently, handling calls for the cellular telephones and paging messages for the selective call receivers 940 operating within each of the respective systems, however, can pose problems when the paging receiver or selective call receiver 940 is combined with the cellular telephone 920. In the preferred embodiment of the present invention, a communication link 930 is established from the service center 932 to the paging terminal 928 and another link 934 is established from the service center 932 to the cellular switch 926. This enables the service center 932 to communicate with the paging terminal 928 to inform it when the cellular telephone portion of the portable communication device 920 is in use for which a paging message is intended and to couple the calls to the paging network or the cellular network.

FIG. 10 is an electrical block diagram of a cellular switch 926 suitable for use with the present invention. In general, the operation of cellular switches is well known in the art, so only a brief description is being provided herein. Calls originated from telephones located throughout the public switched telephone network are coupled through the telephone company central office via telephone lines to the service center 932, the details to be discussed below. The service center 932 is also coupled via the telephone lines 1100 to a cellular switching network 1102. The switching network 1102 is controlled by a processor 1106 to selectively couple calls to the cellular sites in which a cellular telephone 920 is located using duplex voice telephone lines 1104 to each cellular site within the cellular system. The processor 1106 also controls modems 1108 to recover the location data or geographic location information which is then coupled from the modems 1108 to the processor 1106. The location data is stored in the home location register 1112. The processor 1106 controls call routing via the switching network 1102. The processor 1106 also performs the function of a Short Message Service Gateway Mobile Switching Center (SMS-GMSC) which is used to set up a call towards a GSM subscriber (cellular telephone). The functionality of the SMS-GMSC 1106 are related to Short Message Mobile Terminated (SM-MT). The location or geographic location of each of the cellular telephones 920 within the cellular system is communicated to the processor 1106 via duplex data telephone lines 1110 which couple location data modulated as modem tones to modems 1108. The modems 1108 under the control of the processor 1106 obtain the location information which is stored in the home location register (HLR) 1112. A mobile switching center (MSC) 1118 routes the calls towards the cell site where the subscriber unit is located or can obtain service. The mobile switching center 1118 controls the routing and necessary intermediate buffering of short messages and performs the basic switching functions in the GSM network. In addition to fetching locations and routing messages, the processor functions as the SMS-GMSC to receive and send reports via the duplex data lines to other entities, inside and outside the GSM system, e.g., the paging communication system, to let it know if the message has been received successfully or if there was a failure during the transfer.

The processor 1106 also operates as a short message service interworking mobile switching center (SMS-IWMSC) and is used for short message mobile originated (SM-MO). When a short message is originated by the mobile unit, the mobile switching center (MSC) 1118, after receiving the information from a base station controller (BSC) 1124, sends it to the processor operating as the SMS-IWMSC. When the processor operates as SMS-IWMSC, it is responsible for receiving messages, establishing, when necessary, a link through the telephone lines to the base station controller (BSC) 1124 is being addressed, and transferring the short message to the base station controller 1124. The base station controller 1124 is in charge of all the radio interface management through the remote command of the mobile station (MS) 1122. The base station controller's 1124 main assignments are the allocation and release of radio channels and hand-over management. Each base station controller 1124 typically controls up to several hundred base station transceivers, some of them co-located at the base station controller site and others remotely distributed and physically connected to the base station controller 1124 by microwave link or dedicated lease lines. The interface which connects the base station transceiver to a base station controller 1124 is called the Abis interface. The Abis interface carries both traffic and maintenance data and is specified by GSM to be standardized for all manufacturers.

The home location register (HLR) 1112 subscriber's information is relevant to the provision of telecommunications services, e.g., the international mobile subscriber identity (IMSI), and is the number used to reach the user from a public network and also designates the subscriber's permitted supplementary services that is retained in the home location register 1112. The HLR 1112 also includes information related to the current location of the subscriber. The visitor location register (VLR) 1120 is coupled to the mobile switch center 1118. The VLR 1120 functions as a temporary memory for storing the subscription data for the users currently in the network, in particular roamers. In the case of a roaming subscriber, the mobile switch center 1118 updates its own VLR 1120 after receiving the roamer's information from his or her home mobile switch center. In this way, the network can provide the features provided by the roaming subscriber's home network. One major difference between the VLR 1120 and the HLR 1112 is that the VLR 1120 provides the mobile switch center 1118 with the necessary subscriber data when a call is coming from a mobile station. On the other hand, the HLR 1112 performs the same function when the call is coming from the public network. The HLR 1112 and the VLR 1120 also store such information as cellular telephone identification information, billing information, and other information necessary for the operation of the cellular system. An operator's console 1114 is coupled to the processor 1106 to enable control of the operation of the cellular system, and to provide access to and alteration of information stored in HLR 1112 and VLR 1120. The operator's console 1114 also couples to the switching network 1102 to provide monitoring of the operation of the system via the processor 1106. A mobile station (MS) 1122 is preferably equipped for short message service (SMS). A short message entity 1152, e.g., a telephone network switching center or an integrated service digital network (ISDN), receives and submits a short message to the service center 932. The service center 932 transmits the message to the mobile station 1122 and retains the responsibility of the message until a report arrives from the network or until a time-out period expires. The mobile station 1122 after receiving a short message from the service center 932, returns a delivery report to the network for a received short message, notifies the network when it has memory capacity available to receive one or more short messages after it has previously rejected a short message because its memory capacity was exceeded and notifies the user to clear some of the stored messages in order to provide memory capacity for another incoming short message. The mobile station 1122 will have stored in its memory both the FLEX and the GSM protocols.

The cellular switch 926 of the present invention provides a means of communication to the associated paging system. In one embodiment, to be described in detail below, the paging terminal determines the status of the cellular telephone through "busy" signals generated at the telephone company central office. In an embodiment shown in FIG. 11, the communication between the paging terminal and the cellular switch is accomplished using a dedicated duplex data telephone line 1116 when the paging terminal/network 1150 and the cellular switch 926 are remotely located from each other. The duplex data line 1116 can also be part of a local area data network (LAN) when the paging terminal and the cellular switch are closely located to each other. Using the dedicated duplex data telephone line 1116, information regarding the portable communication device 920, including the unitary cellular telephone and pager for which a paging message is intended, is transmitted from the paging terminal to the cellular switch to enable the paging network 1150 to determine when the cellular telephone is actively engaged in a call. When the paging terminal determines that the cellular telephone 920 is actively engaged in a call, the paging message transmission is preferably inhibited.

FIG. 11 is an electrical block diagram of a paging terminal 1150 suitable for use with the present invention. In general, operation of paging terminals are well known to one of ordinary skill in the art, so only a brief description of the operation is provided herein. One or more input ports 1170 are connected to the public switched telephone system enabling paging messages to be entered by a caller using such page origination devices as, e.g., a telephone to access the paging terminal 928. When a call is received by the paging terminal 1150, an output is generated on the digital input bus 1174 which is coupled to the controller 1176. The controller 1176, through the digital input bus 1174, enables the supervisory tone generator 1178 to generate an acknowledgment tone which is coupled to the first input port

1170. This tone is communicated to the caller through the telephone circuit and indicates that the paging terminal 928 is ready to accept the pager number of the paging receiver to be paged. As is well known in the art, the number of digits to be entered for the pager number is dependent upon the number of pagers operational within the system, e.g., as three digits for a 1000 pager system, etc. The three digits, entered as Dual-Tone-Modulated-Frequency (DTMF) tones from a touch-tone telephone when received through the first input port 1170, are processed by a DTMF to binary converter to provide the digital data to be processed by the controller 1176. The controller 1176 checks the received pager number with the subscriber list data base 1180, which is generally a non-volatile memory such as a hard disk or EEPROM memory which may be periodically altered and updated as required for the number of subscribers on the system, to determine the actual pager address code to be transmitted to the selected paging receiver 940.

The subscriber list data base 1180 also includes information on those paging receivers which are combined with cellular telephones. When the controller determines from the subscriber list data base 1180 that the paging receiver is combined with a cellular telephone, a control flag is set to indicate communication to the cellular switch is required prior to the transmission of the paging message, and information identifying the cellular telephone portion of the portable communication device is recovered.

In a first embodiment of the present invention, the controller 1176 through the digital input bus 1174 initiates contact with the cellular switch using a second input port (not shown). The second input port is configured to generate a sequence of DTMF tones corresponding to the cellular telephone number. If a call is being placed to integrated cellular telephone, a busy signal will be generated at the telephone company central office. The busy signal is decoded by a detector circuit within the input port, and the detected output is sensed by the controller which in turn enables supervisory tone generator 1178 to generate a second acknowledgment tone, such as a "busy" tone, indicating to the caller that transmission of the paging message will be delayed. Controller 1176 then initiates the generation of a third acknowledgment tone indicating to the caller to speak the message, as in a voice system, or to enter the message data, as in a numeric or alphanumeric message. It will be appreciated by one of ordinary skill in the art that voice lead-through responses may be generated in lieu of acknowledgment tones directing the caller to enter the pager number, telephone number and message, and to indicate that the paging message transmission is to be delayed.

When the transmission of the paging message is to be delayed, the controller 1176, places the message data in an inactive page file in the active/inactive page file memory 1196. When the message is a voice message, the caller's message is stored by controller 1176 which directs the voice message through the input audio port 1184 to an inactive message file located within the voice storage module 1182.

When the cellular telephone 920 is not actively engaged in a call or when a pager 940 is being called, the controller 1176 places the paging message in an active page file located either in the active/inactive page file memory 1196 or stored voice module 1182, depending upon the paging message type. When the controller 1176 determines it is time to transmit the paging messages, the controller 1176 through digital output bus 1186, enables synthesizer 1188 to generate either the proper digital address sequence corresponding to the selected portable communication device 920 to be paged. This address sequence is outputted to transmitter/receiver control 1190 to be sent to transmitters 908 for transmission. When the message is stored in the voice storage module 1182, the controller 1176 enables the message to be recovered through the digital input bus 1174. The message is routed through the controller 1176 to the output audio bus 1192 to transmitter/receiver control 1190 to be sent to the transmitters 908 for transmission. The paging message signal corresponding to the address sequence and voice or data message is then transmitted by the transmitters 908.

When the cellular telephone 920 is found to be actively engaged in a call, the controller 1176 will then periodically attempt to contact the cellular switch, as described above, at predetermined time intervals, such as once a minute for a predetermined retry period of three to five minutes. The repetition rate for determining the call status of the cellular telephone 920 is determined by such factors as the average minimum length of time for a call on the cellular system, whereas the predetermined retry period is set to the maximum call time interval, or a predetermined time interval after which the paging message is considered by the caller to be "stale". When the cellular telephone message duration exceeds the retry period, the controller deletes the paging message from the active/inactive page file memory 1196.

FIG. 12 is an electrical block diagram of the paging terminal controller 1176 suitable for use with preferred embodiment of the present invention. The controller 1176 comprises of a microcomputer 1200, e.g., an MC6809 microcomputer manufactured by Motorola, for providing digital control through the digital input bus 1174 and the digital output bus 1186. The controller 1176 also has control of the input audio bus 1184 and the output audio bus 1192 through the audio matrix switch 1202 through the audio control port 1204. The microcomputer 1200 includes a central processing unit (CPU) 1206 for operational control. An internal bus 1208 couples or connects all the elements of the microcomputer 1200. The digital input port 1210 couples to the digital input bus 1174, the digital output port 1212 couples to the digital output bus 1186, and the digital audio control port 1204 couples to the audio matrix switch 1202. The timer/counter 1216 is used to generate time intervals required for system operation, such as required to periodically determine the calling status of the cellular telephone 920 and the retry period. The oscillator 1218 provides the clock for operation of the CPU 1206 and the reference clock for the counter/timer 1216. The RAM 1220 is used by the CPU 1206 and also provides an area for paging queues, such as the active paging files and the inactive paging files. It will be appreciated that depending upon the size of the system, additional RAM or other memory means, such as a hard disk, may be required to provide adequate storage for the paging queues and telephone numbers. The read only memory (ROM) 1222 contains the firmware for controlling the microcomputer 1200 operation. Included within the ROM 1222 are routines providing for input control, output control, message queuing control, selective call paging signal generation, and cellular switch communication control, just to name a few.

Referring to FIG. 13, an electrical block diagram of a portable communication device is shown in accordance with the preferred embodiment of the present invention. The portable communication device 920 comprises cellular telephone and a selective call receiver (pager) integrated as a single device. The portable communication device or selective call device 920 comprises an antenna 1302 for receiving and transmitting a cellular signal to and from the GSM base station, e.g., GSM signal. The antenna 1302 coupled to a receiver front-end, e.g., GSM receiving circuit, 1304 is suitable for intercepting or acquiring a transmitted radio frequency (RF) signal, preferably modulated according for the GSM protocol. The GSM front-end 1304 performs functions, e.g., radio frequency amplification, down conversion, radio frequency and intermediate filtering operation, automatic gain control (AGC) and splitting the incoming signal into its baseband In-phase-and-quadrature (I and Q) components. An antenna 1310 is coupled to a receiver circuitry, e.g., FLEX front-end, 1312 for receiving or acquiring a paging or messaging signals. The FLEX front-end 1312 performs the same functions as the GSM front-end but at different bandwidth. Both the GSM front-end and the FLEX front-end are coupled to a voltage control switch 1306 which is used to change from GSM to FLEX receiving mode under the control of a processor 1326 to be discussed in details below. An integrated circuit 1308 is coupled to the switch 1306 and comprises an analog-to-digital convertor (ADC) 1314 and digital-to-analog convertor (DAC) 1318 coupled to a switch 1316. The ADC 1314 converts the received FLEX and GSM signals from analog to digital form and the switch

1316 is used to switch from received to transmit mode during GSM operation. The switch 1316 is controlled by the processor 1326. Similarly, the DAC 1318 converts the base band digital GSM signal into an analog signal before transmission. The processor 1326 comprises a digital signal processor (DSP) 1320, a central processing unit (CPU) 1322 and a voltage regulator 1324. The DSP 1320 demodulates the received GSM and FLEX messages, generates automatic frequency control (AFC) and automatic gain control (AGC) signals, generates the clock signals needed for the ADC 1314, generates the baseband digital I and Q components of the transmitted signal and provides demodulated digital signal which is coupled a Codec 1328 and converts digital signal to analog voice and vice versa. The CPU 1322 generates signals for driving a display 1332, e.g., liquid emitting diode (LED). The voltage regulator 1324 provides a constant voltage independent of the load to the other active components in the front-end receiving circuits and the transmitting circuits. A memory IC 1330 coupled to the DSP 1320 stores filter coefficients, voice samples, etc. and the display 1332 provides a graphical interface to the user. An electrical erasable programmable read only memory (EEPROM) 1334 stores cap codes. A data terminal 1336 enables the coupling a computer, a FAX machine or any other device capable of providing digital information. Coupled to the data terminal 1336 is switch 1338 for switching power to the selective call device from a battery 1340. The switch 1338 is controlled by the CPU 1322 and when the data terminal is able to provide power, the switch shuts off the internal battery 1340 and switch to the power supply from the data terminal 1336.

A quadrature modulator 1342 performs the up-convert in frequency, using two oscillators in quadrature the baseband I & Q components and combines the complex analog signal supplied from the DAC 1318. The quadrature modulator also preamplifies and filters the signal from the DAC 1318. A crystal filter 1344 coupled to the quadrature modulator 1342 filters the signal from the DAC 1318 and attenuates the spurs generated. Coupled to the crystal filter 1344 is an automatic gain control amplifier 1346 that amplifiers the signal according to a control voltage generated by the DSP 1320. A mixer 1348 coupled to the AGC amplifier 1346 which up-converts the intermediate frequency signal to the transmit frequency and a bandpass filter 1350 coupled to the mixer 1348 filters the signal and attenuates spurs generated by the mixer 1348. An amplifier 1352 coupled to the filter 1350 amplifiers the transmitted signal, preferably a GSM signal, which is applied to the antenna 1302 by an RF switch 1354 which is controlled by the CPU. The switch 1354 switches the antenna from the receiving mode to the transmitting mode during GSM by techniques well know to one of ordinary skill in the art.

FIG. 14 shows timing diagrams of a synchronous signal in accordance with the preferred protocol. The selective call (paging) signal, e.g., FLEX™ signal protocol comprises of a number of, preferably one-hundred-twenty-eight (128), message packets or frames 1400. Each frame 1400 is preferably 1.875 seconds in duration and has a preferred base data rate of 6400 bits per second. Although, it will be appreciated that other data rates can be used including the ability to use multiple data rates. Referring to FIG. 15, each frame 1400 comprises of a bit sync signal 1502, preferably 112 bits of alternating 1,0 pattern, followed by a frame sync #1 signal 1504 preferably one of several predetermined thirty-two bit words, and a frame info signal 1506, preferably one thirty-two bit word having twenty-one variable information bits containing information such as a cycle number and a frame number. The bit sync signal 1502 provides bit synchronization to the selective call receiver(s) 940 while the frame sync signal 1504 provides frame synchronization and includes a signal indicative of the data rate of the message information, the details will be discussed below.

Following the frame info word 1506 is a frame sync #2 1508. Following the frame sync #2 1508 is a block info word (BIW) signal 1510 including information such as the number of priority addresses, end of block information field, vector start fields and the system collapse value mask, the BIW 1510 will be discussed in further detail. The system collapse mask is the same for each 928 frames of a selective call transmission, and is used by the selective call receiver to operate in another battery saving mode or period different from the battery saving mode or period preprogrammed in the selective call receiver 940. The code word of each frames 1400 is preferably encoded as 31,21 Bose-Chaudhuri-Hocquenghem (BCH) code words having twenty-one information bits and ten parity bits generated according to the well known BCH algorithm. An additional even parity bit extends the word to a 32,21 code word. The addresses are located in block 1512 and the vectors pointing to the messages, if applicable, are located in block 1514 and the messages are located in the remaining blocks 1516. Preferably, all of the address signals within the frame are located in a first portion 1512 and the information signals are located in a subsequent portion of the block 1516. It is well known to those skilled in the art how the locate addresses in a first portion 1512 and message information 1516 in a second portion of the frame 1400. Words 1512-1516 are shown in a vertical orientation to indicate that these words may be interleaved in order to improve the immunity of the transmission to burst errors. It is understood by one of ordinary skill in the art that interleaving may be modified or eliminated.

Referring to FIG. 15, a detailed block diagram of the block information word 1510 is illustrated. The block information word 1510 includes an information block 1502 and a parity block 1610. The information block 1510 includes twenty-one bits and according to the preferred embodiment of the present invention, the R_0 bit indicates when the cellular system is too busy to transmit any paging messages or information. The P_0 bit or flag indicates when the cellular system is experiencing a peak time or off-peak time loading so the paging system will know the rate for transmitting paging messages on the cellular network. During peak time, the cellular communication system may not want to permit the selective call device to acknowledge receipt of a message. The G_0 bit or a control flag indicates which, if any, GSM frequency that is available within the geographic location or area while the C_0 bit or flag indicate which, if any, code division multiple access (CDMA) cellular channel or frequency is available. The F_{0-6} bits or flags indicate the preferred cellular channel to use when transmitting paging messages on the cellular system.

Referring to FIG. 17, the block information word is shown as a short instruction vector. When bits V_{0-2} are set to the value "001," the block information word corresponds to the short instruction vector and when bits or flags i_{0-1} are set to the value "011," information is instruction type. When the F_0 flag or bit is set, a FAX (facsimile) message is being sent, the V_0 flag or bit indicates a voice message, the D_0 flag or bit indicates a data message while the S_0 flag or bit indicates a secure message. Flags N_{0-3} indicate the message number, while the M_0 flag or bit indicates the message number that has been sent through another medium, e.g., the cellular network. The P_0 flag or bit is a priority bit that indicates that the selective call receiver 940 should move to the cellular network immediately because a message is being transmitted by the cellular system. The I_0 flag or bit indicates that an inbound message is received by the cellular system.

FIGs. 18 and 19 are flow diagrams illustrating the operation of a base station in accordance with the preferred embodiment of the present invention. Referring specifically to FIG. 18, the communication system, e.g., a dual mode base station (that is capable of communicating on both a cellular, e.g., GSM, protocol and a paging, e.g., FLEX, protocol) begins its initialization process, step 1800. The base station receives an incoming call designating a subscriber, step 1802, and first checks or reads the HLR for the latest geographic location of the cellular telephone or pager ("selective call device") that is addressed or designated. If the selective call device identification (ID) is not found in the HLR, the base station then checks the VLR, step 1804. The base station then determine if the message is to be sent or transmitted on the GSM protocol or the FLEX protocol, step 1806. When the base station determines that the message is to be transmitted on the FLEX protocol, step 1806, the message is stored, step 1808, and then placed in a queue to await a transmission cycle, step 1810. Before the message is transmitted, the R flag of the BIW is set to indicate that the message will be transmitted via the FLEX protocol (the cellular system is busy or the message is more appropriate for the FLEX protocol transmission) step 1812. The acknowledge-back (ACK) flag is set or a no-ACK address, step 1814. After the message is transmitted, step 1816, the base station reads or checks if the ACK flag and address are set indicating that it should wait for an ACK response from the selective call device, step 1818. If not, the process returns to wait for other message at step 1802. If the message was set to ACK, step 1818, the base station waits for the ACK from the designated subscriber unit 920, step 1820. Step 1822 determines when the ACK is received or if the time-out period has expired. When the ACK response is received, the message is cleared, step 1824, and then the process returns to step 1802. If the ACK was not received before the time-out period, the predetermined period of time, step 1822, the base station transmits the message in simulcast with a registration request, step 1826. Thereafter, the base station interrogates the HLR and the VLR to determine if the selective call device has to re-register, step 1828. If the selective call device did re-register indicating that the message was successfully received, step 1830, the message is cleared, step 1824 and the process returns to step 1802. When it is determined that the selective call device had not re-registered, the message is stored, step 1832 and transmitted later, step 1834. Although not shown, the base station may retransmit for a predetermined number of times, and if the message was not received before it returns to step 1802.

Returning to step 1806, when the base station has decided that the message should be transmitted on the cellular network because, e.g., the cellular system is available, the message is more suited for transmission on the cellular network or because the rates are lower, etc., the message is stored, step 1840. The process continues, step 1842, to FIG. 19 at step 1900. The base station determines if the message acquired is a real-time or non-real time message, step 1902. When the message is determined to be a non-real time message, e.g., a facsimile message, step 1902, the message is stored, step

1904. The base station encodes the short instruction vector (FIG. 17) by setting, e.g., the F_0 or the D_0 flag of the FLEX protocol to inform the selective call device that a non-real time message will be transmitted via the cellular network, step 1906. The base station then checks if the selective call device was able to access the GSM network, step 1908. If not, the base station checks if the message was delivered through another medium, e.g., the telephone systems (wirelines), step 1910. If yes, the short instruction vector of the FLEX protocol is used to inform the selective call device that the message is already delivered, step 1930. The message is cleared from memory, step 1932, and the FLEX queue is also cleared, step 1934. If the message was not delivered via another medium, step 1910, the message is stored at the base station, step 1912. The base station simulcast the short instruction vector of FLEX with message header, step 1914. In step 1916, the base station checks if the selective call device was able to access the GSM network, and if not, the message is stored at the base station, step 1918.

The process begins at step 1920 either from step 1908 or step 1916, where it is determined if there is a request from the user to forward the message to a different location, step 1920. If not, the base station initiate transmission, step 1922, and after receiving an acknowledgment from the GSM network that the message was transmitted and received properly, the message is then cleared from the base station, step 1924. If a request was received to forward the message, step 1920, the base station determines whether to deliver the message via the wireless medium, e.g., GSM or FLEX or the wireline network, e.g., the telephone lines, step 1926. If the message is to be delivered via the telephone lines, the message transferred to the PSTN, step 1928, and then the FLEX queue is cleared, step 1934.

Alternatively, when a real time message is received or acquired, step 1902, the short instruction vector priority flag is set in the FLEX protocol, step 1940, and then the short instruction vector V flag of the FLEX protocol is also set, step 1942. Thereafter it is checked to determine if the selective call device was able to access the GSM network to receive its message, step 1944.

If so, message transmission is initiated, step 1960. When the selective call device accesses the GSM network, the GSM network transmits the message to ensure a timely delivery. If the selective call device does not access the network, the FLEX network is informed within a predetermined length of time. The GSM provides a status of the communication and wait until the communication ends, step 1962, before the communication is terminated, step 1964. On the other hand, when the selective call fails to access the GSM network, the base station determines if the call was delivered through another medium, e.g., the telephone lines, step 1946. If so, the short instruction vector M flag of the FLEX protocol is used to inform the selective call device that the message has been delivered, step 1948. If the message was not delivered via another medium, step 1946, the caller is informed that the intended subscriber is not available, step 1950. The caller is also asked to enter his/her telephone number or identification (ID), step 1952. A registration request is simulcast with the caller ID via the FLEX protocol, step 1954.

Referring to FIG. 20, a flow diagram is shown illustrating the operation of selective call device operation when the base station originates a message in accordance with the preferred embodiment of the present invention. The process begins at step 2000. The selective call device searches for the control channel, preferably the FLEX channel, Ids and the geographic location data (the station color code), step 2002. After finding the control channel, the selective call device reads or checks the G flag of the block information word (BIW) of the FLEX protocol, step 2004, to determine if the preferred GSM channel is available, step 2006. Generally, information about the preferred GSM channel is stored in memory of the selective call device. If the preferred channel is available, the selective call device switches to that GSM channel, step 2008. Alternatively, when the preferred channel is not available selective call device switches to the GSM protocol and begins to check the signal strength of the different available GSM frequency or channel and selects the GSM channel with the strongest signal strength, step 2010.

Thereafter, whether on the preferred GSM channel or the GSM channel with the strongest signal strength, the selective call device registers with the GSM network and provides the FLEX ID information, step 2012. The selective call device then switches back to the FLEX control channel, step 2014, and remain in standby/receive mode, step 2016. When the selective call device locates its address, it waits to receive any corresponding messages or instruction located in the address vector fields indicating where and when the message will be transmitted, step 2018. The selective call device continues waiting until the instruction arrive, step 2020, and if not it returns to its standby mode, step 2016. When the vector arrives, the vector type is determined, step 2024. If it is a FLEX vector, the selective call device remains of the FLEX network to receive and store the message, step 2028. After the receipt of the message, the selective call device will alerts to let the user know that a message was received, step 2030. The selective call device checks or interrogates the address to determine if an ACK or a no-ACK address was received, step 2032. If a no-ACK address was received, the selective call device returns to its standby mode, step 2046.

However, when an ACK address was received, the selective call device checks or interrogates the BIW of the FLEX protocol to determine if the R flag was set to ACK indicating that the selective call device should send a response, step 2034. The cellular communication system can disable acknowledgment when the system is experiencing peak loading. The R flag and the ACK address determines when the selective call device is permitted to send its acknowledgment. If not, the selective call device waits until the R flag is set indicating that it is ready to transmit the ACK, step 2036, the selective call device then switches to the GSM protocol mode, step 2038. If the R flag was set to ACK, step 2034, the selective call device switches to the GSM mode, step 2040. Either from step 2040 or step 2038, the ACK message is transmitted, step 2042, and then the selective call device switches back to the FLEX control channel, step 2044, to go back to the standby mode, step 2046.

When the vector type indicates GSM vector, step 2024 of FIG. 20, the process continues to FIG. 21, step 2100, and in step 2102, the battery voltage is check to determine whether or not the voltage is below a threshold voltage, step 2102. If voltage is above the threshold, the process transfers to step 2110. When the voltage is below the threshold voltage level, step 2102, the selective call device indicates or set the low battery icon or indicator and let the user know that that there is a GSM message, step 2104. The selective call device stays on the FLEX network, step 2106, returning to the standby mode to receive FLEX messages, step 2108. When the battery voltage is not low, the selective call device switches to the GSM mode, step 2110, and initiates the GSM access procedure, step 2112. If the selective call device accesses the GSM network step 2114, the selective call device switches to the assigned traffic channel (TCH), step 2116. The cellular control channel is used to provide call status to the service center, step 2117 and remains on the GSM channel until the communication is completed, step 2118. After the communication is done, the selective call device switches back to the FLEX control channel, step 2120, and return to the standby mode to receive its FLEX address, step 2122.

Alternatively, when the selective call device fails to access the GSM network, step 2114, it tries to access the GSM network again, step 2124, after which it is determined whether the selective call device was able access the GSM network, step 2126. If the selective call device accesses the GSM network, the process flows to step 2116 as described above. However, if the selective call device fails to access the GSM network again, step 2126, it switches back to the FLEX control channel, step 2128. The selective call device sets the GSM message type indicator to indicate that a GSM message is waiting, step 2130. The received signal strength of the FLEX protocol is monitored, step 2132, and to determine if the received signal strength of the FLEX signal is increasing, step 2134. If there is no improvement of the FLEX received signal strength, the selective call device stays on the FLEX channel, step 2136, to continue to monitor the received signal strength, step 2138, while in the monitoring mode, step 2140.

If the signal strength did improved, step 2134, the selective call device will attempt to determine if the message was delivered by another means, e.g., telephone lines, step 2142. If yes, the selective call device does not access the GSM network, step 2144, and remains on the FLEX network, step 2146, and returns to its standby mode, step 2148. However, if the message was not delivered by another means, step 2142, the selective call device checks if the R flag in the FLEX protocol is set to ACK, step 2152. If yes, the selective call device registers with the GSM network, step 2154. Step 2156 determines if the selective call device was able to register with the GSM network, and if not, the selective call device remains on the FLEX network, step 2150, to monitor the receive signal strength, step 2132. If the R flag was not set, step 2152, the selective call device waits until is set to ACK, step 2160. When the selective call device determines that the R flag is set to ACK, it switches to the GSM mode and begins registration, step 2162. After either step 2156 or step 2162, the selective call device switches back to the FLEX mode, step 2166 and continues in its standby mode, step 2168.

Referring to FIG. 22, a flow diagram of a selective call device originated message protocol is shown in accordance with the preferred embodiment of the present invention. The initialization process begins at step 2200, and the selective call device initiates a message origination command, step 2202, and thereafter checks if the battery voltage is above the threshold voltage level, step 2204. If no, the selective call device remains on the FLEX control channel, step 2206, and display a low battery icon or indicator, step 2208. On the other hand, if the battery voltage is above the threshold voltage level, step 2204, the selective call device checks if the BIW R flag of the FLEX protocol is set to ACK, step 2212. If not, the selective call device display the unavailable GSM channel icon, step 2214, and remains on the FLEX control channel, step 2210. If the R flag is set to ACK, step 2212, the selective call device switches to the GSM mode, step 2216, initiate the GSM access procedure, step 2218. In step 2220, it is determined whether the selective call device was able to access the GSM channel, and if not, the process returns to step 2214 to display the unavailable GSM channel icon. When the selective call device is able to access the GSM network, step 2202, it determines if it is a short message, step 2222. If it is a short message, the short message procedure is used to deliver the message to the dual mode protocol in the service canter 932. When the message is not the short message type, e.g., voice or text, step 2222, the base station initiate the call or end the text or voice message on the assigned cellular traffic channel (TCH), step 2224. The base station uses the cellular control channel to send a short message to let the service center 932 knows that a call is in progress, step 2226. However, before terminating the call or after sending the entire text message, a short message is sent on the cellular control channel to the service center to inform it that the call has terminated, step 2228. From either step 2232 or step 2228, the selective call device then switches to the paging protocol, e.g., FLEX network, step 2230, and there returns to step 2202.

Referring to FIG. 23, a flow diagram illustrating the base station operation when the portable communication unit originates a message is shown in accordance with the preferred embodiment of the present invention. The initialization process begins, step 2300, and base station checks for incoming messages on the GSM network, step 2302. Block 1504 checks if the message is arriving on the FLEX, the GSM or the PSTN network. If message is arriving via the GSM network, the service center checks the call status information on the cellular control channel, step 2305 and allows the base station allows the GSM network to handle the entire communication including the call or message transfer procedure, step 2306. When the message is arriving via the PSTN, step 2304, the message is saved at the base station, step 2308, and then a telephone line interconnection is made, step 2310. When the message is delivered, the short information vector I flag of the FLEX protocol is set, step 2312, and the message is cleared, step 2314.

Finally, when the message is arriving via the FLEX network, the geographic location (or color code) is preferably included in the paging signal, step 2304, the message is saved at the base station, step 2320. The base station checks the latest location in the GSM HLR for the designated subscriber, step 2322, and set the ACK or No-ACK address of the intended or designated subscriber, step 2324. The base station checks the BIW R flag, step 2326, and transfer the message to the appropriate FLEX base station, step 2328, where the message is transmitted, step 2330. After the transmission of the message, it is determined whether the ACK address and the R flag were set, step 2332, and if not the process skips to step 2340. Otherwise, if the ACK address and the R flag are set, step 2332, the base station waits for the ACK for a predetermined period of time, step 2334. If the ACK was received, step 2336, the base station informs the user that the message was delivered by setting the short message vector I flag in the FLEX protocol, step 2338, and then the message is cleared from memory, step 2340.

If the ACK did not arrive within the predetermined period of time, step 2336, the base station simulcast the message on the FLEX control channel, step 2342, and waits for a predetermined period of time or until the ACK is received during re-registration, step 2344. In step 2346, it is determined whether the ACK was received, and if so, the user is informed that the message was delivered by setting the short message vector I flag of the FLEX protocol, step 2348, and then the message is cleared from memory, step 2350. If the ACK did not arrive within the predetermined period, step 2346, the message is saved, step 2352, and when intended subscriber re-register, the base station determines how many messages are in memory for the subscriber, step 2354. The base station retransmits all the pending messages to the re-registered subscriber(s), step 2356 on a cellular control channel while the selective call device is actively communication on the cellular channel.

Referring to FIG. 24, a flow diagram illustration of the selective call device originated registration procedure is shown in accordance with the preferred embodiment of the present invention. The initialization procedure begins at step 2460, followed by the selective call device searching for and acquiring the FLEX control channel including the geographic location code (color code) and storing the station ID (color code), step 2402. The selective call device checks the BIW G flag of the FLEX protocol, step 2404 to determine if there is preferred GSM channel in the area, step 2406. If not, the selective call device switches to the GSM mode to look at the received signal strength to determine the GSM channel with the highest signal strength, step 2408. If a preferred GSM channel is found, step 2406, the selective call device switches to the GSM channel, step 2410, and registers with the GSM network, send the received FLEX channel ID to the base station and the received message number, step 2412. The GSM cell ID is stored, step 2414 and then the selective call device switches back to the FLEX protocol, step 2416. The selective call device checks the transmitted FLEX ID, step 2418, and compare the received FLEX ID with the ID stored in memory, step 2420. After the comparison, step 2422 determines if they are different, if not, the process returns to step 2418. When the FLEX ID is different from the transmitted ID, step 2422, the selective call device checks its battery voltage, step 2424, to determine if it is above a threshold level, step 2426. If the voltage is above the threshold, step 2426, the process returns to step 2404 to check the G flag of the BIW in the FLEX protocol. When the voltage is below the threshold, step 2426, the selective call device remains on the FLEX control channel, step 2428, and indicates or sets the low battery icon or indicator, step 2430, then the process continues to step 2418.

We claim:

1. A combined paging communication system and cellular communication system for communicating with a selective call device, the selective call device comprising:

a receiver for acquiring a paging signal as a control channel for a selective call device, the paging signal indicating a geographic location;

a controller, coupled the receiver, for decoding a control flag to determine a cellular channel is available;

a transmitter, coupled to controller, for registering with the cellular communication system on the cellular channel indicated by the control flag of paging signal;

a service center for transferring status information from the cellular communication system to the paging communication system for authenticating the selective call device;

the receiver for receiving a paging message on the control channel of the paging communication system;

a transmitter, coupled to the service center, for transmitting an address and a vector on the control channel to the selective call device directing the selective call device to the cellular channel of the cellular communication system for receiving the paging message;

the selective call device reads a flag in the paging signal to determine if the paging communication system is requesting the selective call device to acknowledge its receipt of the address and vector;

the service center transfers the paging message to a cellular base station for transmission on the cellular channel to the selective call device in response to the paging communication system receiving an acknowledgment from the selective call device indicating that the vector was received; and

the cellular base station transmits the paging message at a location indicated by registration information stored in cellular communication system.

2. The combined paging communication system and cellular communication system according to claim 1 wherein the receiver of the selective call device measures a signal strength of the paging signal when the selective call device is unable to register with the cellular communication system for determining when to attempt a re-registration with the cellular communication system.

3. The combined paging communication system and cellular communication system according to claim 1 wherein the receiver of the selective call device re-registers with the cellular communication system when the selective call device receives the geographic location of the paging signal different from the geographic location previously received by the selective call device.

4. The combined paging communication system and cellular communication system according to claim 1 wherein the receiver receives an ACK address informing the selective call device to acknowledge a receipt of the paging message and a no-ACK address informing the selective call device to not acknowledge a receipt of the paging message.

5. The combined paging communication system and cellular communication system according to claim 4 wherein the controller interrogates a control flag of the paging signal to determine if the cellular communication system loading permits the selective call device to acknowledge the receipt of the paging signal in response to the selective call device receiving the ACK address.

6. The combined paging communication system and cellular communication system according to claim 5 wherein the controller

continually checks the control flag to determine when to acknowledge the receipt of the paging message upon the receipt of the ACK address.

7. The combined paging communication system and cellular communication system according to claim 1 wherein the service center transfers priority messages and undelivered messages on a cellular control channel to the selective call device which is communicating on the cellular channel.

8. A selective call communication system for coordinating and selecting alternative data channels for communication, comprising:

a base station coupled to a plurality of alternative data communication systems for receiving a message intended for a selective call device designated by an address;

a data scheduler coupled to the base station and the plurality of alternative data communication systems, the data scheduler comprising:

a categorizer for categorizing the message as being suitable for transmission on an alternative data channel;

a controller for coordinating a list of alternative data communication systems suitable for transmitting the message;

a selector for selecting the alternative data channel suitable for transmitting the message;

a controller for encoding a selective call signal including the address and a vector;

a transmitter for transmitting the selective call signal to the selective call device on a control channel; and

a communication link for transferring the message to an alternative data communication system for transmission.

9. The selective call communication system according to claim 8 further comprising an initiator for initiating a retransmission of the message when the selective call device has indicated that the message was not received.

10. The selective call communication system according to claim 8 wherein the categorizer determines if a length of the message is greater than a threshold.

11. The selective call communication system according to claim 8 wherein the selector creates and stores a list of alternative data channels.

12. The selective call communication system according to claim 8 wherein selective call signal further comprising:

the address for identifying the selective call device;

the vector designating a frequency of an alternative data communication system;

a protocol for identifying a data structure;

a message packet identification code for identifying the message; and

a time delay for waiting for a response from the selective call device indicating that the message corresponding to the message packet identification code was received on the alternative data communication system.

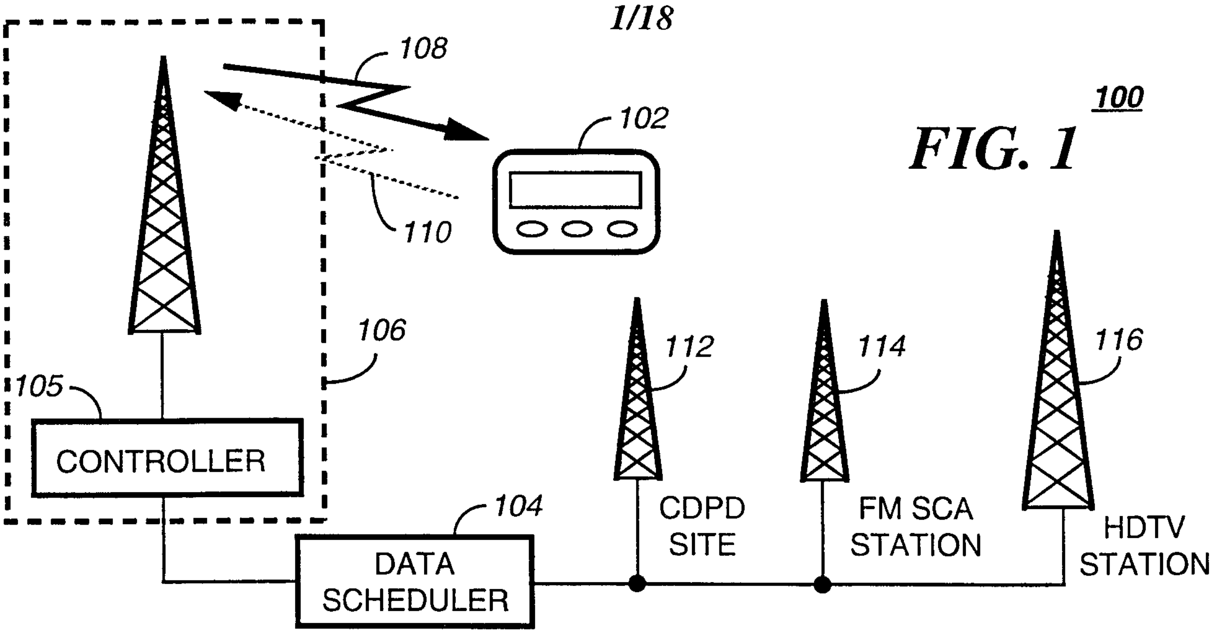


FIG. 1

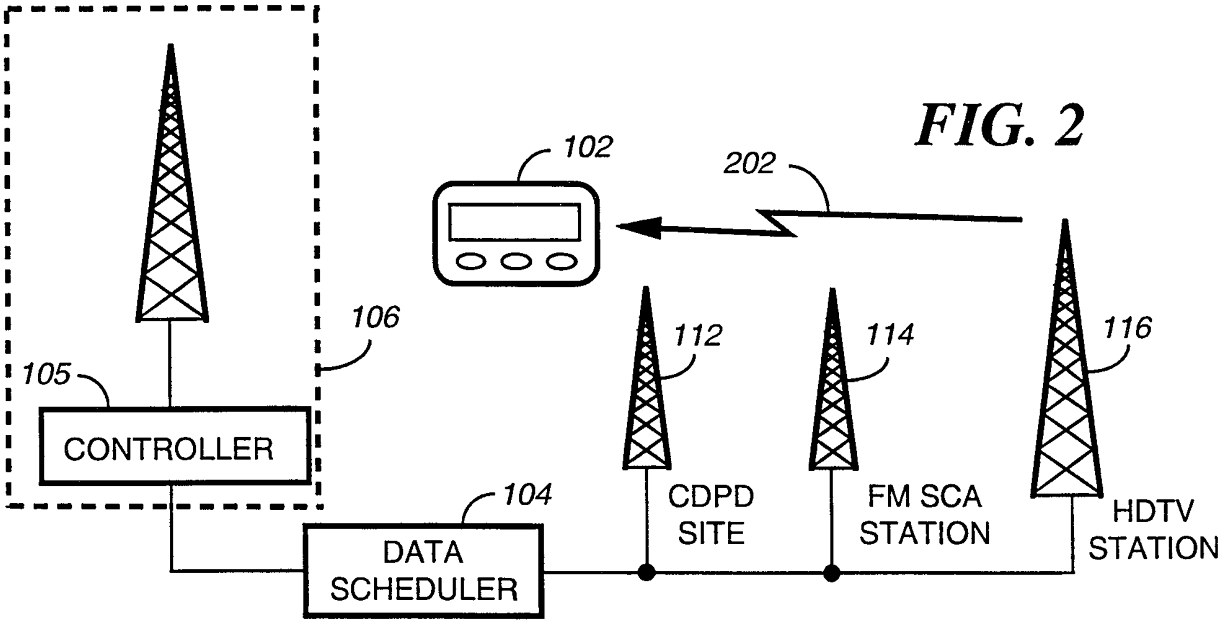


FIG. 2

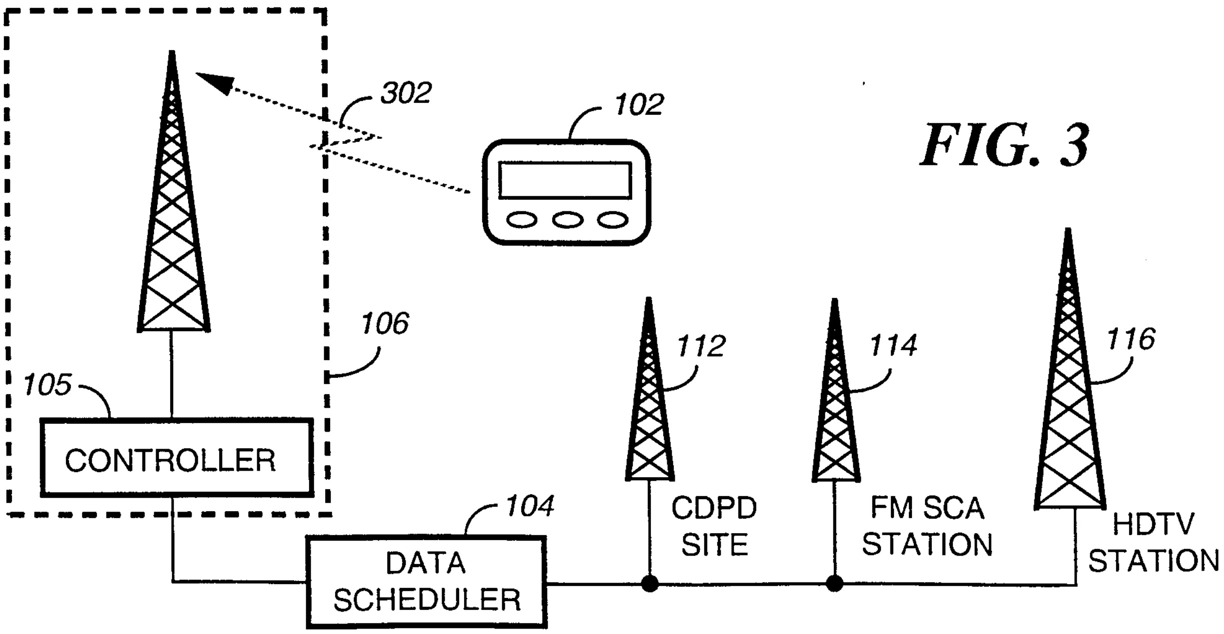


FIG. 3

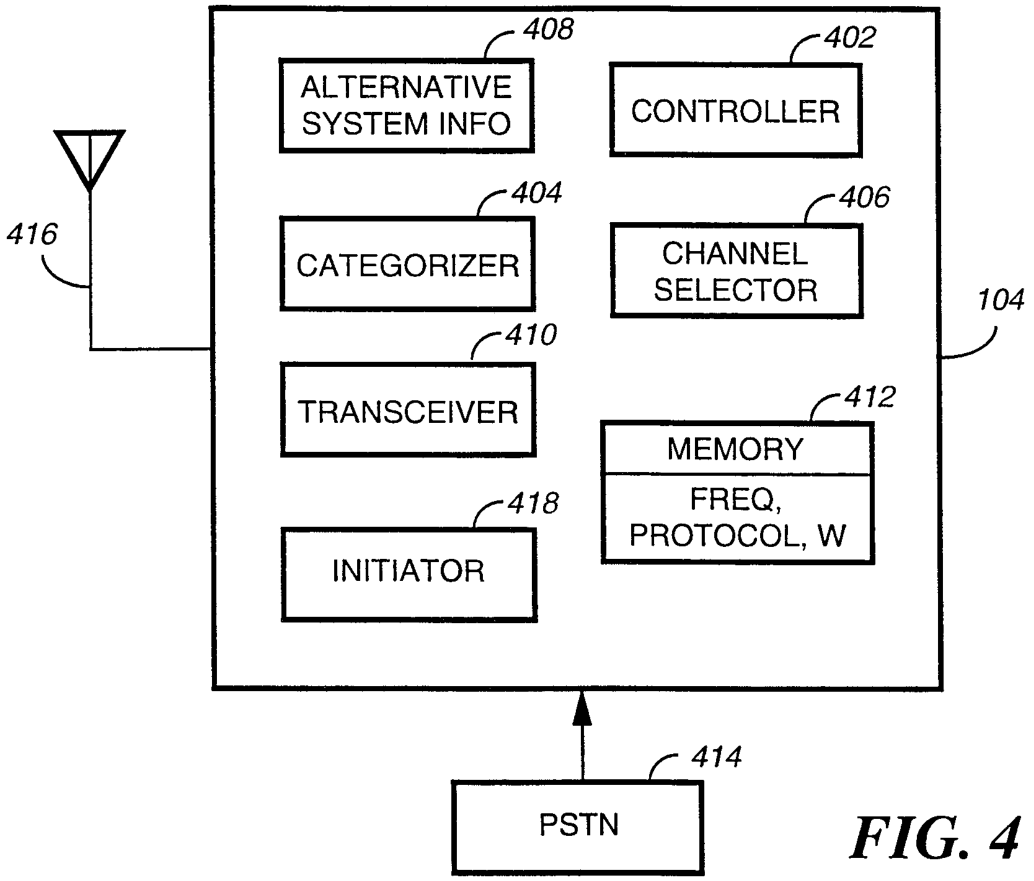

ALTERNATIVE SYSTEM INFO
408
CONTROLLER
402
CATEGORIZER
404
CHANNEL SELECTOR
406
TRANSCEIVER
410
MEMORY
FREQ, PROTOCOL, W
412
INITIATOR
418
416
104
PSTN
414

FIG. 4

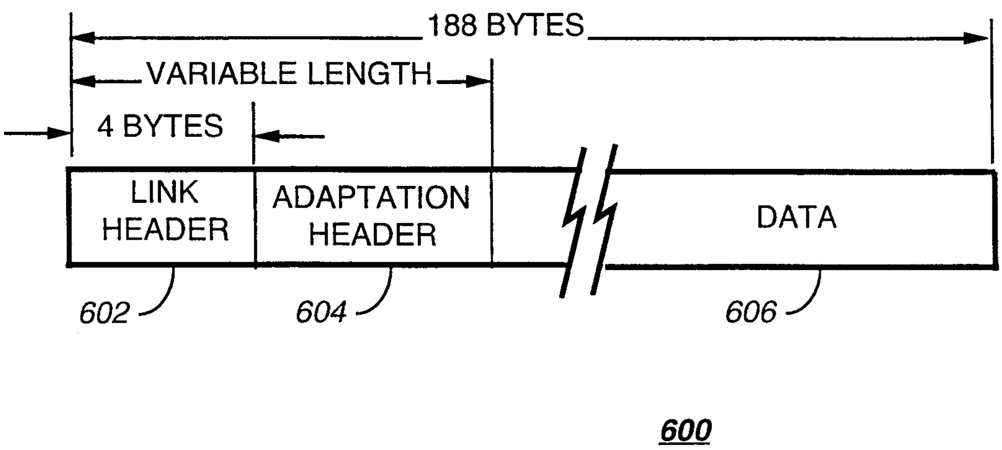

188 BYTES
VARIABLE LENGTH
4 BYTES
LINK HEADER
ADAPTATION HEADER
DATA
602
604
606
600

FIG. 6

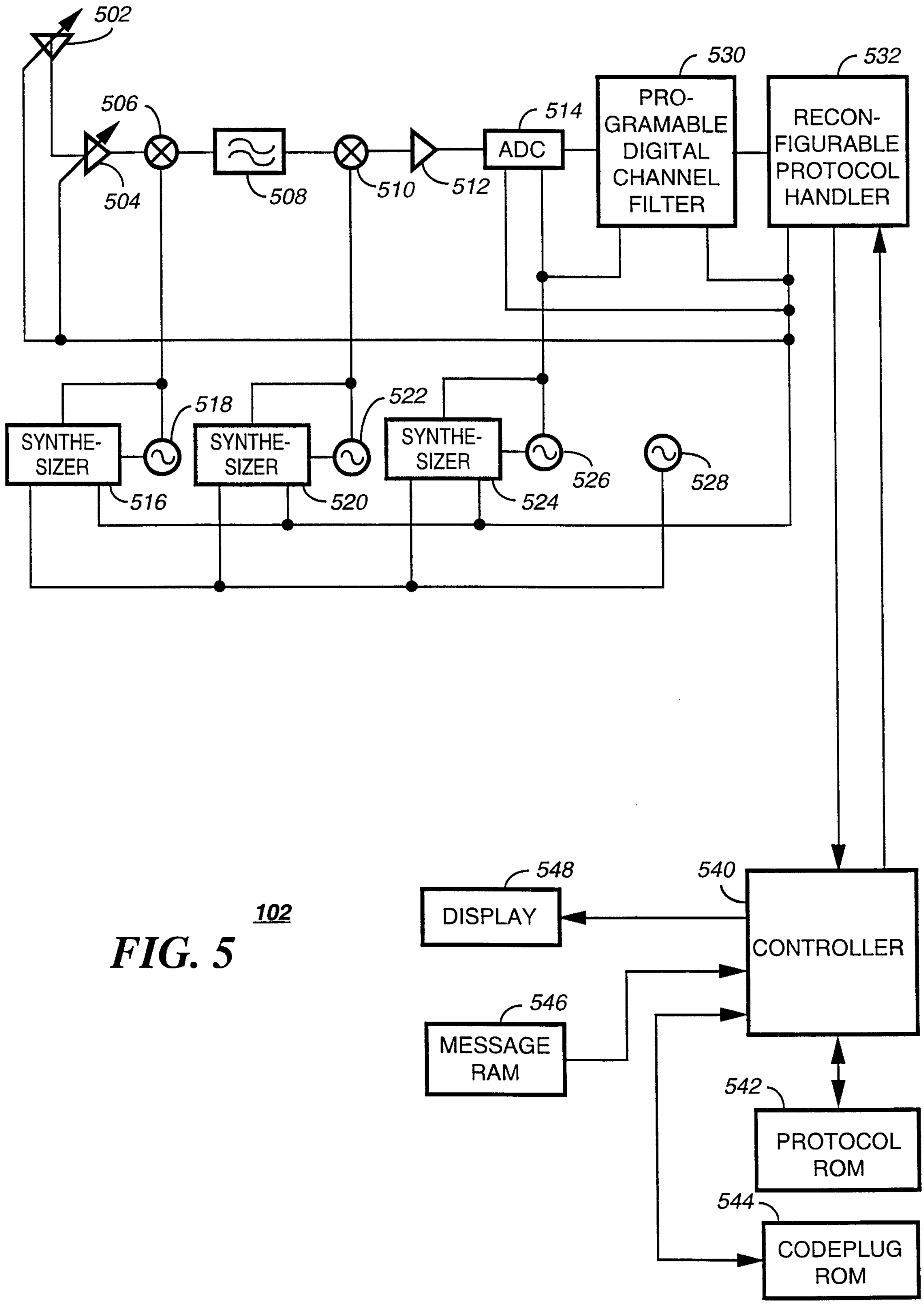
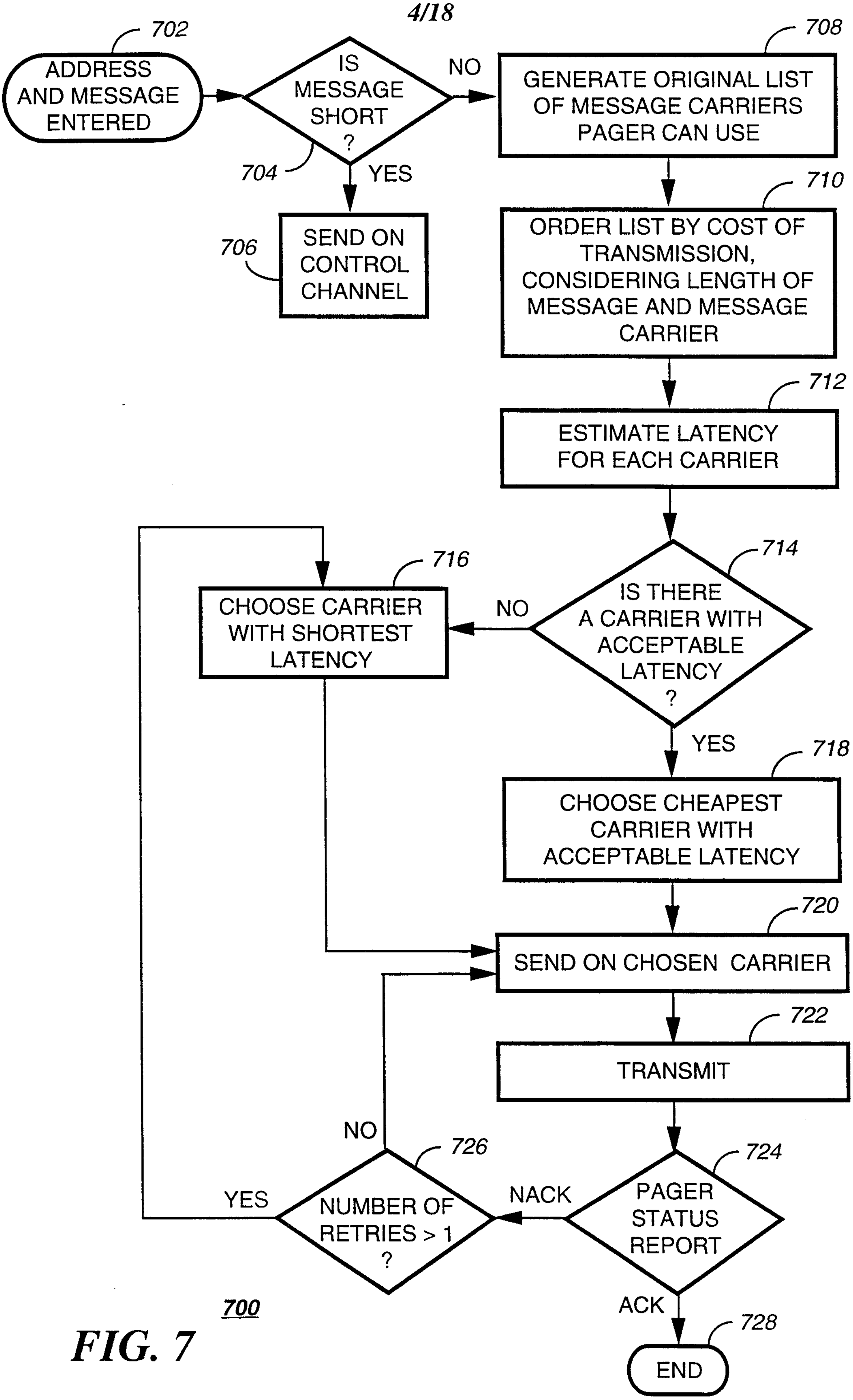

502
506
504
508
510
512
514
ADC
530
PRO-
GRAMABLE
DIGITAL
CHANNEL
FILTER
532
RECON-
FIGURABLE
PROTOCOL
HANDLER
518
522
SYNTHE-
SIZER
SYNTHE-
SIZER
SYNTHE-
SIZER
516
520
524
526
528
548
DISPLAY
540
CONTROLLER
546
MESSAGE
RAM
542
PROTOCOL
ROM
544
CODEPLUG
ROM
102

FIG. 5



702
ADDRESS AND MESSAGE ENTERED
IS MESSAGE SHORT ?
704
NO
YES
706
SEND ON CONTROL CHANNEL
708
GENERATE ORIGINAL LIST OF MESSAGE CARRIERS PAGER CAN USE
710
ORDER LIST BY COST OF TRANSMISSION, CONSIDERING LENGTH OF MESSAGE AND MESSAGE CARRIER
712
ESTIMATE LATENCY FOR EACH CARRIER
714
IS THERE A CARRIER WITH ACCEPTABLE LATENCY ?
NO
716
CHOOSE CARRIER WITH SHORTEST LATENCY
YES
718
CHOOSE CHEAPEST CARRIER WITH ACCEPTABLE LATENCY
720
SEND ON CHOSEN CARRIER
722
TRANSMIT
724
PAGER STATUS REPORT
NACK
ACK
726
NUMBER OF RETRIES > 1 ?
YES
NO
728
END
700

FIG. 7

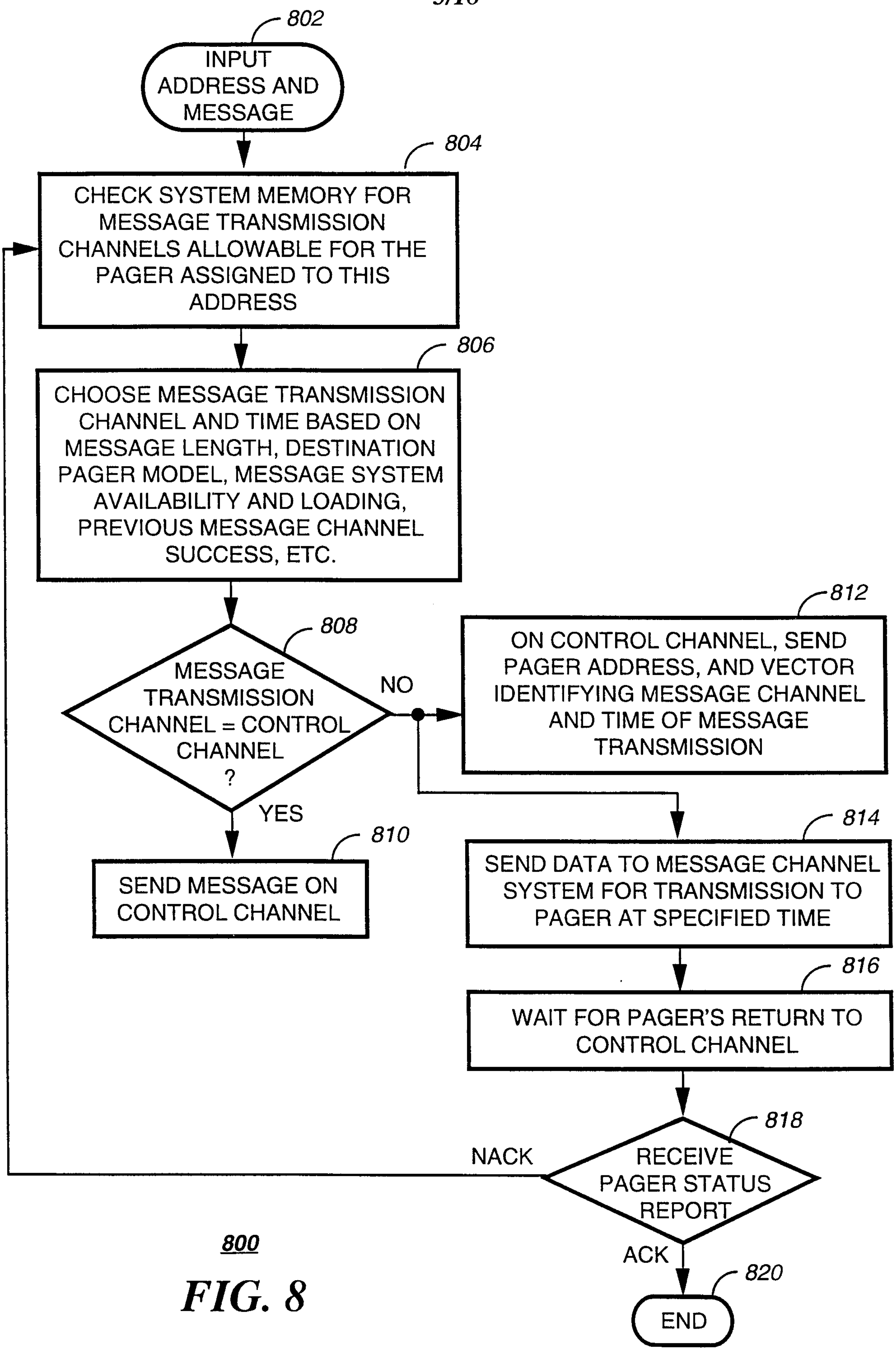

802
INPUT ADDRESS AND MESSAGE
804
CHECK SYSTEM MEMORY FOR MESSAGE TRANSMISSION CHANNELS ALLOWABLE FOR THE PAGER ASSIGNED TO THIS ADDRESS
806
CHOOSE MESSAGE TRANSMISSION CHANNEL AND TIME BASED ON MESSAGE LENGTH, DESTINATION PAGER MODEL, MESSAGE SYSTEM AVAILABILITY AND LOADING, PREVIOUS MESSAGE CHANNEL SUCCESS, ETC.
808
MESSAGE TRANSMISSION CHANNEL = CONTROL CHANNEL ?
NO
YES
810
SEND MESSAGE ON CONTROL CHANNEL
812
ON CONTROL CHANNEL, SEND PAGER ADDRESS, AND VECTOR IDENTIFYING MESSAGE CHANNEL AND TIME OF MESSAGE TRANSMISSION
814
SEND DATA TO MESSAGE CHANNEL SYSTEM FOR TRANSMISSION TO PAGER AT SPECIFIED TIME
816
WAIT FOR PAGER'S RETURN TO CONTROL CHANNEL
818
RECEIVE PAGER STATUS REPORT
NACK
ACK
820
END
800

FIG. 8

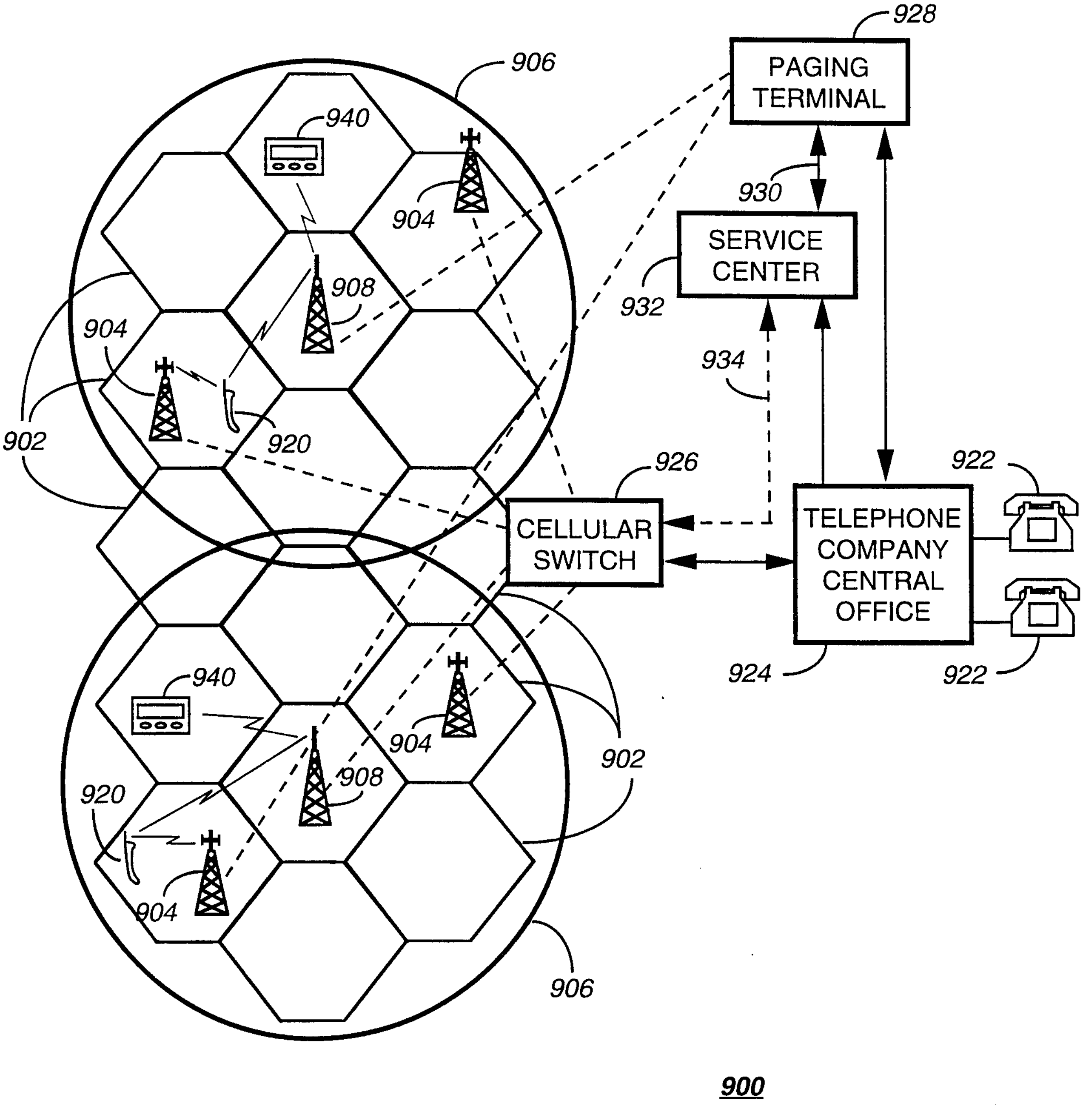

928
PAGING TERMINAL
906
940
904
930
SERVICE CENTER
908
932
904
934
902
920
926
922
CELLULAR SWITCH
TELEPHONE COMPANY CENTRAL OFFICE
940
924
922
904
902
908
920
904
906
900

FIG. 9

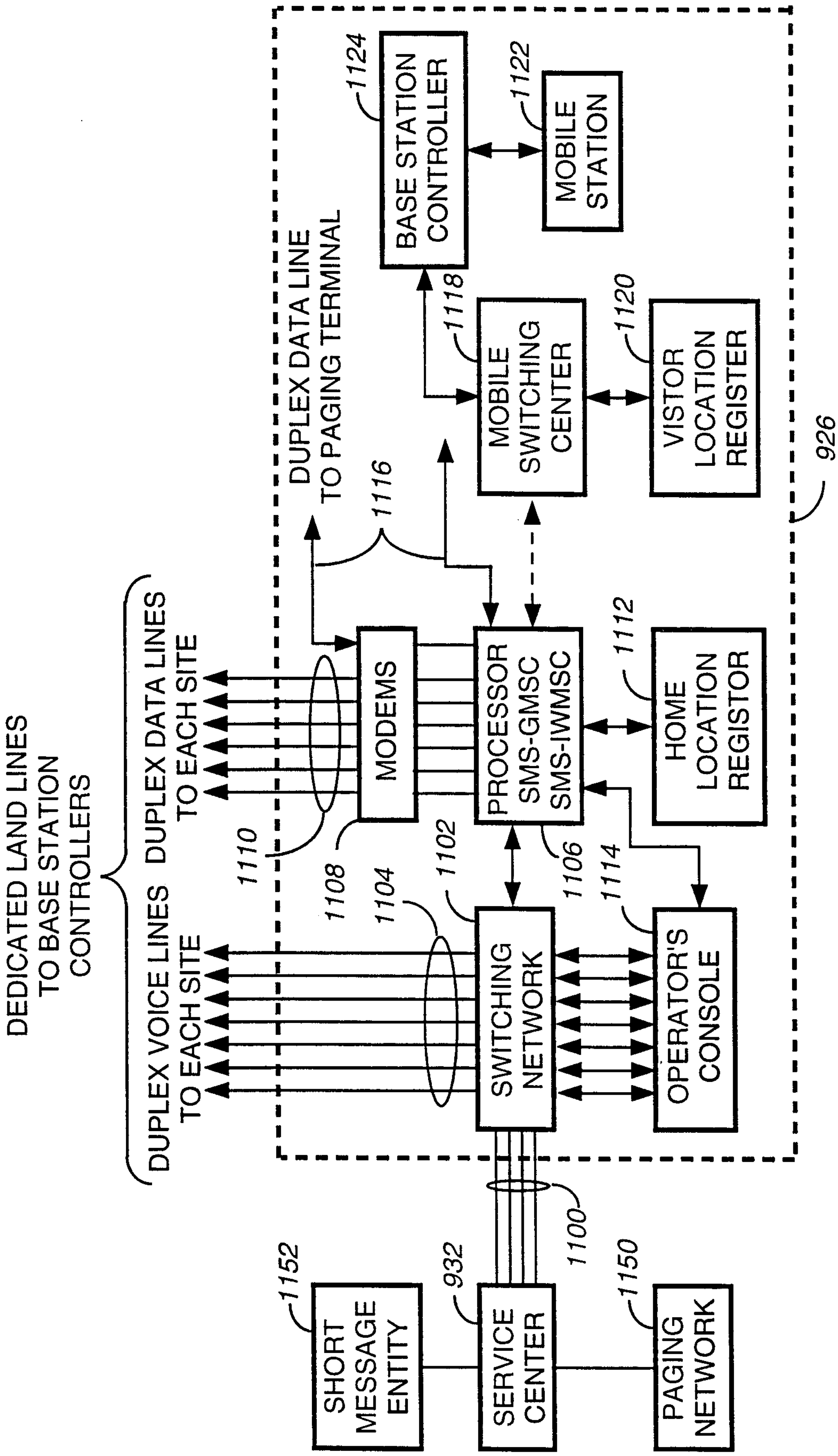

DEDICATED LAND LINES TO BASE STATION CONTROLLERS
DUPLEX VOICE LINES TO EACH SITE
DUPLEX DATA LINES TO EACH SITE
DUPLEX DATA LINE TO PAGING TERMINAL
BASE STATION CONTROLLER
1124
MOBILE STATION
1122
MOBILE SWITCHING CENTER
1118
VISTOR LOCATION REGISTER
1120
1116
926
MODEMS
1108
1110
PROCESSOR SMS-GMSC SMS-IWMSC
1106
HOME LOCATION REGISTOR
1112
SWITCHING NETWORK
1102
1104
OPERATOR'S CONSOLE
1114
1100
SHORT MESSAGE ENTITY
1152
SERVICE CENTER
932
PAGING NETWORK
1150

FIG. 10

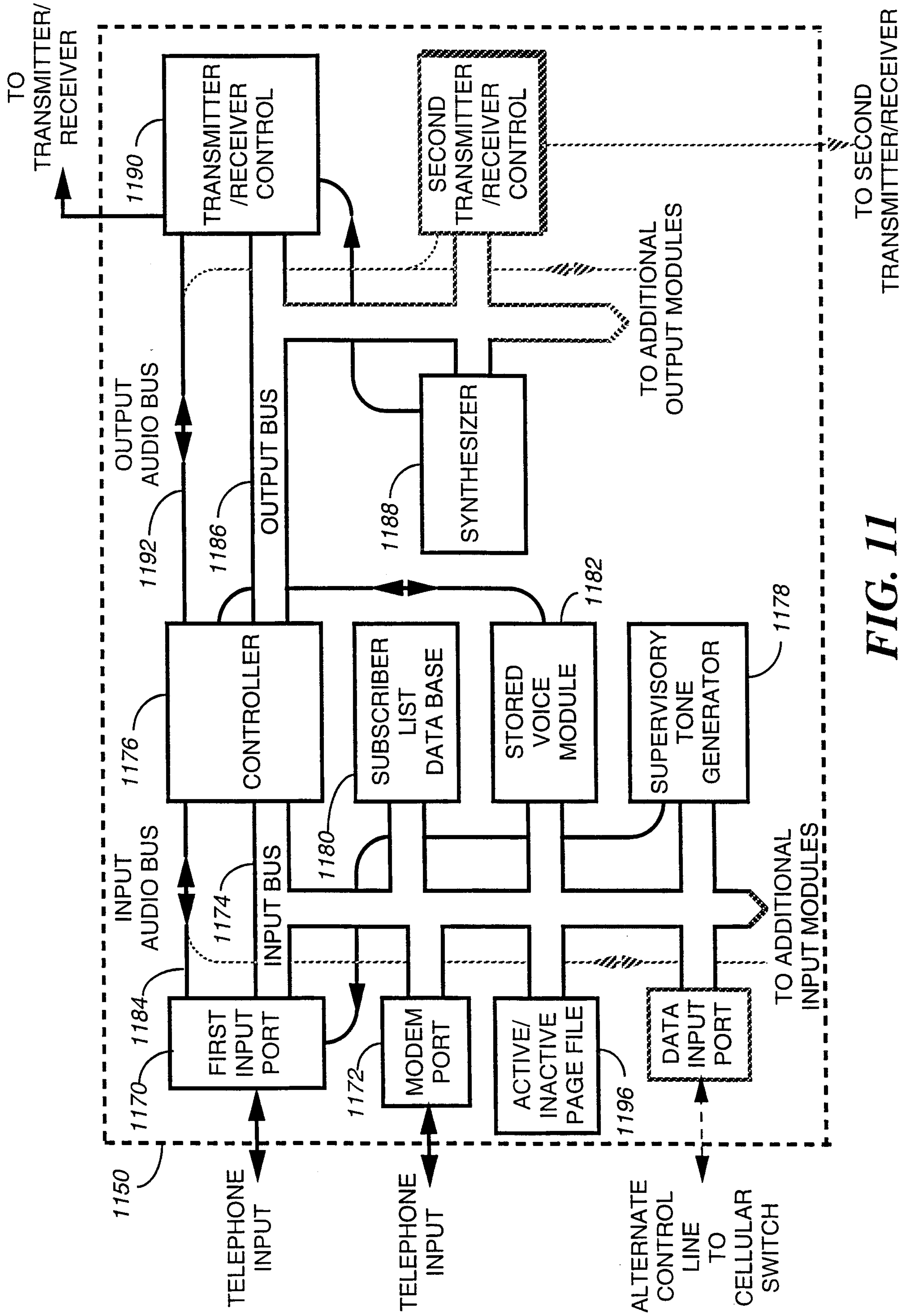

TO TRANSMITTER/ RECEIVER
TRANSMITTER /RECEIVER CONTROL
1190
SECOND TRANSMITTER /RECEIVER CONTROL
TO SECOND TRANSMITTER/RECEIVER
TO ADDITIONAL OUTPUT MODULES
OUTPUT AUDIO BUS
OUTPUT BUS
1192
1186
SYNTHESIZER
1188
CONTROLLER
1176
SUBSCRIBER LIST DATA BASE
1180
STORED VOICE MODULE
1182
SUPERVISORY TONE GENERATOR
1178
INPUT AUDIO BUS
INPUT BUS
1174
1184
FIRST INPUT PORT
1170
MODEM PORT
1172
ACTIVE/ INACTIVE PAGE FILE
1196
DATA INPUT PORT
TO ADDITIONAL INPUT MODULES
1150
TELEPHONE INPUT
TELEPHONE INPUT
ALTERNATE CONTROL LINE TO CELLULAR SWITCH

FIG. 11

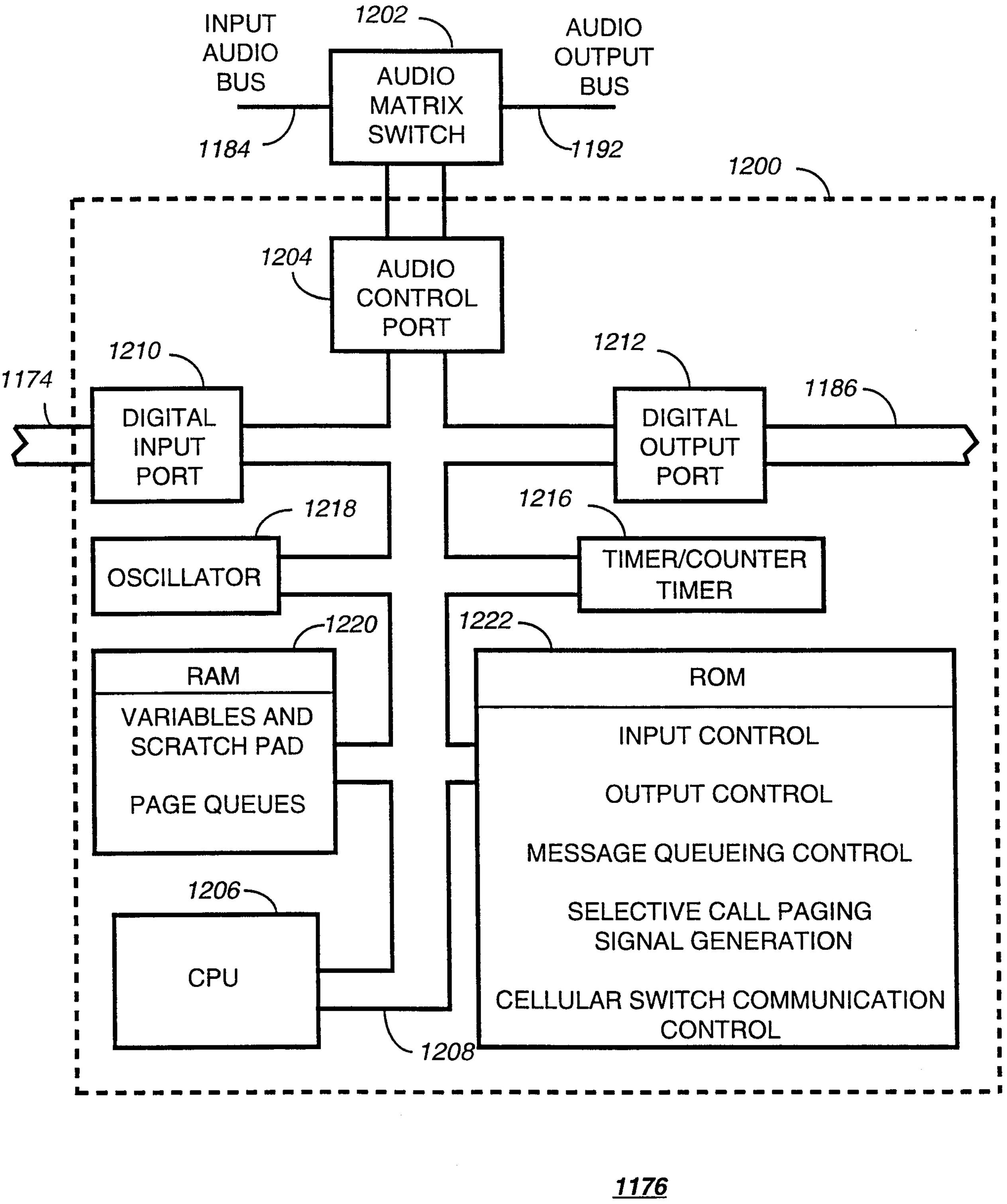
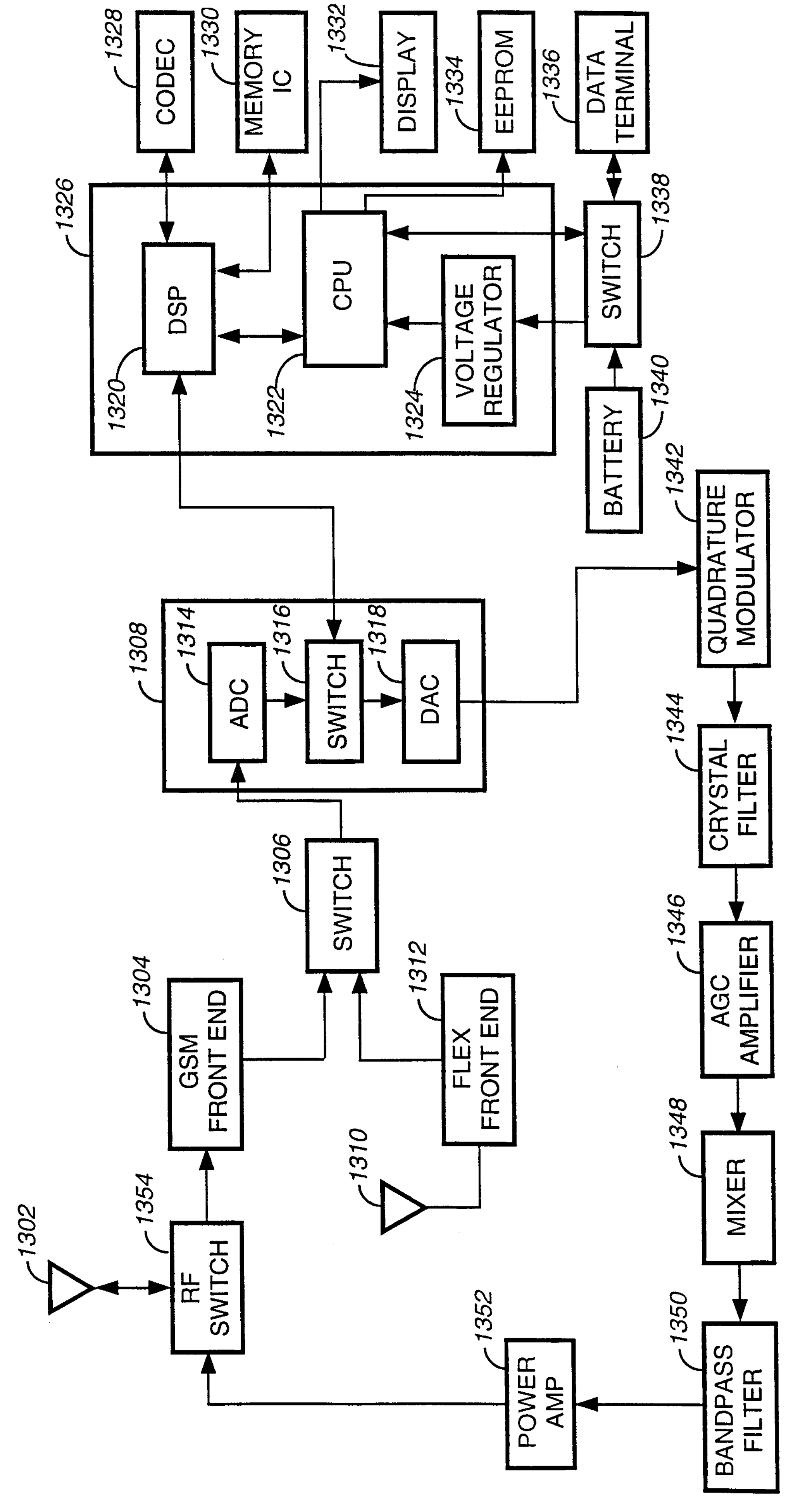

INPUT AUDIO BUS
1202
AUDIO MATRIX SWITCH
AUDIO OUTPUT BUS
1184
1192
1200
1204
AUDIO CONTROL PORT
1210
1212
1174
DIGITAL INPUT PORT
1186
DIGITAL OUTPUT PORT
1218
1216
OSCILLATOR
TIMER/COUNTER TIMER
1220
1222
RAM
VARIABLES AND SCRATCH PAD
PAGE QUEUES
ROM
INPUT CONTROL
OUTPUT CONTROL
MESSAGE QUEUEING CONTROL
SELECTIVE CALL PAGING SIGNAL GENERATION
1206
CPU
CELLULAR SWITCH COMMUNICATION CONTROL
1208
1176

FIG. 12


1328
CODEC
1330
MEMORY IC
1332
DISPLAY
1334
EEPROM
1336
DATA TERMINAL
1326
DSP
1320
CPU
1322
VOLTAGE REGULATOR
1324
SWITCH
1338
BATTERY
1340
1308
ADC
1314
SWITCH
1316
DAC
1318
QUADRATURE MODULATOR
1342
SWITCH
1306
CRYSTAL FILTER
1344
GSM FRONT END
1304
FLEX FRONT END
1312
AGC AMPLIFIER
1346
1310
1354
RF SWITCH
1302
MIXER
1348
POWER AMP
1352
BANDPASS FILTER
1350

920

FIG. 13

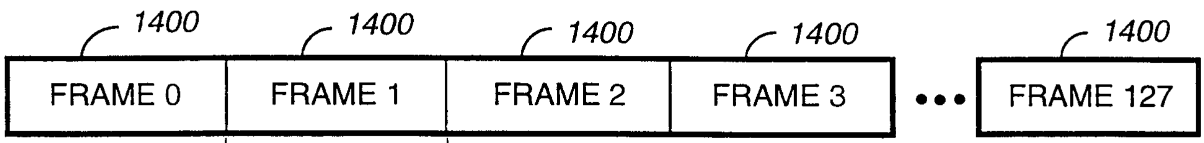


FIG. 14

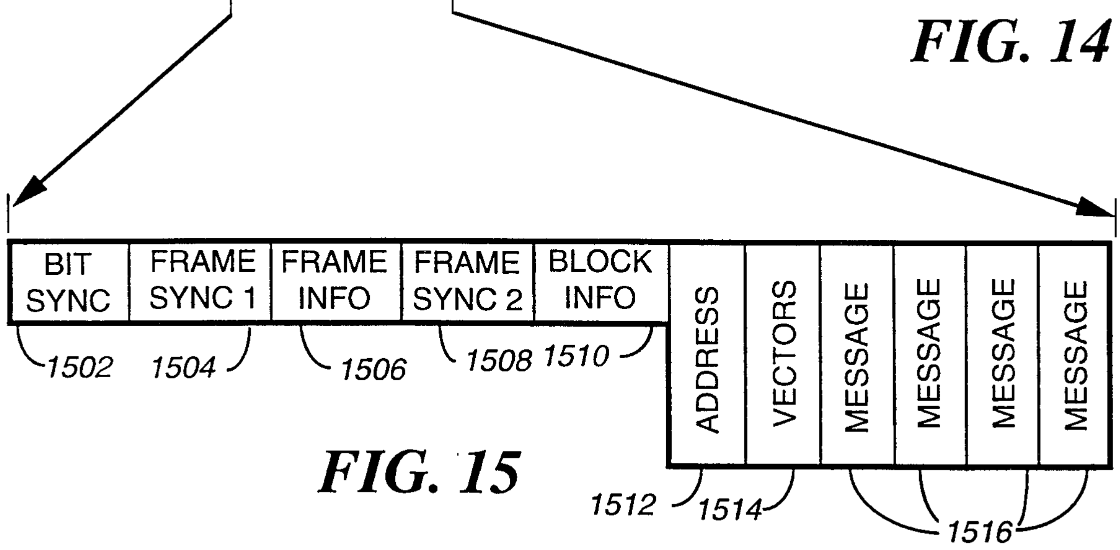


FIG. 15

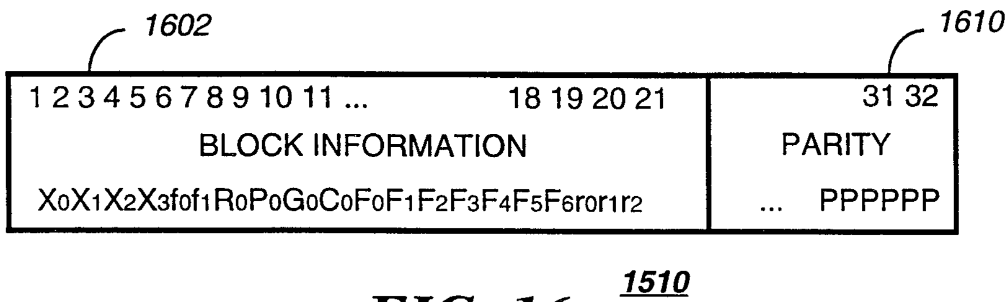


FIG. 16

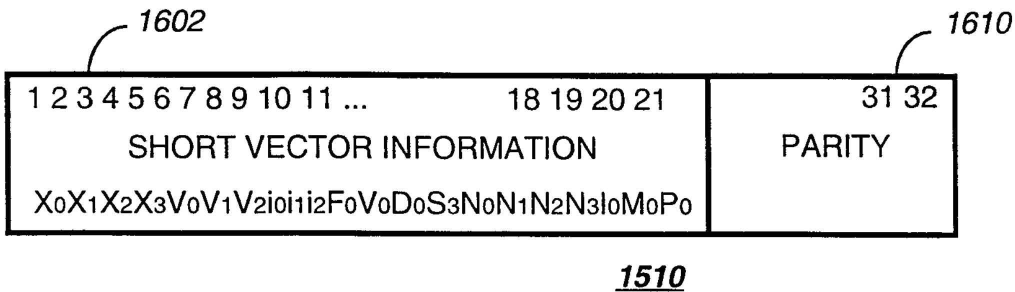


FIG. 17

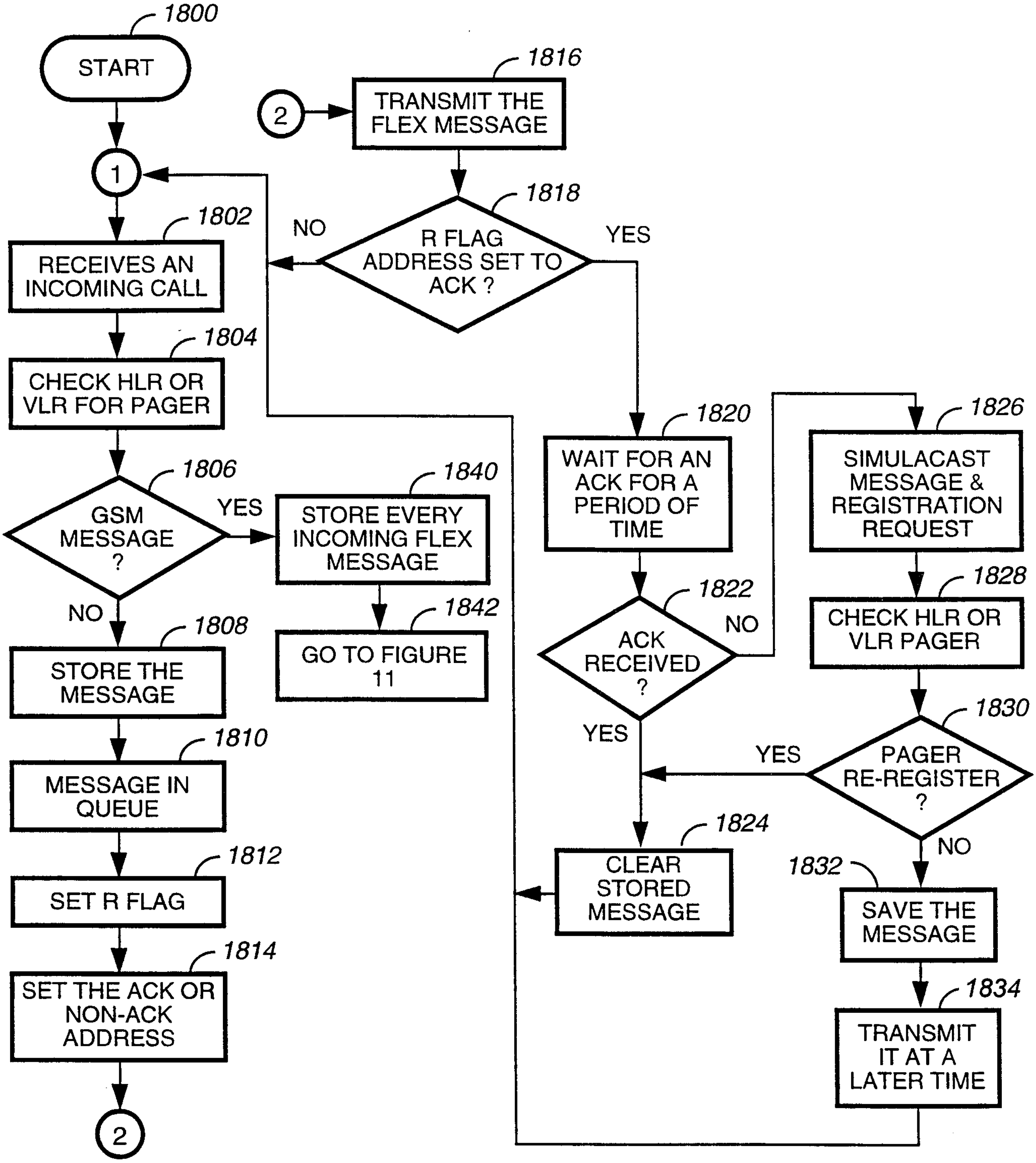

1800
START
1
1802
RECEIVES AN INCOMING CALL
1804
CHECK HLR OR VLR FOR PAGER
1806
GSM MESSAGE ?
YES
NO
1840
STORE EVERY INCOMING FLEX MESSAGE
1842
GO TO FIGURE 11
1808
STORE THE MESSAGE
1810
MESSAGE IN QUEUE
1812
SET R FLAG
1814
SET THE ACK OR NON-ACK ADDRESS
2
1816
TRANSMIT THE FLEX MESSAGE
1818
R FLAG ADDRESS SET TO ACK ?
NO
YES
1820
WAIT FOR AN ACK FOR A PERIOD OF TIME
1822
ACK RECEIVED ?
NO
YES
1824
CLEAR STORED MESSAGE
1826
SIMULACAST MESSAGE & REGISTRATION REQUEST
1828
CHECK HLR OR VLR PAGER
1830
PAGER RE-REGISTER ?
YES
NO
1832
SAVE THE MESSAGE
1834
TRANSMIT IT AT A LATER TIME

FIG. 18

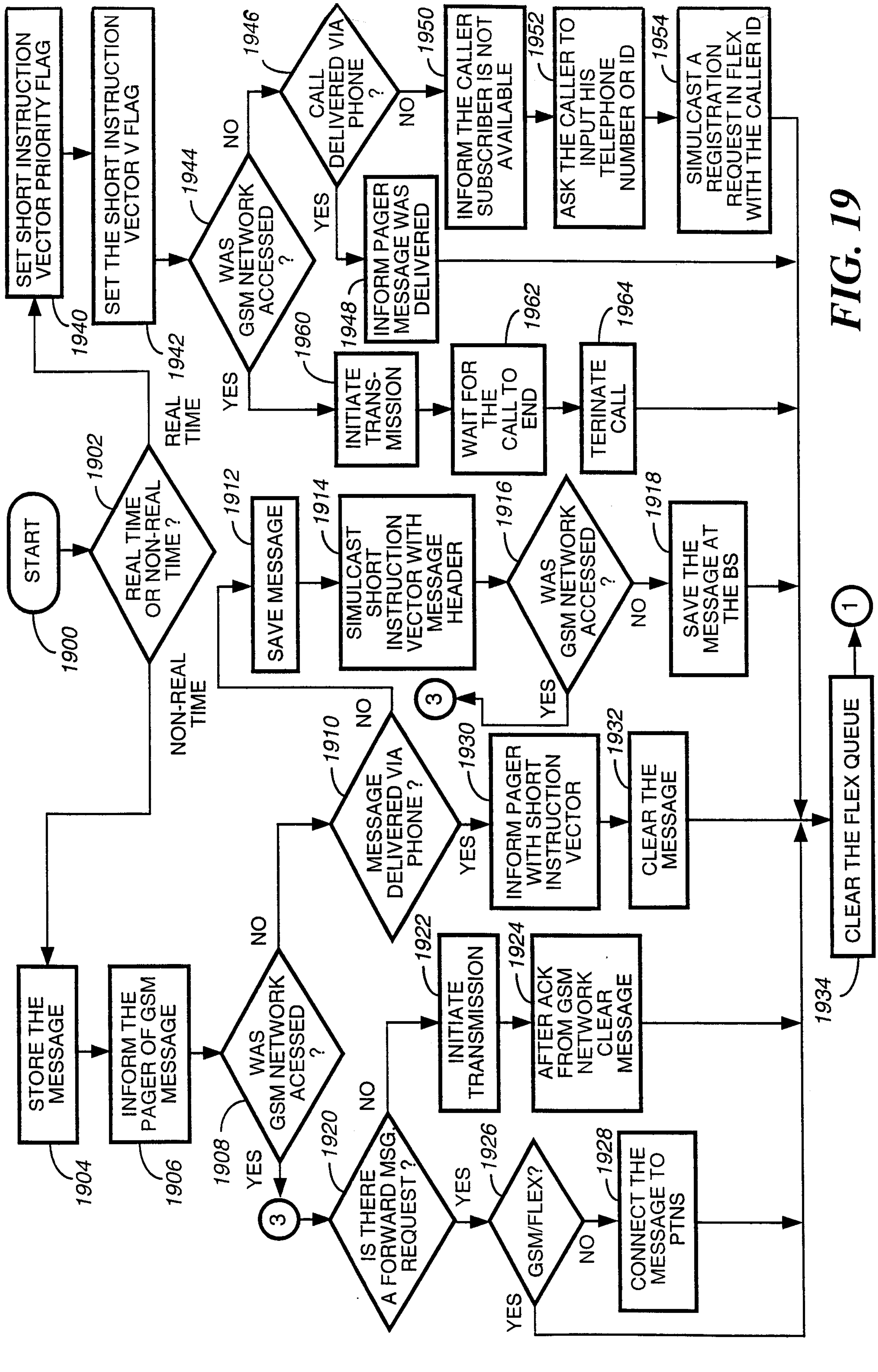

START
1900
REAL TIME OR NON-REAL TIME ?
1902
REAL TIME
NON-REAL TIME
SET SHORT INSTRUCTION VECTOR PRIORITY FLAG
1940
SET THE SHORT INSTRUCTION VECTOR V FLAG
1942
WAS GSM NETWORK ACCESSED ?
1944
YES
NO
CALL DELIVERED VIA PHONE ?
1946
YES
NO
INFORM PAGER MESSAGE WAS DELIVERED
1948
INFORM THE CALLER SUBSCRIBER IS NOT AVAILABLE
1950
ASK THE CALLER TO INPUT HIS TELEPHONE NUMBER OR ID
1952
SIMULCAST A REGISTRATION REQUEST IN FLEX WITH THE CALLER ID
1954
INITIATE TRANS-MISSION
1960
WAIT FOR THE CALL TO END
1962
TERINATE CALL
1964
SAVE MESSAGE
1912
SIMULCAST SHORT INSTRUCTION VECTOR WITH MESSAGE HEADER
1914
WAS GSM NETWORK ACCESSED ?
1916
NO
YES
SAVE THE MESSAGE AT THE BS
1918
3
STORE THE MESSAGE
1904
INFORM THE PAGER OF GSM MESSAGE
1906
WAS GSM NETWORK ACESSED ?
1908
YES
NO
MESSAGE DELIVERED VIA PHONE ?
1910
YES
NO
INFORM PAGER WITH SHORT INSTRUCTION VECTOR
1930
CLEAR THE MESSAGE
1932
3
IS THERE A FORWARD MSG REQUEST ?
1920
YES
NO
INITIATE TRANSMISSION
1922
AFTER ACK FROM GSM NETWORK CLEAR MESSAGE
1924
GSM/FLEX?
1926
YES
NO
CONNECT THE MESSAGE TO PTNS
1928
CLEAR THE FLEX QUEUE
1934
1

FIG. 19

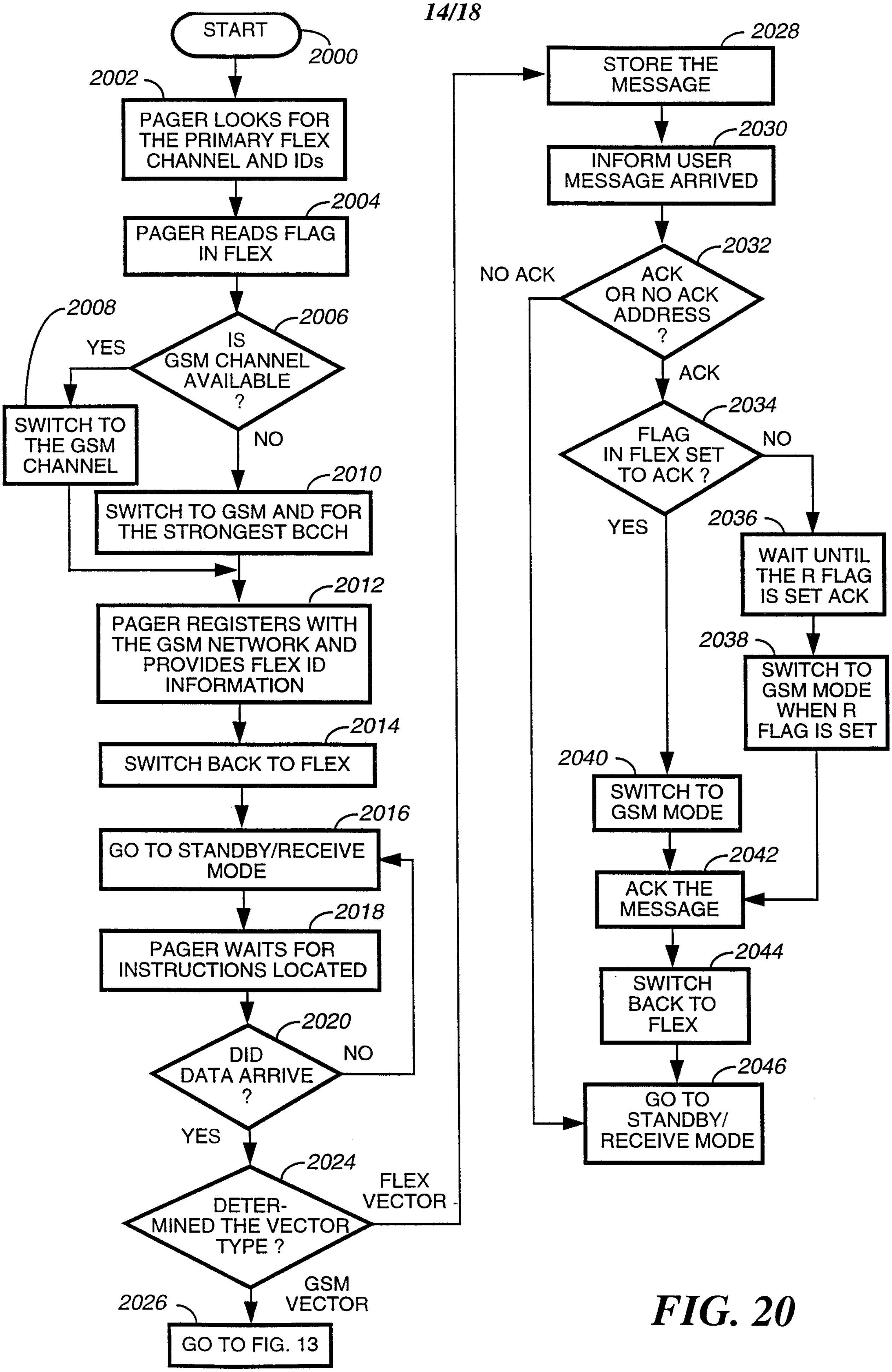
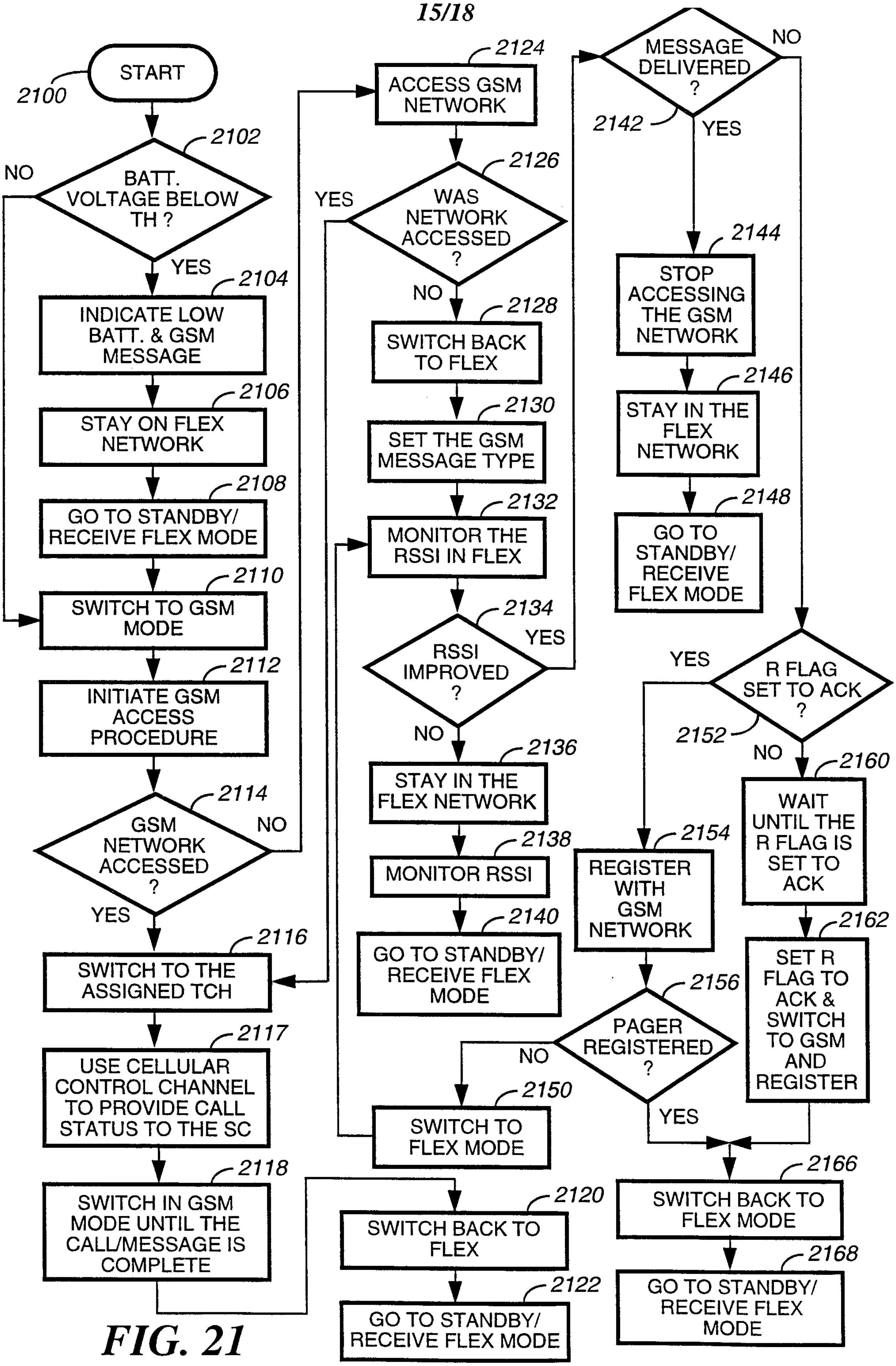

START
2000
2002
PAGER LOOKS FOR THE PRIMARY FLEX CHANNEL AND IDs
2004
PAGER READS FLAG IN FLEX
2006
IS GSM CHANNEL AVAILABLE ?
YES
NO
2008
SWITCH TO THE GSM CHANNEL
2010
SWITCH TO GSM AND FOR THE STRONGEST BCCH
2012
PAGER REGISTERS WITH THE GSM NETWORK AND PROVIDES FLEX ID INFORMATION
2014
SWITCH BACK TO FLEX
2016
GO TO STANDBY/RECEIVE MODE
2018
PAGER WAITS FOR INSTRUCTIONS LOCATED
2020
DID DATA ARRIVE ?
NO
YES
2024
DETER-MINED THE VECTOR TYPE ?
FLEX VECTOR
GSM VECTOR
2026
GO TO FIG. 13
2028
STORE THE MESSAGE
2030
INFORM USER MESSAGE ARRIVED
2032
ACK OR NO ACK ADDRESS ?
NO ACK
ACK
2034
FLAG IN FLEX SET TO ACK ?
NO
YES
2036
WAIT UNTIL THE R FLAG IS SET ACK
2038
SWITCH TO GSM MODE WHEN R FLAG IS SET
2040
SWITCH TO GSM MODE
2042
ACK THE MESSAGE
2044
SWITCH BACK TO FLEX
2046
GO TO STANDBY/ RECEIVE MODE

FIG. 20



START
2100
2102
BATT. VOLTAGE BELOW TH ?
NO
YES
2104
INDICATE LOW BATT. & GSM MESSAGE
2106
STAY ON FLEX NETWORK
2108
GO TO STANDBY/ RECEIVE FLEX MODE
2110
SWITCH TO GSM MODE
2112
INITIATE GSM ACCESS PROCEDURE
2114
GSM NETWORK ACCESSED ?
NO
YES
2116
SWITCH TO THE ASSIGNED TCH
2117
USE CELLULAR CONTROL CHANNEL TO PROVIDE CALL STATUS TO THE SC
2118
SWITCH IN GSM MODE UNTIL THE CALL/MESSAGE IS COMPLETE
2124
ACCESS GSM NETWORK
2126
WAS NETWORK ACCESSED ?
YES
NO
2128
SWITCH BACK TO FLEX
2130
SET THE GSM MESSAGE TYPE
2132
MONITOR THE RSSI IN FLEX
2134
RSSI IMPROVED ?
YES
NO
2136
STAY IN THE FLEX NETWORK
2138
MONITOR RSSI
2140
GO TO STANDBY/ RECEIVE FLEX MODE
2150
SWITCH TO FLEX MODE
2120
SWITCH BACK TO FLEX
2122
GO TO STANDBY/ RECEIVE FLEX MODE
MESSAGE DELIVERED ?
NO
2142
YES
2144
STOP ACCESSING THE GSM NETWORK
2146
STAY IN THE FLEX NETWORK
2148
GO TO STANDBY/ RECEIVE FLEX MODE
R FLAG SET TO ACK ?
YES
2152
NO
2154
REGISTER WITH GSM NETWORK
2156
PAGER REGISTERED ?
NO
YES
2160
WAIT UNTIL THE R FLAG IS SET TO ACK
2162
SET R FLAG TO ACK & SWITCH TO GSM AND REGISTER
2166
SWITCH BACK TO FLEX MODE
2168
GO TO STANDBY/ RECEIVE FLEX MODE

FIG. 21

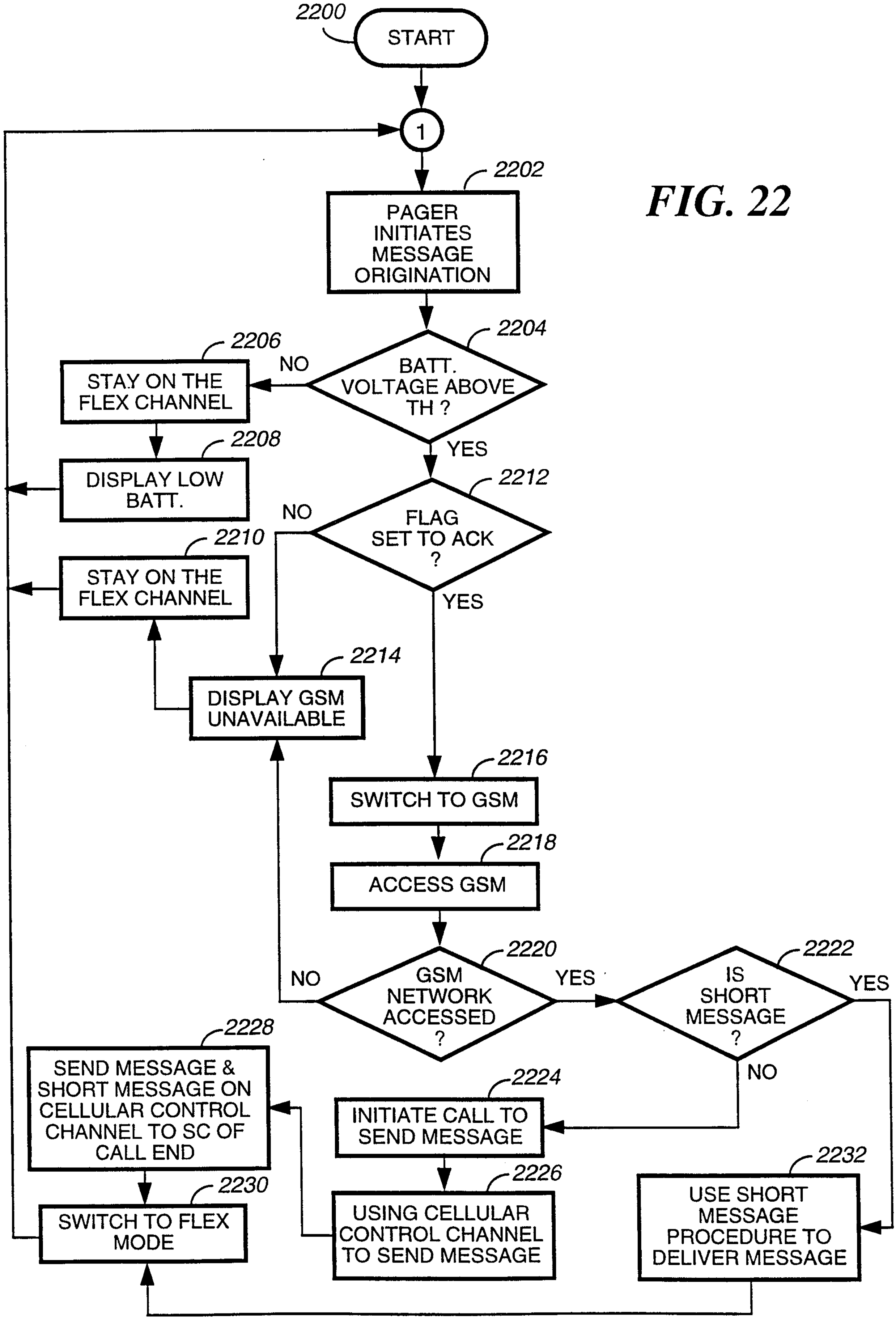

2200
START
1
2202
PAGER INITIATES MESSAGE ORIGINATION
2204
BATT. VOLTAGE ABOVE TH ?
NO
YES
2206
STAY ON THE FLEX CHANNEL
2208
DISPLAY LOW BATT.
2212
FLAG SET TO ACK ?
NO
YES
2210
STAY ON THE FLEX CHANNEL
2214
DISPLAY GSM UNAVAILABLE
2216
SWITCH TO GSM
2218
ACCESS GSM
2220
GSM NETWORK ACCESSED ?
NO
YES
2222
IS SHORT MESSAGE ?
YES
NO
2228
SEND MESSAGE & SHORT MESSAGE ON CELLULAR CONTROL CHANNEL TO SC OF CALL END
2224
INITIATE CALL TO SEND MESSAGE
2232
USE SHORT MESSAGE PROCEDURE TO DELIVER MESSAGE
2230
SWITCH TO FLEX MODE
2226
USING CELLULAR CONTROL CHANNEL TO SEND MESSAGE

FIG. 22

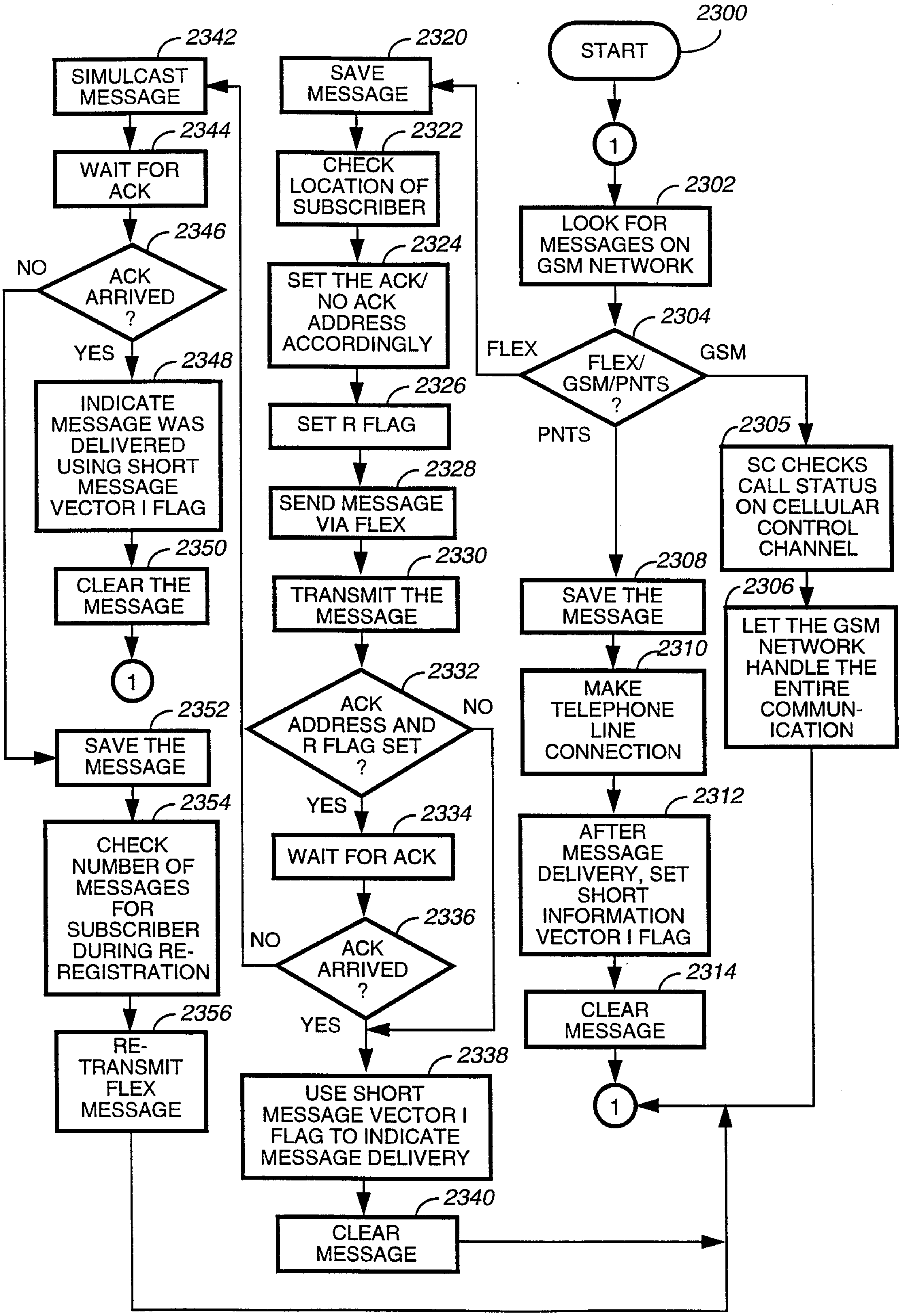

2300
START
1
2302
LOOK FOR MESSAGES ON GSM NETWORK
2304
FLEX/ GSM/PNTS ?
FLEX
GSM
PNTS
2305
SC CHECKS CALL STATUS ON CELLULAR CONTROL CHANNEL
2306
LET THE GSM NETWORK HANDLE THE ENTIRE COMMUN-ICATION
2308
SAVE THE MESSAGE
2310
MAKE TELEPHONE LINE CONNECTION
2312
AFTER MESSAGE DELIVERY, SET SHORT INFORMATION VECTOR I FLAG
2314
CLEAR MESSAGE
1
2320
SAVE MESSAGE
2322
CHECK LOCATION OF SUBSCRIBER
2324
SET THE ACK/ NO ACK ADDRESS ACCORDINGLY
2326
SET R FLAG
2328
SEND MESSAGE VIA FLEX
2330
TRANSMIT THE MESSAGE
2332
ACK ADDRESS AND R FLAG SET ?
NO
YES
2334
WAIT FOR ACK
2336
ACK ARRIVED ?
NO
YES
2338
USE SHORT MESSAGE VECTOR I FLAG TO INDICATE MESSAGE DELIVERY
2340
CLEAR MESSAGE
2342
SIMULCAST MESSAGE
2344
WAIT FOR ACK
2346
ACK ARRIVED ?
NO
YES
2348
INDICATE MESSAGE WAS DELIVERED USING SHORT MESSAGE VECTOR I FLAG
2350
CLEAR THE MESSAGE
1
2352
SAVE THE MESSAGE
2354
CHECK NUMBER OF MESSAGES FOR SUBSCRIBER DURING RE-REGISTRATION
2356
RE-TRANSMIT FLEX MESSAGE

FIG. 23

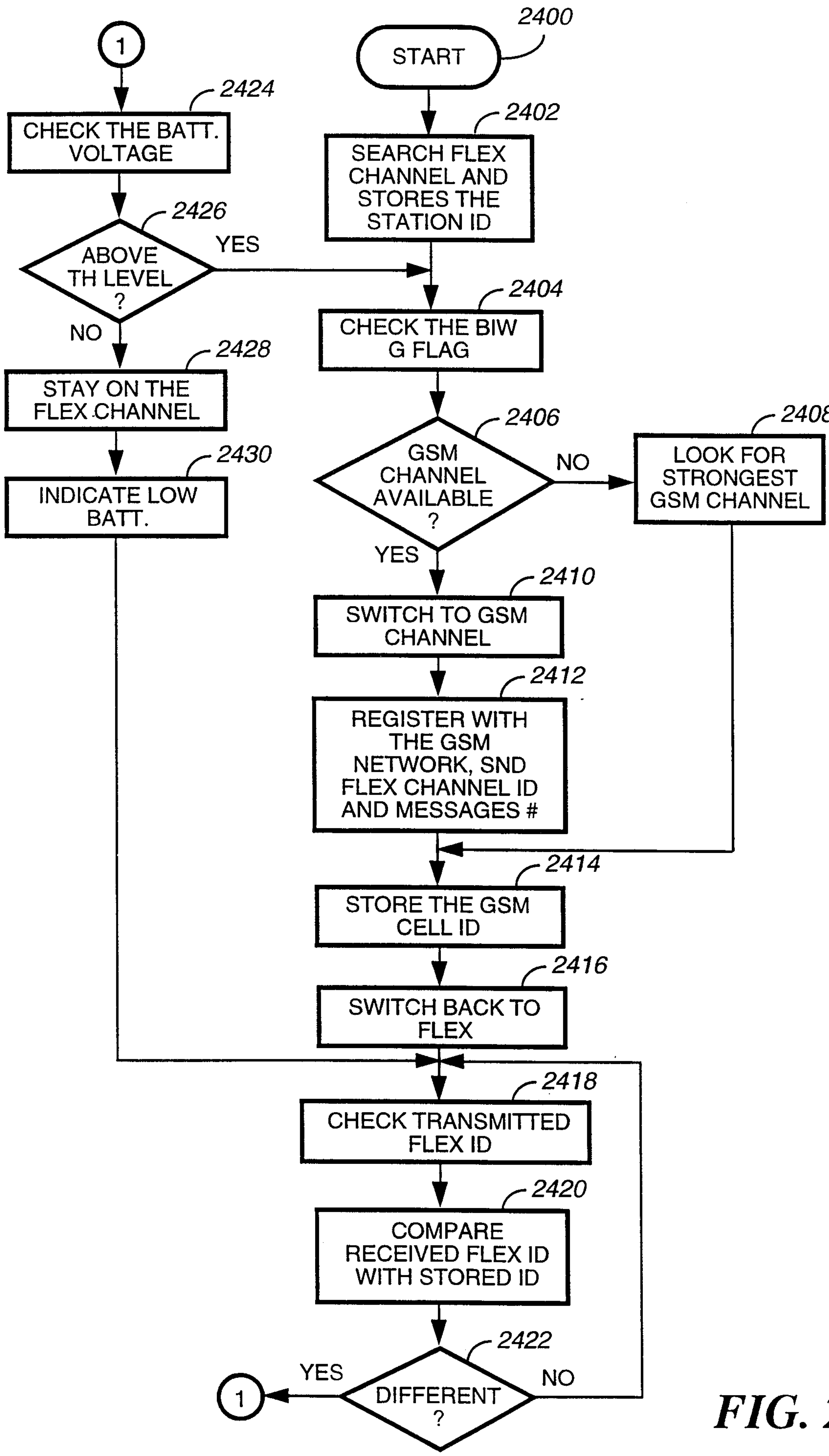

2400
START
2402
SEARCH FLEX CHANNEL AND STORES THE STATION ID
2404
CHECK THE BIW G FLAG
2406
GSM CHANNEL AVAILABLE ?
NO
2408
LOOK FOR STRONGEST GSM CHANNEL
YES
2410
SWITCH TO GSM CHANNEL
2412
REGISTER WITH THE GSM NETWORK, SND FLEX CHANNEL ID AND MESSAGES #
2414
STORE THE GSM CELL ID
2416
SWITCH BACK TO FLEX
2418
CHECK TRANSMITTED FLEX ID
2420
COMPARE RECEIVED FLEX ID WITH STORED ID
2422
DIFFERENT ?
YES
NO
1
2424
CHECK THE BATT. VOLTAGE
2426
ABOVE TH LEVEL ?
YES
NO
2428
STAY ON THE FLEX CHANNEL
2430
INDICATE LOW BATT.

FIG. 24

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02763

A. CLASSIFICATION OF SUBJECT MATTER
IPC(6) :H04Q 7/20
US CL :455/426, 445, 552; 340/825.44
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 455/426, 435, 445, 458, 466, 507, 509, 552, 553, 556, 557, 560, 31.3, 38.1; 340/825.44; 370/465, 466

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,153,903 A (EASTMOND et al) 06 October 1992, see fig. 1.	1-13
A	US 5,392,452 A (DAVIS) 21 February 1995, col. 3, line 3 through col. 4, line 21.	1-13
A	US 5,706,331 A (WANG et al) 06 January 1998, see fig. 2.	1-13

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 MARCH 1999	23 APR 1999

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