

PLU 36 has associated therewith a location receiver 60, paging receiver 62 and a transmitter 64. The PLU 36 is illustrated as having a separate antenna 66 associated with a location receiver 60, an antenna 68 associated with a paging receiver 62 and an antenna 70 associated with the transmitter 64. In actuality, the antennas 66-70 are a single antenna, as will be described hereinbelow. However, for illustrative purposes, they are depicted as separate antennas.

A request transmitter 72 is provided at a remotely disposed location from the PLU 36 for transmitting a request from a transmitting antenna 74 to the antenna 66 associated with the location receiver 60. This request is interpreted by the PLU 36 as requesting transmission of ID information and location information. As described above, the location information is in the form of the location ID of the strongest one of the sticks, which ID was previously received and stored. In addition, the PLU 36 has a paging receiver 62 that is operable to receive paging messages from one of a plurality of sticks 78, 80, 82 or 84, which transmit the paging information therefrom on antennas 86, 88, 90 and 92, respectively.

In the preferred embodiment, the request transmitter 72 is identical to the paging transmitter in the sticks 78-84, such that the antenna 74 is common with antennas 86-92. Additionally, the request is essentially a message that is transmitted in the conventional paging system, which message has data associated therewith that is interpreted by the PLU 36 as a request for an ID. Once a request has been received, the transmitter 64 of the PLU 36 transmits stored the location ID out to a receiving antenna 94 on a PLU receiver (PLUR) 96 in association with the unique ID of the PLU 36. PLUR 96 is connected to a PLU processor 98, which also controls the request transmitter 72. The PLU processor 98 is operable to receive the information from the PLU 36 and process this information. As described above, this information can merely be the stored location ID of the stick having the strongest signal received by the PLU 36 during transmission of location ID from the sticks 78-84. Alternately, the PLU processor 98 could receive multiple inputs from multiple PLURs 96, which have placed a time stamp on the received message from the transmitter 64. This time stamp is utilized to make a TDA estimation, and, knowing the location of the PLURs from which the information was received, determine with relative accuracy the location of the PLU 36 at the time of transmission therefrom. Of course, this is a function of the time base that exists at each of the PLURs 96 and at the PLU processor 98.

With the location portion of the present invention, it is important to note that the first method of location utilizes the location ID of the one of the sticks 78-84 having the strongest signal at the time of transmission of the location ID. This provides not only the ability to determine the location of a PLU 36 knowing the location of the stick, but it also determines the location of the PLU 36 as a function of its power reception capability. This is important as one aspect of the present invention is directed toward locating the PLU 36 for the purposes of transmitting messages thereto. The actual spatial location of a PLU 36 for this purpose is insignificant. Rather, it is important to know which of the sticks 78-84 has the transmitted signal therefrom received with the highest signal strength by the PLU 36. Although the location of the stick is known, the actual transmission characteristics are not exactly known and, in fact, the spatial location is of no use in determining from which stick 78-84 information should be transmitted to be received at the PLU 36. Since the PLU 36 will capture the strongest signal from only one stick, it is that stick that

should have a later message transmitted therefrom in order for the PLU 36 to receive it from only that stick. Conventional paging systems transmit information from all of the antennas 86-92, as they do not know which signal the PLU 36 will receive. This significantly decreases throughput. Rather, if it could be determined clearly that a given PLU 36 is associated with a given stick, then it is only necessary to transmit information from the selected stick during a given time slot to the desired PLU 36. The remaining sticks can transmit different messages to different PLUs. Therefore, it is important to have present in the system database location information for the PLU 36 in the form of which stick in the system will transmit the strongest signal to the PLU 36 for a later paging message, i.e., which one will it "capture". It is not of interest for this application whether the PLU 36 is located to the north or to the south of the stick but, rather, only that the PLU 36 will capture the signal from that stick as the strongest signal.

Since the integrity of the location measurement is a function of time relative to the time at which the location ID was determined, it is necessary to coordinate requests for location information from the transmitter 72 with the actual time at which the location ID was transmitted. The time that the location ID is transmitted is known in a system. Typically, this is transmitted as infrequently as possible, as it will reduce throughput. However, once it is transmitted, transmission requests can then be transmitted immediately thereafter, it being known that a certain time has elapsed before the requested PLUs 36 transmit back a response. For example, if it were desired to determine the location of five paging transmitters (64), the next five messages following the transmission of the location ID would be requests for these five PLUs to transmit back their location information. PLUR processor 98 would therefore expect to receive five sequential messages back from the five PLUs 36 in a predetermined time slot. The time lag would be known, and it would be on the order of a few seconds.

In one application for the present invention, a large number of PLUs 36 can have a location thereof determined for the purpose of increasing throughput for subsequent transmission of data. If, for example, one hundred PLUs 36 were located by the system of the present invention, this could be followed by transmission of messages to all of the sticks in a parallel manner. If it were determined, for example, that all one hundred PLUs 36 were equally divided among four sticks, twenty-five to each, then twenty-five messages could be transmitted to each stick in a sequential and parallel manner to cover all one hundred PLUs 36 such that the throughput is increased by a factor of four for the transmission of those messages.

In another aspect of the present invention, the PLU 36 is operable to compare a received location ID with its stored ID that was previously determined or which is stored in a look-up table that was previously programmed indicating the area in which the paging system expected the PLU 36 to reside. If the received location ID from any one of the sticks in the vicinity of the PLU 36 did not compare with those internally stored, this would indicate that the PLU 36 was outside of its designated location, i.e., the system did not know its location. Under these circumstances, the paging system would not transmit messages designated for that PLU 36 to the sticks in the proximity thereof. Once the PLU 36 recognizes that the ID does not compare with the internally stored IDs, the PLU 36 initiates a transmission of the location ID back to the PLUR receiver 96. This would then be processed by the PLUR processor 98 and forwarded back to a paging terminal such that when message data was encoded, it would be routed to the appropriate hub or stick.

In one application of the above system, a PLU 36 could be associated with a given hub which consisted of two cities. When the individual travels to a different hub, as soon as it came within range of the paging transmitter from one of the sticks in the new hub and at a time that a location ID was transmitted, the PLU 36 would then update the system as to its location. Of course, an acknowledgement would be required in that there may be some contention, as the PLU 36 would transmit its ID with no request. In this mode, it might transmit over another transmit from another PLU 36 in its area. The PLU 36 transmitting its ID information would therefore wait for an acknowledgement message from the system indicating that the location was now in the data base. If the acknowledgement is not received, the PLU 36 retries transmission of the message with the location ID until the system recognizes its location and acknowledges. If the acknowledgement is not received after a predetermined number of tries it sends a message to the use via display or acoustical means.

Referring now to FIG. 4, there is illustrated a block diagram of a base station at one of the sticks and its associated PLUR 96. Each of the sticks has associated therewith a base station 100 that in general includes a satellite receiver for receiving information on a satellite receiving antenna 102. The base station has associated therewith a paging antenna 104 that is similar to the antennas 86, 88, 90 and 92 on the sticks 78-94. Additionally, the request information is transmitted out through the antenna 104 to the PLU 36.

The base station 100 and the PLUR 96 are both connected to a public data network (PDN) 106 through phone lines 110 which allow for transmission of digital data through the data network 106. Data network 106 includes a master clock signal (MCS) 112, which is normally generated by the telephone company, and maintained at a very accurate phase and frequency with minimal drift. This clock is utilized by the uplink 30 through a slave clock system (SCS) 114 and the base station 100 also locks up to this clock through an SCS 116. The Slave Clock (SCS) 116 may be linked to the MCS via a 56 k-bit line or through the data clock from the satellite receiver. The PLUR 96 also is locked with the SCS 116 to the MCS 112. This provides a very stable clock reference for all of the base stations 100 and the PLURs 96. Therefore, in the application whereby the PLUR time stamps a received signal, the time base for all of the PLURs is very stable and is referenced to a common clock in the MCS 112. Without this, some other type of stable clock system would be required. This will be described in more detail hereinbelow.

The PDN is interfaced with a number of hubs 118 at different locations. Each of the hubs 118 is locked up to the MCS 112 through an SCS 120. They are also interconnected to each other through the PDN 106 and also to the uplink 30 through the PDN 106. In addition, a remote trunk concentrator (RTC) 122 is provided that interfaces with the PDN 106 through a modem 124, this being a conventional part of a paging system. All of the hubs 118-120 and the RTC 122 interface with the analog portion of the telephone network, the public switch network (PSN) 126, which PSN 126 and PDN 106 are interconnected, as indicated by a dashed line 128.

Referring now to FIG. 5, there is illustrated a block diagram of a conventional hub and illustrating a spur. The hub in general is comprised of a paging terminal 130 which, in the preferred embodiment, is a Glenayre 3000 XL, manufactured by Glenayre Corporation. This is a fairly conventional paging terminal and is utilized by paging

systems. The hub is interconnected with the uplink systems through the PDN 106 via a primary 56-kilobit telephone line 132 and a secondary 56-kilobit telephone line 134. These lines are operable to connect to a multiplexer 136, which is input to both the paging terminal 130 through a base station controller 138 or directly through a TNPP line 140, which TNPP line provides for paging terminals to communicate with each other. The base station controller 138 is operable to assemble the data and implement the command and control functions for transmission out to the uplink system 114 and subsequently to the base station 100 through the satellite 28. The base station controller is an N1450, manufactured by Motorola. In addition, there are a number of dial-up lines which are received from the PSN through a modem 142 with alternate lines provided connected through a modem 144.

The lines from the PLUR 96 are received on telephone lines 146 through a modem 148 to a PLU receive processor 150, which is similar to the PLUR processor 98 of FIG. 3. The PLUR processor 150 basically processes the signals received from the PLURs 96 and then outputs location information to the paging terminal 132, and updates its internal database. As described above, each paging terminal generates data associated with its database and associated PLUs 36. If a new PLU 36 has come on line, the database can be updated, or if a mode is entered wherein specific sticks are to be transmitted with certain information, this information can be stored in the paging terminal 130.

A phase lock loop (PLL) 152 is provided for linking to the master clock signal which is on the 56-kilobit lines 132 and 134. This comprises the SCS 120. The PLL has a clock that is output to a clock distribution system (CDS) 154, which is utilized by the base station controller 138 and also by the paging terminal 130. The clock distribution is well-known, and is described, generally, in Masami Kihara, "Performance Aspects of Reference Clock Distribution for Evolving Digital Networks", IEEE Communications Magazine, April 1989, pp. 24-34. In addition, the RTC 122 provides the interface with the spur hubs through the telephone lines 158 and a modem 160. The spur interfaces with another modem 162 at the location of the hub for interface with the paging terminal 130.

Referring now to FIG. 6, there is illustrated a block diagram of the PLU 36. An internal antenna 166 provides for both reception and transmission at a frequency in the UHF range. The receive frequency is 929.6625 MHz and the transmit frequency is 921.0 Mhz. An isolator 168 is provided which has three ports. One port is connected to the antenna 166, one input connected to the transmit side of the PLU and one port connected to the receive side. The receive side of the isolator 168 is input to a bandpass filter 170, the output thereof input to a mixer 172. The mixer receives a 921 MHz clock signal from a frequency clock synthesizer 176, such that the output is down converted to a frequency of 8.6625 MHz. The output of mixer 172 is input to a band pass filter 174, which preconditions the filter for input to a conventional FM receiver chip 178, which basically demodulates and hard limits the signal. The output of the FM receiver chip 178 is input to a channel decoder and error detection and correction circuit 180 and also to a channel equalizer 182. The operation of the channel equalizer 182 is described in G. E. Prescott, et al, "Adaptive Estimation of Transmission Distortion in a Digital Communication Channel", Correspondence IEEE Transactional Communications, Vol. 36, No. 4, September 1988, pp. 1070-1073, and the FM receiver chip 178 is described in the Motorola Linear/Interface Integrated Circuits Data Book, DL12AREV2, p. 8-2. These are conventional chips.

The output of the channel decoder 180 is input to a POCSAG decoder 184. The POCSAG decoder is an OMIO33, POCSAG paging decoder device which is manufactured by Signetics, Part No. PCA 5000T. The output of the POCSAG decoder 184 is input to a CPU 186, which CPU also receives as an input the output of the channel decoder 180. The POCSAG data from the output of 184 comprises the message data received during conventional operation of the system. The output of the channel decoder 180 is all the information that is necessary for the CPU 186 to determine the location ID of the stick having the strongest signal during transmission of location IDs. The CPU 186 has associated therewith a display 188, a memory 190 and an input/output 192. The input/output 192 is in the form of a keyboard or input buttons.

The frequency synthesizer chip 176 is a conventional phase lock loop. It is comprised of a voltage controlled oscillator 196 that operates at 921 MHz. The output of the VCO 196 is divided down by a factor of sixty-four by a divide circuit 198 and input to a PLL control chip 200. A loop filter 202 is also provided, the loop filter interfacing with the PLL control chip 200. The PLL control chip 200 is a conventional control chip that has disposed thereon a phase detector and the various circuitry for interfacing and forming the loop filter 202.

The CPU 186 is operable to generate message data for transmission out through the antenna 166, the data being output on a line 204. The data on line 204 is input to the PLL control chip 200 to modulate data and output it on a line 208 for input to a mixer 210. The Local Oscillator input of the mixer 210 is connected to the output of the VCO 196. The output of the mixer 210 is filtered with a filter 212 and then input to a power amplifier 214 for input to the transmit side of the isolator 168.

Referring now to FIG. 7, there is illustrated a block diagram of a system for increasing the power level transmitted by the PLU 36. Since the PLU 36 is operated on a battery, it is necessary to minimize the amount of power transmitted thereby. Therefore, the power level is relatively low. When the PLU 36 is disposed on a person or a moving object that is within the confines of a building, the power level from the PLU 36 may be too low to reach the PLUR 96 and its associated antenna 94, disposed on one of the proximate sticks. Therefore, a building could be equipped with power transmitting units (PTU) 220, which has a receiving antenna 222 and a transmitting antenna 224. The information transmitted by the PLU 36 is received by the PTU 220 on its receiving antenna 222, buffered, and then transmitted out at a later time (preferably one frame) through the transmitting antenna 224 to the PLUR 96 at a higher power level and at the same frequency. This higher power level is sufficient to penetrate the walls of the building. The PTU 220 is powered from an AC outlet and, alternately, the PTU 220 can operate as a PLUR and interface with the PDN through a modem 226.

Referring now to FIG. 8, there is illustrated a cross-sectional view of building 228, illustrating a PTU 220 and a PLU 36. The PLU 36 is disposed within the building 228 and is operable to transmit information to the PTU 220. A stick 230 is disposed proximate to the building 228, having a PLUR antenna 94 associated therewith and a paging antenna 232 associated therewith. In addition, a satellite receiver antenna 234 is associated with the stick 230. Due to the attenuation provided by the walls of the building 228, the PLU 36 cannot transmit from within the building to the PLUR antenna 94. Additionally, the signal strength from the paging antenna 232 is insufficient to reliably penetrate the

walls of the building. The PLU 36 can neither transmit information out nor receive information within the building. Therefore, the building itself is made into a cell or a separate "stick" by disposing a base station 236 and associated satellite receiver antenna 238 on the roof thereof to communicate with the satellite 28. The paging antenna is formed by a leaky coax 240 in the building. The leaky coax is operable to emit radiation at relatively low power, but sufficient to encompass all areas within the walls of the building 228. Therefore, the entire building would be considered a stick in and of itself and would have its own location ID. Therefore, if the paging terminal 36 were transmitting location ID information, it would indicate that it was in a particular building, as this would be the strongest signal received by the PLU 36.

Referring now to FIG. 9, there is illustrated a flowchart for the operation of the PLU 36. The flowchart is initiated at a start block 244 and the system goes to a decision block 246 to determine if the preamble has been received. If not, the program flows back around the "N" path to the input until the preamble is received. When the preamble is received, the program flows along a "Y" path to a decision block 250 to achieve POCSAG sync. The program flows along an "N" path back to the input thereof until sync is achieved, at which time it flows along a "Y" path to the input of a decision block 252 to determine if the address has been received. The program flows along the "N" path to the input of the idle address decision block 248 until the address has been received, at which time it flows along a "Y" path from decision block 252 to a decode data block 256 to decode the data. The decision blocks 250, 248 and 252 and block 256 represent the POCSAG decoder chip.

If the idle address has not been received, the program flows along an "N" path back to the input of decision block 250. When the idle address has been received, the program flows along a "Y" path from decision block 290 to a decision block 291 to determine if the call sign codeword data command (stating that the call sign will follow) has been received. If not, the program returns to input of decision block 250 and, if so, the program flows to decision block 293 to determine the ID sequence. The program then flows to program "A".

After the data has been decoded, the program flows to a decision block 258 to determine if the data is a request. If it is a request, the program flows along a "Y" path to a function block 260 to transmit the stored stick ID to the PLUR 96 in association with the ID of the PLU 36. This is coded and transmitted out through the transmitter. The program then flows to an End block 262. If a request was not received, this indicates a standard message and the program would flow from the decision block 258 along a "N" path to a function block 264 to process the message and then to the End block 262.

When the stick ID is received at decision block 293, the program would flow along a "Y" path therefrom to program "A", which is initiated at a function block 266 to decode the stick ID. The stick ID is then stored, as represented by a function block 268, and then compared with the authorized stick ID stored in the database of the PLU 36. This is indicated by a function block 270. The program flows to a decision block 272 to determine if the comparison was true. If so, this indicates that the pre-authorized stick ID codes compare with the received stick ID codes or the prestored stick ID code compares with the received stick ID code. If so, the program flows along a "Y" path from the decision block 272 down to a return block 274. If the comparison is not true, the program flows along an "N" path indicating a new ID.

When a new ID is received, the program flows to a function block 276 to transmit the stick ID to the PLUR in association with the PLU ID. The program then flows to a decision block 278 to wait for an acknowledgement message, which would be received at the output of the decode data function block 256. If the acknowledgement message has been received, the program would flow along the "Y" path from decision block 278 to the return block 274. However, if the acknowledgement message has not been received, the program flows along the "N" path to a function block 280 to retransmit the PLU ID and stick ID. The program would flow to a function block 282 to increment a value "N" by one and then to a decision block 284 to determine if the value is equal to a maximum value. If not, the program would flow from decision block 284 along an "N" path back to the input of block 278 to again determine if the acknowledgement message has been received. This will be continued until "N" reaches a maximum value, at which time the program flows along a "Y" path from decision block 284 to a function block 286 to output a tone to the user indicating that the PLU 36 has not been able to establish its new location with the local hub. The program would then flow from function block 286 to a return block 274.

Referring now to FIG. 10, there is illustrated a flowchart for calculating the Time-Difference-of-Arrival (TDA). The program is initiated at a start block 290 and then flows to a function block 292 to request transmission of the PLU ID from a PLU 36. The program then flows to a function block 294 to receive a request message, indicating the step whereby the PLU 36 has received the request to transmit its unique PLU ID. The program then flows to a function block 296 indicating the step whereby the PLU 36 transmits the location data consisting of the most recently received stick ID and the PLU ID. In addition, the PLU 36 could also transmit a range code which provides the ability to optimally cross-correlate the received data for time-of-arrival values. This is a conventional technique which is disclosed in R. Dixon, "Spread Spectrum Communications", Wiley. The program then flows to a function block 298, indicating the step whereby the PLU transmission has been received at the PLUR. The PLUR then time tags the signal, as indicated by a function block 300. The program then flows to a function block 302, indicating the step whereby the ID of the PLU and the time tag information, in addition to the stick location information, is sent back to the central processing unit. The PLUR processor then computes the location of the PLU 36 as indicated by a function block 304 by one of the various techniques described above. The program then flows to a function block 306 to store the location as updated data in the database. The program then flows to an End block 308.

Referring now to FIG. 11, there is illustrated a diagrammatic view of the cellular system of the present invention. The satellite 28 is operable to transmit a signal on a downlink 312 to the PLUs 36 that operates a relatively high data rate, 9600 baud, relative to the 1200 baud receiver data rate of the PLUs 36. Of course, the downlink 312 can operate at 56K baud. In general, on a given channel, the satellite 28 can transmit more data than can be transmitted out from the paging transmitters associated with the system. This allows the satellite 28 to transmit to multiple hubs. However, as will be described hereinbelow, the system of the present invention utilizes this feature to transmit multiple messages at the same time to "cells" within a system.

Whenever the system initiates a transmission string to any of the hubs, a key-up sequence is entered wherein the satellite addresses specific satellite receivers on specific sticks within the system. Of course, in simulcast systems

each hub has overlapping RF fields for the individual sticks in the system. It is therefore necessary that all of the sticks be keyed-up at the same time. The key-up sequence is basically initiated by sending a key-up field wherein the ID of each of the sticks is transmitted to all of the sticks in the system. Of course, the sticks in a common hub would have a portion of the ID that would be designated as a group ID such that only one ID would be transmitted to key-up all of the sticks in that group. However, individual sticks can be keyed-up in response to a specific ID contained in the key-up field. After the key-up field is transmitted, a 576 bit preamble is then sent which comprises a synchronization field for the overall system. Thereafter, the messages are sent to the satellite receivers on each of the sticks in batches. Each batch is comprised of a synch word followed by up to eight 20-bit messages. Each message is comprised of an address followed by data. At the end of each batch, another synch word is sent followed by additional messages. After all of the information has been transmitted, a Wait field is interposed between the messages and a key-down field, wherein a key-down sequence is entered to key-down all of the transmitters such that they do not operate when there are no messages to be transmitted.

As illustrated in FIG. 11, there are five sticks, 314, 316, 318, 320 and 322, associated with the system that define a given hub during normal operation, i.e., a simulcast operation. Each of the sticks 314-322 is operable in the simulcast mode to receive simulcast data and transmit this data out into the associated locales for each stick 314-322, wherein it is assumed that all pagers within the hub can be in any locale associated with any of the sticks 314-322. Each of the locales for the sticks 314-322 is represented by brackets 324, 326, 328, 330 and 332, respectively. In each locale, there are associated a plurality of PLUs 36, represented by dots. However, there are a number of PLUs 36 within the locales 324-332 having a known location. These are represented by circles around the dots. For example, in locale 324, there are three PLUs 36 having a known location. In locale 326, there are two PLUs 36 having a known location. In locale 328, there is one PLU 36 having a known location. In locale 330, there is one PLU 36 having a known location. In locale 332, there are two PLUs 36 having a known location. Once the location is known, it is only necessary to transmit data to the stick associated with the paging receiver having the known location. In accordance with the present invention, once the location is known, the satellite 28 is then operable to transmit the information to the sticks 314-322 by selecting which of the sticks 314-322 is to receive the paging information at any given time slot. This is done through the unique ID that each of the sticks 314-322 possesses. Therefore, the satellite 328 can selectively transmit information to any of the sticks 314-322 for transmission only in its associated locale.

Whenever two adjacent sticks are present in a system with overlapping RF fields, which is always the case with respect to paging systems, there is a possibility that an ambiguity might exist as to the actual location of the PLU 36 from an RF field strength standpoint. For example, during the location-determining step the PLU 36 may be receiving from one stick and in the next instance the message may be received from the other stick that is in the adjacent pattern. This may be due to the fact that the PLU 36 is disposed equidistant between the two adjacent sticks. Since the PLU 36 captures the strongest signal, this may vary as a function of time, even though spatial location does not vary, due to fluctuations in atmospheric conditions, slight reorientation of the PLU 36 or even slight variations in the power

transmitted from each of the sticks. Therefore, whenever overlapping RF fields are present, it may be desirable to turn on only the paging transmitter having previously been determined to have the PLU 36 located in its pattern and turning the adjacent paging transmitters off, thus making each stick and individual cell. Of course, this can present some problems in that paging transmitters within an area must be turned on and off in a non-overlapping manner, thus requiring the turn-on procedures for each transmitter to be sequenced for each message transmitted to a given cell. Thereafter, this cell is turned off and the adjacent cell is then turned on.

Referring now to FIG. 12, there is illustrated a grid arrangement for determining which of overlapping ones of the cells are to be turned on and turned off. The cells are arranged in a matrix of A-cells, B-cells, C-cells and D-cells. All of these cells overlap. Therefore, it would be necessary to first turn on the A-cells, followed by the B-cells, followed by the C-cells and then by the D-cells. In an alternate embodiment of the present invention, the system can be controlled such that each of the PLUs 36 can receive messages from two paging transmitters through orthogonal coding. In this manner, two overlapping sites could be turned on and a paging receiver receiving from either one of the sites would receive the message since the messages are transmitted out of both adjacent cell sites. This would necessitate transmission of both messages out of one adjacent site and transmission of both messages out of the next adjacent sites with the PLU 36 being able to discriminate two messages. This will be described in more detail hereinbelow. However, in the preferred embodiment, the A- and B-cells would comprise one set of orthogonally overlapping cells and the C- and D-cells would comprise a second set of overlapping cells. Therefore, it would only be necessary to turn on all of the A- and B-cells, followed by turning on of all the C- and D-cells, thus increasing the throughput by a factor of a minimum of two.

Referring now to FIG. 13, there is illustrated a diagrammatic view of how the throughput can be increased by going to a cellular mode. In the top line, a message string is illustrated as being comprised of two types of messages, batch messages that are transmitted in the cellular mode, and normal messages that are transmitted during simulcast mode. Normal messages are designated as M_x , where x varies from 0 to n and the batch messages are designated as BM_y , where y ranges from 0 to m . The message string received by the paging terminal is illustrated as being comprised of three simulcast messages M_0 , M_1 and M_2 , three messages BM_3 , BM_4 and BM_5 , which are cellular messages, and two additional simulcast messages M_6 and M_7 . The message string is transmitted out through the satellite 28 in two modes, a simulcast mode and a cellular mode. The simulcast mode is first entered and the messages M_0 , M_1 and M_2 broadcast out to all sticks in the particular hub. Thereafter, the batch messages BM_3 , BM_4 and BM_5 are all transmitted out in a single frame simultaneously in the cellular mode. In the cellular mode, the length of the frame is defined by the longest message that is to be transmitted. After the longest message has been transmitted, the system then goes back to the simulcast mode and messages M_6 and M_7 are transmitted. This illustrates the adaptive nature of the cellular system, i.e., it can recognize that messages are to be routed to specific locations, due to knowledge as to the location of the PLUs 36, and then group these messages for transmission in a cellular mode. Of course, the system can use the simulcast mode to determine location if necessary.

Referring now to FIGS. 14a and 14b, there is illustrated another example of transmission in the cellular mode. There

are eight batch messages which are designated for being transmitted to PLUs 36 in the system having known locations. As described above, the location of the PLUs 36 associated with these batch messages is predetermined. As seen in FIG. 14a, the PLUs 36 are defined as being in three non-overlapping areas. The first isolated and non-overlapping area contains PLUs having the designated messages BM_1 , BM_2 , BM_4 and BM_6 associated therewith. The messages BM_3 and BM_5 are designated for a second isolated area and the batch messages BM_3 and BM_7 are designated to PLUs 36 in a third isolated area. Since there are three isolated areas to which messages are to be sent, this means that the three sticks associated with the three areas can be turned on at a given time. Therefore, the batch messages are arranged such that BM_1 , BM_3 and BM_6 are transmitted at a common time. Thereafter, the batch messages BM_2 , BM_5 and BM_7 are then be transmitted in a single time slot message and BM_4 is then be transmitted in a single time slot.

Referring now to FIG. 15, there is illustrated a diagrammatic view of the cells of FIG. 12, illustrating additional building site cells (BC_N), wherein building sites are located within each of the various overlapping cell sites. These are similar to the ones described hereinabove with reference to FIG. 8. As described above, each of the building cell sites is effectively another cell site that essentially overlaps with the present cell sites described in FIG. 12. The building cell sites define another type of cell. However, the interference problem still requires that the cell site in which the building resides be isolated from the building cell site during transmission. Therefore, when building cell sites are transmitting, the cell in which they reside is not transmitting. Of course, building sites will not overlap with each other and there will be little interference due to the their being adjacent.

The message string is illustrated as being comprised of simulcast transmission to all cell sites, cellular transmission to the buildings and cellular transmission to the cell sites. Initially, the system is in a simulcast mode to broadcast the message S_N . The system then goes into a cellular mode broadcasting to the buildings. The first cellular message is BC_N , and the second cellular message is BC_{N+1} . Of course, during BC_N , multiple messages can be transmitted to the different building cell sites. After the message BC_{N+1} is transmitted, the system goes back to the simulcast mode and broadcasts the message S_{N+1} . The system then goes into the cellular mode and transmits messages in a batch mode to all of the A- and B-cells in the orthogonal mode and then switches to transmit messages to the C- and D-cells in the orthogonal mode. The system then switches to transmit two sequential messages to the building sites as cellular messages BC_{N+2} and BC_{N+3} . Thereafter, the next simulcast message S_{N+2} is then transmitted in the simulcast mode and then the system transfers back to the cellular mode. In the cellular mode, the next cellular message is transmitted to the A- and C-cells at the same time by orthogonal coding and then the message is transmitted to the C- and D-cells. The system then converts back to the simulcast mode and transmits message S_{N+3} . As can be seen from the system of FIG. 15, the system can adaptively convert between simulcast and cellular mode and arrange the data in any manner during cellular mode to optimize efficiency of transmission thereof.

Referring now to FIG. 16, there is illustrated an alternate method whereby data is transmitted to the paging system at the stick site through either the phone line or through a CATV system. The paging terminal 44 is operable to interface with the PSN 34 to transmit data thereto. This data is time-tagged or file-tagged prior to transmission to the PSN

34 through a time-sequence controller 337. The paging terminal 44 operates in conjunction with a stick controller 339 and the time-sequence controller 337 to first determine which messages should be transmitted as data through the phone line and then assemble these messages for transmission thereto. As will be described hereinbelow, these messages typically are those that exceed a certain length that would make it impractical for them to be transmitted through the satellite 28. The overall clock system is synchronized through the Master Clock System (MCS) 112 in the PSN 34 with the Slave Clock System (SCS) 120 synchronizing up to the MCS 112 and providing a stable clock for the operation of the paging terminal 44 and the time-sequence controller 337.

The data or message information is transmitted from the paging terminal 44 through the PSN 34 via a modem 338 to a processor 336 associated with the paging system 334. A memory 340 is provided for storing files and data that are to later be transmitted to the PLU 36 through the leaky coax 240 (by way of example). The leaky coax 240 can be any of the paging antennas that are associated with the various paging systems, as illustrated by paging system 334. An alternate route to the PSN 34 is to send the data via a T2 line through a CATV system 341.

In operation, the paging terminal 44 through the time-sequence controller 337 will determine whether the data is to be transmitted as messages, i.e., a short message, or it is to be transmitted through the alternate "hardwired" connection or path to the paging system 334. If, for example, the message is greater than a predetermined length, it will be transmitted as a file via the alternate routing path.

In general, the purpose for transmitting the data over a phone line is that the control link in a paging system is one of the least reliable subsystem entities. This is primarily due to multiple objectives requiring trade-offs with lack of reasonable margins without excessive cost. Also, with a desire to increase the paging rate, the link band width and timing accuracy must increase. This multiple improvement can be achieved in a more reliable and cost-effective manner by isolating the operation wherein the data can be transmitted separately from the control and clock information via an alternate path. Therefore, multiple control links are provided with the satellite 28 primarily providing the clock and control portion thereof.

In conventional systems, the page requests from the phone line input are first formatted by the paging terminal 44. Next, the paging transmitter control signals are then appended by the controller 339 to form a composite control link signal. The control link signal is then transported to the appropriate paging transmitters and paging systems 334. The paging transmitters at the paging system 334 receive this control link signal and execute it on a real-time basis. All time related adjustments, therefore, must be made during non-paging activities and considered an alignment function with respect to the overall system. In simulcast paging systems, as described in the present invention, the phasing or time relationship between adjacent RF field transmitter outputs is bounded, and is set to within a fractional bit time. Therefore, the control link through the satellite 28 must deliver its signal to the paging transmitter with a minimum differential error between the various adjacent RF fields. Therefore, in conventional paging systems, three primary elements exist with respect to-controlling signalling, the command and control signals associated with the paging transmitter, the paging signal to be transmitted, and the timing or phasing of the paging transmitter paging signals transmitted therefrom relative to the adjacent RF field paging transmitter transmit paging signals.

The third element, the timing or phasing, has been the major problem for paging systems. The present system provides this timing through use of the MCS 112 and SCS 120 that utilize the time base of the PSN 34. In addition to all of this, providing data at the destination at or prior to the transmission time allows data to be sent via alternate paths to the required destinations. However, for this system to operate, the paging transmitter must have the ability to hold the data until requested by the transmission sequence. Due to the serial sequential nature of this, the memory 340 acts as an elastic serial memory but standard Random Access Memory also will work.

There are three modes of operation for the system of FIG. 16. The first mode is the normal standard mode using a standard time difference accurate control angle link. This is typically a terrestrial Radio Control Link (RCL), but Direct Satellite Control Link (DSCL) is the preferred embodiment for this time differential accurate control link. In the second mode, the data in each page is evaluated, and if greater than a 20-bit word is present, it is replaced with a 20-bit file name and sent out to the satellite control link as a file name. Also, the named data is tagged with that name and sent by an alternate path to the required sticks at the various paging systems for storage in the associated memory 340. This is the preferred embodiment including the POCSAG format, and a like process would be implemented for other control link formats and options. In the third mode, the command and control signals plus data is sent by the alternate path. Only timing is supported by the satellite link. If the third mode is the only mode of operation, then timing could be acquired from satellite or terrestrial sources such as the GPS, TDRS, LORAN-C, OMEGA, DECCA and related Nav aids.

The second and third modes of operation provide additional benefits. One of the major disadvantages of classical paging systems is that the transmission system is configured such that a request can only be inserted at the originating point of the control link. Two examples are inserting a call sign or secondary pages. If the call sign resides in the paging transmitter, it could be executed more efficiently in an automatic manner, or by remote command if the second or third mode features are present in that set of paging transmitter units. One implementation of the second and third modes can account for interference between two or more paging terminals having continuous RF fields. Since the data arrives at the paging transmitters prior to transmission by a defined time value, the time slot during arrival can then be evaluated for insertion of secondary inputs such as a call sign or paging signals from a second paging terminal. Therefore, any missing data from time zero to that defined time is a non-transmission time from that source. Therefore, a transmission could be inserted during that non-transmission time. In the case of a POCSAG format, if the defined time is an integral of 454 MS, then integer 1200 BPS batches could be synchronously inserted from the secondary source.

With further reference to the second mode of operation, each paging sequence requires the data for a specific pager address to be replaced with a file name. This new sequence is linked to the paging transmitter via the satellite link through satellite 28. The file name is also assigned to the data that it replaced. This data file is then sent to the destination sticks via the phone line or through the CATV system 341 and held until requested via the satellite link. Therefore, a page transmitted with the second mode of operation contains the pager address and the file name of the data to be transmitted, not the actual data. The data is therefore transmitted over the alternative link with the command and control information sent over the satellite

link. The functions that go over the satellite link are basically the paging signal to the uplink, the message content, POC-SAG, which contains the carrier turn-on, the Time of Day (TOD) (optional), the key-up sequence, the preamble, the batches, the frame, the address, the data file name, the hold time and the key-down sequence. The paging system 334 is operable to recognize the data as being a file name and automatically inserts the file having that file in place of the data. Essentially, the satellite transmit sequence is the same as a normal paging sequence, except the data is not actually transmitted over the satellite link, only the file name is sent.

In the third mode of operation, the total paging signal is time/sequence tagged and sent to the paging system 334 via the alternative route where it is stored. When it is time to transmit this signal, it is then transmitted, requiring only some timing information from the satellite 28 through the downlink. The clock and Time of Day (TOD) or sequence signal is derived from the satellite signal. The satellite signal consists of at least the clock and the TOD or sequence signals. All paging signals operating in the third mode of operation are time/sequence tagged and transferred to the sticks via the alternative links with the time and order of transmission controlled by the satellite downlink.

Referring now to FIGS. 17a and 17b, there are illustrated flow charts for the operation of the system of FIG. 16. The program is initiated at a start block 342 and then proceeds to a function block 344 to mark the data. At this function block, it is determined whether the data is to be time-marked or to be marked with a file name. This marked data is then transmitted to the paging system, as indicated by a function block 346. The control and clock signal is then sent to the satellite for transmission to the appropriate one of the paging systems 334. The program then flows to return block 350.

In FIG. 17b, the flowchart for the paging system 334 is illustrated. The program is initiated at a start block 352 and then proceeds to a function block 354 to determine whether the system is operating in the mode wherein data is time-marked. If not, the program flows along the "N" path to a function block 356 wherein a message is received. When the message is received, the data portion thereof is examined to determine if this data is a file name and compares with an already stored file. If so, the program flows along a "Y" path to fetch the file and transmit it, as indicated by a function block 366. The program then would flow back to the input of the decision block 354. However, if it were determined that this were a standard paging message broadcast through a simulcast mode, the program would flow along the "N" path and transmit the message in a normal fashion, as indicated by a function block 360. The program would then flow back to the input of the time decision block 354.

If the system were working in the time-tagged mode of operation, i.e., the third mode of operation, the system would flow from the decision block 354 along the "Y" path to a function block 362 to compare the files that were stored to the time base. The program would then flow to a function block 364 to determine if it were time to transmit. If not, the program would flow along the "N" path back to the input of the function block 362 and, when the time for transmission occurred, the program would flow along a "Y" path to function block 366 to transmit the file.

Referring now to FIG. 18, there is illustrated a more detailed diagram of the system of FIG. 16. The controller 337 is illustrated as an interface controller and time/sequence tagging system. This essentially is a personal computer that, as described above, examines the data to determine if it exceeds a 20-bit word. If so, then it either gives it

a file name or time-tags it and routes it to the paging system through an alternate link. The paging terminal 44 is manufactured by Glenayre Corporation, Part No. 3000XL. The paging transmitter controller is manufactured by Motorola, Part No. DDC1450. These are conventional components of a paging system. The Direct-Inward-Dial (DID) lines enter the paging terminal and then the paging terminal verifies, formats and sends a transmission sequence to the interface controller 337 and then to the paging transmitter controller 339. The controller 339 then sends out the transmitter control sequence to the interface controller 337. The interface controller 337 then sends the clock and the TOD or sequence through a clock and time/sequence distribution system 366, which essentially comprises the satellite 28. The interface controller 337 also sends the command and control functions (the stick and paging) to the command and the control distribution media, represented by a block 368. The data is sent through a data distribution medium 370. Both the blocks 366 and 368 can be represented by the satellite link in the second mode of operation, whereas the data distribution system 370 is represented by the phone link. The paging system 334 is represented by a dotted line which includes the memory 340 and the processor 336, which is referred to as a sequence controller.

The clock and time/sequence distribution system 366 sends the various clock and timing/sequence signals to all paging systems 334 for receipt by the time and event generator, as represented by block 372. The command and control distribution block 368 distributes the command and control signals to at least the required ones of the paging systems 334. The data distribution system 370 distributes the data to destination ones of the paging systems 334. The time and event generator 372 extracts the clock, TOD and sequence signals from the clock and time distribution medium 366 and then sends the clock to a paging transmitter 374. A command and control receiver 376 is provided in the paging system for receiving the command and control signals from the block 368. A data receiver 380 is provided for receiving data from the data distribution system 370. The data receiver inputs the data into the memory 340, whereas the command and control receiver is interfaced with a sequence controller 336. The sequence controller 336 takes the command and control sequence from the receiver 376 and sequences out the paging signal to the paging transmitter 374 in conjunction with the data stored in memory 340 and the time and event signal from generator 372. The paging transmitter 374 can be a system manufactured by Motorola, Part No. PURC5000, which is operable to lock the transmitter clock therein to the receive clock and then transmit out RF transmission signals through the associated antenna 384.

Referring now to FIG. 19, there is illustrated a block diagram of the receiver in the PLU 36 for receiving upper and low sideband signals, to allow orthogonal coding. The PLU 36 has a conventional FM receiver 386 disposed therein which is operable to receive the upper and lower sideband coded signals on an antenna 388. These are then filtered by an upper band filter 390 and a lower band filter 392, such that two signals can be discriminated. These are input to a POC-SAG decoder 394, which operates at a higher rate, i.e., 2400 baud, with both the upper band filter 390 and the lower band filter 392 operating at 1200 baud. The POC-SAG decoder will be operable to decode either one of the signals and output them on an output 396. The coding for the upper and lower sidebands of the signal would require less than 3 kHz bandwidth and is a conventional technique.

Referring now to FIG. 20, there is illustrated a block diagram of an alternate embodiment for increasing the

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throughput. An initial signal is received at 4800 baud in the paging system at the stick site and is input to a precoder, which can be a modem 398. The modem then outputs a conventional phone line signal at a 1200 baud rate, which is input to the paging transmitter 400 and out through an antenna 402. The PLU 36 is then operable to receive this signal on the antenna 388 and downconvert it with the FM receiver 386. A second modem 404 is operated in the demodulation mode to demodulate the 1200 baud input signal to a 4800 baud signal, which is then input to a POCSAG decoder 406 that operates at 4800 baud rate. In this manner, the throughput has been increased by utilizing precoding.

In summary, there has been provided an adaptive cellular paging system wherein paging can be effected on a simulcast basis or on a cellular basis. In the cellular basis, the location of certain pagers is determined such that the RF position is known within the system. Thereafter, multiple messages can be sent simultaneously to different paging transmitters within a system, such that the entire system does not have to receive the same message. This increases the throughput to the system.

Although the preferred embodiment has been described in detail, it should be understood that various changes, substitutions and alterations can be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. An adaptive paging system for transmitting paging messages to a plurality of paging receivers, comprising:

- a plurality of paging systems for receiving the paging messages, each of said paging systems having a paging transmitter associated therewith for transmitting the paging messages to the paging receivers that are within an associated transmission locale about said paging transmitter, which said transmission locale defines the area within which the paging receivers can receive messages;
- a transmission device for generating the paging messages for transmission to the paging receivers;
- a transmission link for connecting said transmission device to said paging systems; and
- a paging terminal for controlling said transmission device to transmit the paging messages to said paging systems for retransmission therefrom by said associated paging transmitters, said paging terminal operating in simulcast and cellular modes, said simulcast mode operable to control said transmission device to transmit said paging messages in a simulcast manner such that all of said paging systems receive said transmitted paging messages at substantially the same time, said paging terminal operating in said cellular mode to control said transmission device to transmit said paging messages to only select ones of said paging systems at a given time for retransmission to said associated paging transmitters.

2. The adaptive paging system of claim 1, wherein said transmission device is operable to transmit said paging messages to said paging systems and said paging transmitters associated with said paging systems are operable to transmit said paging messages within said associated transmission locale in substantially the same time frame.

3. The adaptive paging system of claim 1, wherein said transmission device when controlled by said paging terminal in said cellular mode, is operable to transmit different ones of said paging messages to different ones of said paging systems at substantially the same time.

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4. The adaptive paging system of claim 1, wherein portions of said transmission locales for adjacent ones of said paging systems overlap.

5. The adaptive paging system of claim 4, wherein only ones of said paging systems having paging transmitters with associated transmission locales that are not overlapping are operable to receive paging messages from said transmission device and transmit paging messages therefrom.

6. The adaptive paging system of claim 1, and further comprising:

a location system for determining in which of said transmission locales associated with said paging systems that select ones of the paging receivers can receive predesignated messages, said predesignated messages generated by said transmission device for transmission to the select ones of the paging receivers; and

routing control circuitry operable during said cellular mode of operation in conjunction with said paging terminal for determining which of said predesignated messages is transmitted to which of said paging systems in accordance with the determined locale of the select ones of the paging receivers.

7. The adaptive paging system of claim 6, wherein said location system comprises:

a location transmitter co-located with each of the plurality of paging receivers;

each of said paging transmitters operable to transmit a unique transmit ID for the associated one of said paging systems and confined within said associated transmission locale, and transmitted on a periodic basis;

each of the paging receivers having a unique receive ID associated therewith and operable to receive said unique transmit ID transmitted in the one of said predetermined transmission locales in which the paging receiver is operable to receive transmissions, each of the paging receivers operable to transmit the received transmit ID and the associated unique receive ID through said co-located location transmitter over a location RF link; and

a location receiver disposed at a predetermined location for receiving from said RF link the transmitted transmit ID and associated receive ID from the select ones of the paging receivers, said receive IDs and associated transmit IDs forwarded to said routing control circuitry.

8. The adaptive paging system of claim 7, wherein said location receiver is comprised of a plurality of location receivers, each of said plurality of location receivers co-located with respective ones of said paging transmitters for each of said paging systems.

9. The adaptive paging system of claim 7, wherein:

said transmission device is operable to generate a request-to-send messages for each of the select ones of the paging receivers, and said routing control circuitry is operable to control said transmission device to transmit said request-to-send messages to said paging systems for receipt by all of the plurality of paging receivers within any of said predetermined transmission locales of either of said paging systems; and

the select ones of the paging receivers receiving the one of said request-to-send messages designated therefor operable to transmit the received transmit ID and associated receive ID with said co-located location transmitter over said location RF link.

* * * * *



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/753,178	12/30/2000	Mundi Fomukong		2194

7590 12/17/2001
MUNDI FOMUKONG
10853 ROSE AVE, #49
WLA, CA 90034

EXAMINER

TRIEU, VAN THANH

ART UNIT	PAPER NUMBER
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2632

DATE MAILED: 12/17/2001

#4

Please find below and/or attached an Office communication concerning this application or proceeding.

Handwritten signature

Am

Interview Summary	Application No.	Applicant(s)	
	09/753,178	FOMUKONG, MUNDI	
	Examiner Van T Trieu	Art Unit 2632	

All participants (applicant, applicant's representative, PTO personnel):

(1) Van T Trieu. (3) _____

(2) Mundi Formukong. (4) _____

Date of Interview: 13 December 2001.

Type: a) ☒ Telephonic b) ☐ Video Conference
c) ☐ Personal [copy given to: 1) ☐ applicant 2) ☐ applicant's representative]

Exhibit shown or demonstration conducted: d) ☐ Yes e) ☒ No.
If Yes, brief description: _____

Claim(s) discussed: 1, 5, 7, 9, 10, 12, 14 and 17.

Identification of prior art discussed: Schipper [YS 5,669,061].

Agreement with respect to the claims f) ☒ was reached. g) ☐ was not reached. h) ☐ N/A.

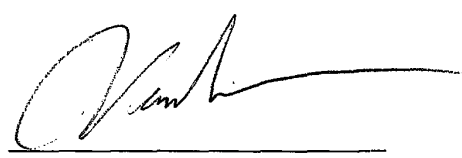
Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: Mr. Mundi will submit an Amendment of the independent claims 1, 5, 7, 9, 12, 14 and 17 with a combination of at least one of the claimed limitations in claims 9, 10 and/or 12. Examiner will update the search.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

i) ☒ It is not necessary for applicant to provide a separate record of the substance of the interview(if box is checked).

Unless the paragraph above has been checked, THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN ONE MONTH FROM THIS INTERVIEW DATE TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

Examiner Note: You must sign this form unless it is an Attachment to a signed Office action.


Examiner's signature, if required

FROM :

PHONE NO. : 3105598133

Dec. 10 2001 03:56PM P1

DRAFT RESPONSE TO OFFICE ACTION

FOR

APPLICATION : US 09/753,178

EXAMINER: VAN TRIEU

ART UNIT : 2632

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Received from <3105598133> at 12/11/01 2:21:18 AM [Eastern Standard Time]

FROM :

PHONE NO. : 3105598133

Dec. 10 2001 03:56PM P2

THE U.S PATENT AND TRADEMARK OFFICE

Application Number: 09/753,178

Applicant: Mundi Fomukong

Examiner: Van Trieu

Art Unit: 2632

1) Proposed Amendments

Commissioner for Patents and Trademarks

Washington, District of Columbia, 20231.

Sir:

In response to the last Office communication mailed 10/19/01 for the above application, kindly amend the application as indicated below. Marked up version of the claims have also been included.

FROM :

PHONE NO. : 3105598133

Dec. 10 2001 03:57PM P3

Replace claim 1 as follows:

1. A method for providing the location of a portable mobile remote unit to a wireless consumer requesting the location of the mobile unit if within a geographic boundary prescribed by the wireless consumer comprising:

obtaining the location of the remote unit;

obtaining from the mobile consumer geographic boundary information within which the location of the remote unit should be disclosed;

determining whether the remote unit is within the said geographic boundary obtained from the mobile consumer;

forwarding the location of the remote unit to the mobile consumer upon determination that the remote unit is within the said geographic boundary provided by the mobile consumer.

Replace claim 5 as follows:

5. A method for providing the location of portable remote units that exist within a prescribed geographic boundary comprising:

receiving at the network a prescribed geographic boundary to query for mobile remote units;

re-defining at least a geographic region in the said prescribed geographic boundary;

recursively requesting in the said re-defined geographic region(s), one after another, the location of remote units that are present in the region;

FROM :

PHONE NO. : 3105598133

Dec. 10 2001 03:57PM P4

verifying after each request in a re-defined region whether a portable remote unit disclosed a global location in the region;

providing to the network upon said verification, the location of at least a remote unit that revealed its location in the said re-defined region.

Replace claim 7 as follows:

7. In a communication system comprising:

at least a first communication unit able to provide location information to the network;

at least a second communication unit able to request for the location of a first communication unit present within a geographic boundary prescribed by the at least second communication unit;

the system able to obtain and provide the location information of the at least first communication unit if within the prescribed geographic boundary defined by the at least second communication unit.

Replace claim 16 as follows:

16. The portable remote unit of claim 15 having means to provide its velocity to the network and having means to further determine if its velocity is within the network's prescribed velocity before divulging its location to the network

FROM :

PHONE NO. : 3105598133

Dec. 10 2001 03:58PM P5

DETAILED RESPONSE TO OFFICE ACTION

In the last Office communication claims 1-15 and 17-19 were rejected under 35 U.S.C 102 (b) as being anticipated by Schipper [US 5,669,061]. Schipper teaches a system for tracking the location of a cellular phone user and method to provide cell-handoff as the cell phone user moves from one cellzone to another. A cell phone user operates within well defined cell zones, and as they approach a new cell boundary calculations are performed to facilitate handoff to the next cell zone. Distances from the cell boundaries are defined by the system and once a cell user is within that boundary a mechanism for handoff to the next cell is enacted by the system.

In applicants invention a system is presented wherein a user in possession of a first cellular telephone may enter into a mode to determine if a second cellular telephone has maintained close proximity to the first over a period of time. As cell phones are getting smaller and equipped with location reporting capabilities, it would be easy for unauthorized location reporting to happen if a device is concealed in a car or object moving with an individual whose location is required, but not authorized by the individual. In the invention, a list of mobile devices traveling in close proximity to a user requesting the service is maintained over a period of time. At the end of that time, a determination is made as to whether the user has been tracked or not by at least another mobile device. None of the cited prior art teaches this technology. Further more, the invention also provides a way to report the location of mobile remote units in a specific geographic area to a wireless mobile consumer that was provided geographic boundary

information as to where the search should be performed for mobile remote units. None of the prior art also teaches that.

RESPONSE TO CLAIM REJECTIONS

- Claim 1:

The rejection misinterpreted claim 1 and misapplied the teachings of the prior art to reject the claim. This claim, now amended, previously recited a method for providing the location of a portable mobile remote unit associated with a network. This was done by reporting the location of a mobile remote unit if the mobile remote unit is within a geographic boundary prescribed by a requestor. Step 3 of this claim :

obtaining at the network geographic boundary information within which the location of the remote unit should be disclosed;

is not disclosed by Schipper. Shipper, as indicated in the rejection, simply obtains geographic boundary information within which a mobile remote unit is located. It does not obtain the geographic boundary information where the mobile should disclose its location. In Applicants invention a mobile may disclose its location only when it is within a boundary prescribed by the network. The network is telling the mobile device to provide location information if within a specified boundary. In this regard only mobile units that are in close proximity to a device that is being tracked would provide their location. Schipper does not teach that and no citing was found in the prior art to suggest that. As a result of the inconsistency in the rejection, all subsequent steps in the claim are valid and the claim should have been allowed.

- **Claim 2:**

Claim 2 should have been allowed in view of the arguments made for the allowance of 1. Furthermore, figure 4 and 5, col 14 lines 15-22, col 15 lines 32-65 does not teach obtaining radii information and calculating angle of inclination as suggested in the rejection.

- **Claim3:**

Claim 3 is depended on 1 and should have been allowed in view of the arguments put forth for the allowance of 1.

- **Claim 4**

Claim 4 is clearly not recited in any of the prior art. No exclusion regions are specified within which a remote unit should not provide its location to the network; and no determination is made thereafter to establish if a remote unit is not in an exclusion zone before providing its location to the network. The claim should have been allowed.

- **Claim 5**

The steps in claim 5 are not disclosed in the cited prior art. The claim has also been amended to further distinguish from the prior art. In applicant's invention, once a request

FROM :

PHONE NO. : 3105598133

Dec. 10 2001 03:59PM P8

is received for the location of mobile remote units in a specified area, the area is divided into sub areas and the areas are paged recursively, starting with the closest, until a mobile remote unit responds with location information. The prior art does not teach that and the claim should be allowed. Figure 2-4, col 10 line 61-65, col 13 lines 35-65 and col 14 lines 1-14 does not teach the above as suggested in the rejection.

- **Claim 6**

Claim 6 recites a technique that is utilized to terminate a request for the location information of mobile remote units within the redefined geographic regions. The prior art does not suggest that, and no matter was actually cited in the rejection to refute this claim. This claim should be allowed.

- **Claim 7**

Claim 7 is intended to define a system that provides the location of a mobile remote unit only when the mobile remote unit is within a prescribed geographic boundary defined by the source of request. If the mobile remote unit is not within the prescribed boundary, then its location is not provided. The prior art does not suggest that. The claim has also been amended to show that limitation.

- **Claim 8**

The system described by the prior art does not show a way for a first communication device to provide its location information to a second if and only if it is within the

geographic boundary prescribed by the second. Claim 8 recites that and should have been allowed.

- **Claim 9**

Claim 9 recites a method to determine if a mobile device has traveled a minimum pre-specified distance while maintaining close proximity to another. The prior art does not remotely suggest this. Also no relevant passage was cited in the rejection to refute this claim, the claim should be allowed.

- **Claim 10**

Claim 10 is dependent on 9 and further teaches a method to determine if a device is being tracked by another by retaining a list of all location reporting devices within proximity of the tracked device. None of the prior art teaches that. The claim should have been allowed.

- **Claim 11**

Claim 11 also teaches a way to find mobile devices that are tracking another over a period of time for use in the method described in 9. The prior art does not teach that and

FROM :

PHONE NO. : 3105598133

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no relevant passage was shown in the rejection to refute this claim. The claim should be allowed.

- **Claim 12**

Claim 12 defines a system to be used to determine if a mobile device is tracking another over a pre-specified distance. The prior art does not teach that and the rejection did not cite any relevant passage from the prior art to refute this claim. Applicant maintains the claim is patentable over the prior art and should be allowed.

- **Claim 14**

Claim 14 teaches a system that has means to provide the location of a mobile remote unit if it is determined that the mobile remote unit is within a prescribed geographic boundary defined by the system. Schipper does not teach that, and no relevant passage was cited in the rejection. Applicant request that the claim be allowed.

- **Claim 15**

The mobile remote unit as shown in Schipper's invention or any of the cited prior art cannot determine if they have been excluded from providing their location when a

request for location is made in an area where they reside. No relevant passage in any of the cited art was presented and applicant solicit that the claim be allowed.

- **Claim 16**

Claim 16 recites providing means at the mobile remote unit of claim 15 to provide its velocity to the network as requested. This claim was rejected under 35 USC 103 (a) as being obvious over Shipper in view of Rubin. It should be noted that neither patents suggest any combination as specified in the rejection. Also the mobile remote unit as described by Schipper does not divulge its velocity information to the network if it is within under a velocity specified by the network. The claim should also be allowed in view of the argument made for the allowance of claim 15.

- **Claim 17 -19**

Claim 17 -19 recites portion of applicant's invention that provide location information to the network if within a specified geographic boundary. This claim was rejected in view of Schipper and should have been allowed, as Schipper does not suggest what the rejection is relying upon as supposedly teaching.

MARKED UP CLAIMS SHOWING CHANGES

1. A method for providing the location of a portable mobile remote unit to a wireless consumer requesting the location of the mobile unit if within a geographic boundary prescribed by the wireless consumer associated with a network comprising:

obtaining the location of the remote unit;

obtaining from the mobile consumer at the network geographic boundary information within which the location of the remote unit should be disclosed;

determining whether the remote unit is within the said geographic boundary obtained at the network from the mobile consumer;

forwarding the location of the remote unit to the network mobile consumer upon determination that the remote unit is within the said geographic boundary provided by the mobile consumer.

5. A method for providing the location of portable remote units that exist within a prescribed geographic boundary comprising:

receiving at the network a prescribed geographic boundary to query for mobile remote units;

re-defining at least a geographic region in the said prescribed geographic boundary;

recursively requesting in the said re-defined geographic region(s), one after another, the location of remote units that are present in the region;

FROM :

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verifying after each request in a re-defined region whether a portable remote unit disclosed a global location in the region;

providing to the network upon said verification, the location of at least a remote unit that revealed its location in the said re-defined region.

7. In a communication system comprising:

at least a first communication unit able to provide location information to the network;

at least a second communication unit able to request for the location of a first communication unit present within a geographic boundary prescribed by the at least second communication unit;

the system able to obtain and provide the location information of the at least first communication unit ~~that is~~ if within the prescribed geographic boundary defined by the at least second communication unit.

16. The portable remote unit of claim 15 having means to provide its velocity to the network and having means to further determine if its velocity is within the network's prescribed velocity before divulging its location to the network

FROM :

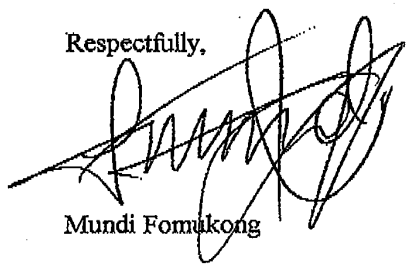
PHONE NO. : 3105598133

Dec. 10 2001 04:01PM P14

Conclusion

Applicant have shown that the amended and existing claims are patentable over the prior art. Applicant solicits the allowance of these claims from the Office.

Respectfully,



Mundi Fomikong

(Applicant).

12/10/01

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 03:04AM P1

RESPONSE TO OFFICE ACTION

FOR

APPLICATION : US 09/753,178

EXAMINER: VAN TRIEU

ART UNIT : 2632

FAX: (703) 872 9314

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Received from <3105598133> at 1/23/02 2:03:32 PM [Eastern Standard Time]

Petitioner Uber Ex-1004, 0264

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 03:04AM P2

#5
AMOTA
1/20/02

THE U.S PATENT AND TRADEMARK OFFICE

Application Number: 09/753,178

Applicant: Mundi Fomukong

Examiner: Van Trieu

Art Unit: 2632

Method of Transmission : Fax

Number of pages excluding cover page: 24

OFFICIAL



1) Proposed Amendments

Commissioner for Patents and Trademarks

Washington, District of Columbia, 20231.

Sir:

In response to the last Office communication mailed 10/23/2001 for the above application, kindly amend the application as indicated below. Marked up version of the claims have also been included.

- **Replace claim 1 as follows:**

sub. c1
1. A method for providing the location of a portable mobile remote unit in a geographic region to a wireless consumer requesting the location of portable mobile remote units that are maintaining close proximity to the wireless consumer in the geographic region comprising:

- A1
- i) obtaining the location of the wireless consumer at intervals over a period of time;
 - ii) requesting at each interval, at the network, that all mobile remote units within close proximity of the wireless consumer disclose their location to the network;
 - iii) maintaining a list of mobile remote units that provided their location at each interval after the request of (ii);
 - iv) from the said list of (iii), forwarding the location of at least a mobile remote unit to the mobile consumer upon determination that the remote unit maintained close proximity to the mobile consumer over the said period of time of (i);

- **Amend claim 2 as follows:**

N. 2
Claim 2 change "The said technique employed by the method of claim 1 to determine if a remote unit is within a prescribed geographic boundary comprising:"

to

"The said technique employed by the method of claim 1 to determine if a mobile remote unit is within a prescribed geographic boundary or within close proximity of a wireless consumer comprising:"

u.l.
- Amend claim 3 as follows:

Claim 3 change "A technique employed by the method according to claim 1 to determine if a remote unit is within a specified geographic boundary comprising:"

to

"A technique employed by the method according to claim 1 to determine if a remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:"

- Replace claim 5 as follows:

Sub. A1
5. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless consumer requesting that information comprising:

i) receiving at the network a wider than normal prescribed geographic boundary to query for mobile remote units from the wireless consumer;

A2
ii) splitting the said geographic boundary of (i) into sub geographic regions to constitute the said prescribed geographic boundary;

iii) requesting in the said sub geographic region(s), the location of remote units that are present in each sub region;

iv) verifying after each request of (iii) in a sub region whether at least a portable remote unit disclosed a global location in the region;

v) maintaining a list of all remote units that disclosed their location after each request from the verification of step (iv) ;

A2

vi) providing to the network, and from the said list of (v) the location of at least a remote unit that revealed its location in the said sub region.

- **Replace claim 6 as follows:**

Sub. D1
A3

6. A technique according to claim 5, utilized to terminate a request for the location information of remote units in the said prescribed geographic boundary comprising: checking to establish that a request for remote unit location information was undertaken in all re-defined or sub regions of the said prescribed boundary or a portable remote unit in a defined or sub region responded with location information.

- **Cancel claim 7**

- **Cancel claim 8**

- **Replace Claim 9 as follows:**

Sub. D2

A4

9. A method for determining that a first portable remote unit associated with a network is being tracked by at least a second portable remote unit over a tracking period comprising;

obtaining the location of the said first portable remote unit or tracked unit;

obtaining the location of the at least second communication unit or tracking unit

that is within proximity or a pre-specified radius of the said tracked unit;

verifying whether the tracking and tracked unit(s) have traveled a minimum pre-specified distance over the tracking period;

forwarding the result of the said verification to the network at the end of the tracking period.

- **Replace claim 12 as follows:**

12. A communication system comprising:
a network of communication units;
at least a first communication unit and at least a second communication unit able
to provide their location information to the said network;
the system able to determine and report that the at least second communication
unit maintained close proximity to the at least first communication unit over a period of
time;

- **Replace claim 14 as follows:**

14. A communication system comprising:
a portable mobile remote unit;
means to obtain the location of the portable mobile remote unit;
means to obtain geographic boundary information in order to disclose a global
location at the network;
means to provide the location of the portable mobile remote unit to the
network upon determination that the portable mobile remote unit is within the said
geographic boundary obtained at the network;
means to determine and report to the system upon request that, another mobile
remote unit of the network has tracked the said portable mobile remote over a period of
time;

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 03:06AM P6

Replace claim 12 as follows:

- Sub. C3
A5
12. A communication system comprising:
a network of communication units;
at least a first communication unit and at least a second communication unit able
to provide their location information to the said network;
the system able to determine and report that the at least second communication
unit maintained close proximity to the at least first communication unit over a period of
time;

Replace claim 14 as follows:

- Sub. C4
A6
14. A communication system comprising:
a portable mobile remote unit;
means to obtain the location of the portable mobile remote unit;
means to obtain geographic boundary information in order to disclose a global
location at the network;
means to provide the location of the portable mobile remote unit to the
network upon determination that the portable mobile remote unit is within the said
geographic boundary obtained at the network;
means to determine and report to the system upon request that, another mobile
remote unit of the network has tracked the said portable mobile remote over a period of
time;

- Replace claim 16 as follows:

A7 sub. C4 16. The portable remote unit of claim 15 having means to establish its velocity at the network and having means to further determine that, its velocity is within the network's prescribed velocity before divulging its location to the network

- Cancel claim 17
- Cancel claim 18
- Cancel claim 19

- Insert new claim 20

sub. C5 20. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing geographic boundary information to mobile remote units in a geographic region to disclose their location;
 - ii) further providing exclusion region information associated with said geographic boundary of (i) to mobile remote units in the said geographic region;
 - iii) determining that a mobile remote unit is in the said geographic boundary of (i) and not in the said exclusion region of (ii) before providing the location of the mobile remote unit to the network;
- AS*

- [Insert new claim 21]

21. A method utilized to provide to a source of request, the location of a mobile remote units that exist in a geographic region from the said list according to claim 5 comprising:

- i) estimating and obtaining from the said list, the location mobile remote units that are closer to the source of request;
- ii) providing the information obtained in (i) to the source of request before releasing the location of other mobile remote units that are further from the source of request;

- [Insert new claim 22]

22. A method for providing the location of a portable remote unit that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing to remote units in the said geographic boundary velocity information required in order to divulge location information;
- ii) estimating at the remote unit or network, the velocity at which the remote unit is moving;
- iii) validating that the estimated velocity of the remote unit meets the velocity requirement provided by the network (i) ,if yes, forwarding the location of the remote unit to the network;

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 03:07AM P9

- **[Insert new claim 23]**

23. A technique utilized in the method according to claim 1, to terminate requesting at each interval, for the location of mobile remote units within close proximity of the wireless consumer comprising;

i) keeping track of the time since the first request for tracking units within proximity of the wireless consumer was enacted by the system;

iii) validating that the elapsed time at each interval when a request is to be made does not exceed the total time set for establishing tracking in the system;

iv) requesting that all mobile remote units within close proximity of the wireless consumer divulge their location if the result of the validation of (iii) is true;

DETAILED RESPONSE TO OFFICE ACTION

In the last Office communication claims 1-15 and 17-19 were rejected under 35 U.S.C 102 (b) as being anticipated by Schipper [US 5,669,061]. Schipper teaches a system for tracking the location of a cellular phone user and method to provide cell-handoff as the cell phone user moves from one cellzone to another. A cell phone user operates within well defined cell zones, and as they approach a new cell boundary calculations are performed to facilitate handoff to the next cell zone. Distances from the cell boundaries are defined by the system and once a cell user is within that boundary a mechanism for handoff to the next cell is enacted by the system.

In applicants invention a system is presented wherein a user in possession of a first cellular telephone may enter into a mode to determine if a second cellular telephone has maintained close proximity to the first over a period of time. As cell phones are getting smaller and equipped with location reporting capabilities, it would be easy for unauthorized location reporting to happen if a device is concealed in a car or object moving with an individual whose location is required, but not authorized by the individual. In the invention, a list of mobile devices traveling in close proximity to a user requesting the service is maintained over a period of time. At the end of that time, a determination is made as to whether the user has been tracked or not by at least another mobile device. None of the cited prior art teaches this technology. Further more, the invention also provide other methods to report the location of mobile remote units in a specific geographic area to a wireless mobile consumer that was provided geographic boundary information as to where the search should be performed for mobile remote units. None of the prior art also teaches that.

RESPONSE TO CLAIM REJECTIONS**- Claim 1:**

The rejection misinterpreted claim 1 and misapplied the teachings of the prior art to refute the claim. This claim, now amended, previously recited a method for providing the location of a portable mobile remote unit associated with a network. This was done by reporting the location of a mobile remote unit if the mobile remote unit is within a geographic boundary prescribed by a requestor. Step 3 of this claim "obtaining at the network geographic boundary information within which the location of the remote unit should be disclosed;" is not disclosed by Schipper. Shipper, as indicated in the rejection, simply obtains geographic boundary information within which a mobile remote unit is located. It does not obtain and provide to the mobile remote unit geographic boundary information where the mobile should disclose its location. In Applicants invention a mobile may disclose its location only when it is within a boundary prescribed by the network. The network is telling the mobile device to provide location information if within a specified boundary. In this regard only mobile units that are in close proximity to a device that is being tracked would provide their location. Schipper does not teach that and no citing was found in the prior art to suggest that. As a result of the inconsistency in the rejection, all subsequent steps in the claim are valid and the claim should have been allowed.

The amended claim1 clearly shows a method for providing - to a wireless consumer - the location of portable mobile remote units that are maintaining close proximity to the wireless consumer over a period of time defined by the system. As agreed in the last interview, the prior art does no teach that , and the method has been

combined with the original claim 1. Applicant solicits the allowance of this claim from the Office.

- **Claim 2:**

Claim 2 is dependent on claim 1 and should have been allowed in view of the arguments made for the allowance of 1. Furthermore, figure 4 and 5, col 14 lines 15-22, col 15 lines 32-65 does not teach obtaining radii information and calculating angle of inclination as suggested in the rejection.

- **Claim 3:**

Claim 3 is dependent on 1 and should have been allowed in view of the arguments put forth for the allowance of 1. Furthermore the prior art does not teach the steps recited in claim 3. Applicant solicits allowance of this claim.

- **Claim 4**

Claim 4 is clearly not recited in any of the prior art. No exclusion regions are specified within which a remote unit should not provide its location to the network; and no determination is made thereafter to establish if a remote unit is not in an exclusion zone before providing its location to the network. The claim should have been allowed.

- **Claim 5**

The steps in the original claim 5 are not disclosed in the cited prior art. The claim has also been amended to further distinguish from the prior art. In applicant's invention, once a request is received for the location of mobile remote units in a specified area, the area is divided into sub areas and the areas are paged recursively, starting with the closest, until a mobile remote unit responds with location information. The prior art does not teach that and the claim should be allowed. Figure 2-4, col 10 line 61-65, col 13 lines 35-65 and col 14 lines 1-14 does not teach the above as suggested in the rejection.

Steps (i) thru (v) in the newly amended claim 5 are not disclosed in the prior art.

- **Claim 6**

Claim 6 recites a technique that is utilized to terminate a request for the location information of mobile remote units within a prescribed geographic boundary. The claim recites ensuring that, all redefined sub-regions in the prescribed geographic boundary are paged for remote unit location in the sub region before the requests are terminated. Also, if a remote unit in any of the sub-regions responds with location information then the process is aborted. The prior art does not suggest that, and no matter was actually cited in the rejection to refute this claim. This claim should be allowed.

- **Claim 7 is withdrawn**

- **Claim 8 is withdrawn**

- **Claim 9**

Claim 9 recites a method to determine if a mobile device has traveled a minimum pre-specified distance while maintaining close proximity to another. As agreed in the last interview, the prior art does not remotely suggest this. Also no relevant passage was cited in the rejection to refute this claim, the claim should be allowed. The claim is now amended to distinguish patentably over the prior art.

- **Claim 10**

Claim 10 is dependent on 9 and further teaches a method to determine if a device is being tracked by another by retaining a list of all location reporting devices within proximity of the tracked device at intervals over a tracking period. None of the prior art teaches that. The claim should have been allowed.

- **Claim 11**

Claim 11 also teaches a way to find mobile devices that are tracking another over a period of time for use in the method described in 9. The prior art does not teach that and no relevant passage was shown in the rejection to refute this claim. The claim should be allowed.

- **Claim 12**

Claim 12 defines a system to be used to determine if a mobile device capable of providing its location information to a network, maintained close proximity to another such device over a period of time. The prior art does not teach that and the rejection did

not cite any relevant passage from the prior art to refute this claim. Applicant maintains the claim is patentable over the prior art and solicits its allowance.

- **Claim 13**

Claim 13 is dependent on claim 12 and should be allowed in view of that. Furthermore the prior art fails to teach what is recited in claim 13. There is no unit provided in the prior art that can invoke a method to determine if a clandestine unit is tracking it as recited in the claim.

- **Claim 14**

Claim 14 teaches a system that has means to provide the location of a mobile remote unit if it is determined that the mobile remote unit is within a prescribed geographic boundary defined by the system. As discussed in the last interview, the ability to determine that a unit of the system is being tracked by another has been added as a limitation to claim 14 to clearly distinguish this claim from the prior art. Schipper does not teach what is recited in the claim. Applicant request that the claim be allowed.

- **Claim 15**

The mobile remote unit as shown in Schipper's invention or any of the cited prior art cannot determine if they have been excluded from providing their location when a request for location is made in an area where they reside. No relevant passage in any of the cited art was presented and applicant solicit that the claim be allowed. Furthermore claim 15 is dependent on claim 14 and should be allowed in view of that.

FROM :

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Jan. 23 2002 03:10AM P16

- **Claim 16**

Claim 16 recites providing means at the mobile remote unit of claim 15 to provide its location to the network as requested. This claim was rejected under 35 USC 103 (a) as being obvious over Shipper in view of Rubin. It should be noted that neither patents suggest any combination as specified in the rejection. Also the mobile remote unit as described by Schipper does not divulge its location information to the network if it is within a velocity specified by the network. The claim should also be allowed in view of the argument made for the allowance of claim 15.

- **Claim 17 –19 have been withdrawn**

MARKED UP CLAIMS SHOWING CHANGES

1. A method for providing the location of a portable mobile remote unit in a geographic region to a wireless consumer requesting the location of portable mobile remote units that are maintaining close proximity to the wireless consumer in the geographic region associated with a network comprising:

i) obtaining the location of the wireless consumer -remote unit at intervals over a period of time;

ii) -obtaining requesting at each interval at the network that all mobile remote units within close proximity of the wireless consumer disclose their location to the network geographic boundary information within which the location of the remote unit should be disclosed;

iii) maintaining a list of mobile remote units that provided their location at each interval after the request of (ii) determining whether the remote unit is within the said geographic boundary obtained at the network;;

iv) from the said list of (iii), forwarding the location of the at least a mobile remote unit to the network mobile consumer upon determination that the remote unit maintained close proximity to the mobile consumer over the said period of time of (i) is within the said geographic boundary.

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 03:11AM P18

2. The said technique employed by the method of claim 1 to determine if a mobile remote unit is within a prescribed geographic boundary or within close proximity of a wireless consumer comprising:

obtaining radii information of the said geographic boundary from the network;

obtaining geographic information describing the origin of the said geographic boundary;

calculating the angle of inclination of the said remote unit to the said geographic boundary origin;

calculating from the said angle of inclination the distance between the remote unit and the said geographic boundary origin;

comparing the said radii of the geographic boundary to the said calculated distance to establish if the remote unit lies in the said geographic boundary .

3. A technique employed by the method according to claim 1 to determine if a remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:

obtaining from the network geographic information describing the said geographic boundary;

estimating at the remote unit if the current location of the remote unit is within the said geographic boundary obtained at the network;

5. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless consumer requesting that information comprising:

i) receiving at the network a wider than normal prescribed geographic boundary to query for mobile remote units from the wireless consumer;

ii) splitting the said geographic boundary of (i) into sub geographic regions to constitute re-defining at least a geographic region in the said prescribed geographic boundary;

iii) requesting in the said re-defined sub geographic region(s), the location of remote units that are present in each sub region;

iv) verifying after each request of (iii) in a re-defined sub region whether at least a portable remote unit disclosed a global location in the region;

v) maintaining a list of all remote units that disclosed their location after each request from the verification of step (iv) ;

vi) providing to the network upon said verification, and from the said list of (v) the location of at least a remote unit that revealed its location in the said re-defined sub region.

6. A technique according to claim 5, utilized to terminate a request for the location information of remote units in the said prescribed geographic boundary comprising:

checking to establish that a request for remote unit location information was undertaken in all re-defined or sub regions of the said prescribed boundary or a portable remote unit in a defined or sub region responded with location information.

7. ~~In a communication system comprising:~~

~~at least a first communication unit able to provide location information to the network;~~

~~at least a second communication unit able to request for the location of a first communication unit present within a geographic boundary prescribed by the at least second communication unit;~~

~~the system able to obtain and provide the location information of the at least first communication unit that is if within the prescribed geographic boundary defined by the at least second communication unit.~~

8. ~~The system of claim 7 the at least first communication unit, able to provide first communication unit location information if it is within a geographic boundary prescribed by the at least second communication unit;~~

9. A method for determining that a first portable remote unit associated with a network is being tracked by at least a second portable remote unit over a tracking period comprising;

obtaining the location of the said first portable remote unit or tracked unit;

obtaining the location of the at least a second communication unit or tracking unit that is within proximity or a pre-specified radius of the said tracked unit;

verifying whether the tracking and tracked unit(s) have traveled a minimum pre-specified distance over the tracking period;

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 03:12AM P21

forwarding the result of the said verification to the network at the end of the tracking period.

12. A communication system comprising:

a network of communication units;

at least a first communication unit and at least a second communication unit able to provide their location information to the said network;

the system able to determine and report that the at least second communication unit maintained a close proximity to distance from the at least first communication unit while traveling a minimum pre-specified distance over a period of time;

14. A portable mobile remote unit associated with a network communication system comprising:

a portable mobile remote unit;

means to obtain the location of the portable mobile remote unit;

means to obtain geographic boundary information in order to disclose a global location at the network;

means to provide the location of the portable mobile remote unit to the network upon determination that the portable mobile remote unit is within the said geographic boundary obtained at the network;

means to determine and report to the system upon request that, another mobile remote unit of the network has tracked the said portable mobile remote over a period of time;

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 03:12AM P22

16. The portable remote unit of claim 15 having means to establish provide its velocity to at the network and having means to further determine ~~it~~ that its velocity is within the network's prescribed velocity before divulging its location to the network

~~17. A communication system comprising:~~

~~at least a first communication and a second communication unit;~~

~~the at least first communication unit able to request for the location of the at least second communication unit;~~

~~the at least second communication unit able to provide second communication unit location information to the at least first communication;~~

~~18. The system of claim 17 the at least a first communication able to provide geographic boundary information for location disclosure by the at least second communication unit;~~

19. The system of claim 17 the at least second communication able to provide its location information to the at least first communication unit if it is within the geographic boundary for location disclosure specified by the at least first communication

20. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing geographic boundary information to mobile remote units in a geographic region to disclose their location;
- ii) further providing exclusion region information associated with said geographic boundary of (i) to mobile remote units in the said geographic region;
- iii) determining that a mobile remote unit is in the said geographic boundary of (i) and not in the said exclusion region of (ii) before providing the location of the mobile remote unit to the network;

21. A method utilized to provide to a source of request, the location of a mobile remote units that exist in a geographic region from the said list according to claim 5 comprising:

- iii) estimating and obtaining from the said list, the location mobile remote units that are closer to the source of request;
- iv) providing the information obtained in (i) to the source of request before releasing the location of other mobile remote units that are further from the source of request;

22. A method for providing the location of a portable remote unit that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing to remote units in the said geographic boundary velocity information required in order to divulge location information;
- iv) estimating at the remote unit or network, the velocity at which the remote unit is moving;
- v) validating that the estimated velocity of the remote unit meets the velocity

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 03:13AM P24

requirement provided by the network (i) if yes, forwarding the location of the remote unit to the network;

23. A technique utilized in the method according to claim 1, to terminate requesting at each interval, for the location of mobile remote units within close proximity of the wireless consumer comprising:

i) keeping track of the time since the first request for tracking units within proximity of the wireless consumer was enacted by the system;

iii) validating that the elapsed time at each interval when a request is to be made does not exceed the total time set for establishing tracking in the system;

iv) requesting that all mobile remote units within close proximity of the wireless consumer divulge their location if the result of the validation of (iii) is true;

FROM :

PHONE NO. : 3105598133

Jan. 23 2002 04:52AM P2

Conclusion

Applicant have shown that the amended , existing and new claims are patentable over the prior art. Applicant solicits the allowance of these claims from the Office.

Respectfully



Mundi Fomukong

(Applicant).

01/23/2002

24

Received from < 3105598133 > at 1/23/02 3:41:56 PM [Eastern Standard Time]

FROM :

PHONE NO. : 3105598133

Mar. 04 2002 11:01PM P1

AMENDMENT
FOR
APPLICATION : US 09/753,178
EXAMINER: VAN TRIEU
ART UNIT : 2632
FAX: (703) 872 9314
PHONE: (703) 308 5220

Received from < 3105598133 > at 3/5/02 10:15:55 AM [Eastern Standard Time]

FROM :

PHONE NO. : 3105598133

Mar. 04 2002 11:01PM P2

THE U.S. PATENT AND TRADEMARK OFFICE

Application Number: 09/753,178

Applicant: Mundi Fomukong

Examiner: Van Trieu

Art Unit: 2632

Method of Transmission: Fax

Number of pages excluding cover page: 5

#6/B
TLR
3/7/02
Official suppl.
3-4-03
RECEIVED

I) Supplemental Amendment

Commissioner for Patents and Trademarks
Washington, District of Columbia, 20231

Sir:

Claim 2 and 3 were amended in applicant's response to the first office communication for the above case, faxed to the office on 01/23/2002. In a phone conversation on Feb. 04, 2002, the Examiner indicated that, the amendments for these claims were not entered as they did not conform to PTO standards. It was suggested that applicant resubmit claim 2 and 3 in a new amendment document.

In view of the, above, kindly amend claim 2 and 3 of the application as indicated below.

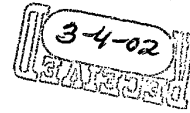
Marked up version of the claims have also been included.

FROM :

PHONE NO. : 3105598133

Official

Mar. 04 2002 11:02PM P3



72

Replace claim 2 as follows:

2. The said technique employed by the method of claim 1 to determine if a mobile remote unit is within a prescribed geographic boundary or within close proximity of a wireless consumer comprising:

obtaining radii information of the said geographic boundary from the network;

obtaining geographic information describing the origin of the said geographic boundary;

calculating the angle of inclination of the said remote unit to the said geographic boundary origin;

calculating from the said angle of inclination the distance between the remote unit and the said geographic boundary origin;

comparing the said radii of the geographic boundary to the said calculated distance to establish if the remote unit lies in the said geographic boundary.

Replace claim 3 as follows:

3. A technique employed by the method according to claim 1 to determine if a mobile remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:

obtaining from the network geographic information describing the said geographic boundary;

estimating at the remote unit if the current location of the remote unit is within the said geographic boundary obtained at the network;

MARKED UP CLAIMS SHOWING CHANGES

2. The said technique employed by the method of claim 1 to determine if a mobile remote unit is within a prescribed geographic boundary or within close proximity of a wireless consumer comprising:

obtaining radii information of the said geographic boundary from the network;

obtaining geographic information describing the origin of the said geographic boundary;

calculating the angle of inclination of the said remote unit to the said geographic boundary origin;

calculating from the said angle of inclination the distance between the remote unit and the said geographic boundary origin;

comparing the said radii of the geographic boundary to the said calculated distance to establish if the remote unit lies in the said geographic boundary .

3. A technique employed by the method according to claim 1 to determine if a mobile remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:

obtaining from the network geographic information describing the said geographic boundary;

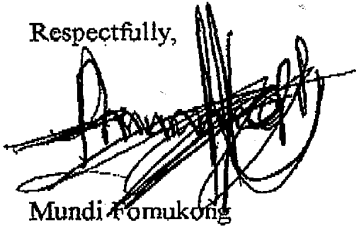
estimating at the remote unit if the current location of the remote unit is within the said geographic boundary obtained at the network;

FROM :

PHONE NO. : 3105598133

Mar. 04 2002 11:02PM P5

Respectfully,

A handwritten signature in black ink, appearing to be 'Mundi Komukong', written over a horizontal line.

Mundi Komukong

(Applicant).

Feb/06/2002

L Number	Hits	Search Text	DB	Time stamp
1	886595	(portable or mobile or mov\$5) near5 (location or position or site or geographic)	USPAT; EPO; JPO; DERWENT	2002/03/29 10:44
6	19490	((portable or mobile or mov\$5) near5 (location or position or site or geographic)) near4 (track\$3 or monitor\$3)	USPAT; EPO; JPO; DERWENT	2002/03/29 10:46
11	127240	(region or area or geographic or boundary) near3 (exist\$3 or predetermined or preselected or prescribed)	USPAT; EPO; JPO; DERWENT	2002/03/29 10:50
16	987	((portable or mobile or mov\$5) near5 (location or position or site or geographic)) near9 ((region or area or geographic or boundary) near3 (exist\$3 or predetermined or preselected or prescribed))	USPAT; EPO; JPO; DERWENT	2002/03/29 10:50
21	35510	(maintain\$3 or proximity or distance) near4 ((period or short or amount or certain) near2 time)	USPAT; EPO; JPO; DERWENT	2002/03/29 10:54
26	170435	(transmit\$4 or forward\$3 or send\$3) near4 (location or position)	USPAT; EPO; JPO; DERWENT	2002/03/29 10:58
31	39	((transmit\$4 or forward\$3 or send\$3) near4 (location or position)) with ((maintain\$3 or proximity or distance) near4 ((period or short or amount or certain) near2 time))	USPAT; EPO; JPO; DERWENT	2002/03/29 10:58
36	0	((portable or mobile or mov\$5) near5 (location or position or site or geographic)) near9 ((region or area or geographic or boundary) near3 (exist\$3 or predetermined or preselected or prescribed))) and (((transmit\$4 or forward\$3 or send\$3) near4 (location or position)) with ((maintain\$3 or proximity or distance) near4 ((period or short or amount or certain) near2 time)))	USPAT; EPO; JPO; DERWENT	2002/03/29 10:59
41	3	((transmit\$4 or forward\$3 or send\$3) near4 (location or position)) with ((maintain\$3 or proximity or distance) near4 ((period or short or amount or certain) near2 time))) and ((region or area or geographic or boundary) near3 (exist\$3 or predetermined or preselected or prescribed))	USPAT; EPO; JPO; DERWENT	2002/03/29 11:04
46	23	((transmit\$4 or forward\$3 or send\$3) near4 (location or position)) with ((maintain\$3 or proximity or distance) near4 ((period or short or amount or certain) near2 time))) and ((portable or mobile or mov\$5) near5 (location or position or site or geographic))	USPAT; EPO; JPO; DERWENT	2002/03/29 11:11
51	18	((portable or mobile or mov\$5) near5 (location or position or site or geographic)) near9 ((region or area or geographic or boundary) near3 (exist\$3 or predetermined or preselected or prescribed))) and (sub near2 (region or area or geographic))	USPAT; EPO; JPO; DERWENT	2002/03/29 11:12

US 6263208 B1	USPAT	Geolocation estimatio	455/456	342/357.02; 455/426
US 5657487 A	USPAT	Mobile telephone loca	455/456	340/995; 342/457; 455/440; 455/441; 701/
US 6351305 B1	USPAT	Exposure apparatus a	355/77	355/53; 355/55; 355/67; 356/399; 356/400
US 6239803 B1	USPAT	Method to achieve lea	345/810	345/834
US 6115501 A	USPAT	Grid moving method f	382/250	358/433; 382/173; 382/295
US 5917949 A	USPAT	Compaction/motion e	382/236	348/384.1; 382/107; 382/243
US 5903670 A	USPAT	Grid moving apparatu	382/232	358/433; 382/250; 382/295
US 5892849 A	USPAT	Compaction/motion e	382/236	382/243; 382/250
US 5869962 A	USPAT	Magnetic detection ap	324/207.2	324/207.2; 324/207.25
US 5499225 A	USPAT	Optical recording metl	369/53.24	
US 5172157 A	USPAT	Automatic light adjust	396/157	396/274
US 5073771 A	USPAT	Control method of zoc	345/667	345/163; 345/661; 345/973
US 5003151 A	USPAT	Method and control ar	219/121.17	219/121.16; 219/121.35
US RE32633 E	USPAT	Cursor control device	345/165	178/18.01; 345/810; 345/856
US RE32632 E	USPAT	Display system	345/165	345/810; 345/856
US 4464652 A	USPAT	Cursor control device	345/165	345/810; 345/856; 74/471XY
JP 08307930 A	JPO	BASE STATION DEVICE FOR MOBILE COMMUNICATION SYSTEM		
JP 63249868 A	JPO	IMAGE FORMING DEVICE		399/377

L 51

US 4232317 A	Quantized hyperbolic	342/464	
US 4658357 A	Time and accounting	705/32	235/380; 340/531; 340/539
US 4371255 A	Electrophotographic c	399/195	399/205; 399/389

L 41

1/30/02

L1 75869 (location or position) near4 (mobile or remot\$3 or portable or transceiver or transponder)
L2 5302 1 near5 (detect\$3 or track\$3 or monitor\$3)
L3 22307 (proximity or clos\$3) near7 (mobile or remot\$3 or portable or transceiver or transponder)
L4 743 3 near4 (region or area or geographic)
L5 24 2 and 4 and (period or intermittent\$2)
L6 261 (request\$3 or quer\$4 or ask\$3) near5 (mobile or remot\$3 or portable or transceiver or tra
L7 1 5 and 6
L8 0 5 and (all near2 (mobile or remot\$3 or portable or transceiver or transponder))
L9 11748 (adjacent or near\$2) near3 (mobile or remot\$3 or portable or transceiver or transponde
L10 7 5 and 9
L11 1108 proximity near3 (mobile or remot\$3 or portable or transceiver or transponder)
L12 9 5 and 11
L13 97630 (two or second) near3 (mobile or remot\$3 or portable or transceiver or transponder or c
L14 96135 (location or position) near4 (mobile or remot\$3 or portable or transceiver or transponder
L15 30472 (proximity or clos\$3) near4 (mobile or remot\$3 or portable or transceiver or transponder
L16 11 (maintain\$3 or track\$3 or monitor\$3) near4 (proximity or adjacent) near4 (mobile or rem
L17 1 13 and 14 and 15 and 16
L18 5947 14 near5 (detect\$3 or track\$3 or monitor\$3)
L19 690 15 near4 (region or area or geographic)
L20 16 18 and 19 and period
L21 420 (request\$3 or quer\$4 or ask\$3) near5 (mobile or remot\$3 or portable or transceiver or tra
L22 0 13 and 20 and 21
L23 6 13 and 20
L24 6 5 and 20 and (boundary or edge)
L25 275 13 and 21
L26 0 20 and 21
L27 1 5 and 21

)

)

ansponder) near4 (proximity or region or area)

r)

ommunication)

or communication)

or communication)

not\$3 or portable or transceiver or transponder or communication) near4 (period or time)

ansponder or communication) near4 (proximity or region or area)

US 5959577 A	Method and structure 342/357.1; 701/208
US 5944659 A	Architecture for TDMA 600/300 128/903
US 5870029 A	Remote mobile monit 340/825.3; 340/573.1; 340/825.49; 379/38
US 5691980 A	Local communication 370/316 340/989; 340/992; 342/457
US 5608412 A	Protocol and mechani 342/457 342/463; 455/517
US 6333703 B1	Automated traffic ma 340/995 340/905; 340/989; 380/271; 701/117; 701/118; 701/1
US 6125286 A	Communication devic 455/566 379/433.04; 455/90
US 5959575 A	Interior GPS navigatic 342/357.0; 701/213
US 5884224 A	Mobile mounted remo 702/2 700/284
US 5839067 A	Corporate communic 455/422 379/201.02; 455/418; 455/445; 455/461; 455/561
US 5769032 A	Method and apparatu 119/721 119/908; 340/573.3; 340/573.4
US 5668739 A	System and method fr 382/103 342/118; 342/159
US 5621417 A	Method and mechanis 342/457 342/463
US 5587929 A	System and method fr 342/159 342/118; 382/103
US 5585575 A	Explosive detection sc 73/863.71 73/23.2; 73/23.33; 73/863.21; 73/864.33
US 5465607 A	Explosive detection sc 73/23.36 250/282; 250/286; 436/106; 73/31.02
US 5345809 A	Explosive detection sc 73/23.2 250/286; 250/287; 250/288; 73/863.12
US 5133935 A	Test area for preventi 422/61 348/152; 4/661; 422/100; 422/102; 436/174; 436/180
US 4992866 A	Camera selection and 348/159 340/3.71; 340/825.49; 348/153; 348/218; 348/705
US 4764757 A	Security detection anc 340/574 340/539; 340/693.1; 379/40
US 4689610 A	Access control and se 340/515 340/528; 340/541
US 4633231 A	Monitoring arrangeme 340/539 340/307; 340/309.15; 455/95
US 3735353 A	ALARM TRANSMISS 340/825.3; 340/518; 340/534; 340/541
US 3644788 A	REMOTE PROTECTI 361/80

119; 701/213

); 436/901; 52/33; 52/34; 600/562; 600/573; 600/584

L1	67877 (monitor\$3 or track\$3) near7 (person or object or individual or portable or vehic
L2	280910 (obtain\$3 or determin\$3 or defin\$3) near4 (location or position)
L3	248307 (obtain\$3 or determin\$3 or defin\$3) near4 (geographic or boundary or region or
L4	4663 1 and 2 and 3
L5	200742 (within or inside) near3 (boundary or region or area)
L6	21525 5 near5 (determin\$3 or defin\$3)
L7	1455 6 same (transmit\$4 or send\$3 or forward\$3)
L8	108 4 and 7
L9	23 8 and (radius or radii)
L10	18593 (calculat\$3 or comput\$3) near4 (inclination or angle)
L11	4 9 and 10
L12	4 11 and distance
L13	69651 (chang\$3 or re-defin\$3 or adjust\$3) near4 (region or area or boundary)
L14	270 13 with (request\$3 or inquir\$3)
L15	0 12 and 14
L16	0 9 and 14
L17	0 8 and 14
L18	11 4 and 14
L19	0 18 and 10
L20	2070 (2 or 3) near7 (request\$3 or inquir\$3)
L22	1 20 and 12
L23	3 20 and 9

US 5977913 A	Method and apparatus for tracking and locating pe342/465	340/825.36
US 5949350 A	Location method and apparatus	340/825.49340/539 ; 340/573.3 ; 3
US 5892855 A	Apparatus for detecting an object located ahead o382/291	348/119 ; 348/149 ; 38
US 5960097 A	Background adaptive target detection and tracking382/103	342/357.07 ; 382/107 ;

L12

US 5669061 A	Automatic cellular phone tracking	455/429	342/357.1 ; 455/440
US 6256773 B1	System, method and article of manufacture for co	717/1	707/203 ; 717/11
US 6198930 B1	Automatic cellular phone tracking	455/440	342/357.07 ; 342/357.1
US 6119000 A	Method and apparatus for tracking identity-code c	455/432	455/435 ; 455/456
US 6038444 A	Method and apparatus for advising cellphone user	455/421	455/440 ; 455/441 ; 45
US 5884175 A	Handover following in a mobile radio system	455/436	455/525 ; 455/67.1
US 5825432 A	Communication apparatus image processing appa	348/563	348/153 ; 348/159
US 5553285 A	File system for a plurality of storage classes	707/202	711/100 ; 714/44 ; 714
US 5291188 A	Method and apparatus for allocating off-screen dis	345/543	
US 5107443 A	Private regions within a shared workspace	345/751	345/759 ; 345/803 ; 34
US 4993030 A	File system for a plurality of storage classes	714/6	714/763 ; 714/777

L18

US 5960097 A	Background adaptive target detection and tracking	382/103	342/357.07 ; 382/107 ;
US 5517690 A	Adaptive cellular paging system with selectively a	455/426	340/7.27 ; 340/7.28 ; 3
US 5423056 A	Adaptive cellular paging system	455/458	455/12.1 ; 455/454 ; 45

L 23

US 6246361 B1	Method and apparatus for determining a geograph	342/357.01
US 5669061 A	Automatic cellular phone tracking	455/429 342/357.1 ; 455/440
US 6252544 B1	Mobile communication device	342/357.1 342/357.06 ; 342/357.1
US 6242907 B1	Apparatus and method of determining the orientat	324/207.17342/462 ; 342/463
US 6198930 B1	Automatic cellular phone tracking	455/440 342/357.07 ; 342/357.1
US 6157621 A	Satellite communication system	370/310 370/394 ; 370/400 ; 37
US 6038444 A	Method and apparatus for advising cellphone user	455/421 455/440 ; 455/441 ; 45
US 5986604 A	Survey coordinate transformation optimization	342/357.12701/213 ; 708/442 ; 70
US 5815118 A	Rubber sheeting of a map	342/451
US 5777580 A	Vehicle location system	342/457
US 5742509 A	Personal tracking system integrated with base sta	701/211 340/990 ; 342/450
US 5736959 A	Earth-fixed cell beam management for satellite co	342/354 342/372 ; 455/13.3
US 5684476 A	Field navigation system	340/988 111/130 ; 221/1 ; 239/1
US 5614913 A	Optimization of survey coordinate transformations	342/357.12
US 5583514 A	Rapid satellite acquisition device	342/359 342/76
US 5581259 A	Life for old maps	342/451 342/357.06 ; 708/442
US 5563606 A	Dynamic mapping apparatus for mobile unit acqui	342/354 342/357.16 ; 455/13.3
US 5418537 A	Location of missing vehicles	342/357.09342/357.14 ; 342/457
US 5408237 A	Earth-fixed cell beam management for satellite co	342/354 342/357.16 ; 455/12.1
US 5404661 A	Method and apparatus for determining the locatio	87/348 37/347 ; 37/905 ; 701/5
US 5075693 A	Primary land arctic navigation system	342/457 701/207 ; 701/213 ; 70

L1 1963 (monitor\$3 or track\$3) near4 (location or position) and GPS
L2 848 1 and (geographic or boundar\$3)
L3 21301 (determin\$3 or defin\$3) near4 velocity
L4 156 2 and 3
L5 679 (determin\$3 or defin\$3) near4 (velocity near2 (information or data))
L6 24 2 and 5

US 6211819 B1	Mobile station location determination in a radio co	342/357.09	342/357.1 ; 342/357.15
US 6181253 B1	Flexible monitoring of location and motion	340/825.37	340/10.1 ; 340/539 ; 34
US 6108365 A	GPS data access system	375/130	340/5.2 ; 725/25
US 6259400 B1	Fast acquisition of GPS signal corrupted by doppl	342/357.06	342/357.05 ; 342/357.1
US 6219594 B1	Landing area obstacle detection radar system	701/16	340/972 ; 342/33 ; 342
US 6195609 B1	Method and system for the control and managem	701/120	342/36 ; 701/117 ; 701
US 6182005 B1	Airport guidance and safety system incorporating	701/120	342/36 ; 701/117 ; 701
US 6127967 A	Low-earth orbit satellite acquisition and synchroniz	342/354	342/356 ; 342/359 ; 45
US 6029111 A	Vehicle navigation system and method using GPS	701/207	701/213 ; 701/214 ; 70
US 6009116 A	GPS TV set top box with regional restrictions	375/130	340/5.74 ; 725/31 ; 725
US 6006158 A	Airport guidance and safety system incorporating	701/120	340/953
US 5991692 A	Zero motion detection system for improved vehicl	701/217	701/213 ; 701/221 ; 73
US 5936570 A	Low-earth orbit satellite acquisition and synchroniz	342/354	342/356 ; 342/359 ; 45
US 5867804 A	Method and system for the control and managem	701/120	340/961 ; 342/36 ; 342
US 5862511 A	Vehicle navigation system and method	701/213	701/208 ; 701/214 ; 70
US 5740047 A	GNSS based, seamless, multi-dimensional contro	701/120	340/961 ; 342/36 ; 342
US 5704546 A	Position-responsive control system and method fo	239/1	239/124 ; 239/146 ; 23
US 5699255 A	Map transmission for in-vehicle navigation system	701/212	340/995 ; 342/450
US 5653389 A	Independent flow rate and droplet size control sys	239/69	239/172
US 5621793 A	TV set top box using GPS	380/240	380/228 ; 380/258
US 5548515 A	Method and system for airport control and manag	701/120	340/961 ; 342/36 ; 342
US 5522567 A	Energy management system for a gliding vehicle	244/3.15	
US 5402347 A	Satellite search methods for improving time to fir	701/213	342/357.15
US 5379224 A	GPS tracking system	701/215	340/989 ; 342/357.09 ;

L6

0/572.1 ; 340/573.1 ; 340/825.49 ; 342/450 ; 379/38

3 ; 701/213

/64 ; 701/208 ; 701/223

/301

/301

5/13.2

1/216 ; 701/221 ; 73/178R

/68

/178R

5/13.2

/456 ; 701/301

1/215 ; 73/178R

/456 ; 701/301

9/69 ; 239/71

/456 ; 701/301

73/178R



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER OF PATENTS AND TRADEMARKS
Washington, D.C. 20231
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/753,178	12/30/2000	Mundi Fomukong		2194

7590

04/02/2002

MUNDI FOMUKONG
10853 ROSE AVE, #49
WLA, CA 90034

EXAMINER

TRIEU, VAN THANH

ART UNIT

PAPER NUMBER

2632

DATE MAILED: 04/02/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

09/753,178

Applicant(s)

FOMUKONG, MUNDI

Examiner

Van T Trieu

Art Unit

2632

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 04 March 2002.
- 2a) ☒ This action is **FINAL**. 2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-6,9-16 and 20-23 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☐ Claim(s) _____ is/are rejected.
- 7) ☒ Claim(s) 1,3,4,10-12,14-16 and 20-23 is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☐ Notice of References Cited (PTO-892) 4) ☐ Interview Summary (PTO-413) Paper No(s). _____
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 5) ☐ Notice of Informal Patent Application (PTO-152)
- 3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ 6) ☐ Other: _____

DETAILED ACTION

Claim Objections

1. Claims 1, 3, 4, 10-12, 14-16 and 20-23 are objected to because of the following informalities:

Claims 1, 3, 4, 12, 14, 15 and 20-23, in the last line, change the semi-column “;” to a period --- . ---;

Claims 10 and 11, each has more than one sentences.

Claim 16 is not terminated by a period.

Appropriate correction is required.

Conclusion

2. Claims 1-6, 9-16 and 20-23 are allowable over the prior arts.
3. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of

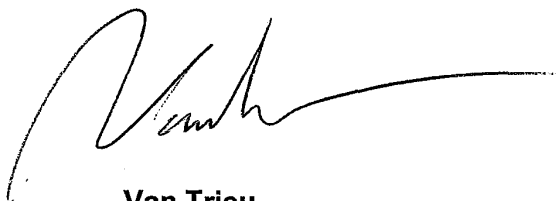
Art Unit: 2632

the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

4. Any inquiry concerning this communication or earlier communications from the examiner should be directed to primary examiner **Van Trieu** whose telephone number is (703) 308-5220. The examiner can normally be reached on Mon-Fri from 7:00 AM to 4:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mr. **Jeffery Hofsass** can be reached on (703) 305-4717.

The office facsimile number is (703) 872-9314.

A handwritten signature in black ink, appearing to read 'Van Trieu', with a long horizontal flourish extending to the right.

Van Trieu
Primary Examiner
Date: 3/29/02

FROM :

PHONE NO. : 3105598133

May. 02 2002 02:42PM P2

THE U.S PATENT AND TRADEMARK OFFICE

Application Number: 09/753,178

Applicant: Mundi Fomukong

Examiner: Van Trieu

Art Unit: 2632

Method of Transmission : Fax

Number of pages excluding cover page: 13

#8645
Official 5-30
Entered
M. H. S. L.
5-8-02
RECEIVED
5-2-02

1) Amendments

1-K -
enter
1/7/02
Commissioner for Patents and Trademarks
Washington, District of Columbia, 20231.

Sir/Madam:

In response to the last Office communication mailed 04/02/2002 for the above application, kindly amend the application as indicated below to overcome the objections that were raised. Marked up version of the claims have also been included.

FROM :

PHONE NO. : 3105598133

May. 02 2002 02:42PM P3



Replace claim 1 as follows:

Sub.D1
1. A method for providing the location of a portable mobile remote unit in a geographic region to a wireless consumer requesting the location of portable mobile remote units that are maintaining close proximity to the wireless consumer in the geographic region comprising:

- C1*
- i) obtaining the location of the wireless consumer at intervals over a period of time;
 - ii) requesting at each interval, at the network, that all mobile remote units within close proximity of the wireless consumer disclose their location to the network;
 - iii) maintaining a list of mobile remote units that provided their location at each interval after the request of (ii);
 - iv) from the said list of (iii), forwarding the location of at least a mobile remote unit to the mobile consumer upon determination that the remote unit maintained close proximity to the mobile consumer over the said period of time of (i).

Replace claim 3 as follows:

Sub.D1
3. A technique employed by the method according to claim 1 to determine if a remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:

- C2*
Cont.
- obtaining from the network geographic information describing the said geographic boundary;
 - estimating at the remote unit if the current location of the remote unit is within the said geographic boundary obtained at the network.

FROM :

PHONE NO. : 3105598133

Official

May. 02 2002 02:43PM P4



[- Replace claim 4 as follows:]

4. A method employed in 1 to further limit the provision of remote unit location to the network comprising:

obtaining at the network, exclusion region information within which the remote unit should not provide its location the network;

determining that the remote unit is not in the said exclusion region before providing the location of the remote unit to the network.

- Replace claim 10 as follows:

10. The verification technique employed in the method of claim 9 comprising:
retaining a tracking list of all tracking units that are within a pre-specified radius or region of the said tracked unit at the first tracking interval;
eliminating or removing at subsequent tracking intervals, all tracking units in the said tracking list that do not report their location during a subsequent tracking interval;
validating at the end of the tracking period that at least a tracking unit exist in the tracking list and a minimum distance was traveled by the tracked unit.

[- Replace claim 11 as follows:]

11. Another verification technique employed in the method of claim 9 comprising:
maintaining a list of all tracking units that are maintaining a close distance to the tracked unit over the said period of time;
searching the tracking list at the end of the tracking period to obtain tracking units that traveled a minimum pre-specified distance with the tracked unit.

[Replace claim 12 as follows:]

12. A communication system comprising:
- a network of communication units;
 - at least a first communication unit and at least a second communication unit able to provide their location information to the said network;
 - the system able to determine and report that the at least second communication unit maintained close proximity to the at least first communication unit over a period of time.

- Replace claim 14 as follows:

14. A communication system comprising:
- a portable mobile remote unit;
 - means to obtain the location of the portable mobile remote unit;
 - means to obtain geographic boundary information in order to disclose a global location at the network;
 - means to provide the location of the portable mobile remote unit to the network upon determination that the portable mobile remote unit is within the said geographic boundary obtained at the network;
 - means to determine and report to the system upon request that, another mobile remote unit of the network has tracked the said portable mobile remote over a period of time.

[- Replace claim 15 as follows:]

15. The portable mobile remote according to claim 14, having means to further determine if location disclosure for the remote unit is prohibited at a specific geographic boundary before sending its location to the network.

[- Replace claim 16 as follows:]

16. The portable remote unit of claim 15 having means to establish its velocity at the network and having means to further determine that, its velocity is within the network's prescribed velocity before divulging its location to the network.

[- Replace claim 20 as follows:]

20. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing geographic boundary information to mobile remote units in a geographic region to disclose their location;
- ii) further providing exclusion region information associated with said geographic boundary of (i) to mobile remote units in the said geographic region;
- iii) determining that a mobile remote unit is in the said geographic boundary of (i) and not in the said exclusion region of (ii) before providing the location of the mobile remote unit to the network.

[- Replace claim 21 as follows:]

21. A method utilized to provide to a source of request, the location of mobile remote units that exist in a geographic region from the said list according to claim 5 comprising:

- (i) estimating and obtaining from the said list, the location mobile remote units that are closer to the source of request;
- (ii) providing the information obtained in (i) to the source of request before releasing the location of other mobile remote units that are further from the source of request.

[- Replace claim 22 as follows:]

22. A method for providing the location of a portable remote unit that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing to remote units in the said geographic boundary velocity information required in order to divulge location information;
- ii) estimating at the remote unit or network, the velocity at which the remote unit is moving;
- iii) validating that the estimated velocity of the remote unit meets the velocity requirement provided by the network (i), if yes, forwarding the location of the remote unit to the network.

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Cant.

[- Replace claim 23 as follows:]

23. A technique utilized in the method according to claim 1, to terminate requesting at each interval, for the location of mobile remote units within close proximity of the wireless consumer comprising;

i) keeping track of the time since the first request for tracking units within proximity of the wireless consumer was enacted by the system;

ii) validating that the elapsed time at each interval when a request is to be made does not exceed the total time set for establishing tracking in the system;

iii) requesting that all mobile remote units within close proximity of the wireless consumer divulge their location if the result of the validation of (ii) is true.

MARKED UP CLAIMS SHOWING CHANGES

1. A method for providing the location of a portable mobile remote unit in a geographic region to a wireless consumer requesting the location of portable mobile remote units that are maintaining close proximity to the wireless consumer in the geographic region comprising:

- i) obtaining the location of the wireless consumer at intervals over a period of time;
- ii) requesting at each interval, at the network, that all mobile remote units within close proximity of the wireless consumer disclose their location to the network;
- iii) maintaining a list of mobile remote units that provided their location at each interval after the request of (ii);
- iv) from the said list of (iii), forwarding the location of at least a mobile remote unit to the mobile consumer upon determination that the remote unit maintained close proximity to the mobile consumer over the said period of time of (i);

3. A technique employed by the method according to claim 1 to determine if a remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:

- obtaining from the network geographic information describing the said geographic boundary;
- estimating at the remote unit if the current location of the remote unit is within the said geographic boundary obtained at the network;

4. A method employed in 1 to further limit the provision of remote unit location to the network comprising:

obtaining at the network, exclusion region information within which the remote unit should not provide its location the network;

determining that the remote unit is not in the said exclusion region before providing the location of the remote unit to the network;

10. The verification technique employed in the method of claim 9 comprising:

retaining a tracking list of all tracking units that are within a pre-specified radius or region of the said tracked unit at the first tracking interval;

eliminating or removing at subsequent tracking intervals, all tracking units in the said tracking list that do not report their location during a subsequent tracking interval;

validating at the end of the tracking period that at least a tracking unit exist in the tracking list and a minimum distance was traveled by the tracked unit.

11. Another verification technique employed in the method of claim 9 comprising:

maintaining a list of all tracking units that are maintaining a close distance to the tracked unit over the said period of time;

searching the tracking list at the end of the tracking period to obtain tracking units that traveled a minimum pre-specified distance with the tracked unit.

12. A communication system comprising:

a network of communication units;

at least a first communication unit and at least a second communication unit able to provide their location information to the said network;

the system able to determine and report that the at least second communication unit maintained close proximity to the at least first communication unit over a period of time;

14. A communication system comprising:

a portable mobile remote unit;

means to obtain the location of the portable mobile remote unit;

means to obtain geographic boundary information in order to disclose a global location at the network;

means to provide the location of the portable mobile remote unit to the network upon determination that the portable mobile remote unit is within the said geographic boundary obtained at the network;

means to determine and report to the system upon request that, another mobile remote unit of the network has tracked the said portable mobile remote over a period of time;

15. The portable mobile remote according to claim 14, having means to further determine if location disclosure for the remote unit is prohibited at a specific geographic boundary before sending its location to the network;

16. The portable remote unit of claim 15 having means to establish its velocity at the network and having means to further determine that, its velocity is within the network's prescribed velocity before divulging its location to the network.

20. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing geographic boundary information to mobile remote units in a geographic region to disclose their location;
- ii) further providing exclusion region information associated with said geographic boundary of (i) to mobile remote units in the said geographic region;
- iii) determining that a mobile remote unit is in the said geographic boundary of (i) and not in the said exclusion region of (ii) before providing the location of the mobile remote unit to the network.

21. A method utilized to provide to a source of request, the location of a mobile remote units that exist in a geographic region from the said list according to claim 5 comprising:

- (i) estimating and obtaining from the said list, the location mobile remote units that are closer to the source of request;
- (ii) providing the information obtained in (i) to the source of request before releasing the location of other mobile remote units that are further from the source of request.

22. A method for providing the location of a portable remote unit that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing to remote units in the said geographic boundary velocity information required in order to divulge location information;
- iv) estimating at the remote unit or network, the velocity at which the remote unit is moving;
- v) validating that the estimated velocity of the remote unit meets the velocity requirement provided by the network (i) ,if yes, forwarding the location of the remote unit to the network;

23. A technique utilized in the method according to claim 1, to terminate requesting at each interval, for the location of mobile remote units within close proximity of the wireless consumer comprising;

- i) keeping track of the time since the first request for tracking units within proximity of the wireless consumer was enacted by the system;
- iii) validating that the elapsed time at each interval when a request is to be made does not exceed the total time set for establishing tracking in the system;
- iiiiv) requesting that all mobile remote units within close proximity of the wireless consumer divulge their location if the result of the validation of (iii) is true;

FROM :

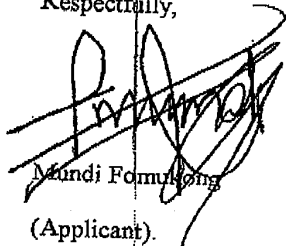
PHONE NO. : 3105598133

May. 02 2002 02:47PM P14

Conclusion

Applicant have amended the existing claims to overcome the objections raised in the last office communication.. Applicant solicits the allowance of these claims from the Office.

Respectfully,



Mundi Formulating
(Applicant).

04/30/2002

FROM :

PHONE NO. : 3105598133

May. 12 2002 04:03PM P1

CLAIM AMENDMENTS
FOR
APPLICATION : US 09/753,178
EXAMINER: VAN TRIEU
ART UNIT : 2632
FAX: (703) 872 9314
PHONE: (703) 308 5220

Received from < 3105598133 > at 5/13/02 5:05:22 AM [Eastern Daylight Time]

FROM :

PHONE NO. : 3105598133

May. 02 2002 02:42PM P1

RESPONSE TO FINAL OFFICE ACTION

FOR

APPLICATION : US 09/753,178

EXAMINER: VAN TRIEU

ART UNIT : 2632

FAX: (703) 872 9314

PHONE: (703) 308 5220

Received from < 3105598133 > at 5/3/02 3:36:47 AM [Eastern Daylight Time]

Petitioner Uber Ex-1004, 0328

FROM :

PHONE NO. : 3105598133

Official

May. 02 2002 02:43PM P4



TL

[- Replace claim 4 as follows:]

4. A method employed in 1 to further limit the provision of remote unit location to the network comprising:

obtaining at the network, exclusion region information within which the remote unit should not provide its location the network;

determining that the remote unit is not in the said exclusion region before providing the location of the remote unit to the network.

- Replace claim 10 as follows:

10. The verification technique employed in the method of claim 9 comprising:

retaining a tracking list of all tracking units that are within a pre-specified radius or region of the said tracked unit at the first tracking interval;

eliminating or removing at subsequent tracking intervals, all tracking units in the said tracking list that do not report their location during a subsequent tracking interval;

validating at the end of the tracking period that at least a tracking unit exist in the tracking list and a minimum distance was traveled by the tracked unit.

[- Replace claim 11 as follows:]

11. Another verification technique employed in the method of claim 9 comprising:

maintaining a list of all tracking units that are maintaining a close distance to the tracked unit over the said period of time;

searching the tracking list at the end of the tracking period to obtain tracking units that traveled a minimum pre-specified distance with the tracked unit.

FROM :

PHONE NO. : 3105598133

May. 12 2002 04:04PM P2

THE U.S PATENT AND TRADEMARK OFFICE

Application Number: 09/753,178

Applicant: Mundi Fomukong

Examiner: Van Trieu

Art Unit: 2632

Method of Transmission : Fax

Number of pages excluding cover page: 18

9/10
N.E.
Aug
5/13
Entered
Official
DECEMBER
5-12-02
5-16-02

1) Amendments

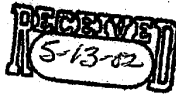
Commissioner for Patents and Trademarks

Washington, District of Columbia, 20231.

Sir/Madam:

In relation to the phone interview of May 10, 2002, with the Examiner, kindly amend the claims of the above application as indicated below. Marked up version of the claims have also been included.

OK.
to enter
5/15/02



Replace claim 1 as follows:

1. A method for providing the location of a portable mobile remote unit in a geographic region of a wireless network to a wireless consumer requesting the location of portable mobile remote units that are maintaining close proximity to the wireless consumer in the geographic region comprising:

- i) obtaining the location of the wireless consumer at intervals over a period of time;
- ii) requesting at each interval, at the network, that all mobile remote units within close proximity of the wireless consumer disclose their location to the network;
- iii) maintaining a list of mobile remote units that provided their location at each interval after the request of (ii);
- iv) from the list of (iii), forwarding the location of at least a mobile remote unit to the mobile consumer upon determination that the remote unit maintained close proximity to the mobile consumer over the period of time of (i).

D1
Cont

[E] Replace claim 2 as follows:

2. A technique according to claim 1, utilized to determine if a mobile remote unit is within a prescribed geographic boundary or within close proximity of a wireless consumer comprising:

- obtaining radii information of the geographic boundary from the network;
- obtaining geographic information describing the origin of the geographic boundary;

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FROM :

PHONE NO. : 3105598133

1010

May. 12 2002 04:05PM P4

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5-13-02

calculating the angle of inclination of the remote unit to the geographic boundary origin;

calculating from the angle of inclination the distance between the remote unit and the geographic boundary origin;

comparing the radii of the geographic boundary to the calculated distance to establish if the remote unit lies in the geographic boundary .

E Replace claim 3 as follows:

3. A technique employed by the method according to claim 1 to determine if a remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:

obtaining from the network geographic information describing the geographic boundary;

estimating at the remote unit if the current location of the remote unit is within the geographic boundary obtained at the network.

E Replace claim 4 as follows:

4. A method according to claim 1 utilized to further limit the provision of remote unit location to the network comprising:

obtaining at the network, exclusion region information within which the remote unit should not provide its location the network;

determining that the remote unit is not in the exclusion region before providing the location of the remote unit to the network.

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D

Replace claim 5 as follows:

6 E
A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless consumer requesting that information comprising:

- 21
could
- i) receiving at the network a wider than normal prescribed geographic boundary to query for mobile remote units from the wireless consumer;
 - ii) splitting the geographic boundary of (i) into sub geographic regions to constitute the prescribed geographic boundary;
 - iii) requesting in the sub geographic region(s), the location of remote units that are present in each sub region;
 - iv) verifying after each request of (iii) in a sub region whether at least a portable remote unit disclosed a global location in the region;
 - v) maintaining a list of all remote units that disclosed their location after each request from the verification of step (iv);
 - vi) providing to the network and from the list of (v) the location of at least a remote unit that revealed its location in the sub region.

Replace claim 6 as follows:

7 E
A technique according to claim 5, utilized to terminate a request for the location information of remote units in the prescribed geographic boundary comprising:

checking to establish that a request for remote unit location information was undertaken in all re-defined or sub regions of the prescribed boundary or a portable remote unit in a defined or sub region responded with location information.

Replace claim 9 as follows:

9. A method for determining that a first portable remote unit associated with a network is being tracked by at least a second portable remote unit over a tracking period comprising;

obtaining the location of the first portable remote unit or tracked unit;

obtaining the location of the at least a second communication unit or tracking unit that is within proximity or a pre-specified radius of the tracked unit;

verifying whether the tracking and tracked unit(s) have traveled a minimum pre-specified distance over the tracking period;

forwarding the result of the verification to the network at the end of the tracking period.

Replace claim 10 as follows:

10. The verification technique employed in the method of claim 9 comprising:

retaining a tracking list of all tracking units that are within a pre-specified radius or region of the tracked unit at the first tracking interval;

eliminating or removing at subsequent tracking intervals, all tracking units in the tracking list that do not report their location during a subsequent tracking interval;

validating at the end of the tracking period that at least a tracking unit exist in the tracking list and a minimum distance was traveled by the tracked unit.

[- Replace claim 11 as follows:]

11. Another verification technique employed in the method of claim 9 comprising:
- maintaining a list of all tracking units that are maintaining a close distance to the tracked unit over the period of time;
- searching the tracking list at the end of the tracking period to obtain tracking units that traveled a minimum pre-specified distance with the tracked unit.

[- Replace claim 12 as follows:]

12. A communication system comprising:
- a network of communication units;
- at least a first communication unit and at least a second communication unit able to provide their location information to the network;
- the system able to determine and report that the at least second communication unit maintained close proximity to the at least first communication unit over a period of time.

[- Replace claim 13 as follows:]

13. The system of claim 12, the at least first communication unit able to invoke a tracking mode at the at least first communication unit in order to determine if a clandestine unit is tracking it.

[- Replace claim 14 as follows:]

14. A communication system comprising:

a portable mobile remote unit;

a network of communication units;

means to obtain the location of the portable mobile remote unit;

means to obtain geographic boundary information in order to disclose a global location at the network;

means to provide the location of the portable mobile remote unit to the network upon determination that the portable mobile remote unit is within the geographic boundary obtained at the network;

means to determine and report to the system upon request that, another mobile remote unit of the network has tracked the portable mobile remote over a period of time.

[- Replace claim 15 as follows:]

15. The portable mobile remote according to claim 14, having means to further determine if location disclosure for the remote unit is prohibited at a specific geographic boundary before sending its location to the network.

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D

[- Replace claim 16 as follows:]

16. The portable remote unit of claim 15 having means to establish its velocity at the network and having means to further determine that, its velocity is within the network's prescribed velocity before divulging its location to the network.

[- Replace claim 20 as follows:]

17 ~~20~~. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing geographic boundary information to mobile remote units in a geographic region to disclose their location;
- ii) further providing exclusion region information associated with said geographic boundary of (i) to mobile remote units in the geographic region;
- iii) determining that a mobile remote unit is in the geographic boundary of (i) and not in the exclusion region of (ii) before providing the location of the mobile remote unit to the network.

[- Replace claim 21 as follows:]

8 ~~21~~. A method utilized to provide to a source of request, the location of a mobile remote units that exist in a geographic region from the list according to claim 5 comprising:

- (i) estimating and obtaining from the list, the location mobile remote units that are closer to the source of request;
- (ii) providing the information obtained in (i) to the source of request before releasing the location of other mobile remote units that are further from the source of

FROM :

PHONE NO. : 3105598133

May. 12 2002 04:07PM P10

request.

18 ²² - Replace claim 22 as follows:

A method for providing the location of a portable remote unit that exist within a prescribed geographic boundary to a wireless network comprising:

- i) providing to remote units in the geographic boundary velocity information required in order to divulge location information;
- ii) estimating at the remote unit or network, the velocity at which the remote unit is moving;
- iii) validating that the estimated velocity of the remote unit meets the velocity requirement provided by the network (i) ,if yes, forwarding the location of the remote unit to the network.

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@mbl
5 ²³ E Replace claim 23 as follows:

A technique utilized in the method according to claim 1, to terminate requesting at each interval, for the location of mobile remote units within close proximity of the wireless consumer comprising;

- i) keeping track of the time since the first request for tracking units within proximity of the wireless consumer was enacted by the system;
- ii) validating that the elapsed time at each interval when a request is to be made does not exceed the total time set for establishing tracking in the system;
- iii) requesting that all mobile remote units within close proximity of the wireless consumer divulge their location if the result of the validation of (ii) is true.

MARKED UP CLAIMS SHOWING CHANGES

1. A method for providing the location of a portable mobile remote unit in a geographic region of a wireless network to a wireless consumer requesting the location of portable mobile remote units that are maintaining close proximity to the wireless consumer in the geographic region comprising:

- i) obtaining the location of the wireless consumer at intervals over a period of time;
- ii) requesting at each interval, at the network, that all mobile remote units within close proximity of the wireless consumer disclose their location to the network;
- iii) maintaining a list of mobile remote units that provided their location at each interval after the request of (ii);
- iv) from the ~~said~~ list of (iii), forwarding the location of at least a mobile remote unit to the mobile consumer upon determination that the remote unit maintained close proximity to the mobile consumer over the ~~said~~ period of time of (i).

2. ~~The said A technique employed by the method of according to claim 1~~ utilized to determine if a mobile remote unit is within a prescribed geographic boundary or within close proximity of a wireless consumer comprising:

- obtaining radii information of the ~~said~~ geographic boundary from the network;
- obtaining geographic information describing the origin of the ~~said~~ geographic boundary;

calculating the angle of inclination of the said remote unit to the said geographic boundary origin;

calculating from the said angle of inclination the distance between the remote unit and the said geographic boundary origin;

comparing the said radii of the geographic boundary to the said calculated distance to establish if the remote unit lies in the said geographic boundary .

3. A technique employed by the method according to claim 1 to determine if a remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:

obtaining from the network geographic information describing the said geographic boundary;

estimating at the remote unit if the current location of the remote unit is within the said geographic boundary obtained at the network.

4. A method employed in ~~1~~ according to claim 1 utilized to further limit the provision of remote unit location to the network comprising:

obtaining at the network, exclusion region information within which the remote unit should not provide its location the network;

determining that the remote unit is not in the said exclusion region before providing the location of the remote unit to the network.

5. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless consumer requesting that information comprising:

i) receiving at the network a wider than normal prescribed geographic boundary to query for mobile remote units from the wireless consumer;

ii) splitting the said geographic boundary of (i) into sub geographic regions to constitute the said prescribed geographic boundary;

iii) requesting in the said sub geographic region(s), the location of remote units that are present in each sub region;

iv) verifying after each request of (iii) in a sub region whether at least a portable remote unit disclosed a global location in the region;

v) maintaining a list of all remote units that disclosed their location after each request from the verification of step (iv) ;

vi) providing to the network and from the said list of (v) the location of at least a remote unit that revealed its location in the said sub region.

6. A technique according to claim 5, utilized to terminate a request for the location information of remote units in the said prescribed geographic boundary comprising:

checking to establish that a request for remote unit location information was undertaken in all re-defined or sub regions of the said prescribed boundary or a portable remote unit in a defined or sub region responded with location information.

9. A method for determining that a first portable remote unit associated with a network is being tracked by at least a second portable remote unit over a tracking period comprising;

obtaining the location of the said first portable remote unit or tracked unit;

obtaining the location of the at least a second communication unit or tracking unit that is within proximity or a pre-specified radius of the said tracked unit;

verifying whether the tracking and tracked unit(s) have traveled a minimum pre-specified distance over the tracking period;

forwarding the result of the said verification to the network at the end of the tracking period.

10. The verification technique employed in the method of claim 9 comprising;

retaining a tracking list of all tracking units that are within a pre-specified radius or region of the said tracked unit at the first tracking interval;

eliminating or removing at subsequent tracking intervals, all tracking units in the said tracking list that do not report their location during a subsequent tracking interval;

validating at the end of the tracking period that at least a tracking unit exist in the tracking list and a minimum distance was traveled by the tracked unit.

11. Another verification technique employed in the method of claim 9 comprising;

maintaining a list of all tracking units that are maintaining a close distance to the tracked unit over the said period of time;

FROM :

PHONE NO. : 3105598133

May. 12 2002 04:09PM P15

searching the tracking list at the end of the tracking period to obtain tracking units that traveled a minimum pre-specified distance with the tracked unit.

12. A communication system comprising:

a network of communication units;

at least a first communication unit and at least a second communication unit able to provide their location information to the said network;

the system able to determine and report that the at least second communication unit maintained close proximity to the at least first communication unit over a period of time.

13. The system of claim 12, the at least first communication unit able to invoke a tracking mode at the at least first communication unit in order to determine if a clandestine unit is tracking it.

14. A communication system comprising:

a portable mobile remote unit;

a network of communication units;

means to obtain the location of the portable mobile remote unit;

means to obtain geographic boundary information in order to disclose a global location at the network;

FROM :

PHONE NO. : 3105598133

May. 12 2002 04:09PM P16

means to provide the location of the portable mobile remote unit to the network upon determination that the portable mobile remote unit is within the ~~said~~ geographic boundary obtained at the network;

means to determine and report to the system upon request that, another mobile remote unit of the network has tracked the ~~said~~ portable mobile remote over a period of time.

15. The portable mobile remote according to claim 14, having means to further determine if location disclosure for the remote unit is prohibited at a specific geographic boundary before sending its location to the network.

16. The portable remote unit of claim 15 having means to establish its velocity at the network and having means to further determine that, its velocity is within the network's prescribed velocity before divulging its location to the network.

20. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless network comprising:

i) providing geographic boundary information to mobile remote units in a geographic region to disclose their location;

ii) further providing exclusion region information associated with said geographic boundary of (i) to mobile remote units in the ~~said~~ geographic region;

FROM :

PHONE NO. : 3105598133

May. 12 2002 04:10PM P17

iii) determining that a mobile remote unit is in the said geographic boundary of (i) and not in the said exclusion region of (ii) before providing the location of the mobile remote unit to the network.

21. A method utilized to provide to a source of request, the location of a mobile remote units that exist in a geographic region from the said list according to claim 5 comprising:

- (ii) estimating and obtaining from the said list, the location mobile remote units that are closer to the source of request;
- (ii) providing the information obtained in (i) to the source of request before releasing the location of other mobile remote units that are further from the source of request.

22. A method for providing the location of a portable remote unit that exists within a prescribed geographic boundary to a wireless network comprising:

- i) providing to remote units in the said geographic boundary velocity information required in order to divulge location information;
- iv) estimating at the remote unit or network, the velocity at which the remote unit is moving;
- v) validating that the estimated velocity of the remote unit meets the velocity requirement provided by the network (i) ,if yes, forwarding the location of the remote unit to the network.

FROM :

PHONE NO. : 3105598133

May. 12 2002 04:10PM P18

23. A technique utilized in the method according to claim 1, to terminate requesting at each interval, for the location of mobile remote units within close proximity of the wireless consumer comprising;

i) keeping track of the time since the first request for tracking units within proximity of the wireless consumer was enacted by the system;

ii) validating that the elapsed time at each interval when a request is to be made does not exceed the total time set for establishing tracking in the system;

iii) requesting that all mobile remote units within close proximity of the wireless consumer divulge their location if the result of the validation of (ii) is true.

FROM :

PHONE NO. : 3105598133

May. 12 2002 04:11PM P19

Conclusion

Applicant request that the amended matter be entered into the application in order to overcome the objections raised by the Office. Applicant solicits the allowance of these claims from the Office.

Respectfully,



(Applicant).

05/13/2002

FROM :

PHONE NO. : 3105598133

Jul. 14 2002 01:24PM P1



PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: **Mail** Box ISSUE FEE
 Commissioner for Patents
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 7590 05/16/2002

MUNDI FOMUKONG
 10853 ROSE AVE, #49
 WLA, CA 90034

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 I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Box Issue Fee address above, or being facsimile transmitted to the USPTO, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

09/753,178	MUNDI FOMUKONG
APPLICATION NO.	FILING DATE
09/753,178	12/30/2000
FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
Mundi Fomukong	2194

TITLE OF INVENTION: METHOD AND APPARATUS FOR LOCATING MOBILE UNITS TRACKING ANOTHER OR WITHIN A PRESCRIBED GEOGRAPHIC BOUNDARY

METHOD AND APPARATUS FOR LOCATING MOBILE UNITS TRACKING ANOTHER OR WITHIN PRESCRIBED GEOGRAPHIC BOUNDARY

APPL. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	\$640	\$300	\$940	08/16/2002
	YES	640	300	\$940	08/16/2002

EXAMINER	ART UNIT	CLASS-SUBCLASS
TRIEU, VAN THANH	2832	340-988000
TRIEU, VAN THANH	2832	340-988000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.303).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47) attached. Use of a Customer Number is required.

2. For printing on the patent front page, list (1) the names of up to 3 registered patent attorneys or agents OR, alternatively, (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. Inclusion of assignee data is only appropriate when an assignment has been previously submitted to the USPTO or is being submitted under separate cover. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) ☐ individual ☐ corporation or other private group entity ☐ government

4a. The following fee(s) are enclosed:

☒ Issue Fee

☐ Publication Fee

☐ Advance Order - # of Copies

4b. Payment of Fee(s):

☐ A check in the amount of the fee(s) is enclosed.

☒ Payment by credit card. Form PTO-2038 is attached.

☐ The Commissioner is hereby authorized by charge the required fee(s), or credit any overpayment, in Deposit Account Number (enclose an extra copy of this form).

Commissioner for Patents is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

(Authorized Signature)

(Date)

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant, a registered attorney or agent, or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, Washington, D.C. 20231. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, Washington, DC 20231.

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Received from <3105598133> at 7/15/02 3:00:18 AM [Eastern Daylight Time]

Received from 3105598133 at 7/15/02 3:09 PM [Eastern Daylight Time]

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PART B - FEE(S) TRANSMITTAL

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7591 05/16/2002

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WLA, CA 90034

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(Signature)
(Date) 7/15/02

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/753,178	12/30/2000	Mundi Fomukong		2194

TITLE OF INVENTION: METHOD AND APPARATUS FOR LOCATING MOBILE UNITS TRACKING ANOTHER OR WITHIN A PRESCRIBED GEOGRAPHIC BOUNDARY

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
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EXAMINER	ART UNIT	CLASS-SUBCLASS
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(Date)

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Jul. 14 2002 01:27PM P2

PTO-2038 (02-2000)

Approved for use through 01/31/2003. OMB 0651-0043

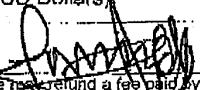
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Signature:			Date: 7/15/02
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Application No. 09/753,178	Application No.	Serial No.	IDON Customer No.
Patent No.	Patent No.	Registration No.	
Attorney Docket No.		Identify or Describe Mark	

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Interview Summary

Application No.

09/753,178

Applicant(s)

FOMUKONG, MUNDI

Examiner

Van T Trieu

Art Unit

2632

All participants (applicant, applicant's representative, PTO personnel):

(1) Van T Trieu. (3) _____

(2) Mundi Formukong. (4) _____

Date of Interview: 10 May 2002.

Type: a) ☒ Telephonic b) ☐ Video Conference
c) ☐ Personal [copy given to: 1) ☐ applicant 2) ☐ applicant's representative]

Exhibit shown or demonstration conducted: d) ☐ Yes e) ☒ No.
If Yes, brief description: _____.

Claim(s) discussed: 1-6,9-16 and 20-23.

Identification of prior art discussed: None.

Agreement with respect to the claims f) ☒ was reached. g) ☐ was not reached. h) ☐ N/A.

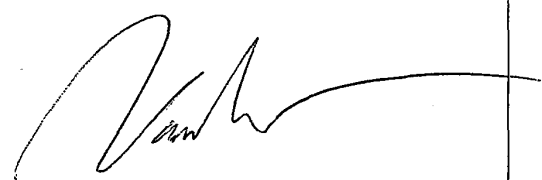
Substance of Interview including description of the general nature of what was agreed to if an agreement was reached, or any other comments: Mr. Mundi will submit an Amendment to correct all of the 112 second problems such as the antecedent basis of "the network" and "the said" to all claims above. A supplemental amendment will be faxed to Examiner on Monday, 13 May 2002.

(A fuller description, if necessary, and a copy of the amendments which the examiner agreed would render the claims allowable, if available, must be attached. Also, where no copy of the amendments that would render the claims allowable is available, a summary thereof must be attached.)

i) ☒ It is not necessary for applicant to provide a separate record of the substance of the interview (if box is checked).

Unless the paragraph above has been checked, THE FORMAL WRITTEN REPLY TO THE LAST OFFICE ACTION MUST INCLUDE THE SUBSTANCE OF THE INTERVIEW. (See MPEP Section 713.04). If a reply to the last Office action has already been filed, APPLICANT IS GIVEN ONE MONTH FROM THIS INTERVIEW DATE TO FILE A STATEMENT OF THE SUBSTANCE OF THE INTERVIEW. See Summary of Record of Interview requirements on reverse side or on attached sheet.

Examiner Note: You must sign this form unless it is an Attachment to a signed Office action.


VAN TRIEU
Primary Examiner

Examiner's signature, if required

Notice of Allowability

Application No.

09/753,178

Examiner

Van T Trieu

Applicant(s)

FOMUKONG, MUNDI

Art Unit

2632

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to the Final Amendment filed on 12 May 2002.
2. ☒ The allowed claim(s) is/are 1-6, 9-16 and 20-23.
3. ☒ The drawings filed on 30 December 2000 are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 - a) ☐ All b) ☐ Some* c) ☐ None of the:
 1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).
- * Certified copies not received: _____.
5. ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
 - (a) ☐ The translation of the foreign language provisional application has been received.
6. ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application. **THIS THREE-MONTH PERIOD IS NOT EXTENDABLE**

7. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
8. ☐ CORRECTED DRAWINGS must be submitted.
 - (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
 - 1) ☐ hereto or 2) ☐ to Paper No. _____.
 - (b) ☐ including changes required by the proposed drawing correction filed _____, which has been approved by the Examiner.
 - (c) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No. _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the top margin (not the back) of each sheet. The drawings should be filed as a separate paper with a transmittal letter addressed to the Official Draftsperson.

9. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

- | | |
|--|---|
| 1 ☐ Notice of References Cited (PTO-892) | 2 ☐ Notice of Informal Patent Application (PTO-152) |
| 3 ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) | 4 ☒ Interview Summary (PTO-413), Paper No. _____ |
| 5 ☐ Information Disclosure Statements (PTO-1449), Paper No. _____ | 6 ☐ Examiner's Amendment/Comment |
| 7 ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material | 8 ☒ Examiner's Statement of Reasons for Allowance |
| | 9 ☐ Other |

DETAILED ACTION

Allowable Subject Matter

1. The following is an examiner's statement of reasons for allowance: there are no references teaching of a method for providing the location of a portable mobile remote unit in a geographic region to a wireless consumer requesting location of portable mobile remote unit that are remaining close proximity to the wireless consumer in the geographic region, comprising:

maintaining a list of mobile remote units that provided their location at each interval after the request; and

from the list of forwarding the location of at least a mobile remote unit to the mobile consumer upon determining that the remote unit maintained close proximity to the mobile consumer over the period of time.

In another method embodiment:

receiving at the network a wider than normal prescribed geographic boundary to query for mobile remote units from the wireless consumer;

splitting the geographic boundary into sub geographic regions to constitute the prescribed geographic boundary; and

providing to the network, and from the list of the location of at least a remote unit revealed its location in the sub region.

Art Unit: 2632

In another method embodiment:

obtaining the location of the first portable remote unit or tracked unit;

obtaining the location of the at least second communication unit or tracking unit that is within proximity or pre-specified radius of the tracked unit;

verifying whether the tracking and tracked unit(s) have traveled a minimum pre-specified distance over the tracking period; and

forwarding the result of the verification to the network at the end of the tracking period.

In another method embodiment:

providing to remote units in the geographic boundary velocity information required in order to divulge location information;

estimating at the remote unit or network, the velocity at which the remote unit is moving; and

validating that the estimated velocity of the remote unit meets a velocity requirement provided by the network, if yes, forwarding the location of the remote unit to the network.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Art Unit: 2632

1. Any inquiry concerning this communication or earlier communications from the examiner should be directed to primary examiner **Van Trieu** whose telephone number is (703) 308-5220. The examiner can normally be reached on Mon-Fri from 7:00 AM to 4:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Mr. **Jeffery Hofsass** can be reached on (703) 305-4717.

The office facsimile number is (703) 872-9314.

A handwritten signature in black ink, appearing to read 'Van Trieu', with a long horizontal flourish extending to the right.

Van Trieu
Primary Examiner
Date: 5/15/02



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NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 05/16/2002
MUNDI FOMUKONG
10853 ROSE AVE, #49
WLA, CA 90034

EXAMINER

TRIEU, VAN THANH

ART UNIT

CLASS-SUBCLASS

2632

340-988000

DATE MAILED: 05/16/2002

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/753,178	12/30/2000	Mundi Fomukong		2194

TITLE OF INVENTION: METHOD AND APPARATUS FOR LOCATING MOBILE UNITS TRACKING ANOTHER OR WITHIN A PRESCRIBED GEOGRAPHIC BOUNDARY

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	\$640	\$300	\$940	08/16/2002

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. **PROSECUTION ON THE MERITS IS CLOSED.** THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. **THIS STATUTORY PERIOD CANNOT BE EXTENDED.** SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above. If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

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B. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check the box below and enclose the PUBLICATION FEE and 1/2 the ISSUE FEE shown above.

☐ Applicant claims SMALL ENTITY status.
See 37 CFR 1.27.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Box ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/753,178	12/30/2000	Mundi Fomukong		2194

7590 05/16/2002
MUNDI FOMUKONG
10853 ROSE AVE, #49
WLA, CA 90034

EXAMINER

TRIEU, VAN THANH

ART UNIT	PAPER NUMBER
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2632

DATE MAILED: 05/16/2002

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The patent term adjustment to date is 0 days. If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the term adjustment will be 0 days.

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Fax To: 571-273-6500

RE: US Patent: 6,441,751
US Pat. Application: 09,753,178

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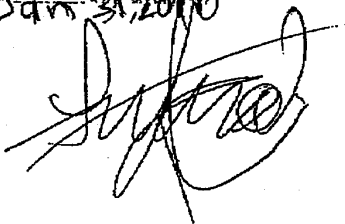
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Dear USPTO Director,

In view of Applicant's letter dated December 20th 2009, that requested the entity status of US patent 6,441,752 to be changed from small to large entity, Applicant has included PTO form 2038 - Credit Card Authorization Form - such that an additional fee of \$1240.00, should be charged and added to the maintenance fee paid by Applicant on 10-09-2009 for US patent 6,441,752.

Sincerely,
/Mundi Fomukong/
(Applicant)

Jan 31, 2010



1.28(c)

02/03/2010 MBANGURA 00000105 6441752

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MAR 04 2010

In re Patent No. 6,441,752
Issue Date: August 27, 2002
Application No. 09/753,178
Filed: December 30, 2000
Title: Method And Apparatus For Locating
Mobile Units Tracking Another Or Within A
Prescribed Geographic Boundary

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ON PETITION

This is a notice regarding your request for acceptance of a fee deficiency submission under 37 CFR 1.28. On September 1, 1998, the Court of Appeals for the Federal Circuit held that 37 CFR 1.28(c) is the sole provision governing the time for correction of the erroneous payment of the issue fee as a small entity. See DH Technology v. Synergystex International, Inc. 154 F.3d 1333, 47 USPQ2d 1865 (Fed. Cir. Sept. 1, 1998).

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This patent is no longer entitled to small entity status. Accordingly, all future fees paid in this patent must be paid at the large entity rate.

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Joan Olszewski
Petitions Examiner
Office of Petitions



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February 3, 2010

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Payment Amount Received: \$ 1,240.00

Payment Year: 7.5 (e.g., 3.5, 7.5, 11.5)

PAYMENT RECEIPT DATE (Mailroom Date Stamp): 01/31/2010

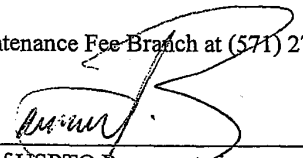
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Michael Bangura (571) 272-6365
Printed Name of USPTO Representative


Signature of USPTO Representative

Petitioner Uber Ex-1004, 0361

APPLICATION TRANSFER REQUEST FOR S.N. 09/753178

Section I. TRANSFER REQUEST BY (PRINT NAME) CE Date 3-2-01

TO: Art Unit 2635 Class/sub 340/825.49+ FROM: A.U. 3661 Class 701

REASON:

The claims are directed to a communication system. No vehicle control or navigation is claimed for 701. It appears proper for 340/825.49+

Gatekeeper concurrence AT

Hand carried: Personally accepted by _____

Section II a. DISPOSITION BY RECEIVING TC By: BB A.U. 2635 Date 3/12/01

☐ ACCEPTED BY RECEIVING T.C.

NOT ACCEPTED

☒ Forward to receiving TC Post Classifier

☐ Non-classification issue/other, return to Originating TC/AU _____

REASON: no selective communication

342/352 - system like GPS to locate vehicle.

Section II b. DISPOSITION BY RECEIVING TC POST CLASSIFIER

☒ This dispute was resolved. Forward to TC/AU 2635 Class/Sub 340/825.49 Post Classifier AT Date 3/26/01

Concurring _____ Date _____

☐ This dispute was not resolved, forward to DISPUTE RESOLUTION PANEL

Post Classifier Assessment:

Refused by 342/352, 340/825.49, 455/
mobile unit position tracking seems proper 340/988

Gatekeeper Concurrence _____

Post Classifier _____

Date _____

Section III. DISPOSITION BY DISPUTE RESOLUTION PANEL

Date _____

Panel Decision: Forward to Technology Center / Art Unit _____ Class/sub _____

REASON:

Panel Member _____

Concurring Panel Member _____

☐ This application MAY NOT be returned to the dispute resolution panel. THIS IS A FINAL DISPOSITION.

3/14/01

PALM INTRANETDay : Monday
Date: 7/15/2002
Time: 14:57:39**Application Number Information**Application Number: **09/753178** Order
This File from PUBS AssignmentsExaminer Number: **73161 / TRIEU, VAN**Filing Date: **12/30/2000**Group Art Unit: **2632**Effective Date: **12/30/2000**Class/Subclass: **340/988.000**

Waiting for Response

Application Received: **01/03/2001**Lost Case: **NO**

Desc.

Patent Number:

Interference Number:

Mail N/=.Issue Date: **00/00/0000**Unmatched Petition: **NO**Date of Abandonment: **00/00/0000**L&R Code: Secrecy Code: **1**

Attorney Docket Number:

Third Level Review: **NO**Secrecy Order: **NO**Status: **93 /NOTICE OF ALLOWANCE MAILED -- APPLICATION
RECEIVED IN OFFICE OF PUBLICATIONS**Status Date: **05/23/2002**Confirmation Number: **2194**Title of Invention: **METHOD AND APPARATUS FOR LOCATING MOBILE UNITS
TRACKING ANOTHER OR WITHIN A PRESCRIBED GEOGRAPHIC BOUNDARY**

Bar Code	Location	Location Date	Chrg to Loc	Charge to Name	Emp. ID	Infra Loc
09753178	7540 PUBS - FILE MAINTENANCE FACILITY, BAILEYS X-RD, 308-6789	07/01/2002		No Charge to Name	MMOORE3	FMF/01/ 01

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November 2, 2023

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Minesoft LLC
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UNITED STATES

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09753178 Certified patent file wrapper

Pages missing from patent number 6,441,752

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Sincerely,

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Wanda Montgomery
Customer Service
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US006441752B1

(12) **United States Patent**
Fomukong

(10) **Patent No.: US 6,441,752 B1**
(45) **Date of Patent: Aug. 27, 2002**

(54) **METHOD AND APPARATUS FOR LOCATING MOBILE UNITS TRACKING ANOTHER OR WITHIN A PRESCRIBED GEOGRAPHIC BOUNDARY**

(76) **Inventor: Mundi Fomukong**, 10853 Rose Ave.
#49., West Los Angeles, CA (US)
90034

(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) **Appl. No.: 09/753,178**

(22) **Filed: Dec. 30, 2000**

(51) **Int. Cl.⁷ G08G 1/123**

(52) **U.S. Cl. 340/988; 340/989; 340/992**

(58) **Field of Search 340/988, 989, 340/993, 573.1, 573.3, 573.4, 573.7, 7.27, 7.28, 992; 342/357.07, 465, 357.1; 455/429, 440, 441**

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,418,537 A 5/1995 Bird 340/357.09
5,504,491 A 4/1996 Chapman 342/357.09
5,517,690 A * 5/1996 Linquist et al. 340/7.27

5,539,395 A 7/1996 Buss 340/7.43
5,669,061 A * 9/1997 Schipper 455/429
5,689,245 A 11/1997 Noreen et al. 340/825.49
5,918,159 A 6/1999 Fomukong et al. 340/7.21
6,108,365 A * 8/2000 Rubin et al. 340/5.2
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6,211,819 B1 * 4/2001 King et al. 342/357.09

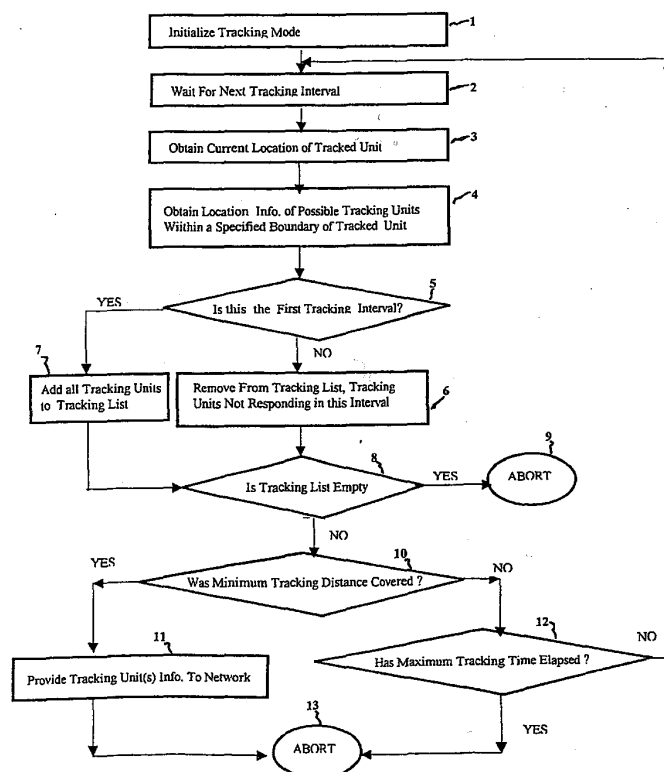
* cited by examiner

Primary Examiner—Van Trieu

(57) **ABSTRACT**

A mobile location reporting communication system consists of a network of communication sources and targets managed by one or more control stations. In the system, a communication source may request for the location of a mobile communication target from the network. The target conveys its location to the network and that information is provided to the source. In the invention a mobile communication source request for the location of mobile communication targets that are present in a prescribed geographic boundary. The network provides to the source only remote targets that are present in the prescribed boundary. Also in the invention, a concealed or clandestine mobile portable target, close to the mobile portable source, may be tracking the source. The source may invoke a method that may result in the disclosure of mobile targets that have traveled a pre-specified distance with the source while maintaining proximity to the source.

18 Claims, 7 Drawing Sheets



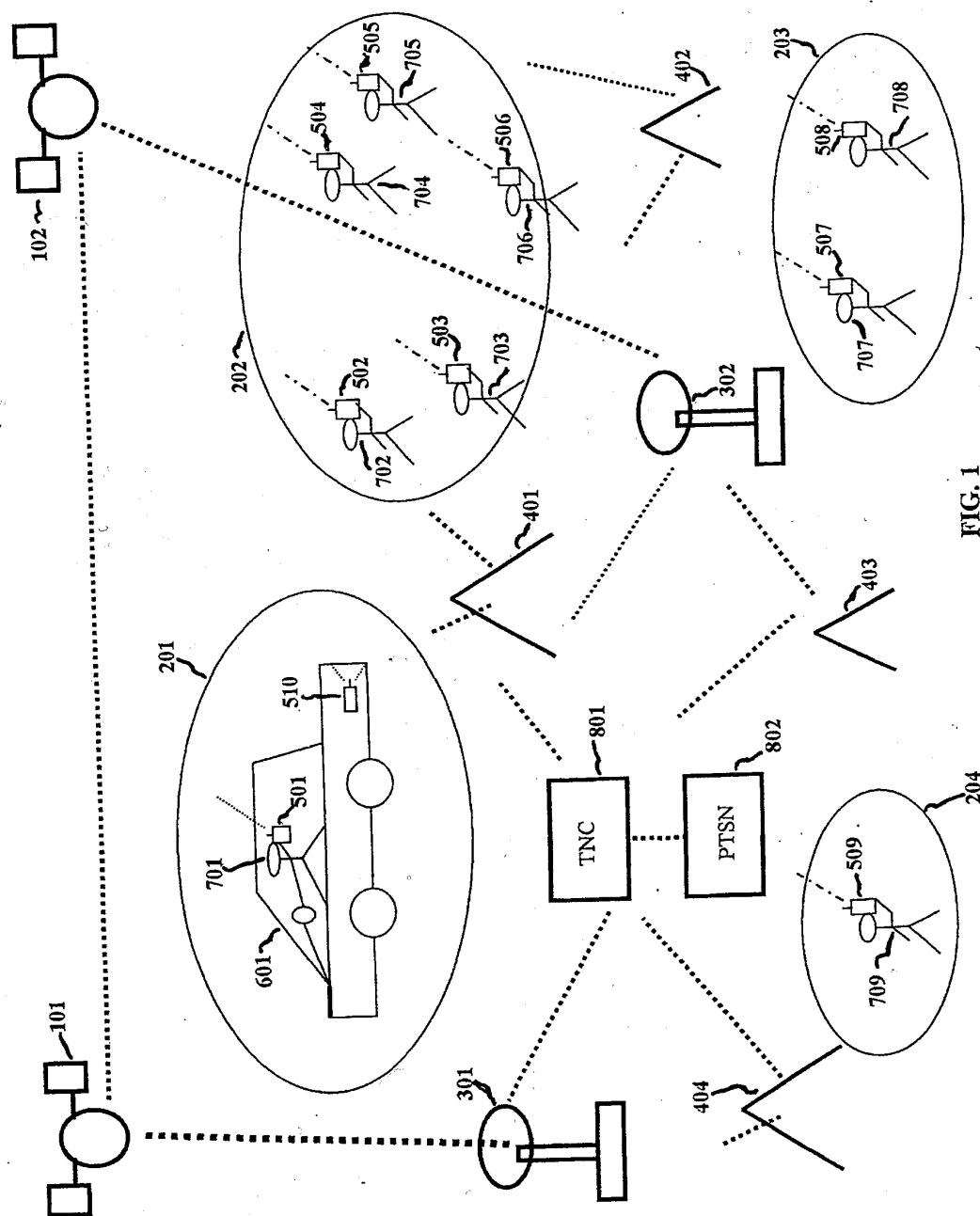


FIG. 1

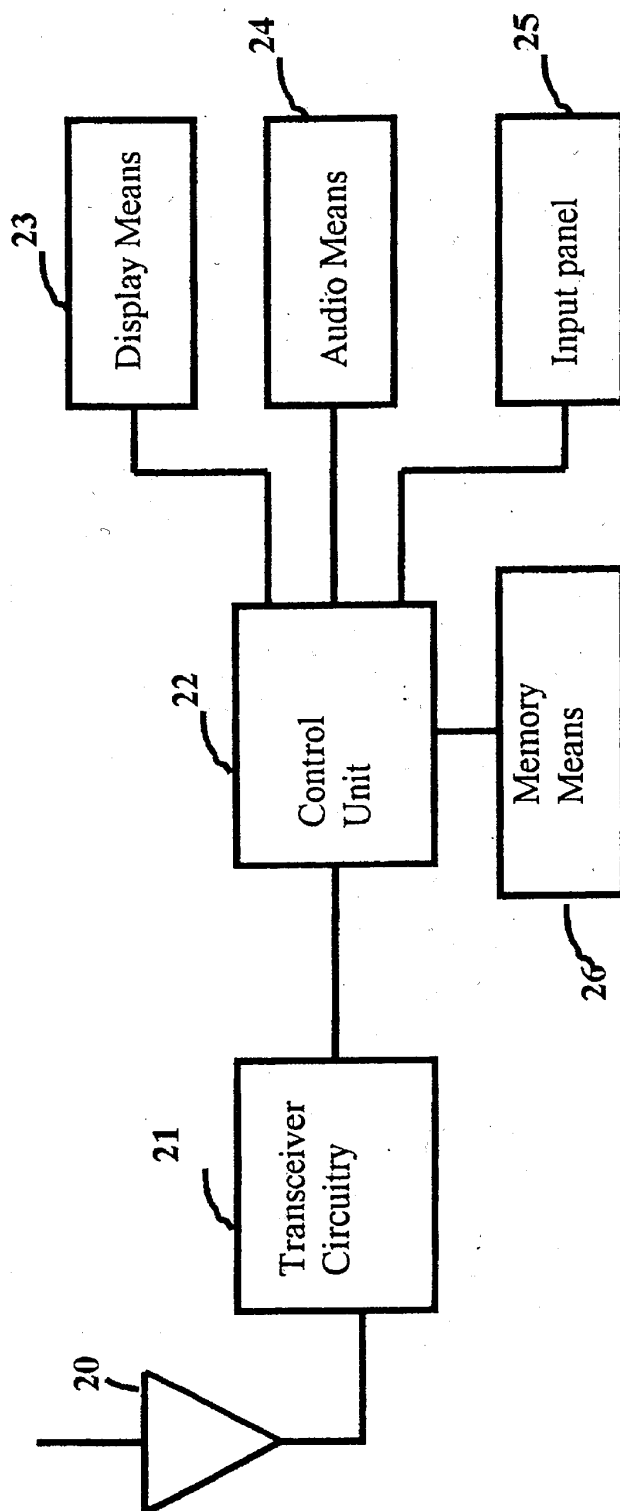
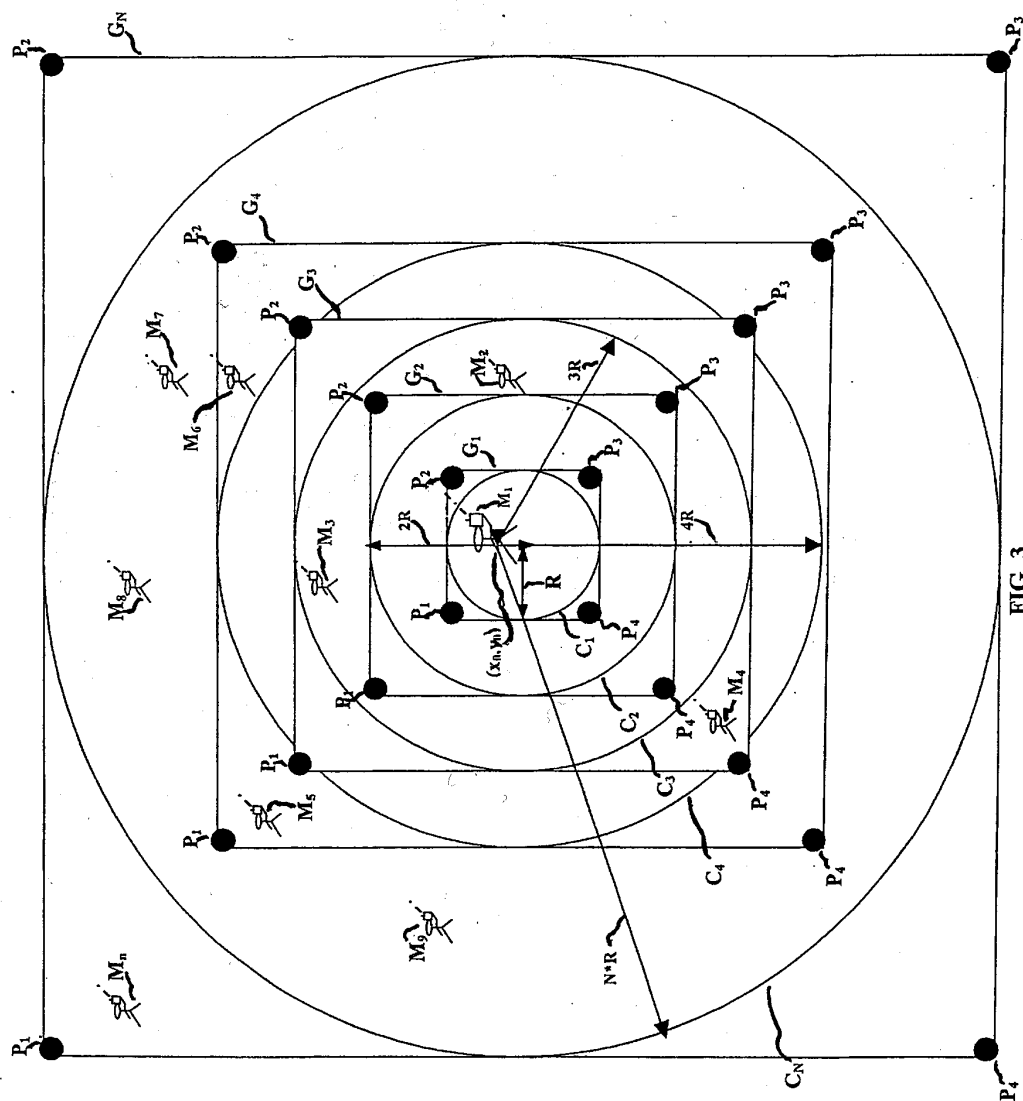


FIG. 2



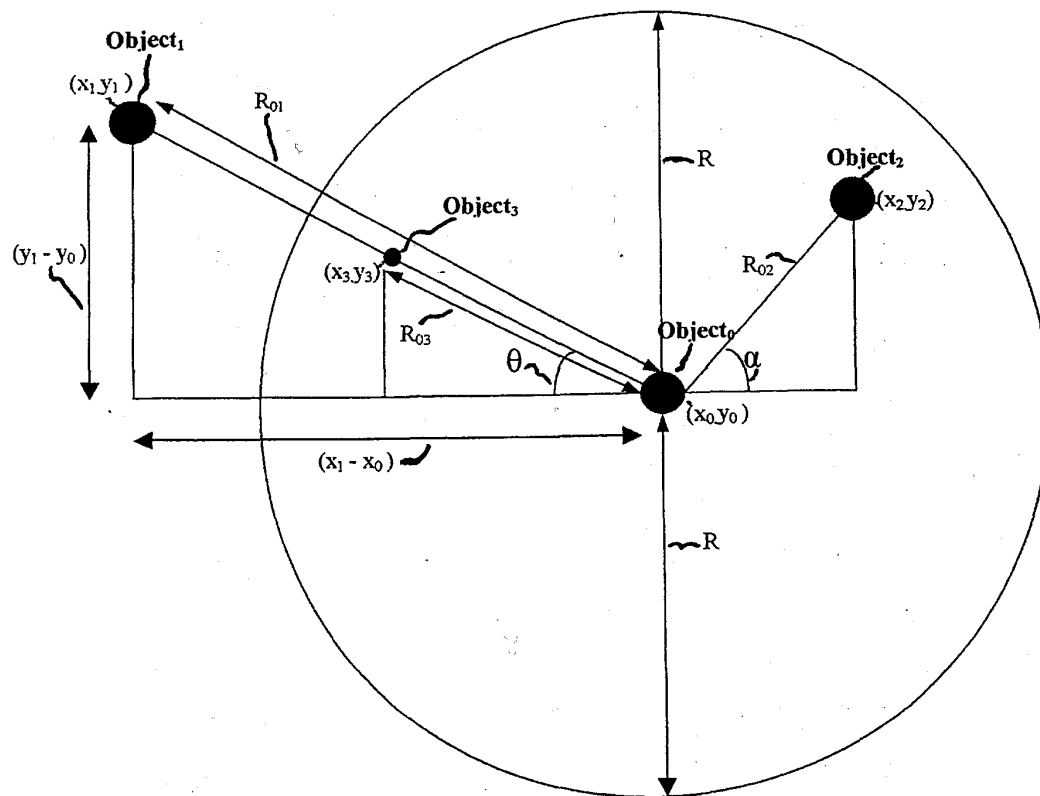


FIG. 4

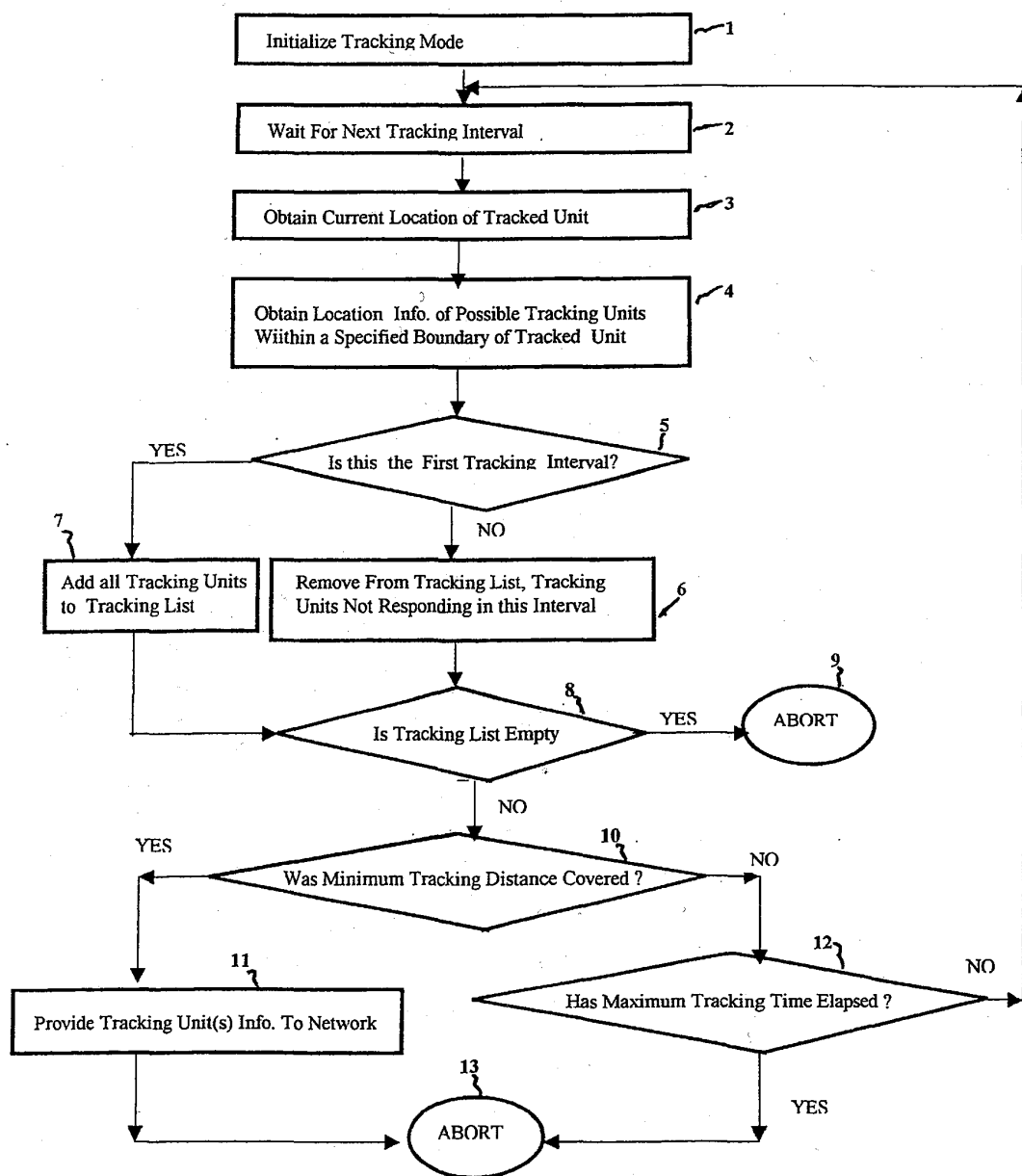


FIG. 5

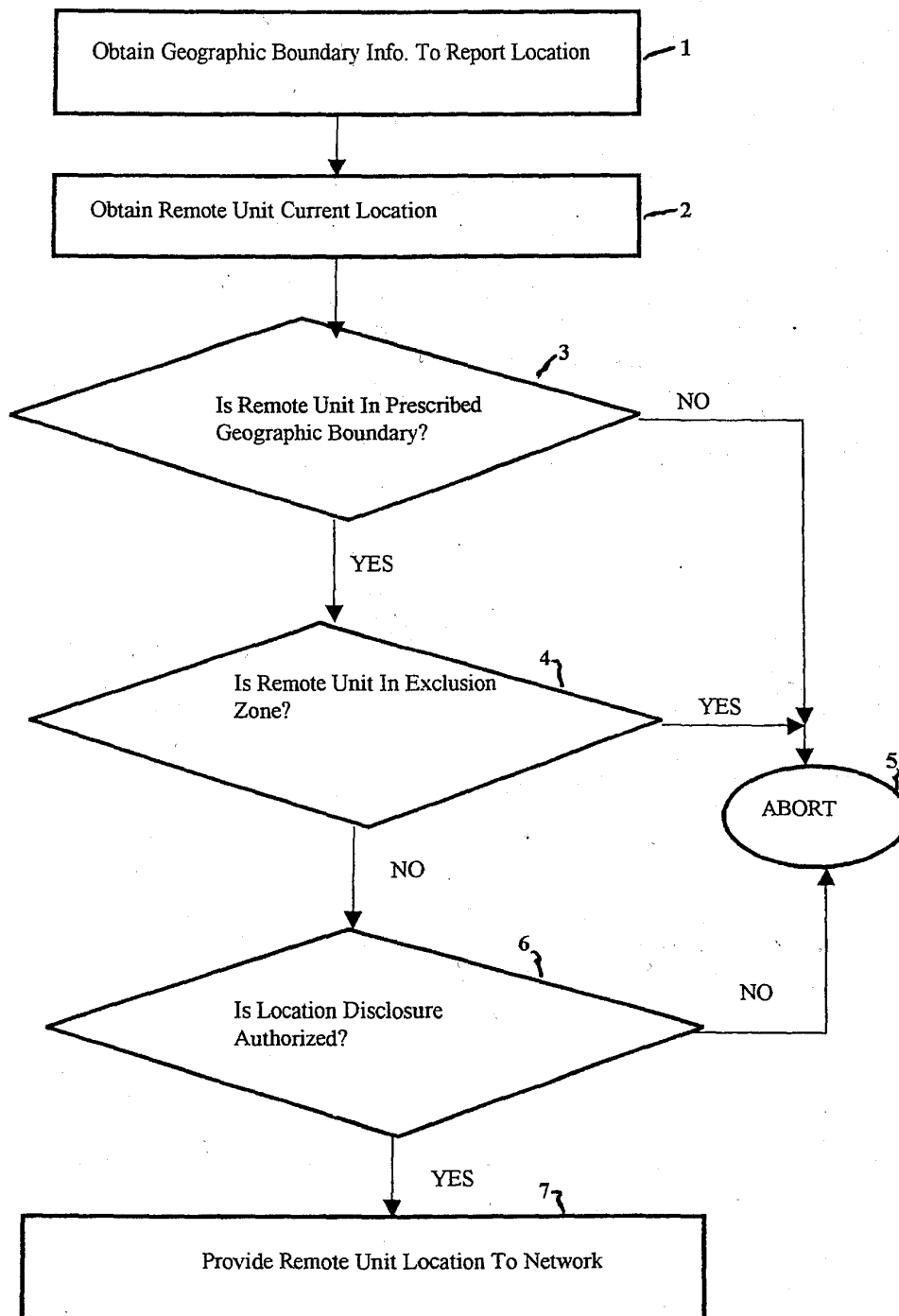


FIG. 6

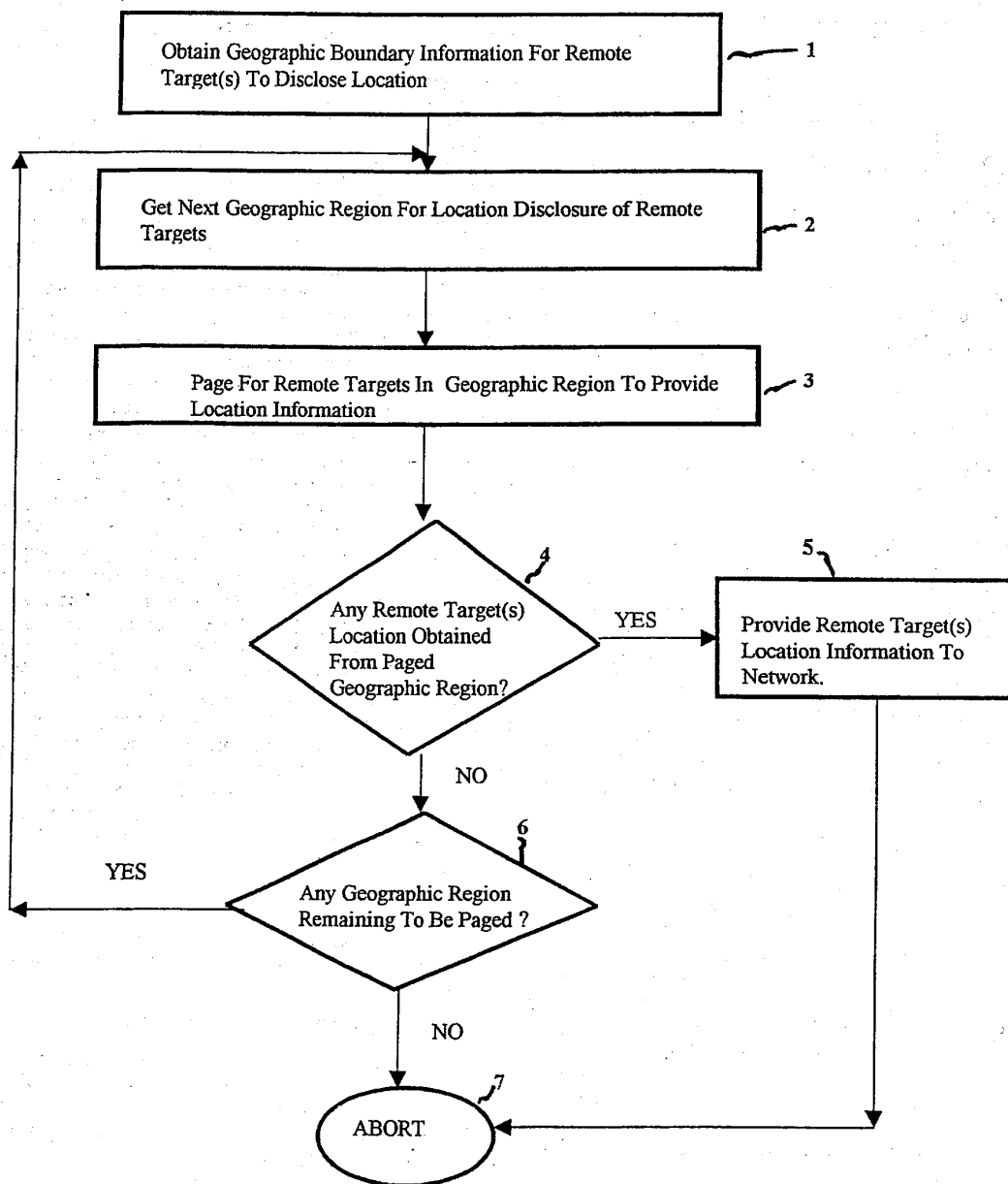


FIG. 7

1

METHOD AND APPARATUS FOR LOCATING MOBILE UNITS TRACKING ANOTHER OR WITHIN A PRESCRIBED GEOGRAPHIC BOUNDARY

BACKGROUND OF THE INVENTION

This invention relates to telecommunication services and systems, specifically such services and systems that convey the location of a mobile unit.

The wireless industry is currently gearing towards the provision of a wide range of location based services to the general public. Such services will include utilizing the location of a subscriber's portable remote unit to channel a wide range of location-based services to the subscriber. For such a service to be successful, the remote unit must be able to obtain and relay its location information to other communication targets of the network requesting such information.

In relevant prior art such as U.S. Pat. No. 5,689,245, Noreen and al, the location of a remote unit is employed to execute location specific instructions transmitted to the remote unit.

In Bird, U.S. Pat. No. 5,418,537, a missing vehicle is located through the use of a GPS receiver mounted on the vehicle. When the vehicle is missing, a paging request is broadcast by the vehicle location center. Upon receiving the broadcasted message, the vehicle resolves and conveys its location to the service center.

In Buss, U.S. Pat. No. 5,539,395, a remote unit is presented whereby the unit selects and displays messages matching the location of the remote unit. The network provides the unit with messages having a location signal. If the location signal picked up by the unit is within the unit's current location, the message is displayed, otherwise it is kept in memory for display at the appropriate location.

In Chapman, U.S. Pat. No. 5,504,491, a global status and positioning reporting system is described. A remote unit obtains its global location and updates the network with status information and location information as required. Such status information may include an emergency condition or relevant condition of the remote unit required by the network.

In Fomukong and al, U.S. Pat. No. 5,918,159 a location reporting satellite paging system with optional blocking of location reporting is disclosed. In that invention, a remote mobile unit obtains its location information and provides that information via the network to other network units requesting the information. The provision of such location information is done based on authorization information provided and routinely updated by the remote unit.

In all of the above-disclosed inventions, the location of the remote unit is utilized by the system. The deployment of location services could be quite beneficial to the general public if safely implemented. In today's market, such mobile units are usually small, compact and lightweight. These devices could easily be concealed to reveal the location of a mobile user without the user knowing or authorizing the disclosure of their location. Most wireless consumers might not want their location disclosed to the network or general public and the thought of being tracked by a clandestine unit concealed in an object such as a car or luggage to reveal the location of an individual would be unacceptable by the general public. The risk of abuse clearly exists and must be handled appropriately by wireless vendors. In U.S. Pat. No. 5,918,159 that provides authorization for location reporting,

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it would be almost impossible for the network to prevent a concealed location-reporting unit to provide the location of an individual being tracked, given an abuse is occurring. A need therefore exists for location reporting devices in a specific geographic region to reveal their location upon request. In situations where a user is being tracked, the network would be able to determine which units are tracking the user by querying for the location of remote units within a specified radius of the user or tracked unit. The techniques required to provide the above result are described in the invention.

Whenever a mobile user is stranded and requires immediate help, another mobile party may exist not too far from the location of the user. The mobile user may not be aware of the presence of the other mobile party at that geographic location. By paging for the location of portable remote units (PRU) within the stranded area, a distressed subscriber might immediately sought help at that location. If the prescribed boundary specified by the mobile user exceeds pre-specified limits, the network may split that geographic area as described hereinafter. Pages may then be sent to specific areas in order to obtain the location of portable remote units in that geographic area. The location of any mobile location-reporting unit in a geographic area that is closest to the user will be revealed to the user.

Lots of other uses exist for such a service to be lucrative to a service provider. A wireless subscriber may opt to participate in the program and users of the system may be charged a fee each time the location of another PRU at a requested geographic boundary is provided to the user. Also, users in possession of portable remote units may be charged whenever they invoke the tracking mode in their PRU. To improve subscriber enrollment in the program, subscribers may also received benefits each time their location is provided to a distressed individual. Subscribers not requiring their locations disclosed at any time may block such information at the network. In situations where a PRU user is being tracked by another, the network will only reveal the location of the tracking unit only after both units have traveled a certain distance over a pre-specified period of time with the tracking unit maintaining proximity to the source during that period. Such distances and elapse times could be set as a standard by the industry to clearly define tracking.

From the above there is clearly a need for a system whereby a remote unit should be able to request for the location of other remote units within a specific geographic area. The components of such a system are described hereinafter.

OBJECTS OF THE INVENTION

It is an objective of the present invention to provide a mobile telecommunication system, method and technique that could facilitate the secure provision of location information pertaining to one or more mobile communication targets that are tracking another.

It is an objective of this invention to provide a mobile telecommunication system whereby a communication source residing in a geographic location may poll for the location of communication targets that are present in another geographic area.

It is an objective of this invention to provide a technique to report the location of communication units within a pre-specified boundary.

It is an objective of the current invention to provide adequate technology that would facilitate the disclosure of

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location information of communication units that are present in a wider than normal geographic area.

It is an objective of this invention to provide a remote unit that could provide location information and geographic boundary information where a search could be initiated for the presence of one or more location reporting communication targets.

SUMMARY OF THE INVENTION

The aforementioned objectives and others are achieved by a telecommunication system that can provide location information pertaining to other communication targets that are present within a pre-specified geographic boundary.

In the system, a communication source may query for the location of communication targets at a specified geographic boundary. The communication source may also enter into a mode to determine if another communication unit is tracking it. Communication sources and targets of the system should be able to obtain their location using any relevant location determination technique. This information is conveyed securely across the network based on system and subscriber requirements. When a communication source requires the location information of communication targets in a specific geographic area, the source obtains its location and may determine if the geographic boundary of the required targets is within its querying radii. Although the design could also be such that the network handles all queries, a communication source may poll directly for the location information of targets in a specified geographic boundary. This could happen if the communication targets are within the source's querying radii; preventing unnecessary overloading of shared network resources. For more complex and distant queries, the source may simply provide its location and geographic boundary information where targets should be interrogated for location disclosure. The network utilizes its resources and determines where and how a search for relevant communication targets should be initiated. Once the search for possible communication targets within the specified geographic boundary is completed, the network provides the communication source with information pertaining to communication target(s) closest to the source and in the geographic region specified by the source.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 shows a general schema depicting the invention.

FIG. 2 shows a diagram of a mobile portable remote unit employed by the system.

FIG. 3 shows a diagram indicating how a wider than normal geographic area is divided to locate remote units in the area.

FIG. 4 shows a diagram that is employed to determine if a remote unit is within a prescribed geographic boundary.

FIG. 5 shows a flow chart illustrating the steps that a communication unit may employ to determine if it is being tracked by another unit.

FIG. 6 is a flow chart illustrating the steps utilized by a communication unit to disclose a global location when the unit is within a pre-specified geographic area.

FIG. 7 is a flow chart illustrating how a search for the location of mobile communication units in a wider than normal pre-specified geographic boundary is carried out.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A general overview of the present system in accordance with the invention is depicted in FIG. 1. The system consists

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of a network of portable remote units (PRU) 501-510 scattered throughout a wide geographic area. Mobile Users 701-709 are in possession of the portable remote units 501-509, respectively. Geographic regions 201-204 are standard geographic areas that may have present, one or more portable mobile users 701-709 as shown in FIG. 1. Mobile user 701 is in geographic region 201 and mobile users 502-506 are in geographic regions 202. Other mobile portable users exist in the system and are scattered as shown in FIG. 1. Geographic location 201-204 may simply be defined by their latitude, longitude and radii information or simply by points defining their geographic boundary as illustrated in FIG. 3. The terrestrial network center (TNC) FIG. 1, 801 is used to control the actions of the mobile system. The TNC communicates with ground based transmitters (GBT) 401-404 and earth based satellite transmitters 301-302 to relay information pertaining to the mobile system across the network. Other functionalities of the terrestrial network center may include determining which transmitters to employ to complete a call and how to prevent portable remote units from receiving calls when they are out of jurisdiction. Multiple terrestrial control or network centers may be employed as required by the system. Ground based transmitter stations (GBT) FIG. 1, 401-404 are employed to relay mobile information to and from the portable mobile units of the network. Interface to a fixed telephone network such as home telephone or other communication units such as the personal computer could be achieved through the public telephone switching network (PTSN). Satellites 101-102 are employed by the system to relay information to remote areas and also to provide referenced signals, which ground base communication units, may utilize in establishing their geographic location. Communication between the satellites and the ground network is achieved through earth based satellite transmitters 301-302.

A general internal circuitry of a portable remote unit or PRU, FIG. 1, 501-510 is shown in FIG. 2. The portable remote unit consists of an antenna 20 and a transceiver circuitry 21. The transceiver circuitry receives and transmits portable remote unit information via the antenna 20. On receipt, this information is processed and the intelligence portion is extracted and sent to the control unit 22 for further processing. The transceiver also receives portable remote unit information from the control unit 22, processes it, and forwards it as required to the network via the antenna 20. The control unit 20 controls the action of the PRU. Relevant information pertaining to the PRU could be stored in the allocated memory means 26. The memory means may include a Random Access Memory, a Read Only Memory and additional memory to store PRU data. Input panel 25 is employed to take user instructions and the display 23 is used to present PRU information to a user. The audio means 24 is used for annunciation of voice messages. A PRU may be able to assist the network in determining its global location or use any location determination technique to resolve and provide its location to the network. As a PRU is carried from one location to the other it may obtain and provide information concerning its current location to the network.

As stated in one of the objectives of the invention and illustrated in FIG. 1, a portable remote unit 501, utilized by a subscriber 701, in a moving vehicle 601, could be tracked by a clandestine unit 510, such unit concealed in vehicle 601. A subscriber—let say 704 in region 202—in another geographic region trying to keep track of the whereabouts of user 701 may have concealed unit 510 in vehicle 601 to track subscriber 701. As most portable remote units are small and compact they could easily be hidden without subscriber 701

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knowing of such activity. As vehicle 601 travels from one location to the next, authorized users will be able to receive location information from PRU 510 whenever they poll for it. As PRU 510 discloses its location to the authorized party, the party may obtain the location of subscriber 701 without their authorization. It is of utmost importance that a subscriber in possession of unit 501 should be able to determine if they are being tracked by another unit. In the current invention subscriber 701 will at any point in time activate the tracking feature provided in PRU 501. This could be achieved by invoking the appropriate function through the input panel, FIG. 2, 25 of the PRU. In tracking mode, a tracked PRU, FIG. 1, 501, may simply alert a user in possession of the tracked PRU with the location information of any tracking device—PRU 510—that has resided within a pre-specified radius of the tracked PRU, with both units having traveled a minimum distance. Parameters such as elapse time, minimum distance traveled and tracking radii could be set as a standard by the industry. The tracking feature could be invoked by the tracked PRU or a request could simply be forwarded to the closest ground control station so that the operation is performed for the tracked PRU. In tracking mode the geographic location of the tracked unit, FIG. 1, 501, is utilized to determine the geographic boundary where a search for possible tracking units 510 could be initiated. Over a period of time and at pre-determined time intervals a page is sent to the geographic location 201 where the tracked unit 501 resides for all location-reporting units within that geographic boundary to disclose their location. The geographic boundary required to establish tracking could be set as a standard by the industry. For instance, it could be agreed upon that a unit could be deemed as tracking another if it stays within a 5 meter radius of the tracked unit over a 1 mile stretch. As the tracked unit 501 is moving, that unit or an appropriate network unit, may page for the location of other communication units within the tracking boundary of the tracked unit to disclose their location. Only communication units within that geographic boundary would disclose their location. Timing information could also be included in the disclosed information to help eliminate errors that may occur when a tracked unit, FIG. 1, 501, is in a vehicle 601 that is moving at a high velocity. This exercise could be done at fixed time intervals and over a pre-determined time period. At the first time interval, a list could be maintained of all the PRUs that responded within the specified geographic boundary defined for tracking. At subsequent time intervals, PRUs that were in the list at the first tracking interval and not responding in later intervals could be eliminated as possible tracking units. At the end of the tracking period, if there are any units in the tracking list and the minimum tracking distance was covered, such communication units are deemed to be tracking another and are reported to the requested party. The minimum traveling distance must be maintained to eliminate the risk of identifying communication units that reside in a fixed geographic boundary over the tracking period as possible tracking units. Also, a maximum time limit must be set for the tracking exercise such that if the minimum distance is not traveled within that time period the tracking process is aborted. If such a time is not maintained a PRU could be in the tracking mode indefinitely. The steps for this process are shown in FIG. 5.

According to FIG. 5, once the tracking mode is invoked at a search unit, tracking is initialized, FIG. 5, 1. Note that the search unit could be any relevant mobile communication unit trying to identify possible mobile communication units that are tracking another. The search unit then operates

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repeatedly over pre-defined time intervals 2 until the end of the tracking period 9, 13. At each tracking interval 2, the location of the tracked unit is obtained 3. Possible tracking units within a specified geographic boundary of the tracked unit are paged to reveal their location 4. For the first tracking interval 5, all tracking units that provided their location at that interval are stored in a list 7. At subsequent tracking intervals, a tracking unit that responded in the first tracking interval and not responding in a subsequent tracking interval is eliminated 6 as a possible tracking unit. If the tracking list is empty at any tracking interval 8, the tracking process is aborted 9. A test 10 is next performed to verify that the tracking units in the list traveled the minimum pre-defined distance. If it is determined that the tracking units traveled the minimum distance 10, they are reported as tracking units to the network 11. If it is determined that the tracking units have not yet traveled the minimum distance 10, a check is done to establish if the maximum tracking time has elapsed 12. If no time is left to establish tracking 12, the process is aborted, 13, otherwise it is repeated 2. A maximum time must be set for the tracking process to ensure that a PRU is not in tracking mode indefinitely.

As previously indicated, a PRU may invoke this method directly to determine if other units residing in its immediate geographic area have been tracking it. This would help reduce network overload and, at the end of the tracking period, a status signal may simply be forwarded to the network. In circumstances where a tracked PRU cannot perform this operation, a ground control unit may be employed to carry out the tracking operation for the PRU and report any findings to the PRU. Maintaining a list of all tracking units at the first tracking interval is efficient as it reduces storage space and processing time. It is also possible to maintain a list of all units that are within a pre-defined geographic boundary of the tracked unit throughout the entire tracking process. At the end of the process, the list could be used to determine which units reported their location over a pre-specified distance traveled by the tracked unit.

For a unit to report a global location within a specified geographic boundary, the unit must be able to obtain geographic boundary information and further determine if its location is within the prescribed boundary. There are several techniques well known in the art that a remote unit may employ to resolve its geographic location or assist the network in resolving its location. Once the PRU obtains its location from whatever technique, that information is utilized to perform the functions in accordance with the invention. Apart from determining if a remote unit is being tracked, other uses exist for a remote unit to disclose its location at a particular geographic location. For instance a distress subscriber at a specific global location may simply want to know if there are mobile users in the immediate geographic area. Furthermore, a subscriber might want to know if there are any individuals at their home, office or a specified geographic location. By specifying the required location and further information such as radii information, the network may provide a portable remote unit with the location portable remote targets that are closest to the PRU and in the geographic area specified by the PRU.

For a simple search where the geographic region does not exceed a pre-specified limit, a page may simply be sent to the required region for all units in the region to disclose their location. As it would be inefficient to page for portable remote units in wider geographic boundaries to reveal their location, searches in these areas could be managed differently by the network. In this situation, the network may

simply split the wider area into sub regions and recursively query for the location of PRUs, starting in sub-regions that are close to the origin before extending to geographic regions that are further away.

To disclose a global location within a prescribed geographic boundary, a PRU at the geographic location picking up the request must determine if it is within that boundary before providing its location to the network. FIG. 3 shows a geographic location with mobile units M_1 – M_N . This location is divided into cells (C_1 – C_n) or grids (G_1 – G_n) where n is the total number of cells or grids, also known as region. Each region could be defined by its latitude, longitude and radii information or by distinct points that define the grid. Looking at FIG. 3, cell C_1 is defined by radius R and its latitude and longitude information is that of mobile user M_1 (x_0, y_0). Grid G_1 is defined by four points P_1 , P_2 , P_3 and P_4 . Subsequent cells and grids are defined in that fashion as shown in FIG. 3. FIG. 3 depicts a wide geographic area. Ground stations and control centers, not shown, may also be available in that area. Such an illustration may also be seen in a general sense in FIG. 1.

As shown in FIG. 3, a distressed mobile user M_1 may need to find where another party might exist in that geographic region. The user could initiate a page from their PRU for the closest available PRUs that could be found in that geographic jurisdiction. Looking at FIG. 3, mobile user M_1 will provide its location, latitude and longitude (x_0, y_0) to the closest available ground station serving area C_1 or grid G_1 . As stated earlier, appropriate terrestrial technology will be scattered in that region to serve the PRUs in that area as shown in FIG. 1. Once a ground station picks up this signal, it sends a page for all location reporting devices in the specified boundary surrounding mobile unit M_1 , FIG. 3 to disclose their location. Such boundary information could simply be specified by the latitude and longitude of unit M_1 and appropriate radii information. For the very first request, such radii information would be the distance R as shown in FIG. 3. A PRU within that area will pick up the signal and determine if it is within the specified radii. Also, if the ground station specifies grid information for the first cell, G_1 , a PRU will have to determine if it lies within the grid G_1 boundary, P_1 , P_2 , P_3 and P_4 . According to FIG. 3, when a ground station sends a page for the location of PRUs in cell C_1 or grid G_1 , only mobile unit M_1 may respond. As M_1 is the PRU that initiated the search, the ground control station would make the determination and obtain the next region—radii or grid—information for a possible search. The geographic boundary information of cell C_2 or grid G_2 will be provided for the next search. Subsequent searches will include incrementing the radii information to from $C_1 \dots C_N$ or grid boundary information from G_1 – G_N until a PRU within that geographic boundary responds or system limitations are encountered. A possible limitation may be the size of a geographic boundary to page for remote unit locations. According to FIG. 3, the radius of each cell is from the origin of mobile unit M_1 , (x_0, y_0). The radii of subsequent cells is a factor of the radius of the first cell, C_1 . The grid is usually the tightest rectangular boundary defining the cell. As the grid or cells become larger, exclusion zones, as described hereinafter, may also be specified if it is required that PRUs in certain areas should not disclose their location. Another possibility might be not to increase the next geographic area on a subsequent page but split the entire geographic boundary into small regions of about the same size. Each region could then be paged, starting in areas that are closed to the origin. This could be done until a PRU at a region discloses their location.

Considering that mobile unit M_1 is initiating a search for possible portable remote units in its immediate area, a relevant ground control station will send three pages. The first page will cover cell C_1 or grid G_1 . As no units are available in the area a second page will be sent to cover cell C_2 or grid G_2 . Examining FIG. 3, the next PRUs exist only in cell C_3 or grid G_3 . Once a page is sent out for cell C_3 , PRU, M_2 and M_3 will respond. If grid G_4 specified PRU M_2 , M_3 , M_4 and M_5 will respond. The ground control station will next select the unit closest to PRU M_1 , which is M_2 , in this instance. The location of PRU M_2 will then be forwarded to PRU M_1 . M_1 may also choose to request for the number of PRUs in its area and the ground control station would respond again, based on system requirements. Using the system, a user in possession of a PRU may check for the existence or other PRUs at another geographic location. A user may select a geographic area from a map presented by the PRU. In FIG. 1, a mobile user 709 at location 204 may utilize this system to request for the location of mobile units in another geographic region such as 202 or 203. This could be for instance, checking to see if there are PRUs at the office or house or any location of interest. The system would simply return the appropriate information such as number of PRUs responding, location of PRUs and relevant information requested. In such a system, subscribers may choose to participate to have their location disclosed when a search is initiated. Subscribers may also opt to block or activate this feature at any time at the network. A subscriber to the service may be charged a fee each time the system is used. A possible technique utilized to implement the above is shown in FIG. 7.

According to FIG. 7, the geographic information of the area where a search for possible remote targets sought is first obtained 1. This information could be provided by a PRU to the network. This information may simply be the latitude and longitude of the area where the search would be performed and other relevant information to assist the network with the search. A PRU may display a map where a user may select a specific geographic area. From this information the next geographic region where a possible search for PRUs is estimated 2. This could be the latitude longitude and radii information of the searched area. Also, the tightest rectangular grid surrounding the cell having that radii information could also be calculated and utilized. Once that information is obtained a page is sent out to that geographic region for remote units in the region to reveal their location 3. If remote units are identified in the paged area 4, that information is forwarded to the network 5 and the process is aborted 7. If no remote units are identified in the area 4, a check is done to establish if there are any remaining cells or grids higher up in the chain to be searched 6. If no regions exist for a possible search, the process is aborted, otherwise, the process is repeated until all geographic cells or grids have are searched for the existence of portable remote units.

Whenever a portable remote unit receives a page to disclose its location within a specified geographic boundary, the PRU obtains its location and attempts to determine if it is within that boundary. As mentioned before, the PRU may employ any relevant location determination technique well known in the art to obtain its geographic location. If the boundary information specified by the network contains a well-defined set of points—latitude and longitude for that region—defining the geographic region, the PRU will simply establish if its location is within the geographic boundary and provide its location to the network based on that. The points may simply define the minimum and maximum latitude and longitude values within which a PRU should

respond. Such a procedure would be stored in the memory means, FIG. 2, 26 of the PRU and invoked by the control unit FIG. 2, 22 of the PRU as required. If the network simply provides the origin—latitude and longitude—and radii information of the region where a search is to be performed, the PRU will utilize these values to establish if it is within the area defined by the network as shown in FIG. 4.

FIG. 4 shows four mobile objects, Object₀, Object₁, Object₂, and Object₃. Considering that Object₀ is the source and needs to know if any portable remote units are available in the geographic region of radius R. The location of Object₀ is the origin of the region and the radii information provided by the network for that region is R. All objects within that radius must respond upon receiving the signal requesting for their location in the specified radii. Looking at FIG. 4, only Object₃ and Object₂ exist in the region specified and would respond to the page. If all the mobile objects are served by the same ground station they will all receive the signal for location disclosure if in the region. To establish if they are within the region specified, each mobile object will obtain its location and calculate its tangential information from the specified geographic origin (x₀, y₀) defined by the source, Object₀. The tangent of an angle is usually the opposite/hypotenuse. Looking at FIG. 4, the tangent is between the origin of Object₀ and Object₁, and that angle is θ . As Object₃ lie on the same line as Object₁, the tangent between the origin of Object₀ and Object₃ is also θ . The tangent between the origin of Object₀ and Object₂ is α . Standard trigonometric equations dictate that the tangent of an angle is the opposite/hypotenuse. According to FIG. 4, $\tan \theta = (y_1 - y_0) / (x_1 - x_0)$ for Object₁ and $(y_3 - y_0) / (x_3 - x_0)$ for Object₃. For Object₂ $\tan \alpha = (y_2 - y_0) / (x_2 - x_0)$. Once the inclination or tangent of the object to the origin is calculated, the distance of the object to the origin could easily be calculated by using the sine formula—Sine θ = opposite/hypotenuse where the opposite is (y₁ - y₀), (y₃ - y₀) for Object₁ and Object₃ respectively. The hypotenuse is the distance from the mobile object to the origin; R₀₁ and R₀₃ for Object₁ and Object₃ respectively. For Object₂, the distance from the origin R₀₂ = (y₂ - y₀) / Sine α . Once the distance from the origin (x₀, y₀) is calculated for each mobile object, an evaluation could easily be made as to whether the mobile object lies within the specified boundary and the location of the mobile object could be provided to the network based on that. Furthermore, the network may choose to provide an exclusion region or regions to the portable mobile remote units or PRUs. A PRU in that exclusion region will not disclose its location to the network even if it lies in the network's specified geographic boundary. This exclusion zones may be specified simply as grid points anywhere in the paged region or as a direction aft the origin. A direction aft the origin contains information that will indicate to PRUs in the region not to disclose their location if they are East, West, North or South of the origin. Considering FIG. 3 as a further example, if a request is received in that region for the location of mobile units in G₄ or C₄ and the origin is the location of M₁, with the exclusion zone specified as East, all the mobile units in G₄ or C₄ will receive the request to disclose location in that area. Upon detecting the exclusion zone information in the signal only the mobile units to the West of M₁ will reveal their location. Again, such exclusion zone information may simply specify sub region(s), where PRUs should not reveal their location.

FIG. 6 shows the steps utilized by a remote unit to reveal its location if it is within the geographic boundary specified by the network. The unit first obtains geographic boundary information specified by the network 1. This information may consist of latitude and longitude information defining

the regions origin and radii information. The unit next obtains its location 2. This could be done in association with the network or by using any remote unit location determination techniques such as GPS. The next step is to determine if the unit is within the boundary prescribed by the network 3. Such a technique has already been described in the invention. Further checks are carried out to ensure that remote unit is not in a location reporting exclusion zone defined by the network 4. The location of the remote unit is provided to the network 7 once it is established at the remote unit that the subscriber 6 authorized such an action.

It could be made mandatory that all PRUs reveal their location once they receive a request to establish tracking. A PRU may not respond to any tracking establishing routines if it is at a fixed location. Tracking is only possible when the tracking and tracked unit are in motion. If a network's request is just to establish if a PRU is within a geographic location, the PRU's response could be based solely on the requirements of the subscriber—whether such action is authorized or not. A PRU may choose to instruct the network to relay certain information to mobile units in a specific geographic region. That information would then be appended to the geographic boundary information and beamed in the specified geographic region. The target PRUs would determine if they are in the specified boundary before alerting a subscriber as to the content of the message. In circumstances where a subscriber in possession of the PRU is in motion and a request is received for the location of the PRU if within a specified region, the PRU may provide this information and also provide additional information such as its velocity to the network. This might help a party seeking help to establish if they would be able to catch up with another subscriber in the region which help was sought. Also, a party requesting for the location of remote units in a geographic boundary may also forward maximum velocity information. If a PRU is in the region and establishes its velocity is above what is specified, no response is sent to the network. A PRU may calculate its velocity by using the equation, velocity = distance/time. At time intervals T₁ and T₂, a PRU may obtain its location, Y₁ and Y₂ and calculate the distance between these two points, as previously disclosed. The velocity is given by (distance between Y₂ and Y₁) / (Time at Y₂ - Time at Y₁). Such information could then be provided to the network. In situations where a PRU cannot perform any of the tasks described herein, the network may obtain its location information and the required functions performed at the network and forwarded to the appropriate communication target on completion.

What is claimed is:

1. A method for providing the location of a portable mobile remote unit in a geographic region of a wireless network to a wireless consumer requesting the location of portable mobile remote units that are maintaining close proximity to the wireless consumer in the geographic region comprising:

- i) obtaining the location of the wireless consumer at intervals over a period of time;
- ii) requesting at each interval, at the network, that all mobile remote units within close proximity of the wireless consumer disclose their location to the network;
- iii) maintaining a list of mobile remote units that provided their location at each interval after the request of (ii);
- iv) from the list of (iii), forwarding the location of at least a mobile remote unit to the mobile consumer upon determination that the remote unit maintained close proximity to the mobile consumer over the period of time of (i).

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2. A technique according to claim 1, utilized to determine if a mobile remote unit is within a prescribed geographic boundary or within close proximity of a wireless consumer comprising:

obtaining radii information of the geographic boundary from the network;

obtaining geographic information describing the origin of the geographic boundary;

calculating the angle of inclination of the remote unit to the geographic boundary origin;

calculating from the angle of inclination the distance between the remote unit and the geographic boundary origin;

comparing the radii of the geographic boundary to the calculated distance to establish if the remote unit lies in the geographic boundary.

3. A technique employed by the method according to claim 1 to determine if a remote unit is within a specified geographic boundary or close proximity to a wireless consumer comprising:

obtaining from the network geographic information describing the geographic boundary;

estimating at the remote unit if the current location of the remote unit is within the geographic boundary obtained at the network.

4. A method according to claim 1 utilized to further limit the provision of remote unit location to the network comprising:

obtaining at the network, exclusion region information within which the remote unit should not provide its location the network;

determining that the remote unit is not in the exclusion region before providing the location of the remote unit to the network.

5. A technique utilized in the method according to claim 1, to terminate requesting at each interval, for the location of mobile remote units within close proximity of the wireless consumer comprising:

i) keeping track of the time since the first request for tracking units within proximity of the wireless consumer was enacted by the system;

ii) validating that the elapsed time at each interval when a request is to be made does not exceed the total time set for establishing tracking in the system;

iii) requesting that all mobile remote units within close proximity of the wireless consumer divulge their location if the result of the validation of (ii) is true.

6. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless consumer requesting that information comprising:

i) receiving at the network a wider than normal prescribed geographic boundary to query for mobile remote units from the wireless consumer;

ii) splitting the geographic boundary of (i) into sub geographic regions to constitute the prescribed geographic boundary;

iii) requesting in the sub geographic region(s), the location of remote units that are present in each sub region;

iv) verifying after each request of (iii) in a sub region whether at least a portable remote unit disclosed a global location in the region;

v) maintaining a list of all remote units that disclosed their location after each request from the verification of step (iv);

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vi) providing to the network and from the list of (v) the location of at least a remote unit that revealed its location in the sub region.

7. A technique according to claim 6, utilized to terminate a request for the location information of remote units in the prescribed geographic boundary comprising:

checking to establish that a request for remote unit location information was undertaken in all re-defined or sub regions of the prescribed boundary or a portable remote unit in a defined or sub region responded with location information.

8. A method utilized to provide to a source of request, the location of a mobile remote units that exist in a geographic region from the list according to claim 6 comprising:

(i) estimating and obtaining from the list, the location mobile remote units that are closer to the source of request;

(ii) providing the information obtained in (i) to the source of request before releasing the location of other mobile remote units that are further from the source of request.

9. A method for determining that a first portable remote unit associated with a network is being tracked by at least a second portable remote unit over a tracking period comprising:

obtaining the location of the first portable remote unit or tracked unit;

obtaining the location of the at least a second communication unit or tracking unit that is within proximity or a pre-specified radius of the tracked unit;

verifying whether the tracking and tracked unit(s) have traveled a minimum pre-specified distance over the tracking period;

forwarding the result of the verification to the network at the end of the tracking period.

10. The verification technique employed in the method of claim 9 comprising:

retaining a tracking list of all tracking units that are within a pre-specified radius or region of the tracked unit at the first tracking interval;

eliminating or removing at subsequent tracking intervals, all tracking units in the tracking list that do not report their location during a subsequent tracking interval;

validating at the end of the tracking period that at least a tracking unit exist in the tracking list and a minimum distance was traveled by the tracked unit.

11. Another verification technique employed in the method of claim 9 comprising:

maintaining a list of all tracking units that are maintaining a close distance to the tracked unit over the period of time;

searching the tracking list at the end of the tracking period to obtain tracking units that traveled a minimum pre-specified distance with the tracked unit.

12. A communication system comprising:

a network of communication units;

at least a first communication unit and at least a second communication unit able to provide their location information to the network;

the system able to determine and report that the at least second communication unit maintained close proximity to the at least first communication unit over a period of time.

13. The system of claim 12, the at least first communication unit able to invoke a tracking mode at the at least first



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Welles, II et al.

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[45] **Date of Patent:** Nov. 25, 1997

[54] **LOCAL COMMUNICATION NETWORK FOR POWER REDUCTION AND ENHANCED RELIABILITY IN A MULTIPLE NODE TRACKING SYSTEM**

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[73] **Assignee:** General Electric Company, Schenectady, N.Y.

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[52] **U.S. Cl.** 370/316; 340/989; 340/992; 342/457; 455/54.1

[58] **Field of Search** 370/95.1, 95.2, 370/85.7, 85.8, 316; 340/933, 988, 989, 991, 992, 993; 455/33.1, 33.2, 54.1; 342/450, 457

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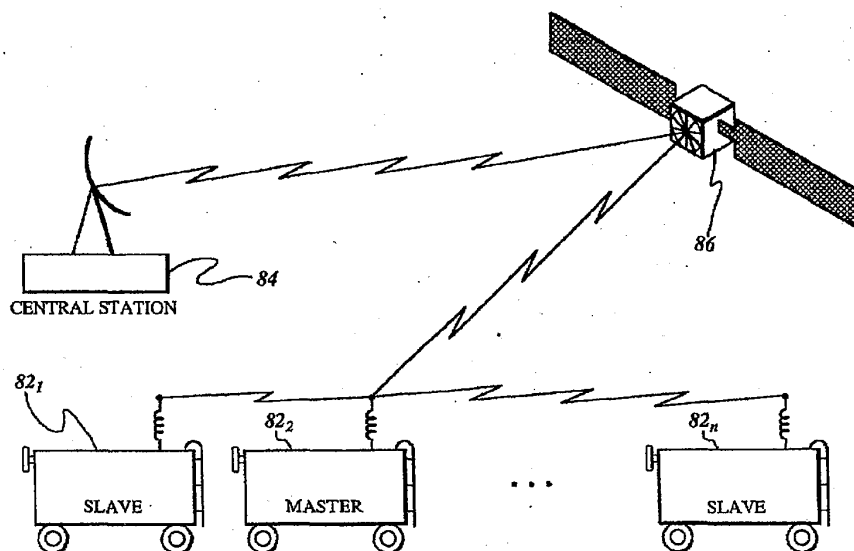
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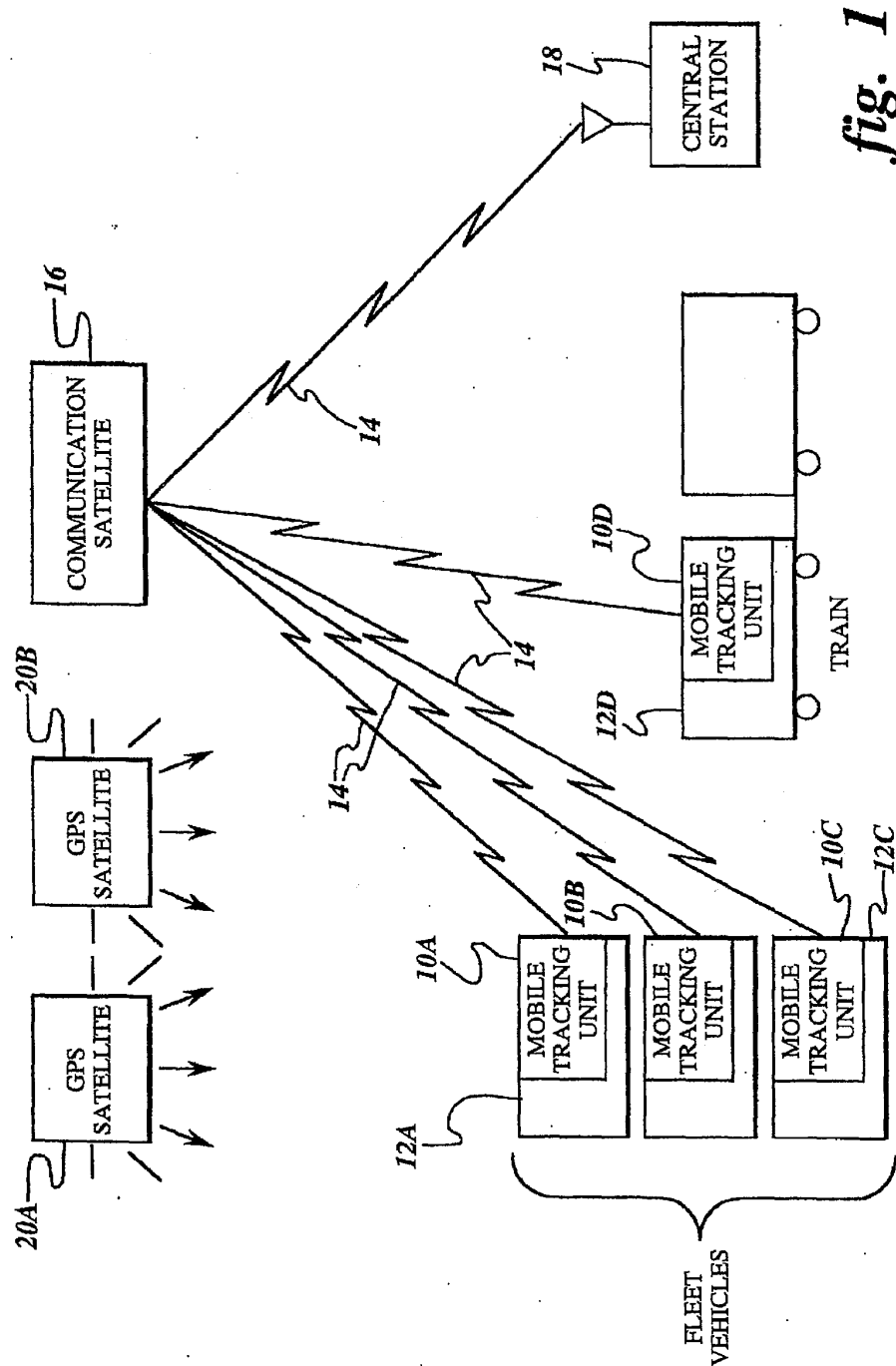
Primary Examiner—Douglas W. Ohms
Assistant Examiner—Min Jung
Attorney, Agent, or Firm—Marvin Snyder

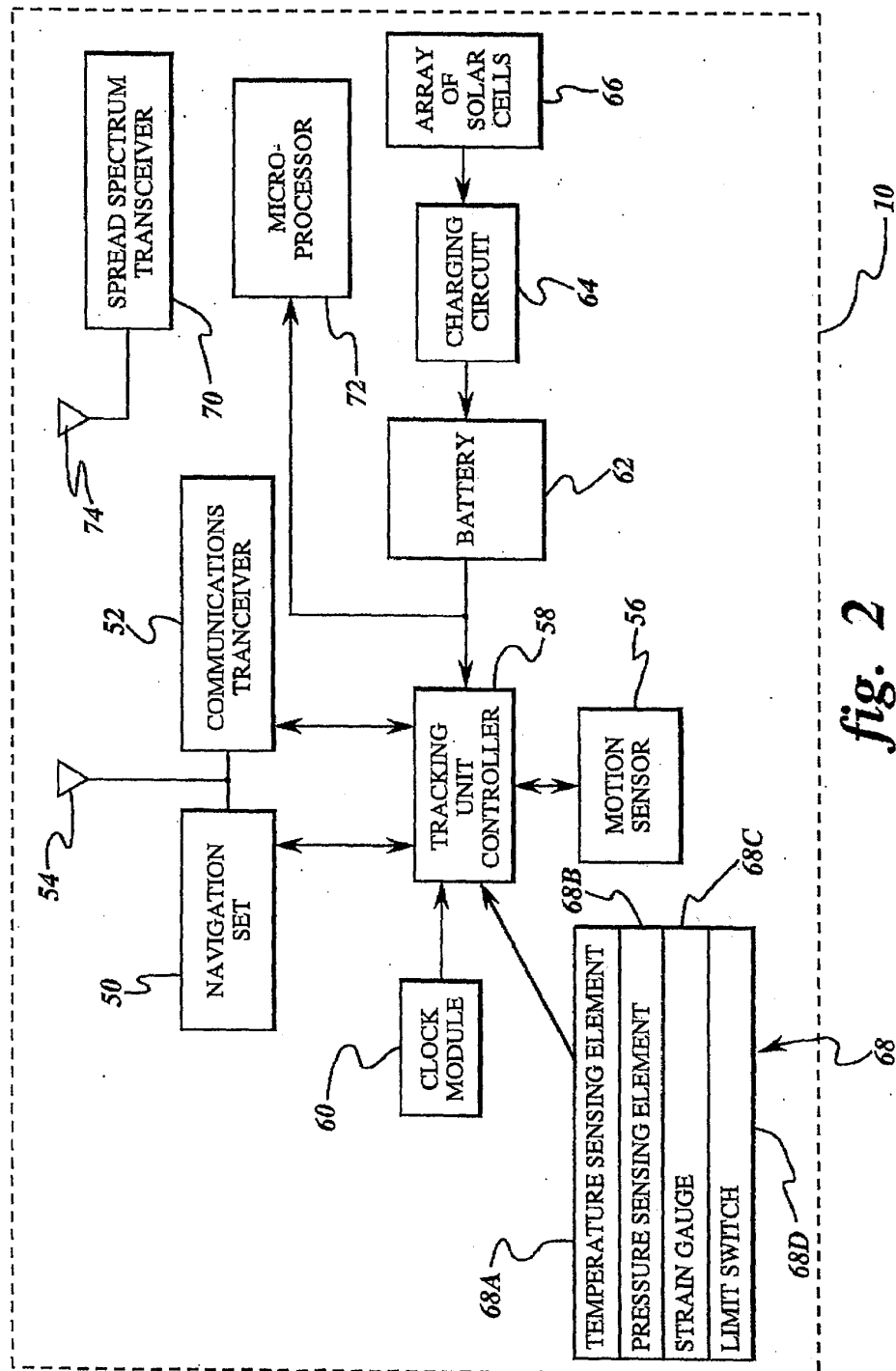
[57] **ABSTRACT**

A mobile local area network (LAN) of tracked assets utilizing minimal power and bandwidth allows a large number of assets to be tracked in a practical manner. The mobile LAN is established between a plurality of tracking units in close proximity. Assets are approximately located according to their connection in the mobile LAN where the exact location of at least one of the network nodes is known. Each tracked asset has capability to independently determine and report its position to a central station, and each asset also has capability to communicate locally with other cooperative assets via the LAN. The LAN is dynamically reconfigurable so that as other cooperative assets come into proximity, they can join the network, and as others move away, they can leave the network. Within the network, a protocol is followed which assigns one of the assets to be the "master" and all others to be "slaves". The master asset takes responsibility for determining its own exact geographical position via LORAN, OMEGA, Global Positioning System (GPS) or other navigational aid. When connected in a LAN, slave assets report their ID to the master asset and do not determine their own locations in order to conserve power. The master reports its location and ID, as well as the IDs of the other assets in the LAN, to the central station. Uncertainty in the location of a slave asset is limited by the known possible geographical extent of the LAN which is known a priori.

11 Claims, 8 Drawing Sheets







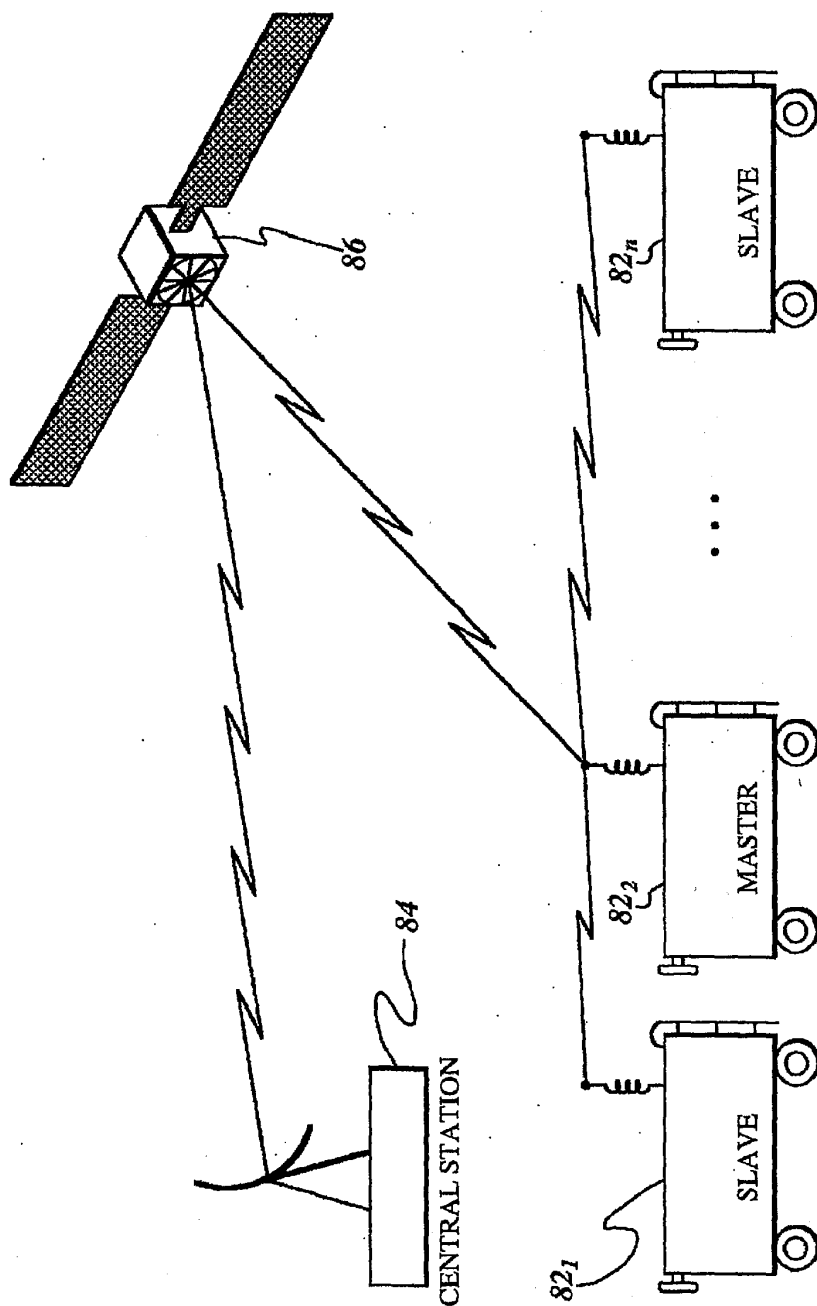


fig. 3

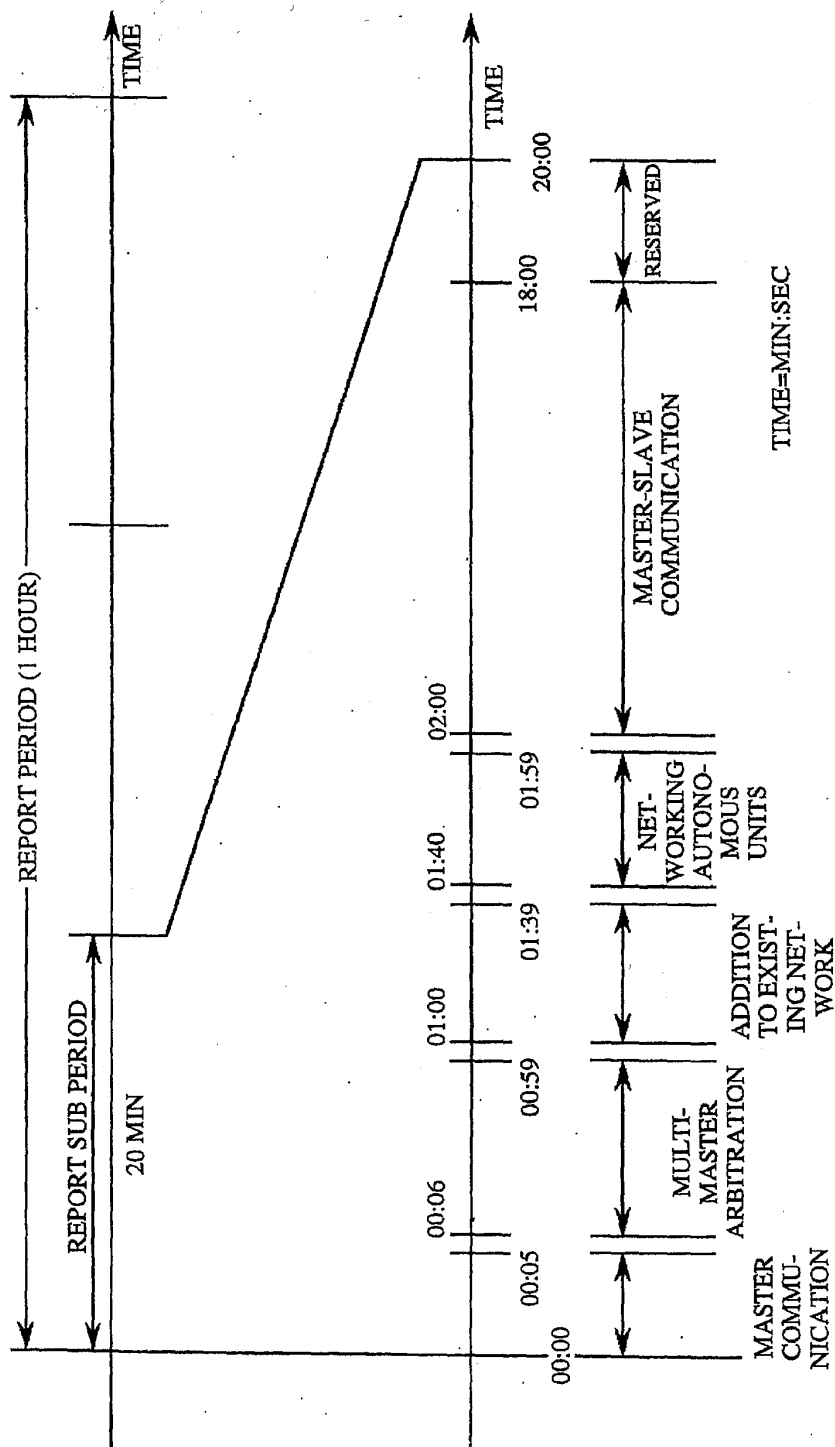
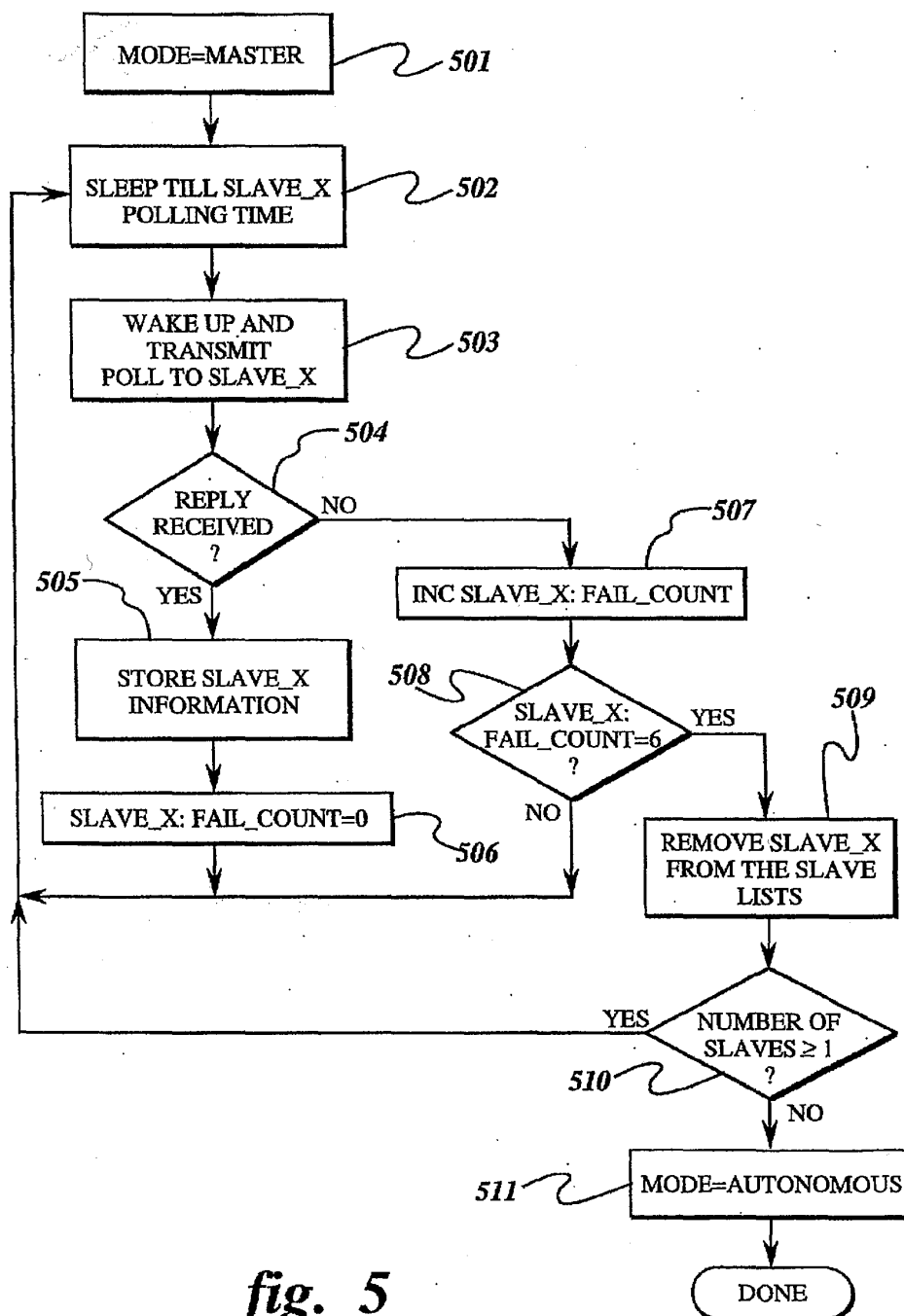
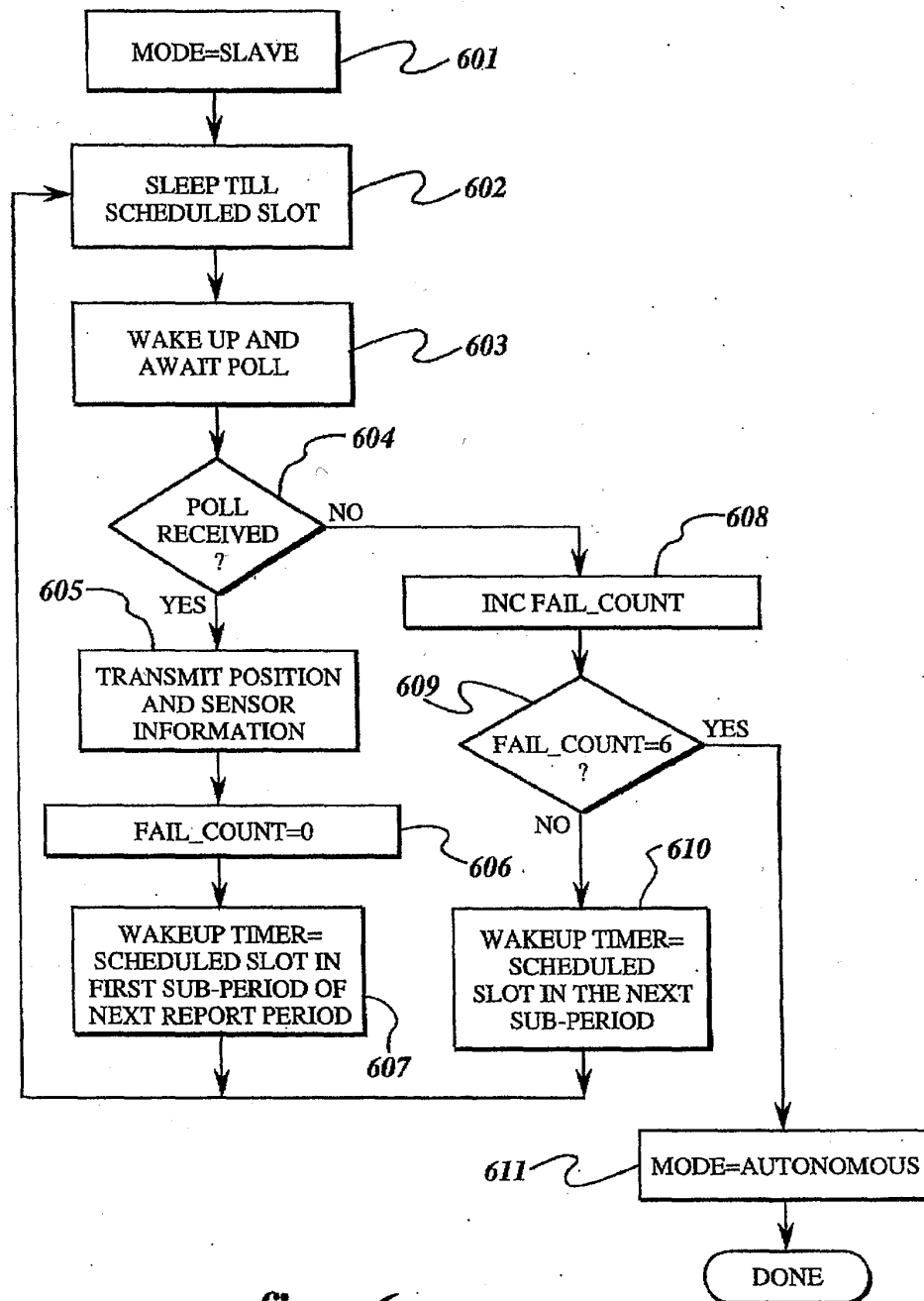


fig. 4

*fig. 5*

*fig. 6*

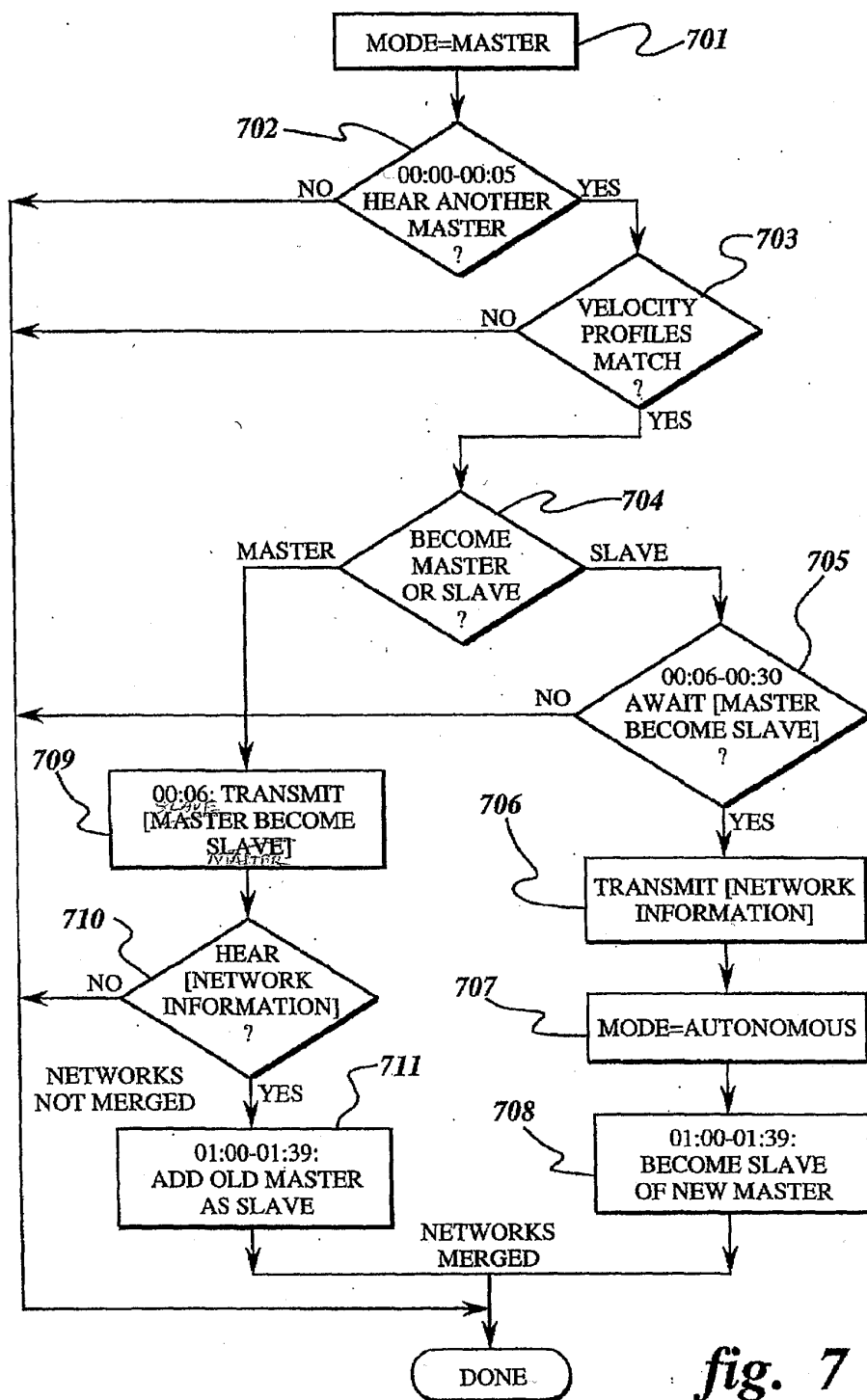
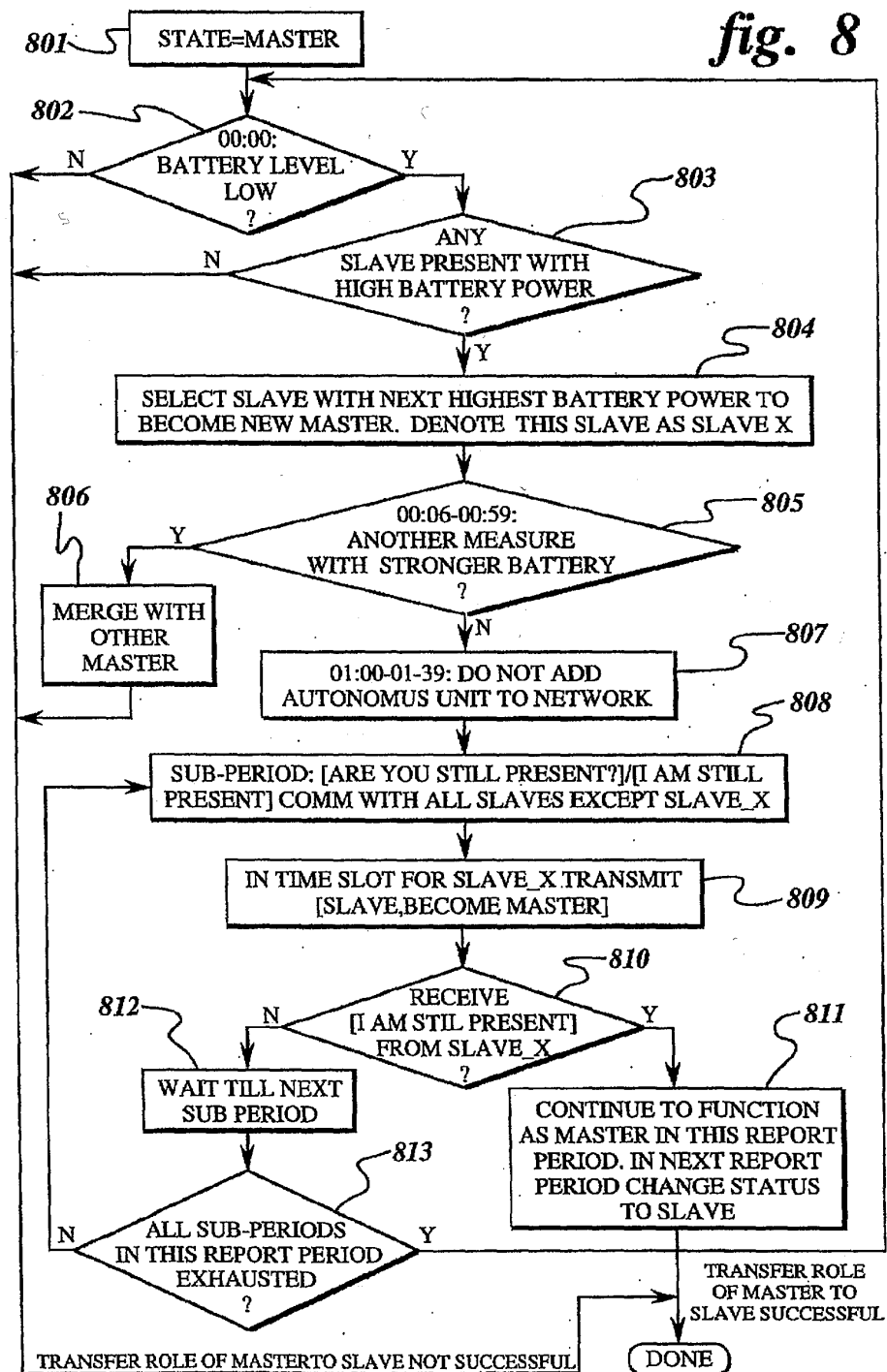


fig. 8



**LOCAL COMMUNICATION NETWORK FOR
POWER REDUCTION AND ENHANCED
RELIABILITY IN A MULTIPLE NODE
TRACKING SYSTEM**

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to asset tracking and, more particularly, to tracking of assets, including goods and vehicles, using the Global Positioning System (GPS). While goods are an example of assets that need to be tracked, the cargo containers, container trucks and railcars in which the goods are shipped are themselves assets which need to be tracked.

2. Description of the Prior Art

Goods shipped from a manufacturing plant, warehouse or port of entry to a destination are normally tracked to assure their timely and safe delivery. Tracking has heretofore been accomplished in part by use of shipping documents and negotiable instruments, some of which travel with the goods and others of which are transmitted by post or courier to a receiving destination. This paper tracking provides a record which is completed only on the safe delivery and acceptance of the goods. However, during transit, there sometimes is a need to know the location and position of the goods. Knowledge of the location of goods can be used for inventory control, scheduling and monitoring.

Shippers have provided information on the location of goods by tracking their vehicles, knowing what goods are loaded on those vehicles. Goods are often loaded aboard shipping containers or container trucks, for example, which are in turn loaded aboard railcars. Various devices have been used to track such vehicles. In the case of railcars, passive radio frequency (RF) transponders mounted on the cars have been used to facilitate interrogation of each car as it passes a way station and supply the car's identification. This information is then transmitted by a radiated signal or land line to a central station which tracks the locations of cars. This technique, however, is deficient in that while a particular railcar remains on a siding for an extended period of time, it does not pass a way station. Moreover, way station installations are expensive, requiring a compromise that results in way stations being installed at varying distances, depending on the track layout. Thus, the precision of location information varies from place to place on the railroad.

Recently, mobile tracking units have been used for tracking various types of vehicles, such as trains. Communication has been provided by means of cellular mobile telephone or RF radio link. Such mobile tracking units are generally installed aboard the locomotive which provides a ready source of power. However, in the case of shipping containers, container truck trailers and railcars, a similar source of power is not readily available. Mobile tracking units which might be attached to containers and vehicles must be power efficient in order to provide reliable and economical operation. Typically, a mobile tracking unit includes a navigation set, such as a Global Positioning System (GPS) receiver or other suitable navigation set, responsive to navigation signals transmitted by a set of navigation stations which may be either space-based or earth-based. In each case, the navigation set is capable of providing data indicative of the vehicle location based on the navigation signals. In addition, the tracking unit may include a suitable electromagnetic emitter for transmitting to a remote location the vehicle's location data and other data acquired from sensing elements on board the vehicle. Cur-

rent methods of asset localization require that each item tracked be individually equipped with hardware which determines and reports location to a central station. In this way, a tracked asset is completely "ignorant" of other assets being shipped or their possible relation to itself. In reporting to the central station, such system requires a bandwidth which scales approximately with the number of assets being reported. The aggregate power consumption over an entire such system also scales with the number of assets tracked. Further, since both the navigation set and the emitter are devices which, when energized, generally require a large portion of the overall electrical power consumed by the mobile tracking unit, it is desirable to control the respective rates at which such devices are respectively activated and limit their respective duty cycles so as to minimize the overall power consumption of the mobile tracking unit.

Most current asset tracking systems are land-based systems wherein a radio unit on the asset transmits information to wayside stations of a fixed network, such as the public land mobile radio network or a cellular network. These networks do not have ubiquitous coverage, and the asset tracking units are expensive. A satellite-based truck tracking system developed by Qualcomm Inc., known as OMNITRACS, is in operation in the United States and Canada. This system requires a specialized directional antenna and considerable power for operation, while vehicle location, derived from two satellites, is obtained with an accuracy of about one-fourth kilometer. A rail vehicle positioning system described in U.S. Pat. No. 5,129,605 to Burns et al. is installed on the locomotive of a train and uses, to provide input signals for generating a location report, a GPS receiver, a wheel tachometer, transponders, and manual inputs from the locomotive engineer. The rail vehicle positioning system of Burns et al. is not readily adaptable to use of battery power and, therefore, is unsuitable for applications which are not locomotive-based.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a local area network of tracked assets which utilizes minimal power and bandwidth so as to allow a large number of assets to be tracked in a practical manner.

In accordance with the invention, a mobile local area network (LAN) is established among a plurality of mobile tracking units in close proximity. Assets are approximately located according to their connection in the mobile LAN where the exact location of at least one network node is known. Each tracked asset may have the capability to independently determine and report its location to a central station, and each asset also has the capability to communicate locally with other cooperative assets via the LAN. Because of the inherent mobility of the tracked assets, the LAN is a wireless network preferably using low power spread spectrum transceivers. The LAN is dynamically reconfigurable so that as other cooperative assets come into proximity, they can join the network, and as others move away, they can leave the network.

Within the network, a protocol is established which assigns one of the assets to be the "master" and all others to be "slaves". The master asset takes the responsibility of determining its own exact geographical position. This may be done via LORAN, OMEGA, Global Positioning System (GPS) or other navigational aid. When operating in a LAN, slave assets report their identification (ID) to the master asset according to the local protocol and do not determine their own location in order to conserve power. The master

reports to the central station its location and ID, as well as the ID of each of the other assets in the LAN. The central station can then know that the assets associated with each ID are within the communication range of the geographical position reported by the master. Uncertainty in the location of a slave asset is limited by the known possible geographical extent of the LAN, which is known a priori.

In one preferred embodiment of the invention, a railcar location and tracking system is comprised of independent mobile tracking units affixed to railroad freight cars. These tracking units are battery powered and have Global Positioning Satellite (GPS) receiving and communication transmitting capabilities. The units have an extremely low power radio data link between units on the freight cars which are in close proximity (about 1 km). This radio link allows units which are part of the same train to share information. Sharing information allows use of a single GPS receiver and a single communications transmitter. Since the GPS receiving and communications transmitting functions are the most power consuming tasks performed by the units, this sharing of information reduces the average power consumed by the units on the train. System reliability is significantly enhanced by allowing units with inoperative GPS receivers or communications transmitters to continue to provide location and tracking information through the LAN.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the invention believed to be novel are set forth in the appended claims. The invention, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawing(s) in which:

FIG. 1 is a block diagram of an exemplary asset tracking system which employs independent mobile tracking units in accordance with the present invention;

FIG. 2 is a block diagram showing in further detail a tracking unit as used in the tracking system shown in FIG. 1;

FIG. 3 is a block diagram illustrating organization of the mobile local area network implemented by the present invention;

FIG. 4 is a timing diagram showing organization of time used for mutter-mode communications;

FIG. 5 is a flow diagram showing the process employed at a master unit for polling a slave unit;

FIG. 6 is a flow diagram showing the process employed at a slave unit for transmitting information to the master unit and for changing state to autonomous;

FIG. 7 is a flow diagram showing the process of merging two established local area networks; and

FIG. 8 is a flow diagram of the process employed at a master unit for transferring the role of master to slave.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

FIG. 1, illustrates mobile tracking units which employ navigation signals from a GPS satellite constellation, although, as suggested above, other navigation systems can be used in lieu of GPS. A set of mobile tracking units 10A-10D are installed in respective cargo-carrying conveyances, such as vehicles 12A-12D, which are to be tracked or monitored. A communication link 14, such as a satellite communication link through a communication satellite 16, can be provided between each mobile tracking unit

(hereinafter collectively designated as 10) and a remote central station 18 manned by one or more operators and having suitable display devices and the like for displaying location and status information for each vehicle equipped with a respective mobile tracking unit. Communication link 14 can be conveniently used for transmitting vehicle conditions or events measured with suitable sensing elements. Communication link 14 may be one-way (from mobile tracking units to remote central station) or two-way. In a two-way communication link, messages and commands can be sent to the tracking units, thereby further enhancing reliability of the communication. A constellation of GPS satellites, such as GPS satellites 20A and 20B, provides highly accurate navigation signals which can be used to determine vehicle location and velocity when the signals are acquired by a suitable GPS receiver.

Briefly, the GPS was developed by the U.S. Department of Defense and gradually placed into service throughout the 1980s. The GPS satellites constantly transmit radio signals in L-Band frequency using spread spectrum techniques. The transmitted radio signals carry pseudo-random sequences which allow users to determine location on the surface of the earth (within approximately 100 feet), velocity (within about 0.1 MPH), and precise time information. GPS is a particularly attractive navigation system to employ, being that the respective orbits of the GPS satellites are chosen so as to provide world-wide coverage and being that such highly-accurate radio signals are provided free of charge to users by the U.S. government.

FIG. 2 is a block diagram of a mobile tracking unit 10 which includes a navigation set 50 capable of generating data substantially corresponding to the vehicle position. Choice of navigation set depends on the particular navigation system used for supplying navigation signals to any given mobile tracking unit. Preferably, the navigation set is a GPS receiver such as a multichannel receiver; however, other receivers designed for acquiring signals from a corresponding navigation system may alternatively be employed. For example, depending on the vehicle location accuracy requirements, the navigation set may comprise a Loran-C receiver or other such less highly-accurate navigation receiver than a GPS receiver. Further, the navigation set may can conveniently comprise a transceiver that inherently provides two-way communication with the central station and avoids the need for separately operating an additional component to implement such two-way communication. Briefly, such transceiver would allow for implementation of satellite range measurement techniques whereby the vehicle location is determined at the central station simply through use of range measurements to the vehicle and the central station from two satellites whose position in space is known. The need for power by either such navigation set imposes a severe constraint for reliable and economical operation of the mobile tracking unit aboard vehicles which typically do not carry power sources, e.g., shipping containers, railcars used for carrying freight, truck trailers, etc. Typical GPS receivers currently available generally require as much as two watts of electrical power for operation. For the GPS receiver to provide a location fix, it must be energized for some minimum period of time in order to acquire sufficient signal information from a given set of GPS satellites so as to generate a navigation solution. A key advantage of the present invention is the ability to substantially reduce the energy consumed by the mobile tracking unit by selectively reducing the activation or usage rate for the navigation set and other components of the mobile tracking unit. In particular, if, while the vehicle is stationary, the activation

rate for the navigation set is reduced, then the energy consumed by the mobile tracking unit can be substantially reduced, for example, by a factor of at least one hundred.

Mobile tracking unit 10 includes a communications transceiver 52 functionally independent from navigation set 50. If the navigation set comprises a transceiver, the function of transceiver 52 can be performed by the transceiver of navigation set 50. Both transceiver 52 and navigation set 50 are actuated by a controller 58 which, in turn, is responsive to signals from a clock module 60. Transceiver 52 is capable of transmitting the vehicle location data by way of communication link 14 (FIG. 1) to the central station and receiving commands from the central station by way of the same link. If a GPS receiver is used, the Transceiver and the GPS receiver can be conveniently integrated as a single unit for maximizing efficiency of installation and operation. An example of one such integrated unit is the Galaxy Inmarsat/GPS integrated unit which is available from Trimble Navigation, Sunnyvale, Calif., and is conveniently designed for data communication and position reporting between the central station and the mobile tracking unit. A single, low profile antenna 54 can be used for both GPS signal acquisition and satellite communication.

A low power, short distance radio link permits joining the nearby tracking units in a network to minimize power consumption and maintain high reliability and functionality such network. As shown in FIG. 2, in addition to a power source 62 (which may comprise a battery pack that can be charged by an array of solar cells 66 through a charging circuit 64), a GPS receiver 50, a communications transceiver 52, and various system and vehicle sensors 68A-68D, each tracking unit includes a low power local transceiver 70 and a microprocessor 72. Microprocessor 72 is interfaced to all of the other elements of the tracking unit and has control over them. Transceiver 70 may be a commercially available spread spectrum transceiver such as those currently utilized in wireless local area networks. Spread spectrum transceiver 70 is equipped with its own low profile antenna 74.

Utilizing local transceiver 70, microprocessor 72 communicates with all other tracking units within communications range, forming a dynamically configured LAN, hereinafter denominated a "mutter network". Such mutter network is generally shown in FIG. 3. When a train includes multiple freight cars 82₁, 82₂, . . . , 82_n, equipped with tracking units of the type shown in FIG. 3, all of these units will exchange information. Because each microprocessor is interfaced to its own power source, respectively, the status of available power for each tracking unit can also be exchanged. Once this information is available, then the tracking unit with the most available power (i.e., most fully charged batteries) will become the designated master, the other tracking units being slaves. The master unit performs the GPS position and velocity reception function, assembles these data along with the IDs of all other tracking units on the train, and transmits this information periodically in a single packet to a central station 84 via communication satellite 86.

Because one GPS receiver among all of the tracking units is turned on at a time (as well as only one communications transceiver), total system power is reduced. Moreover, this function also increases reliability for each tracking unit because it automatically reduces the power consumed by a unit which has a degraded or partially functional power source. Thus, while a unit with weak batteries cannot perform the GPS receiving or information transmitting and command receiving functions, which are the most power consuming functions in the tracking unit, a tracking unit with damaged solar cells or a battery which can not hold a

full charge can still be fully functional when it is part of a train with fully functional tracking units.

In each tracking unit the GPS receiver (or navigation set) and the satellite transceiver and their antennae are major, complex modules, so that a failure of any of these modules would render its tracking unit inoperative if no alternative communication system existed. Using low power spread spectrum transceiver 70 shown in FIG. 2 allows a tracking unit with this malfunctioning module to operate when it is part of a train with fully operational tracking units, thereby increasing the tracking system reliability and the reliability of the tracking unit. Another reliability feature is that the malfunctioning tracking unit can report its faulty status along with its location so that repairs can be scheduled.

An additional reliability feature allows location of a malfunctioning tracking unit that is not part of a train carrying a properly functioning tracking unit. A solitary railcar with a malfunctioning tracking unit (or a malfunctioning tracking unit which is the only tracking unit on a train) will monitor or "listen" on the low power transceiver at a low duty cycle (to conserve power). If the malfunctioning tracking unit comes within communication range of a properly functioning tracking unit (which continuously broadcasts ID requests to other tracking units), the malfunctioning unit will send out its own ID and status. This information will be passed on to the central station where data are collected. In this fashion, a solitary tracking unit with a malfunction in the power source, GPS receiver, satellite transmitter or antenna will still be reported each time it comes within range of a functional tracking unit.

The ability to exchange the roles of master and slave among the tracking units provides transmission diversity which enhances link quality and received data integrity. This occurs because one of the two units (i.e., the one with the most charged batteries) could experience severe attenuation of its transmitted signal due to shadowing loss resulting from an obstruction in the line of sight to the satellite. Selecting between the two units can mitigate this effect. Inclusion of more units in the selection procedure improves link quality at the cost of averaging power over a large number of tracking units. Currently, the GPS function consumes the most power and, in this case, the transmission selection is restricted to two tracking units.

If the satellite has dual channels (i.e., two frequencies or two time slots) for transmitting information on the reverse up-link (railcar to satellite) and on the forward down-link (satellite to ground station), then the two tracking units with the most charged batteries can be used to provide receive diversity. In this scheme, the ground station will poll the two transmissions and detect them either by combining the signals or by selecting between the two signals. This form of diversity reception reduces the link power budget, implying that both transmissions can be of lower power.

If there is a two-way link between the ground station and railcar tracking units, then it is possible to use the return link to control which of the two tracking units to use for transmission. This is useful when the unit with the stronger battery is more heavily shadowed, and can help to conserve the battery power.

To make use of the mutter mode, a protocol is provided which allows certain operations to occur. These operations include the following:

1. Forming a network from two or more independent tracking units and determining which unit is master of the network.
2. Maintaining a network with regular communication between master unit and all slave units.

3. Removing one or more units from a network when they are moved out of communication range from the master unit.
4. Adding one or more units to a network when they are brought into communication range with the master unit.
5. Merging two or more networks when the network master units come within communication range of each other.
6. Transferring the role of master unit from a master unit with weak battery power to a slave unit with a stronger battery.

The above operations must be performed in a manner that conserves battery power, which implies providing a minimal amount of transmitted data from any tracking unit and minimizing the time during which the unit's receiver must be on. These objectives must be met within realistic economic and technological constraints such as limited individual clock accuracy and a communication channel which has a finite error rate.

Certain characteristics and parameters must be defined for a description of the "mutter mode", or mode by which a subset of tracking units communicate with each other in a mobile, dynamically-configured LAN. As shown in the timing diagram of FIG. 4, all slave units in a network communicate with the master unit of that network during a report period. Shorter report periods provide better time resolution of asset movements, while longer report periods use less power. The report period is divided into several sub-periods. Shorter sub-periods allow more message retransmissions for more reliability, while longer sub-periods promote fewer message collisions and accommodate more assets per network. As indicated in FIG. 2, each asset tracking unit includes a moderately accurate local clock 60. This clock has a short term relative clock accuracy measured over one report period and a long term absolute clock accuracy measured over several days. The long term clock accuracy is corrected during any communications with the GPS satellite communication system, or any other tracking or communication system with which the tracking unit is in periodic contact. Greater accuracy reduces system power consumption, while lesser accuracy lowers system hardware costs.

Messages sent between tracking units in the mutter mode have a transmission time which includes any preamble and synchronization bits, the data bits and error checking bits. A poll-acknowledge bit pair occupies a time slot, including all guard bands and turnaround times. Shorter transmission times reduce power consumption, while longer transmission times increase message transmission success rate. Tracking units can transmit and/or receive on two different channels. These channels may be different frequencies, or they may be different sequences in a PN sequence spread spectrum code. The channels will be identified as channel 1 and channel 2. In this protocol, it is also possible to use the same channel for all communications, but interfaces to protocols in other applications may make use of these two channels.

The communications actions of a tracking unit depend on what state or mode it is in. A tracking unit can be in one of the following modes:

1. Autonomous Mode—In this mode, a tracking unit communicates with the central station directly. It is not networked to a mutter mode network.
2. Orphan Mode—In this mode, the tracking unit (i.e., "orphan" tracking unit) is unable to communicate with the central station and is not included in a mutter network. The central station does not have information

about the current location of the orphan tracking unit. The orphan unit may or may not have data identifying its current location.

3. Master Mode—The master tracking unit communicates with the central station directly. It is also networked to other tracking units in the mutter network and transmits information about the networked tracking units to the central station.

4. Slave Mode—Each slave tracking unit does not communicate with the central station directly, but is included in a mutter network and sends its sensor data and, optionally, its location data, to a master tracking unit. The master tracking unit in turn transmits the data from the slave tracking unit to the central station.

When a mutter network has been formed, the following protocol is used when no tracking units are joining or leaving the network. The times given are by way of example only. Time is given as minutes:seconds for a one hour report period, and the master tracking unit and slave tracking unit are respectively referred to as "master" and "slave".

00:00-00:05—The network master is tuned to receive on channel 1 during this interval except for the short (50 msec) transmission time during which the master transmits a "CALL FOR NEW MEMBERS" on channel 1.

The transmission time is randomly placed within the center second of the five second period. A different random position is chosen for each sub-period. During steady state (no slaves or masters join the network), no data will be received.

01:00-01:39—This period is reserved for adding new tracking units to an existing network. It is not used in steady state operations.

01:40-01:59—This period is reserved for forming new networks among two or more autonomous tracking units. It is not used in steady state operations.

02:00-18:00—This period is divided into $16 \times 60 / 0.1 = 9600$ time slots (each slot is 100 msec long) for poll-acknowledge pairs.

Each slave tracking unit has a time slot assigned by the master tracking unit. The master unit randomly distributes the assigned time slots among the 9600 available slots, and each slave unit keeps the same time slot from one report period to the next unless specifically reassigned by the master. When the master clock arrives at a time slot occupied by a slave, the master unit turns on its transmitter and sends an "ARE YOU STILL PRESENT?" message, which takes the first 50 msec of the time slot. The master unit then turns off its transmitter, turns on its receiver, and monitors its channel frequency for the reply "I AM STILL PRESENT". After 50 msec, i.e., at the end of the time slot, the master receiver is turned off whether a correct reply is received or not. The master tracking unit stays in a low power or "sleep" mode until the next occupied time slot when this procedure is repeated.

Each slave unit stays in a low power or "sleep" mode until a time that is twice the short term clock accuracy before the beginning of the time slot assigned to it (as measured by the slave unit's own clock). At this time, the slave unit turns on its receiver and waits until a time that is twice the short term clock accuracy after the end of the time slot assigned to it, at which time the radio transceiver is turned off. The slave unit awaits the "ARE YOU STILL PRESENT?" message which contains the slave unit's ID code. If the slave unit receives this message, it immediately turns off its receiver, turns on its transmitter and sends the "I AM STILL PRESENT" reply, and returns to the low power mode. If the

slave unit receives a correct interrogation message from the master unit, then the slave unit uses the time of the start of the received message to resynchronize its clock based on the master clock for the next scheduled "ARE YOU STILL PRESENT?" message. This procedure ensures that even if the local clocks of the master and slave units at slightly different rates, the slave will always have its receiver turned on when the master transmits an interrogation to it. This further ensures that the slave unit will be turned off for as much of the time as is possible, thereby conserving power.

18:01-19:59—Reserved for future use.

20:00-20:05—Repeat of 00:00-00:05

20:06-21:59—Repeat of 00:06-01:59

22:00-38:00—During the 02:00-18:00 period, the master queries all slaves for their presence.

If any of these queries does not receive a successful reply, the master unit retransmits the "ARE YOU STILL PRESENT?" message for that particular slave unit in the same time slot (of the 9600 time slots available) and awaits a reply. If the slave unit had not received its interrogation during the 02:00-18:00 period, then the slave waits for the same period of time (i.e., two short term clock accuracy periods on either side of the assigned time slot) as in the 02:00-18:00 period. If the query is received, the slave unit transmits a reply.

38:01-39:59—Reserved for future use

40:00-40:05—Repeat of 00:00-00:05

40:06-41:59—Repeat of 00:06-01:59

42:00-58:00—If the master unit made any queries during the 02:00-18:00 period and the 22:00-38:00 period with a slave unit responding in neither, then the master unit queries in the same time slot one more time.

If the slave unit does not receive its interrogation during the 02:00-18:00 period or the 22:00-38:00 period, then the slave waits once again during its assigned time slot. If the query is received, the slave unit transmits a reply.

58:01-59:59—This period is reserved for communication between multiple masters. It is not used in steady-state operations.

This completes one report period. This same sequence is repeated every hour and is synchronized to universal time (UTC) as received from GPS, satellite communication or other location or communication system.

The general format followed by all message packets is given below:

Bits	8	24	24	8	variable	16
	SYNCH	DEST ADDR	SOURCE ADDR	C	DATA	FEC

where SYNCH is the synchronization preamble to establish carrier synchronization and symbol boundaries, DEST ADDR is the destination address of the tracking unit to which the packet is destined and may be a broadcast address in case the packet is addressed to all tracking units, SOURCE ADDR is the address of the source unit, C is a control field designating the message type, DATA is the main information in the message, and FEC is a forward error correction for errors formed over DEST ADDR field through DATA field. The number above each segment of the packet (except DATA) indicates the number of bits that make up the respective segment.

The different types of messages used in the mutter mode are the following:

"ARE YOU STILL PRESENT?" message (88 bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bits slave ID
SOURCE ADDR: 24 bit master ID
C: "01" - normal presence query
DATA: 8 bits clock information
FEC: 16 bits error control

"I AM STILL PRESENT" message (92 bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bits slave ID
SOURCE ADDR: 24 bit master ID
C: "02" - normal presence reply
DATA: 12 bits sensor data or exceptions
FEC: 16 bits error control

"CALL FOR NEW MEMBERS" message (88 bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bit broadcast address
SOURCE ADDR: 24 bits network master ID
C: "03" - call for new members
DATA: 8 bits clock information
FEC: 16 bits error control

"SEARCHING FOR A NETWORK" message (92 bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bit broadcast address
SOURCE ADDR: 24 bits autonomous unit ID
C: "03" - search for a network
DATA: 4 bits battery level, 4 bits direction of travel, 4 bits additional info (status of satellite communication, emergency data present, etc.)
FEC: 16 bits error control

"MERGE TWO MASTERS" message (variable bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bits receiving master ID
SOURCE ADDR: 24 bit transmitting master ID
C: "04" - merge two masters
DATA: 16 bits clock correction data, 8 bits velocity of transmitting master, 8 bits direction of travel of transmitting master, 16 bits number of slaves in network of transmitting master, 24 bits ID + 8 bits time slot of slave #1, 24 bits ID + 8 bits time slot of slave #2, . . . , 24 bits ID + 8 bits time slot of slave #N
FEC: 16 bits error control

"MERGER SUMMARY" message (144 bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bits receiving master ID
SOURCE ADDR: 24 bit transmitting master ID
C: "05" - merge two masters
DATA: 16 bits clock correction data, 8 bits velocity of transmitting master, 8 bits direction of travel of transmitting master, 16 bits number of slaves replying in network of transmitting master, 16 bits number of slaves replying in network of receiving master
FEC: 16 bits error control

"AUTONOMOUS, JOIN THE NETWORK" message (112 bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bits autonomous unit ID
SOURCE ADDR: 24 bit master ID
C: "06" - join the network
DATA: 16 bits clock correction data, 16 bits time slot assignment, 8 bits velocity of master, 8 bits direction of travel of master
FEC: 16 bits error control

"I AM JOINING THE NETWORK" message (88 bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bits master ID
SOURCE ADDR: 24 bits autonomous unit ID
C: "07" - joining the network
DATA: 8 bits status and sensor data
FEC: 16 bits error control

"SLAVE, BECOME MASTER" message (variable bits):

SYNCH: 8 bits preamble/synchronization
DEST ADDR: 24 bits slave ID
SOURCE ADDR: 24 bit master ID
C: "08" - transfer role of network master to a slave
DATA: 16 bits clock correction data, 8 bits time slot to query current master, 8 bits direction of travel of transmitting master, 16 bits number of slaves in network, 24 bits ID + 8 bits time slot of

-continued

slave #1, 24 bits ID + 8 bits time slot of slave
 #2, ..., 24 bits ID + 8 bits time slot of slave #N
 FEC: 16 bits error control

Trains carrying many freight cars with tracking units can be quite lengthy, up to two kilometers (km) from front to back. Varying environmental conditions such as weather, radio reflecting objects close to the track, and track curvature combined with distance makes it probable that some messages between master and slave tracking units will not be received. The protocol described above assures that multiple attempts are made in every report period to successfully communicate between master and slave tracking units. Additionally these attempts are made at widely separated times so that communication obstacles that are time or position dependent on a moving train will vary to allow one of the multiple attempts to succeed.

When consists of multiple cars carrying tracking units are delivered to a destination, cars (and tracking units) are removed from the train and the train leaves the vicinity. When this occurs, the master unit must have a way of removing the slave units from the network, and the slaves units must have a way of recognizing that they are now autonomous. The procedure for removing one or more tracking units from the network is described below.

As the master unit and any remaining slave units are separated from one or more slave units by sufficient distance (for example, five km), radio communication between them is no longer possible. During all of the sub-periods (three in the example given) of one report period, the slave unit will not receive any "ARE YOU STILL PRESENT?" messages. When two full report periods have elapsed with no such receptions, the slave unit changes its own status to that of an autonomous unit.

The process for having a master unit remove a slave unit from its network is similar. Once the master has gone for two full report periods without receiving a reply from a slave, that slave is removed from the network, and the master will no longer query it. If the master loses all slaves in the network, it reverts to autonomous status.

When two mutter networks come within range of each other, they must either merge into one network or remain separate. The following protocol defines the operations for one report period. The times given are an example using the parameter values chosen above, but this protocol works for other choices of parameters. Time is given in minutes:seconds for the one hour report period.

00:00-00:05—The network master listens on channel 1 during all of this time except for the short transmission time during which the master transmits a "CALL FOR NEW MEMBERS" on channel 1.

The transmission time is randomly placed within the center second of the five second period. During this time period, a second network master unit is now within communication range of the first network master unit, and is following a similar protocol. Because the network master units have not communicated with each other previous to this time, the clocks of the master units are not synchronized. The length of time spent listening (receiving) relative to the long term clock accuracy specification is such that the masters are guaranteed to overlap. At the end of 00:05, the masters have received each other's signals, but neither has directed a reply to the other.

00:06-00:59—Whichever master unit first transmitted its "CALL FOR NEW MEMBERS" sends out a "MERGE TWO MASTERS" message at 00:06.

The other master unit records this information and determines if its is desirable to merge. If the speed and/or heading information (i.e., velocity profile) of the two master units are different, then these two masters should not be merged, and no reply is given by the second master.

If the velocity profiles are identical, the second master replies to the "MERGE TWO MASTERS" message with its own "MERGE TWO MASTERS" message. Each master now has the network information of both networks. Each master now looks for conflicts where the "ARE YOU STILL PRESENT?"—"I AM STILL PRESENT" query/reply time slots of the different networks interfere. Interference may mean occupying the same time slot in the two networks, or it may also include occupying a nearby slot. Where interference is found, the two masters each move the interfering time slots away from each other by a small amount (e.g., two time slots) to assure that they do not interfere. If the identical time slots are occupied, then the direction of displacement is such that the master which first transmitted the "CALL FOR NEW MEMBERS" moves its network members earlier and the other network's members later. The new transmission times, however, will still occur during the time that the proper slave receivers are turned on.

01:00-58:00—Normal operation, polling done with one master sending, both masters receiving the "ARE YOU STILL PRESENT?"/"I AM STILL PRESENT" query/reply.

The times that the "ARE YOU STILL PRESENT?" queries are sent out may be shifted slightly, but they still overlap the times in which the slave receiver is operational. Slaves receiving the time-shifted query reply immediately and reset their internal time slot for the perceived change in slot position.

58:01-59:59—Whichever master first transmitted its "CALL FOR NEW MEMBERS" message sends out a "MERGER SUMMARY" message at 58:03.

The 16 bits representing the number of slaves replying in the network of the transmitting master specify the number of receivable marked slaves that belong to the original network of the transmitting master. Similarly, the 16 bits representing the number of slaves replying in the network of the receiving master specify the number of receivable marked slaves that belong to the original network of the other, receiving master. Each master now holds information as to how many slaves from both networks the other master will become a slave in the new network. In case both masters receive responses from the same number of slaves, then whichever master first transmitted its "CALL FOR NEW MEMBERS" becomes the master for the new network. The new network master now issues an "AUTONOMOUS, JOIN THE NETWORK" message, to which the old master replies with an "I AM JOINING THE NETWORK" message. The old master is now a slave in the new network.

Assume that a mutter network has been formed. During the course of polling its slaves, the battery power of the network master might become sufficiently low that the network master is prompted to pass the responsibility of the master on to one of the slaves whose battery power is still strong. When an extant network master is ready to transfer its role to another slave, it begins the process of transferring the role in the next reporting period. The network master selects the slave having the highest battery power. The following protocol is used to transfer the role of master from the network master to one of the slaves. The activity represented is one report period. Again, the times given are an example using the parameter values chosen above, but this protocol works for other choices of parameters. Time is given in minutes:seconds for the one hour report period.

00:00-02:00—The network master performs its role as usual. If, during this time, the network master receives a transmission from another master, it will not attempt to merge with the other master.

02:00-18:00—The network master polls all the slaves in the normal fashion with the "ARE YOU STILL PRESENT?"/"I AM STILL PRESENT" query/reply sequence except for the slave to which it will pass on the role of the master.

In the scheduled time slot of this slave, the network master transmits the "SLAVE, BECOME MASTER" message which includes ID and time slot information for polling all the slaves in the mutter network. In the message, it also includes its own ID and time slot at which the slave should poll the master. The slave responds by transmitting an "I AM STILL PRESENT" message. This acknowledges that the slave has taken over the role of the new master and will function as a new master in the next report period. In the present report period, the extant master operates as usual. The operation of sending and receiving a "SLAVE, BECOME MASTER"/"I AM STILL PRESENT" query/reply sequence is the same as the "ARE YOU STILL PRESENT?"/"I AM STILL PRESENT" query/reply sequence.

If, however, the intended slave has not received the "SLAVE, BECOME MASTER" message, the slave does not transmit the "I AM STILL PRESENT" message. In this case, the master again attempts to transmit the "SLAVE, BECOME MASTER" message in the requisite time slot in the next report sub-period (22:00-38:00). If during this time the master is still unable to reach the slave, it will attempt to reach the slave in the subsequent report sub-period.

If during the entire report period a master is unable to transfer the role of the master to a slave, it will select a new slave to which it will attempt to pass on the role of the master in the next report period. The network master will go through this process until it finds a slave which is ready to take up the role of the master.

Again assume that a mutter network has been formed. The following protocol is used when one tracking unit is joining the network. The times given are an example using the parameter values chosen above, but this protocol works for other choices of parameters. Time is given in minutes:seconds for the one hour report period.

00:00-00:05—The network master receives on channel 1 during all of this time except for the short (50 msec) transmission time during which the master transmits a "CALL FOR NEW MEMBERS" message on channel 1.

The transmission time is randomly placed within the center second of the five second period. A different random position is chosen for each sub-period.

During this time period, an autonomous tracker that is now within communications range of the network master follows a similar protocol. The autonomous unit sends a 50 msec transmission "SEARCHING FOR A NETWORK" message randomly within the center second of the five seconds in which it is listening for available masters. Because the autonomous unit has not had any communication with the master previous to this time, the clocks of the master and the autonomous unit are not synchronized. The length of the time spent receiving relative to the long term clock accuracy specification is such that the master and the autonomous units are guaranteed to overlap. At the end of 00:05, the master has received a transmission from the autonomous unit and the autonomous unit has received a transmission from the master, but neither has directed a reply to the other.

00:06-00:59—Used for multiple masters

01:00-01:39—At a fixed time (say, 60 seconds) after the autonomous unit has sent its "SEARCHING FOR A NETWORK" message, the autonomous unit turns on its receiver.

At 60 seconds after the master receives the "SEARCHING FOR A NETWORK" message, the master sends out an "AUTONOMOUS, JOIN THE NETWORK" message. This message contains time slot and clock correction information. The autonomous unit replies with a "I AM JOINING THE NETWORK" message. At this time, the autonomous unit becomes a slave, and it starts replying to "ARE YOU STILL PRESENT" messages in the assigned time slot of the 02:00-18:00 time interval immediately following.

If the master does not receive the "I AM JOINING THE NETWORK" reply message from the autonomous unit immediately, the master will retransmit the "AUTONOMOUS, JOIN THE NETWORK" message for up to three times. If no response is received, then the autonomous unit is assumed not to be a member of the network. Similarly, the autonomous unit awaits receipt of the "AUTONOMOUS, JOIN THE NETWORK" message addressed to itself and reply. If the autonomous unit does not receive the "AUTONOMOUS, JOIN THE NETWORK" message addressed to it, then it continues to await its receipt for some period of time (say, five seconds) after the last message received from the master. If the autonomous unit does receive and reply to the "AUTONOMOUS, JOIN THE NETWORK" message, it waits for another five seconds to receive the message if it is sent again (in case the master did not receive the reply) and reply again if the message is received.

If transmissions from more than one autonomous unit are received by the master, then the master performs the above request/reply procedure with each autonomous unit from which it received transmissions during the 00:00-00:05 period of time. The autonomous units are addressed in the order in which the master has received their "SEARCHING FOR A NETWORK" message.

01:40-59:59—Normal network polling operations

The following protocol is used when combining two or more autonomous trackers to form a network.

00:00-00:05—During this time period, multiple autonomous trackers that are now within communications range of each other send a 50 msec transmission message, "SEARCHING FOR A NETWORK", randomly within the center of the five second period.

Because the autonomous units have not had any communication with each other previous to this time, the clocks of the units are not synchronized. Relative to the long term clock accuracy specification, the length of time spent receiving is such that all of the autonomous units transmissions and receptions will overlap. At the end of 00:05, the autonomous units have received each other's "SEARCHING FOR A NETWORK" message, but no replies have been sent. Each autonomous unit has recorded the IDs of all of the other autonomous units which it has received. The autonomous units individually sort all of the IDs received and their own ID into ascending order. Because all IDs are unique, there are no duplications.

If any autonomous unit has received a master unit's "CALL FOR NEW MEMBERS" message, then that autonomous unit will attempt to join the master. It will not attempt to combine with other autonomous units.

00:06-01:39—Used for units to join masters (see above)

00:140-01:59—Each unit examines its sorted list of IDs. The unit which has its own ID as the smallest value of

the list now acts as a master which has received several "SEARCHING FOR A NETWORK" messages.

Alternatively, any algorithm which determines a unique master based on address, battery level and other parameters can be used. This self appointed master then chooses a random time within 01:40-01:44 to start sending out a series of "AUTONOMOUS, JOIN THE NETWORK" messages addressed to all the other autonomous units on the list. This message contains time slot and clock correction information for the new network.

The autonomous units turn on their receivers at 01:40 and monitor transmissions. When an autonomous unit receives an "AUTONOMOUS, JOIN THE NETWORK" message which has its own ID as the autonomous ID and also has the lowest number on its own internal list as the master ID, then it replies with an "I AM JOINING THE NETWORK" message. After all "AUTONOMOUS, JOIN THE NETWORK"/"I AM JOINING THE NETWORK" messages have been exchanged, this new network stands fully formed by the self-appointed master and all of the autonomous units which have successfully joined. Any autonomous units which have not successfully joined remain autonomous for the rest of this report period.

02:00-59:59—Normal network polling operations

The protocol described above is summarized and illustrated in the flow diagrams of FIGS. 5 to 8. FIG. 5 is a flow diagram illustrating the process at a master for polling one slave. For each slave, the master goes through a similar logic. The mode is set to master at step 501. The master unit "sleeps" until the slave unit polling time at step 502. At that time, the master unit "wakes up" and transmits a poll to the slave unit at step 503. A test is then made at decision block 504 to determine whether a reply was received from the slave. If so, the slave information received is saved at step 505, and the failure count for that slave is set to zero at step 506. The process loops back to step 502. If, however, a reply is not received, the failure count for that slave is incremented at step 507. A test is made at decision block 508 to determine if the failure count for that slave is equal to six. If not, the process loops back to step 502; otherwise, the slave is removed from the master's slave list at step block 509. Next, a test is made at decision step 510 to determine if the number of slaves on the master's slave list is equal to or greater than one. If so, the process loops back to step 502. If not, the mode for the unit is set to autonomous at step 511, and the process exits.

FIG. 6 is a flow diagram illustrating the process at a slave for transmitting information to the master and for changing state to autonomous. The mode is initially set to slave at step 601. The slave unit "sleeps" until the slave unit's scheduled time slot at step 602. At that time, the slave unit "wakes up" and awaits receipt of a poll from the master unit at step 603. A test is then made at decision step 604 to determine whether a poll was received from the master. If so, the slave transmits position and sensor information to the master at step 605, and the failure count for that slave is set to zero at step 606. Then, at step 607, the wake-up timer is set for the scheduled time slot of the first sub-period of the next report period. The process loops back to step 602. If, however, a reply is not received, the failure count for that slave is incremented at step 608. A test is made at decision step 609 to determine if the failure count for that slave is equal to six. If not, the wake-up timer is set for the scheduled time slot of the first sub-period of the next report period at step 610, and the process loops back to step 602; otherwise, the state of the slave unit is changed to autonomous at step 611.

FIG. 7 shows the flow diagram for the process at a master unit for merging two established networks. The mode is

initially set to master at step 701. A test is made at decision step 702 during the time period 00:00-00:05 to determine if another master unit is transmitting. If not the process ends; otherwise, a further test is made at decision step 703 to determine if the velocity profile of the other master unit matches that of this master unit. If not, the process ends; otherwise, another test is made at decision step 704 to determine if this master unit is to become a slave unit. If this master is to become a slave unit, it awaits, at 00:06-00:30, receipt of the message "MASTER BECOME SLAVE" from the other master unit, as indicated at decision block 705. If that message is not received, the process ends; otherwise, upon receiving the message, this master unit transmits its network information to the other master unit at step 706 and then sets its mode to autonomous at step 707. In the time period 01:00-01:39, the master unit becomes a slave unit of the other master unit at step 708, completing the process of merging the networks.

On the other hand, if this master unit is to remain the master unit as determined at decision step 704, at time 00:06 it transmits the message "MASTER BECOME SLAVE" at step 709. Then the master unit waits for the other master unit to transmit its network information at decision step 710. If the master unit does not receive the network information from the other master unit, the process ends. However, when the network information is received, the other master unit is added to this master unit's slave list in the time period 01:00-01:39 at step 711, completing the process of merging the networks.

FIG. 8 shows the flow diagram for the process at a master unit for transferring the role of master to a slave unit. The mode is initially set to master at step 801. A test is made at decision step 802 to determine if the battery is low. This is done at the beginning of the time period. If the battery is not low, the process ends. If, however, the battery is low, a further test is made at decision step 803 to determine if there is any slave unit present with a higher battery power. If not, the process ends; otherwise, the slave unit with the highest battery power is selected to become the new master unit at step 804. At time period 00:06-00:59 the master unit awaits transmission from another master unit which may have a stronger battery. If such a master exists, as determined at decision step 805, then the procedure described with respect to FIG. 7 is called for at step 806. Otherwise, at time period 01:00-01:39, the process of adding an autonomous unit to the network is inhibited at step 807. Then the polling query/response procedure is performed at step 808 except that the slave unit selected to become the new master unit is not polled with the "ARE YOU STILL PRESENT" message; instead, at step 809, the "SLAVE, BECOME MASTER" message is transmitted to that slave unit in its time slot. At decision step 810, the master unit waits for an "I AM STILL PRESENT" message from the slave unit selected to become the new master unit. If that message is received, the master unit continues to function as a master unit for the balance of the report period, but at the end of the report period, the master unit changes its status to slave at step 811, completing the process of transferring its role of master to slave.

Should, however, the "I AM STILL PRESENT" message not be received from the slave unit selected to become the new master unit, then the current master unit waits until the next sub-period at step 812. If all sub-periods in this period have not been exhausted in the current period (see FIG. 4) as determined at decision step 813, the process loops back to step 808 where the query/response protocol is repeated. The master unit again waits to receive the "I AM STILL

PRESENT" message from the slave unit selected to become the new master. If the message is not received and all the sub-periods for the period have been exhausted, the process loops back to decision step 802 to begin the process again, this time to select a different slave unit to become the new master unit.

While only certain preferred features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1. A method of tracking assets comprising the steps of:

affixing a tracking unit to each asset to be tracked;
establishing a mobile local area network of a plurality of tracking units in close proximity, each of said tracking units constituting a respective node of the mobile local area network; and

each of said tracking units capability to independently determine and report its location to a central station and capability to communicate locally with other cooperative tracking units via the mobile local area network, said method further comprising the step of dynamically reconfiguring the mobile local area network so that other cooperative tracking units that come into proximity with the network can join the network, and tracking units that distance themselves from the network can leave the network; and

identifying locations of tracked assets according to their connection in the mobile local area network where the exact location of at least one of the network nodes is known.

2. A method of tracking assets comprising the steps of:

affixing a tracking unit to each asset to be tracked;
establishing a mobile local area network of a plurality of tracking units in close proximity, each of said tracking units constituting a respective node of the mobile local area network;

identifying locations of tracked assets according to their connection in the mobile local area network where the exact location of at least one of the network nodes is known;

assigning one of the tracking units to function as a "master" and all others to function as "slaves", each of the master and slave tracking units having its own, respective, unique identification (ID);

determining by the master tracking unit its own exact geographical position;

reporting by the slave tracking units their ID's to the master tracking unit according to a local protocol without determining their own locations, so as to conserve power; and

reporting by the master tracking unit to a central station the master tracking unit location and ID as well as the IDs of the other tracking units in the local area network.

3. A method of tracking assets comprising the steps of:

affixing a tracking unit to each asset to be tracked;
establishing a mobile local area network of a plurality of tracking units in close proximity, each of said tracking units constituting a respective node of the mobile local area network,

issuing a "CALL FOR NEW MEMBERS" message by a first one of the tracking units acting as a "master unit";

issuing an "I AM JOINING THE NETWORK" message by a second one of the tracking units, said second one of the tracking units acting as a "slave unit"; and adding said second one of the tracking units to a slave list maintained by said first one of the tracking units; and

identifying locations of tracked assets according to their connection in the mobile local area network where the exact location of at least one of the network nodes is known.

4. The method of tracking assets as recited in claim 3 further comprising the steps of:

periodically issuing an "ARE YOU STILL PRESENT?" message by said first one of the tracking units; and

responding to the "ARE YOU STILL PRESENT?" message by said second one of the tracking units by issuing an "I AM STILL PRESENT" message.

5. The method of tracking assets as recited in claim 4 further comprising the steps of:

incrementing a failure count by said first one of the tracking units when an "I AM STILL PRESENT" message is not received from said second one of the tracking units in response to the "ARE YOU STILL PRESENT?" message;

determining if the failure count exceeds a predetermined value; and

removing said second one of the tracking units from said slave list when the failure count exceeds said predetermined value.

6. The method of tracking assets as recited in claim 5 further comprising the steps of:

checking the slave list of said first one of the tracking units; and

changing said first one of said tracking units to an autonomous state if the slave list is empty.

7. The method of tracking assets as recited in claim 3 further comprising the steps of:

issuing a "SEARCHING FOR A NETWORK" message by a third one of said tracking units acting in an autonomous state;

issuing an "AUTONOMOUS, JOIN THE NETWORK" message by said first one of the tracking units;

issuing an "I AM JOINING THE NETWORK" message by said third one of the tracking units, said third one of the tracking units then assuming status of a slave unit; and

adding said third one of the tracking units to said slave list.

8. The method of tracking assets recited in claim 3 further comprising the steps of:

detecting by the master tracking unit a transmission from a second master tracking unit of a second network;

determining if the two master tracking units have identical velocity profiles; and

merging the two networks when the two master tracking units have identical velocity profiles by changing one of the two master tracking units to a new slave tracking unit of the other master tracking unit; and

adding the new slave tracking unit to a slave list maintained by the other of the two master tracking units.

9. The method of tracking assets as recited in claim 8 wherein the step of merging the two networks includes the step of transmitting network information from the one master tracking unit to the other of the two master tracking units.

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10. The method of tracking assets recited in claim 3 wherein each of said tracking units is battery powered, further comprising the steps of:

determining by the master tracking unit if the master tracking unit battery power is low and, if so, checking the slave list to select a slave tracking unit have a higher battery power; and

transferring the role of master tracking unit to the selected slave tracking unit.

11. The method of tracking assets recited in claim 10 wherein the step of transferring the role of master tracking

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unit to the selected slave tracking unit comprises the steps of:

issuing by said first one of the tracking units a "SLAVE, BECOME MASTER" message;

changing states of the first and second ones of the tracking units from master to slave and from slave to master, respectively; and

adding said first one of the tracking units to a slave list maintained by said second one of the tracking units.

* * * * *



US005949350A

United States Patent [19]

Girard et al.

[11] **Patent Number:** 5,949,350[45] **Date of Patent:** Sep. 7, 1999[54] **LOCATION METHOD AND APPARATUS**

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[73] **Assignee:** Mobius Innovations, Inc., Glencoe, Mich.

[21] **Appl. No.:** 08/897,344

[22] **Filed:** Jul. 21, 1997

[51] **Int. Cl.⁶** G08B 21/00; G08B 23/00

[52] **U.S. Cl.** 340/825.49; 340/825.54; 340/539; 340/568; 340/572; 342/454; 342/458

[58] **Field of Search** 340/825.49, 825.54, 340/825.37, 539, 568, 572, 3; 342/450, 458; 379/38

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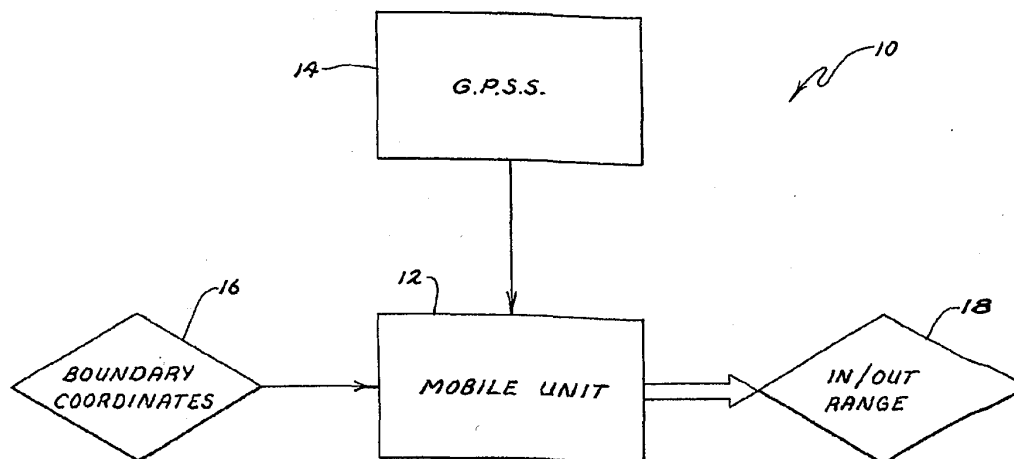
Primary Examiner—William A. Cuchlinski, Jr.

Assistant Examiner—Yonel Beaulieu

Attorney, Agent, or Firm—Briggs & Morgan, Craig M. Gregersen

[57] **ABSTRACT**

A system for training an animal to remain in a specified area of containment. The perimeter of containment being easily tailored to fit a specific geometry. The system includes apparatus for determining the location of the animal, apparatus for specifying boundary coordinates, apparatus for determining if the location of the animal is within the containment perimeter, and apparatus for administering stimulus to the animal if warranted.

24 Claims, 18 Drawing Sheets

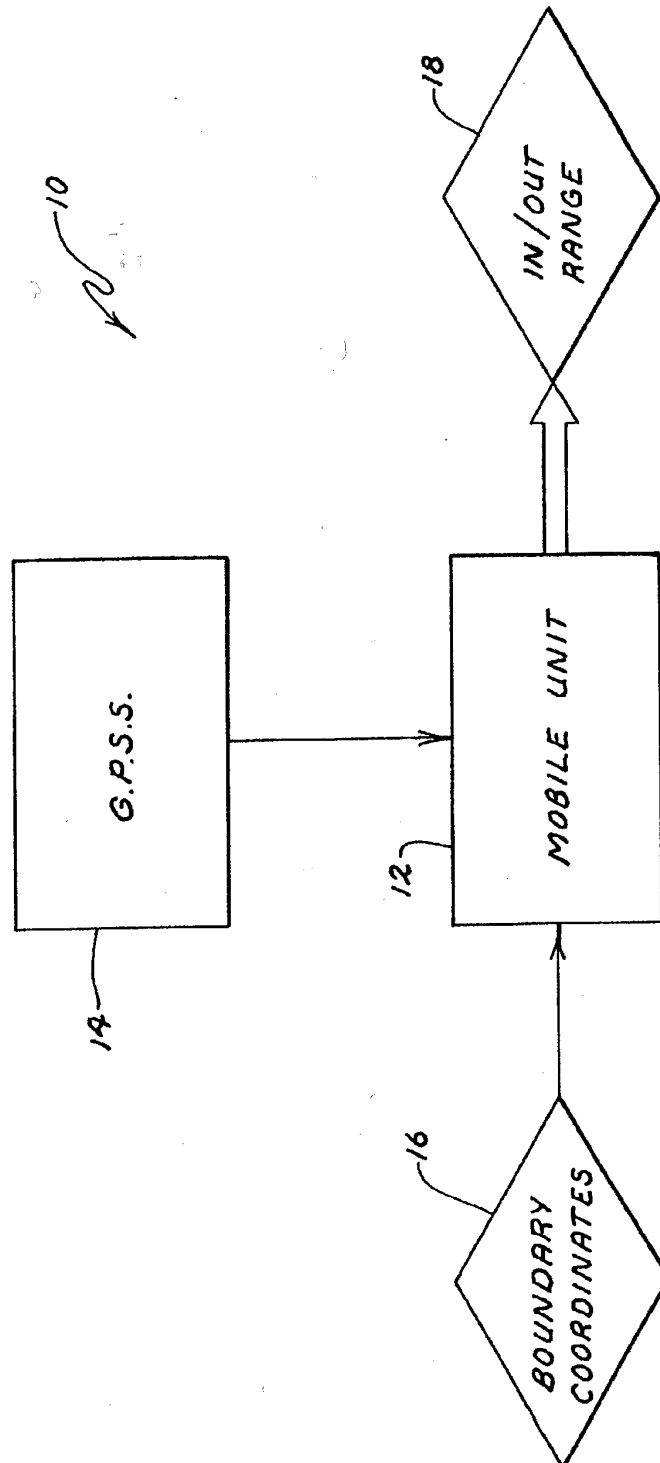
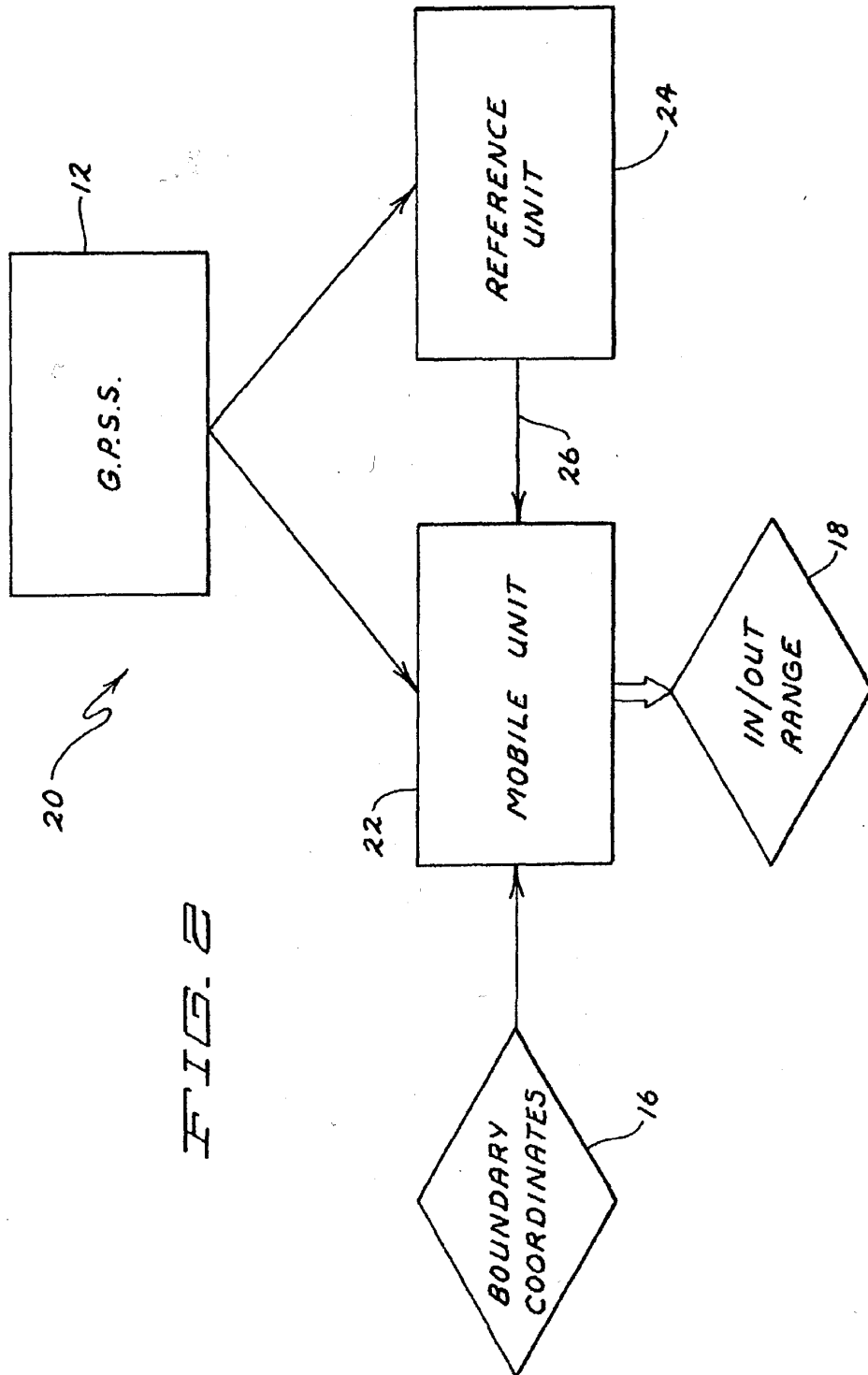
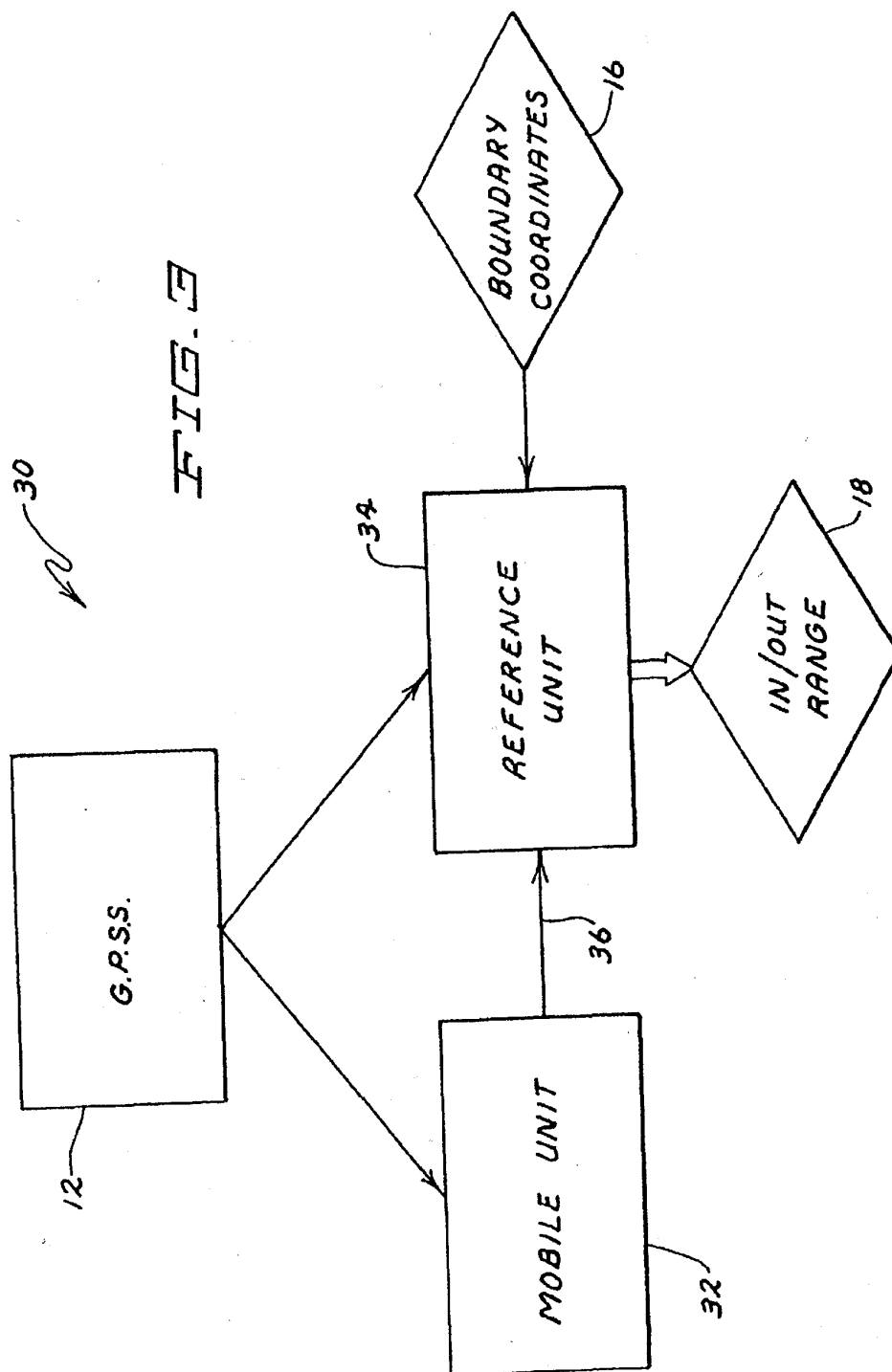


FIG. 1





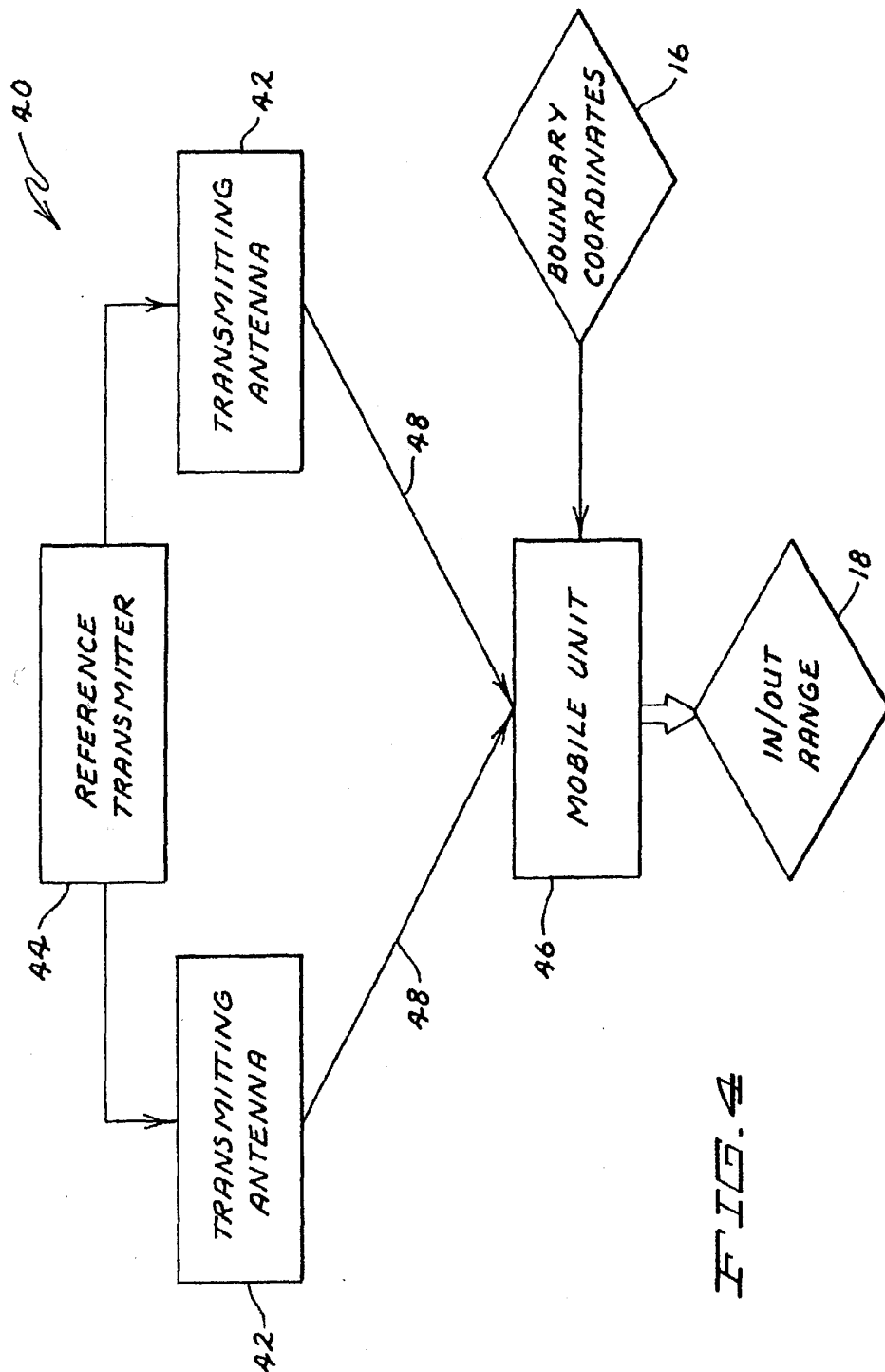


FIG. 4

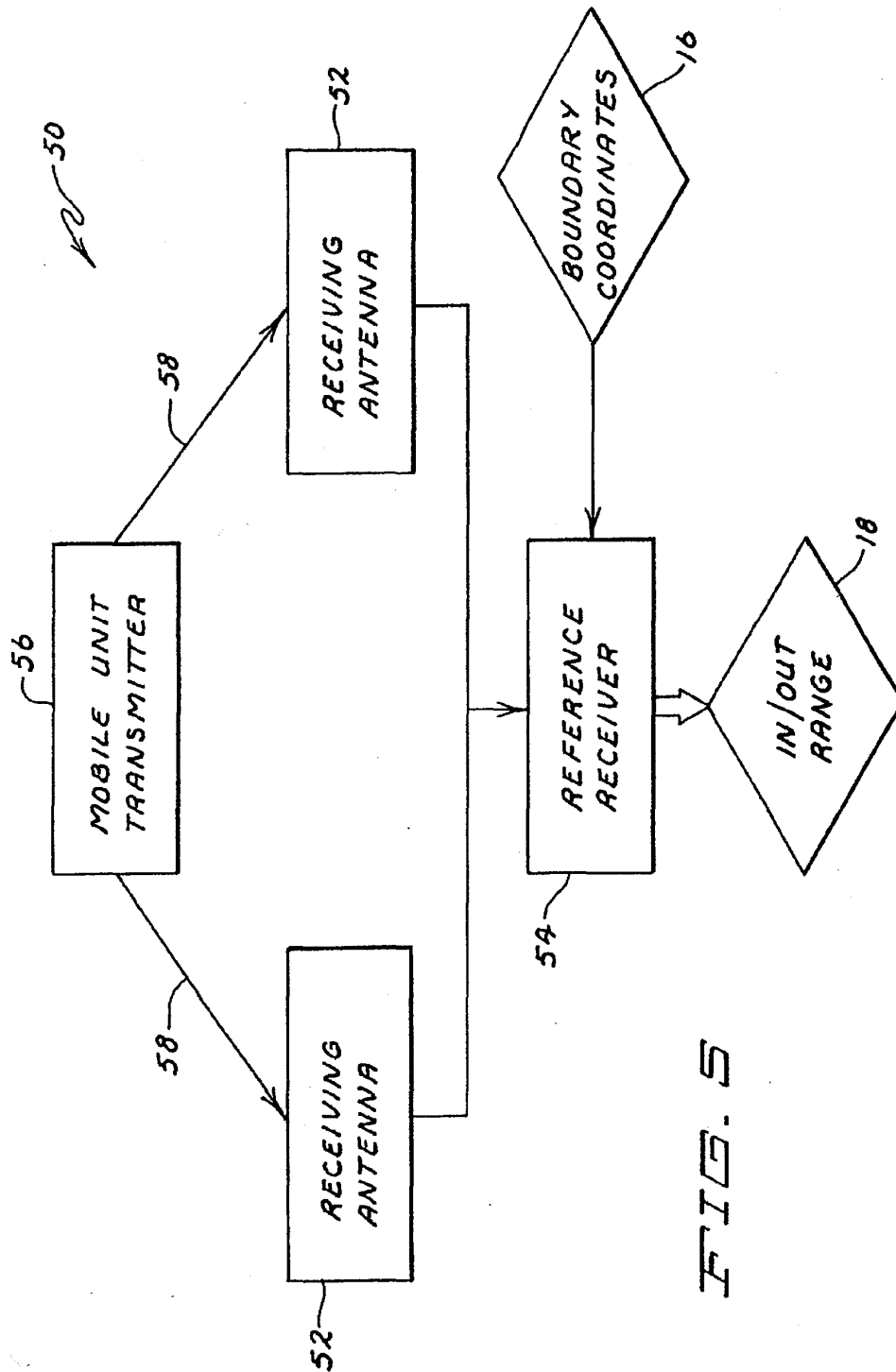
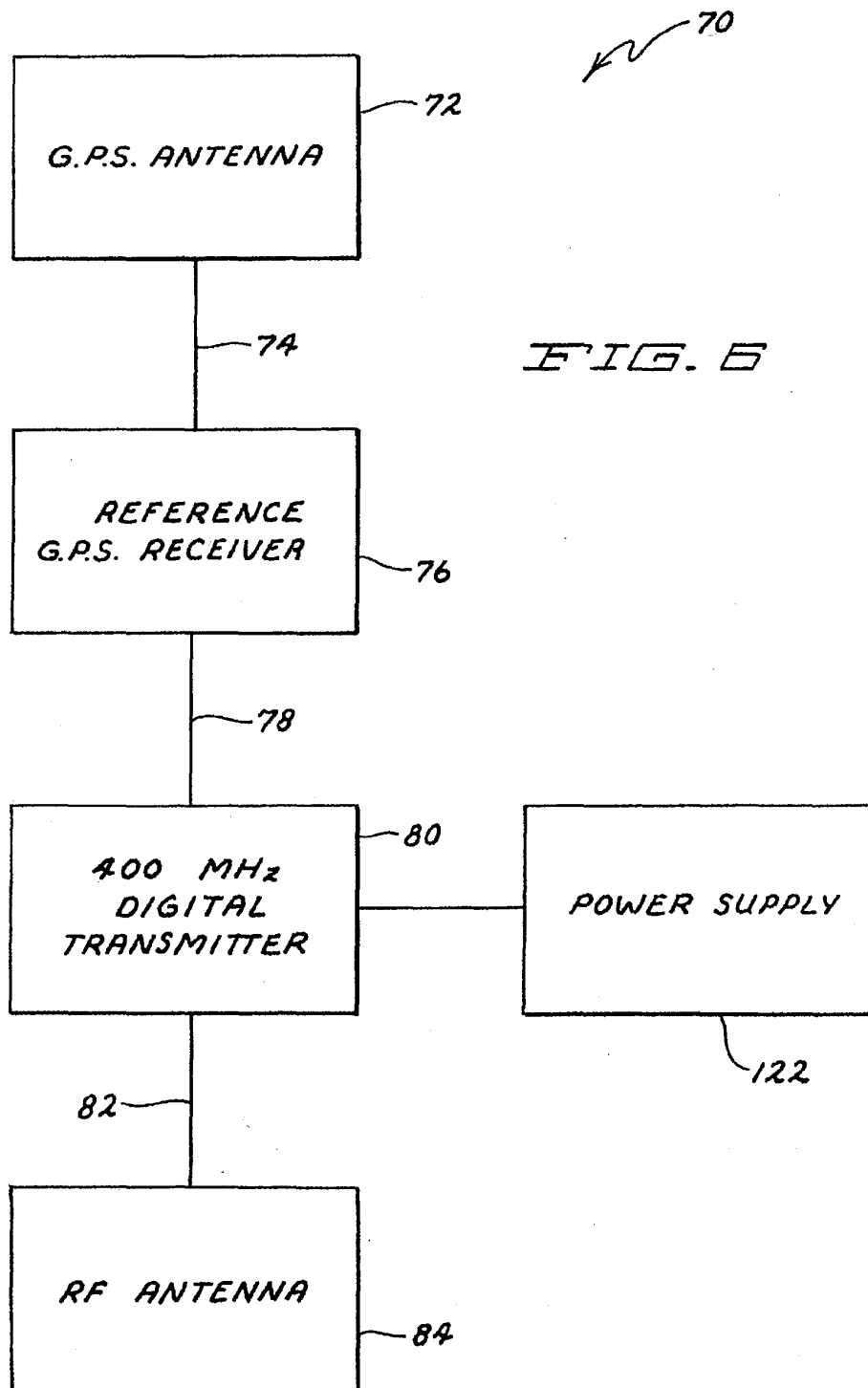


FIG. 5



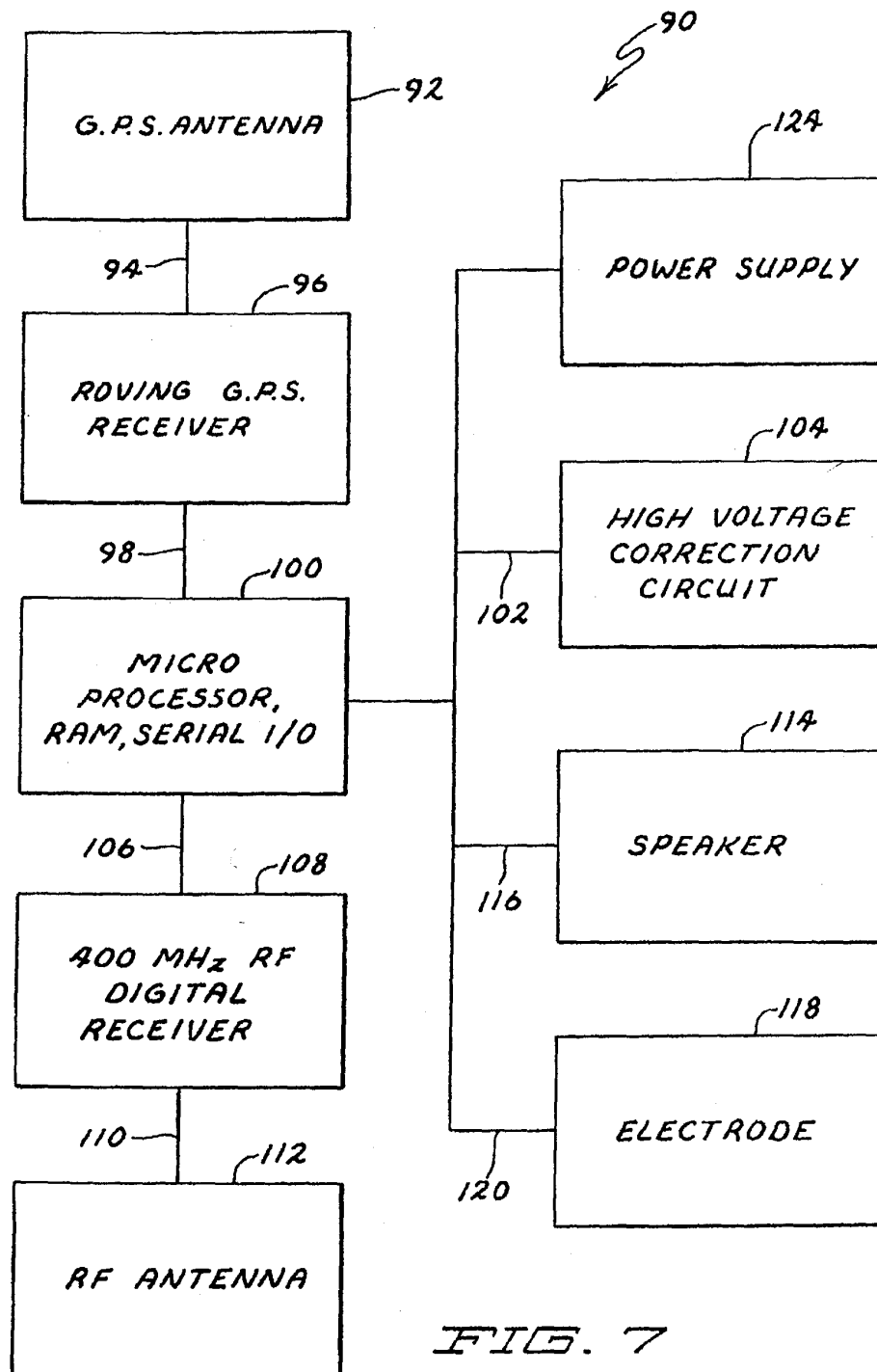


FIG. 7

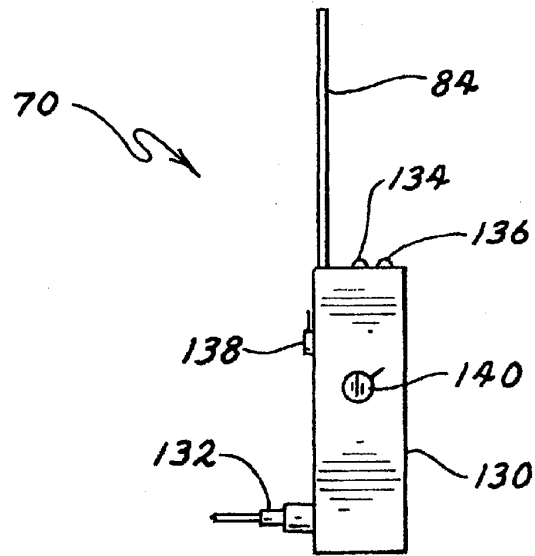


FIG. 8

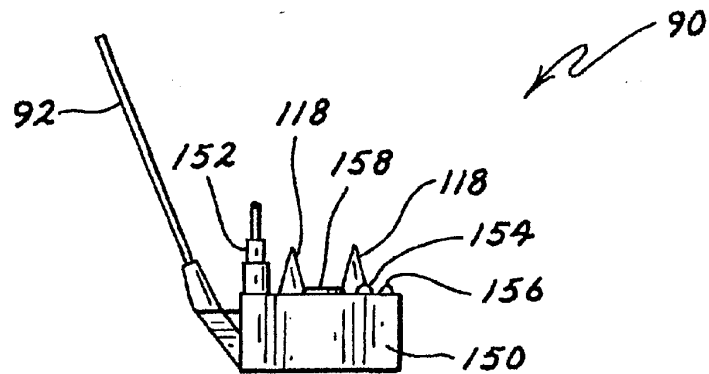


FIG. 9

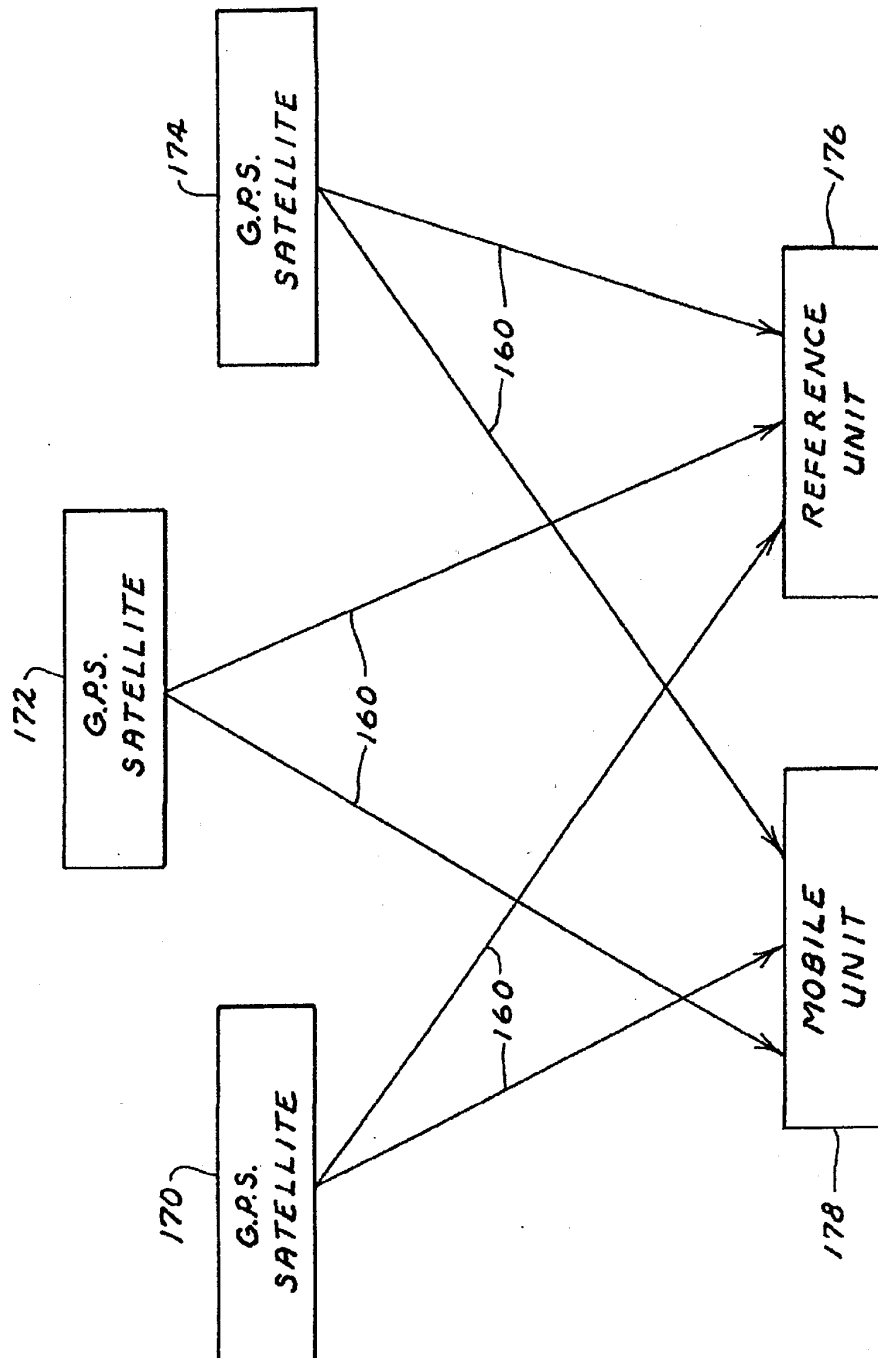


FIG 10

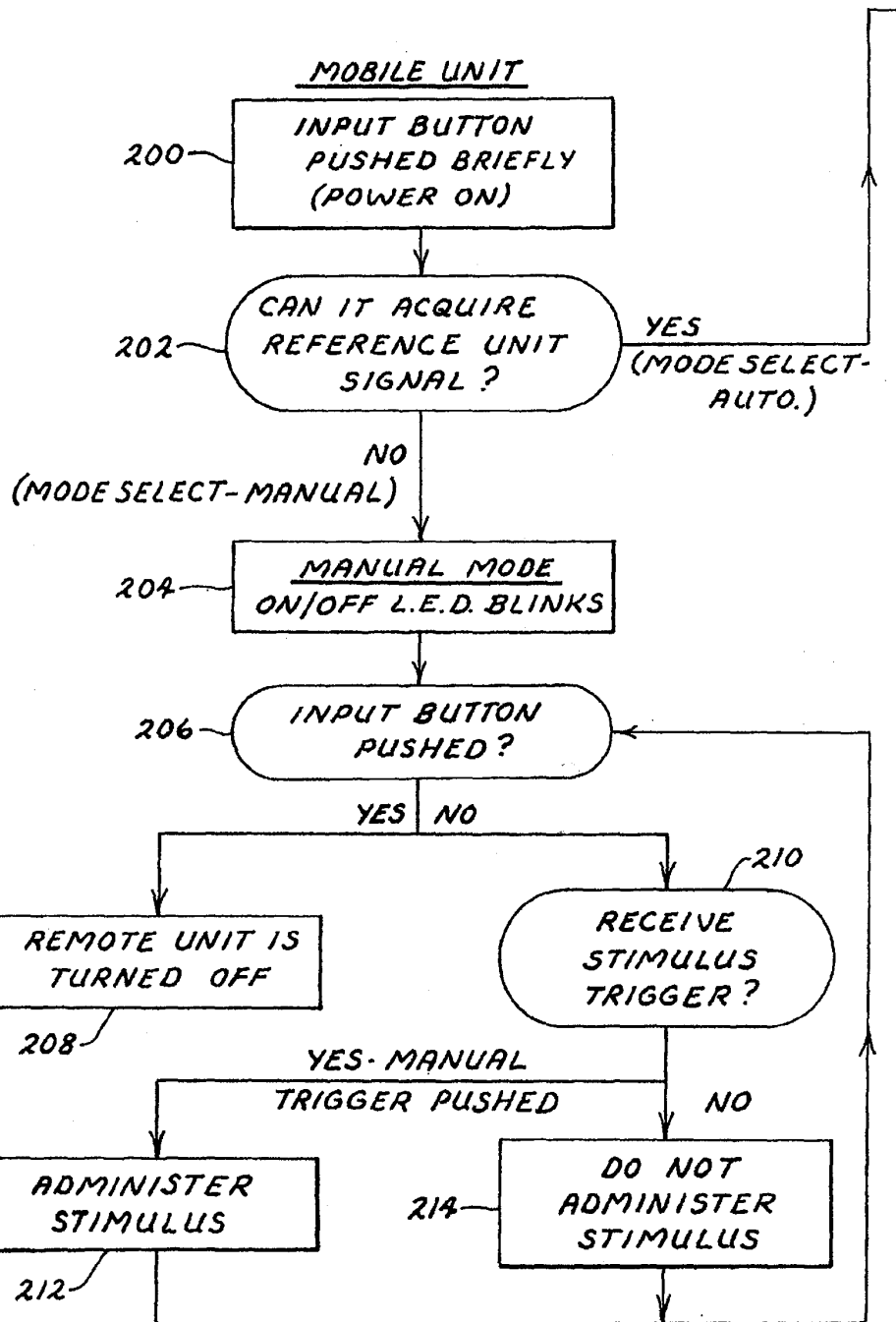


FIG. 11A

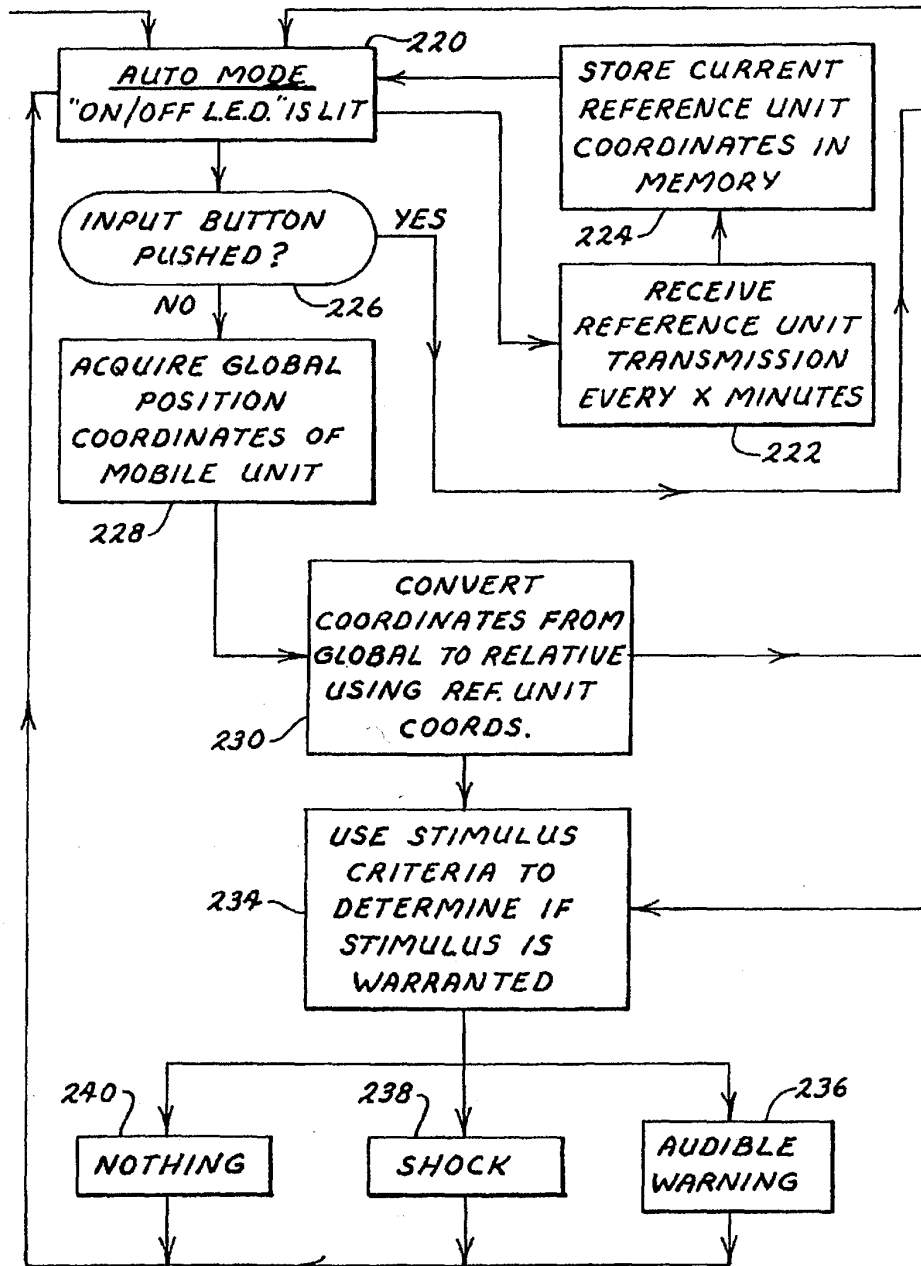


FIG. 11B

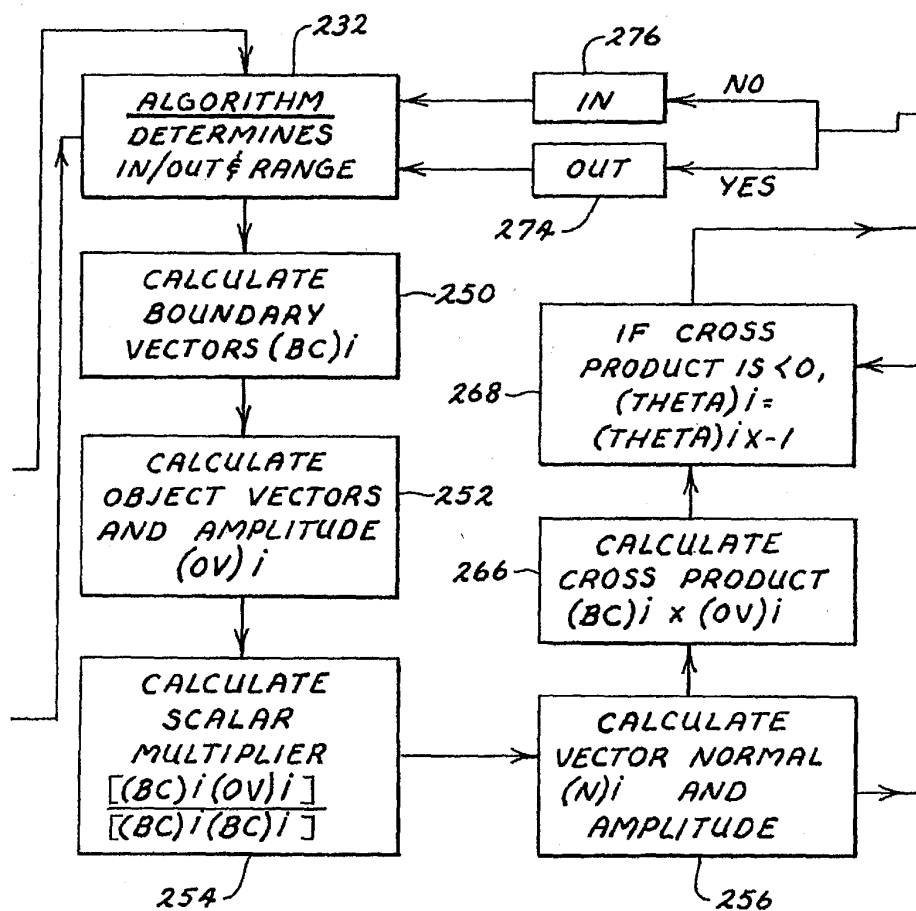


FIG. 11C

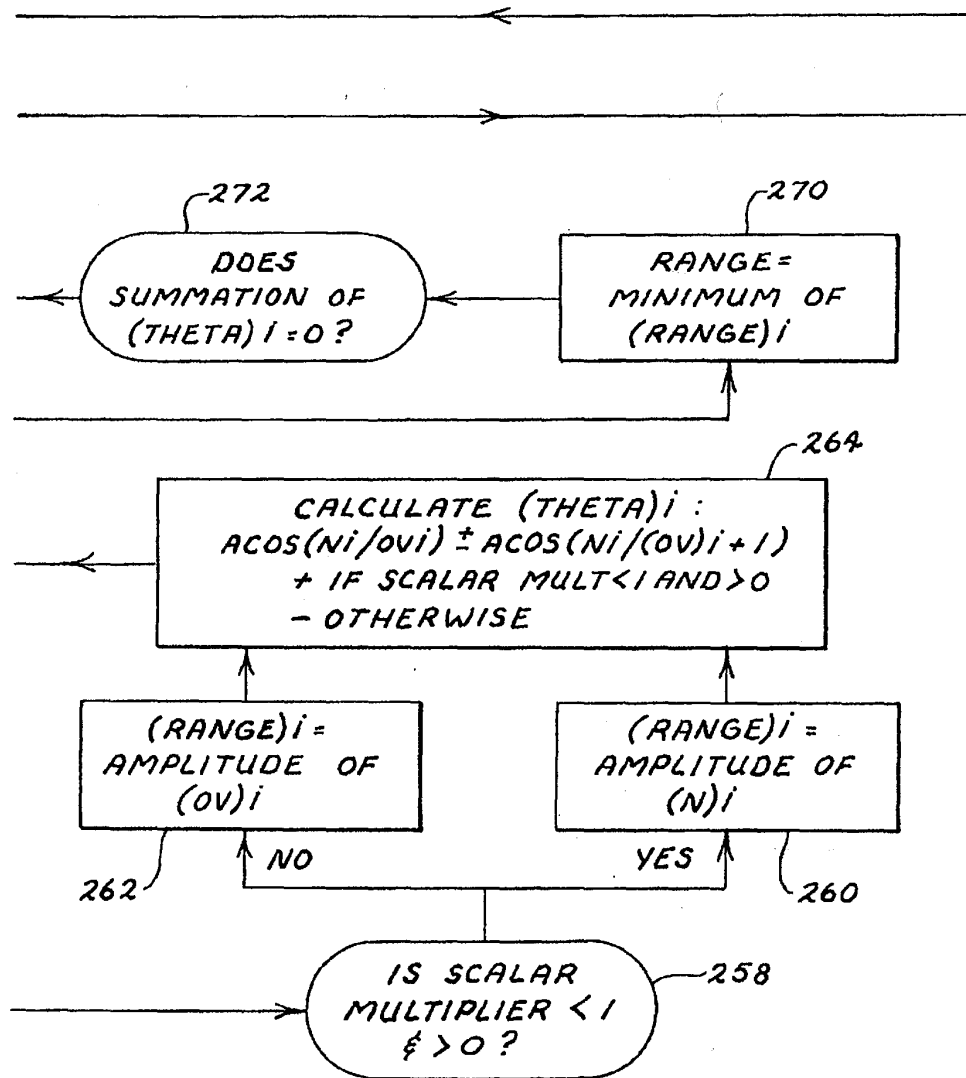
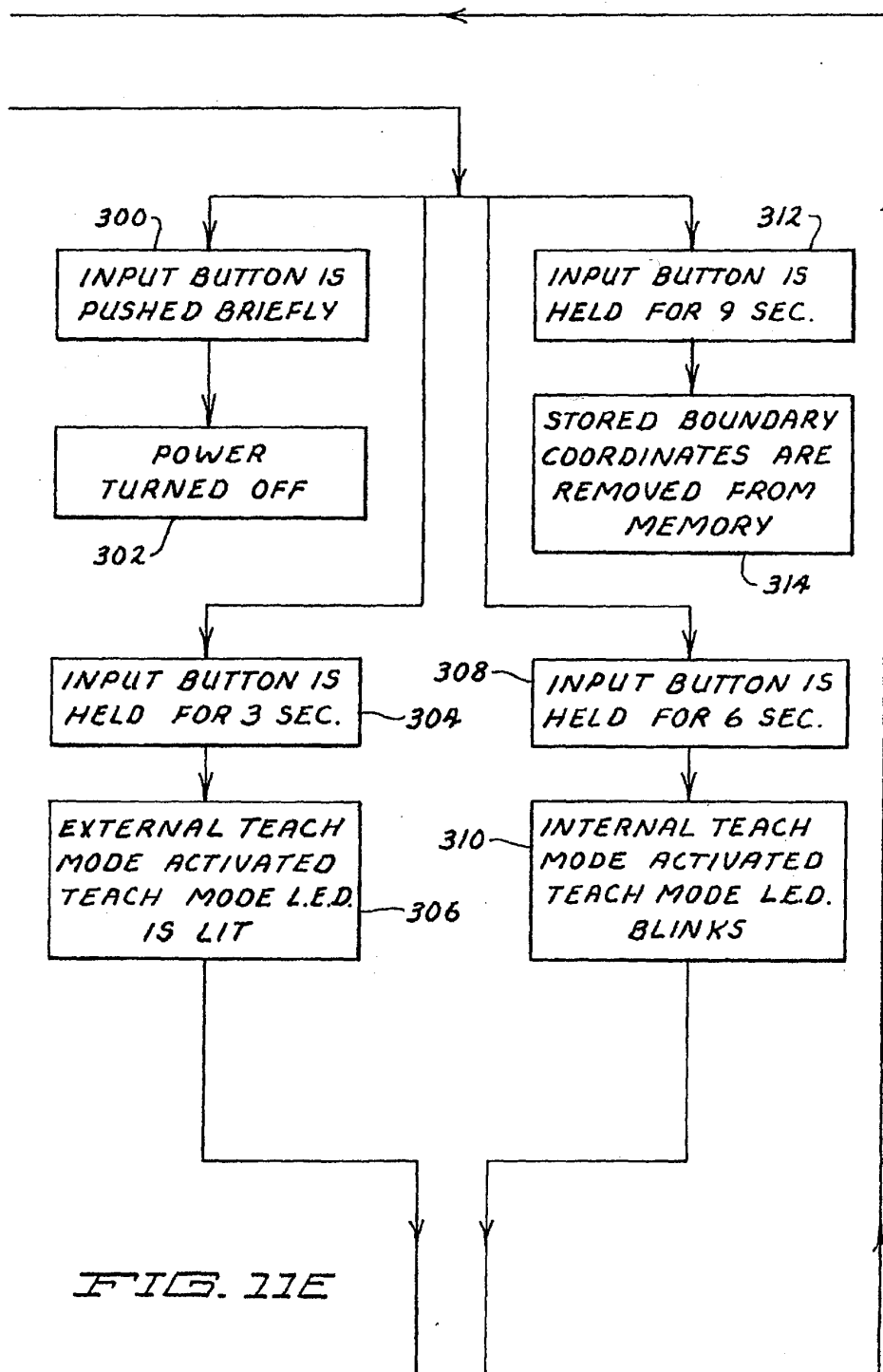


FIG. 11D



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communication unit in order to determine if a clandestine unit is tracking it.

14. A communication system comprising:

a portable mobile remote unit;

a network of communication units;

means to obtain the location of the portable mobile remote unit;

means to obtain geographic boundary information in order to disclose a global location at the network;

means to provide the location of the portable mobile remote unit to the network upon determination that the portable mobile remote unit is within the geographic boundary obtained at the network;

means to determine and report to the system upon request that, another mobile remote unit of the network has tracked the portable mobile remote over a period of time.

15. The portable mobile remote according to claim 14, having means to further determine if location disclosure for the remote unit is prohibited at a specific geographic boundary before sending its location to the network.

16. The portable remote unit of claim 15 having means to establish its velocity at the network and having means to further determine that, its velocity is within the network's prescribed velocity before divulging its location to the network.

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17. A method for providing the location of portable remote units that exist within a prescribed geographic boundary to a wireless network comprising:

i) providing geographic boundary information to mobile remote units in a geographic region to disclose their location;

ii) further providing exclusion region information associated with said geographic boundary of (i) to mobile remote units in the geographic region;

iii) determining that a mobile remote unit is in the geographic boundary of (i) and not in the exclusion region of (ii) before providing the location of the mobile remote unit to the network.

18. A method for providing the location of a portable remote unit that exist within a prescribed geographic boundary to a wireless network comprising:

i) providing to remote units in the geographic boundary velocity information required in order to divulge location information;

ii) estimating at the remote unit or network, the velocity at which the remote unit is moving;

iii) validating that the estimated velocity of the remote unit meets the velocity requirement provided by the network (i), if yes, forwarding the location of the remote unit to the network.

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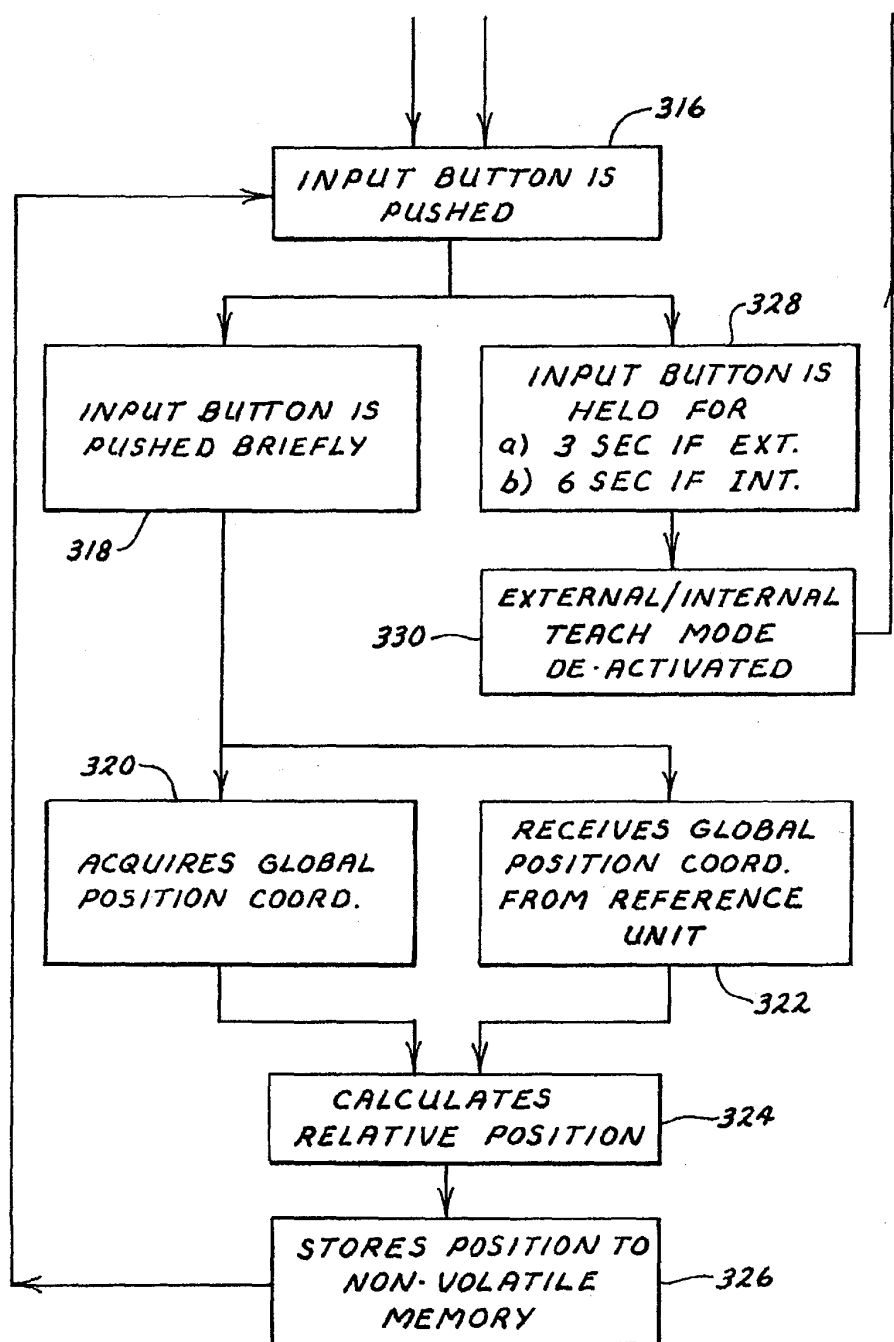
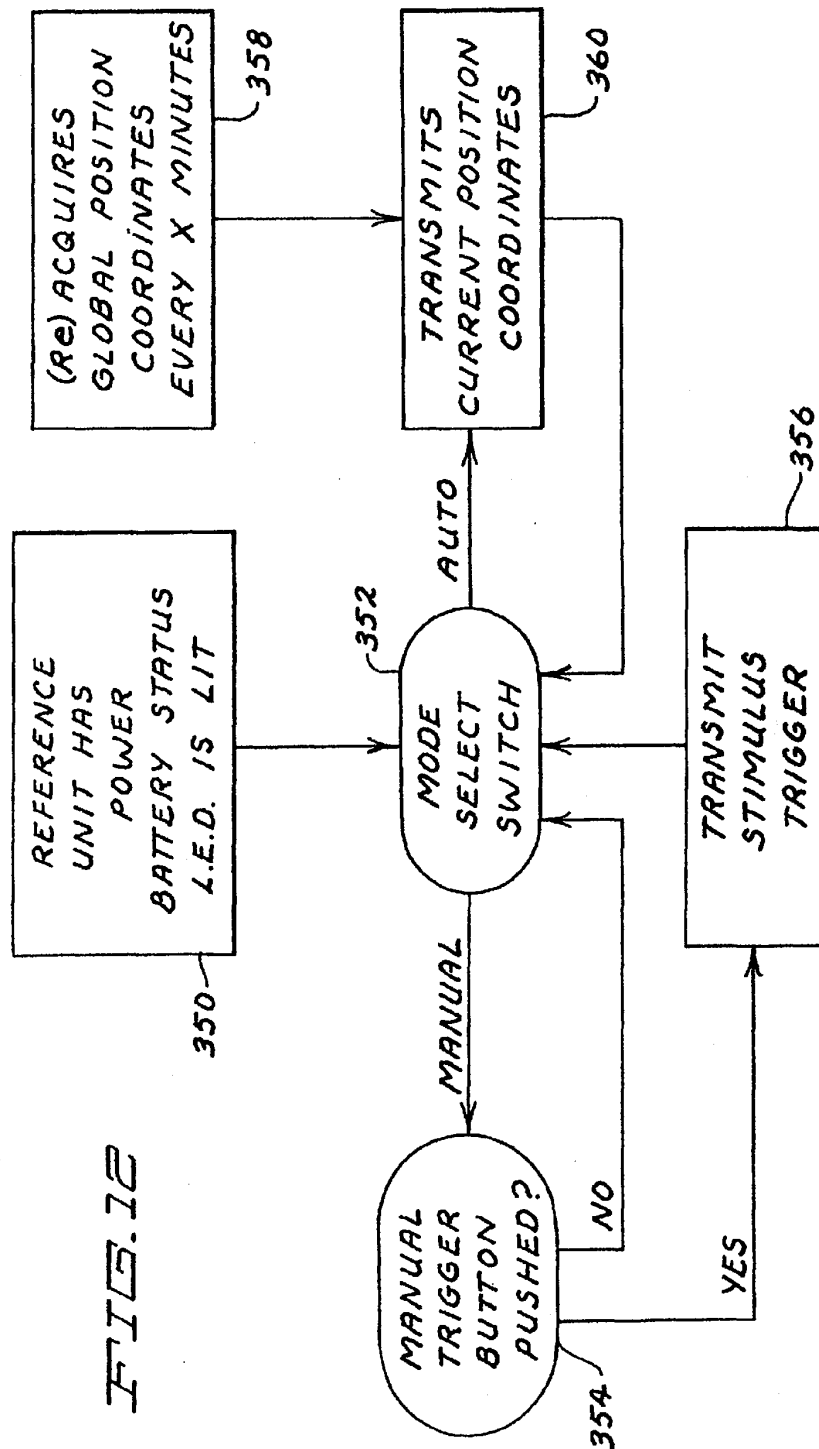


FIG. 11F



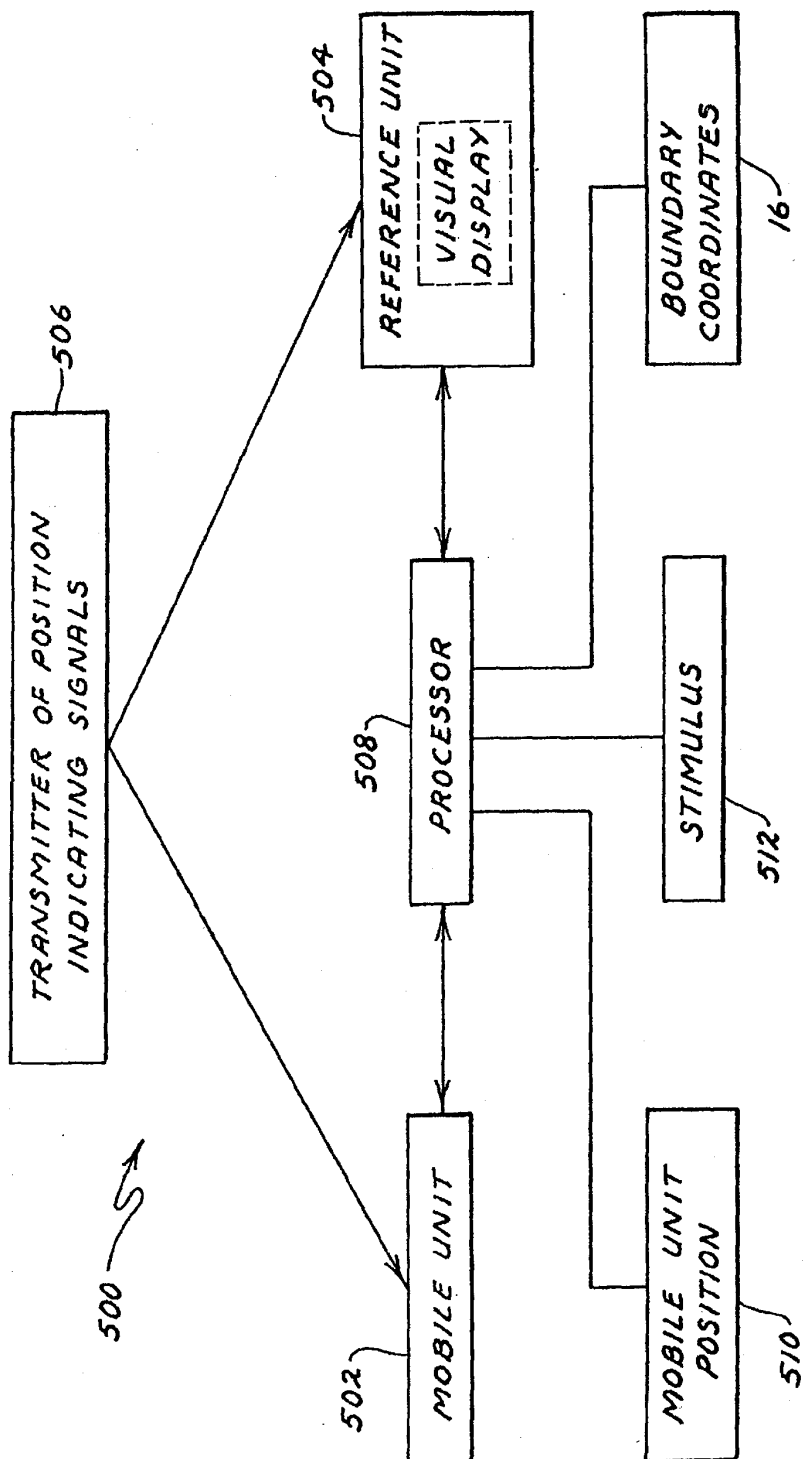


FIG. 14

LOCATION METHOD AND APPARATUS

FIELD OF THE INVENTION

The present invention relates generally to systems useful in identifying the location of a mobile transmitter utilizing the global positioning system (GPS) and particularly to such a system useful in creating, operating, and maintaining an animal confinement or containment system.

BACKGROUND OF THE PRESENT INVENTION

Animal confinement systems that provide a stimulus to an animal approaching a predetermined boundary to encourage the animal to remain within the predetermined area defined by the boundary are well known and are commercially available. Generally, there are two such types of systems being sold or otherwise available today—a wire system and a wireless system. The first of these relies on the placement of a transmitter wire above or under ground to define the boundary of a containment area. The transmitter wire transmits an electrical current that in turn sets up an electrical field about the wire. An animal, such as a dog, is equipped with a receiver that senses the electrical field generated by the current in the transmitter wire. The receiver, based upon the strength of the electrical field signal received (and, hence, the distance from the transmitter wire) can be programmed to provide an auditory and/or electrical stimulus. In other words, the receivers worn by the dog typically can be programmed to emit “beeps” at a certain distance from the transmitter wire and/or it can be programmed to provide an electrical shock to the dog when the dog gets within a predetermined distance of the transmitter wire. Usually, the receiver is placed on a collar worn by the dog.

Another known system relies on a single stationary transmitter to broadcast a signal. The transmission is substantially omnidirectional with a substantially uniform signal strength in all directions. The broadcast signal is received by a receiver worn by the dog. Again, the receiver measures the signal strength, determines the distance of the receiver and hence the dog from the transmitter, and applies the appropriate stimulus to the animal if necessary. Conversely, there could exist a centrally located receiver that would receive a signal broadcast by a transmitter worn by the animal. The centrally located transmitter would then measure the signal strength of the broadcast signal and determine whether the animal was approaching the boundary and whether a stimulus should be applied according to pre-determined criteria. This latter variant of such a confinement system would be more expensive than the first variant because it would require a transmitter and a receiver to be placed both on the animal and at the central location, unlike the first, which requires a single transmitter and a single receiver.

A third confinement system that has been proposed relies on ultrasound signal transmissions. With the ultrasound system, a responder worn by the animal is responsive to an ultrasonic signal broadcast by a centrally located transmitter. The distance of the animal from the transmitter is measured by the round trip time of the transmitter signal from the transmitter to the responder and back to the transmitter. When the round trip time indicates that the animal is approaching or within the predetermined stimulus application area, the centrally located ultrasound transmitter will broadcast a signal to the responder directing that a stimulus be applied to the animal. As with the wireless system just described, the ultrasound system also is constrained to use a substantially circular confinement area.

Another wireless system has been proposed that relies on the broadcast and reception of electromagnetic, that is, radio, signals to define the boundary and the stimulus application area. A multiple receiver/multiple antenna unit is worn by the animal. Through a complex vector analysis of the signals received by the unit the exact distance from the animal to the transmitting antenna can be determined and the appropriate stimulus can then be applied. This particular wireless system consumes large amounts of power, necessitating frequent battery recharging and/or replacement in the unit worn by the animal.

Yet another wireless system is known to the prior art. In this system, a transmitter modulates the electromagnetic signals produced by the transmitter to produce non-random patterns of signals. A comparator in the receiver compares the signal levels of the received signals with a predetermined signal level held in memory and produces an output indicative of the signal degradation. The receiver also compares the phase of the modulation of the received signals with a reference phase held in memory. Through additional processing of the output signals the distance of the animal from the transmitter is determined and the appropriate stimulus is applied.

Typically, with either of the afore described systems, some training period is necessary before the animal will learn the boundary beyond which it is not to pass. Often this involves marking the boundary with flags such that the animal will have a visual representation of the boundary to associate with the stimulus received from the collar.

These commercially known systems, while being admirable attempts to devise a workable confinement system for pets, suffer, however, from several notable drawbacks. In the first or wire system, the requirement of the transmitter wire means that the boundary, once placed, is relatively fixed and the system itself is likewise also fixed. In other words, once the wire has been used to define the boundaries, redefining the boundaries requires that the wire be moved, often by digging it up and reburying it. The system suffers, then, from being unable to be moved easily, if at all, so as to define temporary boundaries, such as when a pet is taken on a family vacation.

In addition, when the wire system is used, the homeowner's entire yard effectively cannot be used by the pet. For example, placement of the transmitter wire underground will usually be accomplished entirely on the pet owner's own property, barring excessively good neighborly relations. Since it is typically desired to keep the pet within one's own yard, the stimulus will be applied within several feet of approaching the transmitter wire. In essence, then, an area defined by the yard's perimeter by several feet wide will be inaccessible to the pet. In small yards in particular, this can mean that a substantial percentage of the yard will be inaccessible to the animal for play and exercise.

An additional drawback is that the wire system can be rather expensive when the cost of obtaining the necessary wire to define the area as well as the installation costs are calculated.

Finally, if the confined animal chances to escape the containment area, the animal will receive a warning stimulus if and when it tries to return to the pre-defined area since the stimulus is given when the animal is within a certain distance of the transmitter wire, regardless of which side of the wire it is standing. In other words, as the animal tries to return home, it will receive a stimulus from the receiver as it approaches the transmitter wire and enters the defined distance at which a stimulus will be given. The animal will

then be discouraged from coming home if it should happen to escape, thus defeating the purpose of trying to keep the animal within the home yard in the first place.

The wireless systems discussed above, while potentially portable, do not allow for any flexibility in the boundary, which is substantially defined by the directional properties of the transmitter and is most often circular in configuration about the transmitter location. Thus, while a wireless system can be used readily on a vacation to define a pet area, it suffers from the lack of an ability to take advantage of a homeowner's entire yard; or if the entire yard is within the circular containment area, usually a portion of a neighbor's yard is also since rarely, if ever, are yards circularly configured. In addition, particularly with dogs, it is often desired to keep the pet away from a newly planted area, whether lawn or other forms of landscaping. If the newly planted area happens to be within the defined circular boundary, only by redefining the circular boundary to lie closer to the transmitter can the dog be kept away from the newly planted area. Such a boundary redefinition, however, would typically remove a great deal of otherwise useable lawn area from the confinement area, which is rarely an acceptable solution. In other words, the presently available systems do not provide a method of setting off preselected areas where the pet is not allowed within the larger allowable areas where the pet can enter.

Prior art confinement systems can be found in U.S. Pat. Nos. 3,753,421 to Peck; 3,980,051 to Fury; 4,898,120 to Brose; 5,067,441 to Weinstein; and 5,381,129 to Boardman, among others. Reference can be made to those patents and others for a more complete description and understanding of the prior art.

Thus, while the prior art contains many inherent deficiencies, a presently available technology offers the opportunity to develop a more useful system. For example, development of Satellite Positioning Systems (SATPSs), such as the Global Positioning System (GPS) in the United States and the Global Orbiting Navigational System (GLOSNASS) in the former Soviet Union, has allowed location coordinates of an object on or near the Earth to be determined with improved accuracy. Under normal circumstances, these systems allow coordinates to be determined with an accuracy of no more than 30 meters.

A Satellite Positioning System (SATPS) is a system of satellite signal transmitters, with receivers located on or near to the earth's surface, that provides means for determining the location of a receiver and/or time of observation. Two operational systems currently in place are the Global Positioning System and the Global Orbiting Navigational System.

The Global Positioning System (GPS) is a satellite-based navigational system developed by the United States Department of Defense. The GPS system employs 24 satellites, 4 of which share one of six orbits around the earth at a radius of 26,560 kilometers and are approximately circular. The system allows that three or more satellites are visible on most points of the earth's surface at any given time. Each satellite carries a cesium or rubidium atomic clock to provide timing information for the transmitted signals.

Each GPS satellite transmits two spread spectrum, L-band carrier signals: an L1 signal having a frequency $f_1=1575.42$ MHz. These two frequencies are multiples of a base frequency, $f_0=1.023$ MHz. These two transmitted signals allow for partial compensation of propagation delay of such a signal through the ionosphere as put forth by MacDoran in U.S. Pat. No. 4,463,357. The L1 signal is binary phase shift

key (BPSK) which is modulated by two pseudo-random noise (PRN) codes. The two PRN codes are modulated in phase quadrature, and are termed C/A-code and P-code. The L2 signal from each satellite is BPSK modulated by only the P-code.

Use of the PRN codes allows use of a plurality of GPS signals. A signal transmitted by a particular GPS satellite is selected by creating and matching the PRN code for that particular satellite. PRN codes for all satellites are known and stored in each GPS satellite signal receiver. A first P-code for each GPS satellite is a relatively lengthy code which includes an associated clock rate of $10 F_0=10.23$ MHz. A second PRN code for each GPS satellite, the C/A code, or clear/acquisition code, is a short code which allows for rapid satellite signal acquisition and has a clock rate of $F_0=1.023$ MHz. The C/A-code for any GPS satellite has a length of 1023 chips or time increments before this code repeats. The full P-code has a length of 259 days, with each satellite transmitting a unique portion of the full P-code. The portion of P-code used for a given GPS satellite has a length of precisely one week (7 days) before this code portion repeats. Accepted methods for generating the C/A code and P-code are set forth in the document GPS Interface Control Document ICD-GPS-200, published by Rockwell International Corporation, Satellite Systems Division, Revision A, Sep. 26, 1984, which is incorporated by reference herein.

The GPS satellite bit stream includes navigational information on the ephemeris of the transmitting GPS satellite and an almanac for all GPS satellites, with parameters providing corrections for ionospheric signal propagation delays suitable for single frequency receivers and for an offset time between satellite clock time and true GPS time. The navigational information is transmitted at a rate of 50 Baud. A useful discussion of the GPS techniques for deciphering position information of GPS satellite signals can be found in the NAVSTAR Global Positioning System, Van Nostrand Reinhold, New York, 1992, pp. 1-90.

A second configuration for global positioning is the Global Orbiting Navigation Satellite System (GLONASS), developed by the former Soviet Union. GLONASS also uses 24 satellites, but they are spread evenly over three circular orbits of radii of about 25,510 kilometers. The GLONASS system also uses two carrier signals L1 and L2 with frequencies of $f_1=(1.602+9 k/16)$ GHz and $f_2=(1.246+7 k/16)$ GHz, where k is (0, 1, 2, 3, . . . 23) is the satellite number or satellite tag. The methods for receiving and analyzing the GLONASS signals are similar to the methods used for the GPS signals.

Reference to a Satellite Positioning System or SATPS herein refers to a Global Positioning System, to a Global Orbiting Navigation System, and to any other satellite-based navigational system which is compatible with the present invention.

A SATPS uses transmission of coded radio signals, with the structure described above, from a plurality of Earth-orbiting satellites. A single receiver of such signals is capable of determining receiver absolute position in an Earth-centered or -fixed coordinate system.

Two or more receivers can be used to more accurately determine the relative positions between the receivers or stations. This method, known as differential positioning, is far more accurate than absolute positioning, provided that the distances between these stations are substantially less than the distances from these stations to the satellites. In differential position determination, many of the errors in the SATPS that compromise the accuracy of absolute position

have little or no effect on differential positioning due to a process of partial error cancellation.

An SATPS antenna receives a SATPS signals from a plurality of SATPS satellites and passes these signals to an SATPS signal receiver/processor, which (1) identifies the SATPS satellite tag, or satellite source, for each SATPS signal, (2) determines the time at which each SATPS signal arrived at the antenna, and (3) determines the present location of the antenna based upon this information and from information stored on the ephemerides for each identified satellite.

In order to further improve the accuracy provided by SATPS location determination, differential GPS (DGPS), and more generally differential SATPS (DSATPS) has been introduced and used. A DSATPS can provide locations with inaccuracies as low as a few meters, or lower in some instances. Implementation of a DSATPS requires than an SATPS reference station, whose location coordinates are known with high accuracy (to within a fraction of a meter) be provided to receive the normal SATPS signals from SATPS satellites. The reference station compares its known pseudorange (pseudorange refers to the distance between a SATPS receiver antenna and a given SATPS transmitting satellite), based on its known location and known satellite and clock biases, with the pseudorange computed using the acceptable SATPS signals received from each visible satellite. The difference, called a pseudorange correction, between the known pseudorange and the computed pseudorange is transmitted for each such SATPS satellite, along with an indicium that identifies that satellite. A mobile SATPS station within 100-200 kilometers (km) of the reference station receives and uses these pseudorange corrections to correct its own SATPS-determined pseudorange values for each acceptable satellite signal. The pseudorange corrections must be received and processed at the mobile station.

While pseudorange correction techniques currently employed with DSATPS do provide for positional accuracy of the mobile SATPS receiver, they also require additional logic and circuitry, which in turn leads to increased cost. Additionally, a consumer is forced to pay for access to the DSATPS correction signals from the reference stations currently in use (such a service is available from Omnistar, of Houston, Tex.). There is a need for a low cost method of determining the position of a mobile SATPS receiver relative to a reference SATPS receiver when in close proximity to each other (within 1-20 kilometers).

Although SATPS-assisted determination of location and/or time coordinates is quite well known, only a few patents disclose procedures for using differential positioning techniques in order to improve the accuracy of relative location coordinates of a mobile receiver with respect to a given reference receiver. Rather, pseudorange corrections and such are generally used to improve the accuracy of the global positioning coordinates produced by SATPS. For example, in U.S. Pat. No. 5,495,257 Loomis discloses a method for enhancing the accuracy of global location coordinates computed for a mobile SATPS receiver by using pseudorange corrections generated by a reference SATPS station, whose location coordinates are known with a high degree of accuracy. Similar methods are disclosed by Babu in U.S. Pat. No. 5,451,964, and Kyrtos in U.S. Pat. No. 5,490,073.

However, one method for determining the relative position of two SATPS receivers is disclosed in U.S. Pat. No. 5,202,829 by Geier. This system solves the problem of finding the relative positions of SATPS receivers by time-

tagging candidate pseudoranges, aligning like-tagged pseudoranges from respective GPS receivers, and subtracting the difference between corresponding pseudorange to arrive at accurate relative position determinations. Although this method does provide for accurate relative position determination, there are drawbacks. Namely, complex logic and circuitry is required to use the pseudorange differences to arrive at a relative position. This results in additional cost and computational time. As a matter of fact, Geier's system utilizes a personal computer to perform this function.

Thus, is a need for a relative positioning method provided with simple, low-cost logic. Furthermore, it would be desirable to have a confinement system was portable, that would take full advantage of the available area in a pet owner's yard; that was flexible in operation so as to accommodate desirable boundary changes in a confinement area, such as when new yard plantings occurred; that enabled the operator to designate "islands" of non-allowed areas within a larger allowable use area for the animal; and that consumed reduced amounts of power so as to provide long battery life.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide new and improved apparatus that is not subject to the foregoing disadvantages.

It is another object of the present invention to provide a position locator system primarily for use in confining animals that enabled the operator to tailor the confinement boundary to the operator's pleasure.

It is still another object of the present invention to provide a position locator and confinement system that was portable but that was not limited to a substantially circular confinement area.

It is yet another object of the present invention to provide an animal confinement system that takes advantage of the accuracy provided by GPS to define the animal confinement area.

It is still yet another object of the present invention to provide a system that can be "taught" the desired location of a boundary of a confinement area and "re-taught" as desired by the confinement system operator such that the confinement area can be changed at will.

It is another object of the present invention to provide a wireless system at an affordable cost that utilizes GPS to locate a mobile transmitter or receiver unit within a predetermined area and to utilize the mobile unit to apply a stimulus adapted to encouraging the unit wearer to remain within the predetermined area.

The foregoing objects of the present invention are provided by method and apparatus for determining the position of a portable transmitter or receiver and applying a stimulus to the carrier thereof when the carrier is determined to be within a predetermined stimulus application area. An apparatus in accord with an embodiment of the present invention will include a mobile unit including a receiver that is preferably receptive to signals broadcast by Global Positioning System Satellites (GPSS). The mobile unit will include a microprocessor and a memory capable of storing the boundary coordinates of the predetermined boundary. The microprocessor will be further capable of determining continuously or at predetermined intervals its location relative to the predetermined boundary. The mobile unit may include a stimulus producing apparatus such as a speaker or electrode to provide audible warnings or electrical shocks as appropriate. The mobile unit may also include a transmitter for transmitting its position to a receiver within a reference unit.

A method for confining an animal in accord with the present invention will include the steps of determining a boundary, teaching the boundary to the system by inputting the boundary coordinates into an appropriate memory of a mobile unit, providing a processor for processing received signals indicative of position, whether such signals are actual coordinates, GPS signals, or some other such position indicating reference signals, processing the signals to determine the position of the mobile unit, comparing the position of the mobile unit relative to a predetermined boundary, and providing an output indicative of the relative position of the mobile unit to the predetermined boundary. Such an output could be an audible tone, an electric shock, or a human voice.

As a further step in a method according to the present invention, the method could include the step of designating certain areas within the previously determined external boundary as being unavailable or off limits to the wearer of a mobile unit. For example, certain yard areas or "islands" within the larger yard could be designated as off limits and warning stimuli provided to the wearer of the mobile unit when the wearer approached the island. Thus, a pet could be taught to stay away from certain yard areas, such as a garden, for example.

The present invention finds wide application in many areas. For example, a parent could attach a mobile unit of a system in accord with the present invention to a child and monitor the child's location within a predetermined boundary. The system would be useful where the parent would be vacationing away from home or visiting away from home or where a yard wasn't fenced. A system useful with such an application could include the parent's voice pre-recorded and held in a memory within the mobile unit. The mobile unit would then provide the parent's voice as an auditory output through a speaker included within the mobile unit when the child was within predetermined distances of the predetermined boundary. The unit could provide one or more levels of warnings as the child approached or left the predetermined boundary, such as a yard or playground. Rather than using an electrical shock as an ultimate stimulus, the mobile unit could include an odor producing apparatus that would emit a strong, unpleasant odor as the child approached a prohibited area.

Another application for the present invention would be with automated devices, such as a solar powered lawn mower. The mobile unit would be attached to the mower and the lawn's boundary would be programmed into the reference unit. The mower could then mow the lawn accurately insuring accurate coverage of the entire lawn since it could determine that it had mowed all of the area because it would know its position at all times.

Yet a third application for the present invention would be to provide sight-disadvantaged person with a reference system for determining their position continuously and accurately. Such persons would carry the mobile unit with them as they moved around a city. The system could be enhanced by the inclusion of a speaker in the mobile unit that was capable of replicating the sound of a human voice. The mobile unit could thus audibly inform the users of their locations based upon the unit's position, providing them with information concerning familiar landmarks such as buildings and building entrances, approaching intersections, or the like.

In such an embodiment a city may provide a centrally located reference unit and those sight disadvantaged persons could obtain mobile units with the desired landmarks pre-programmed, permanently or otherwise, into the unit.

Finally, another such application is the use of the present system in a pet confinement system. In such a system the mobile unit can include both auditory and shock stimulus producing and providing apparatus. Such a system would enable the pet owner to designate substantially the entire yard for the pet's use, while reserving specific areas, such as new plantings.

It will be understood that rather than using either auditory or electrical shocks as a stimuli, other forms of stimuli could also be used, such as vibration as is found in many pager devices currently marketed or some form of light stimuli, such as a brightly flashing light.

The foregoing objects of the invention will become apparent to those skilled in the art when the following detailed description of the invention is read in conjunction with the accompanying drawings and claims. Throughout the drawings, like numerals refer to similar or identical parts.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of one embodiment of a system according to the present invention.

FIG. 2 is a schematic illustration of another embodiment of a system according to the present invention.

FIG. 3 is a schematic illustration of another embodiment of a system according to the present invention.

FIG. 4 is a schematic illustration of another embodiment of a system according to the present invention.

FIG. 5 is a schematic illustration of another embodiment of a system according to the present invention.

FIG. 6 is a block diagram of a reference unit capable of being used in accordance with the present invention.

FIG. 7 is a block diagram of a mobile unit capable of being used in accordance with the present invention.

FIG. 8 is an external side view of a reference unit in accord with the present invention.

FIG. 9 is an external side view of a mobile unit in accord with the present invention.

FIGS. 10 is a schematic illustration of the functioning of the GPS system.

FIGS. 11A-11F is a block diagram of a flow chart for programming of a programmable microprocessor useful in a mobile unit in accord with the present invention.

FIG. 12 is a block diagram of a flow chart for programming of a programmable microprocessor useful in a reference unit in accord with the present invention.

FIG. 13 is an illustration of one application of the present invention to a residential home.

FIG. 14 is an illustration of the present invention and including an apparatus for providing a visual display.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. 1-5 represent alternative embodiments of a system in accord with the present invention. According to the system 10 of FIG. 1, a mobile unit 12, such as might be attached to a dog collar, receives a position indicating data signal from GPSS 14. The mobile unit 12 has been preprogrammed to include the boundary coordinates 16 of the confinement area. The mobile unit includes a microprocessor that compares the position derived from the GPS signal 14 with the boundary coordinates 16. The logic programmed into the mobile unit 12 will determine the location of the mobile unit relative to the coordinate boundaries 16 and will

then determine if the animal is within or without of the predefined range of movement 18. The mobile unit can then apply the appropriate stimulus to the animal if the determined position indicates that a stimulus is warranted according to the predetermined stimuli application criteria.

FIG. 1 is a preferred embodiment of the present invention, but due to inherent inaccuracies preprogrammed into the GPS signals presently broadcast by GPS satellites a single receiver such as mobile unit 12 cannot be used to determine position with sufficient accuracy that GPS can be used as a reference signal to determine position within a typically sized lawn. That is, with GPS signals broadcast today a position can be determined only to an accuracy of ± 30 meters (100 feet). This inherent inaccuracy is too large to use as a reference signal in a typical lawn, which may measure less than 150 feet (45 meters) on a side (approximately $\frac{1}{2}$ acre).

FIG. 2 shows another embodiment 20 of a system in accord with the present invention. System 20 includes a mobile unit 22 and a stationary or reference unit 24, both of which include a receiver (not shown) to receive signals from GPSS 14. Mobile unit 22 is preprogrammed to include the boundary coordinates 16. The reference unit 24 includes a transmitter (not shown) that broadcasts a reference signal 26 containing reference data to the mobile unit 22. The mobile unit 22, using the GPS signals and the reference data, determines whether it is within or without the stimulus application range 18. The system 20 of FIG. 2 can be used to determine position even considering the present inherent, intentional inaccuracies in GPS signals as will be explained further below.

FIG. 3 shows yet another embodiment 30 of the present invention wherein the embodiment 30 includes a mobile unit 32 and a reference unit 34, both of which include a receiver (not shown) to receive GPS signals 12. In this embodiment, the boundary coordinates 16 are programmed into the reference unit. Mobile unit 32 broadcasts a mobile signal 36 including information relating to the position of the mobile unit to the reference unit 34. The reference unit 34 in turn continuously determines the position of the mobile unit based upon the GPS signal 12 and the mobile data signal 36. This position is compared to the boundary coordinates 16 to determine if the mobile unit is within or without the stimulus application range 18. If it is determined that the mobile unit is within the stimulus application range 18, the reference unit 34 will transmit a signal to the mobile unit 32 directing the application of a stimulus to the animal. This system requires the presence of both receivers and transmitters in both the mobile and reference units 32 and 34, unlike the system 20, which requires only that the reference unit include a transmitter. This system may have desirable application where a stimulus was perhaps not desired, such as where the mobile unit is worn by a small child and the child's position is relayed to the reference unit monitored by a parent. In such a system, a stimulus producing device would not be used, or would be limited to an auditory or vibratory apparatus such as is presently found on pagers.

Referring now to FIGS. 4 and 5, other systems in accord with the present invention will be described. In FIG. 4, an animal containment system 40 includes a pair of antennas 42, a transmitter 44, and a mobile unit 46. The transmitter 44 provides a signal to the antennas 42, each of which broadcasts a signal 48, electromagnetic or ultrasound, capable of being received by the mobile unit 46. The mobile unit 46 calculates its position by triangulation using the signals received from the antennas 42, compares them with the boundary coordinates 16 to determine its position relative

thereto, and then applies the appropriate stimulus as predetermined by the operator.

FIG. 5 illustrates a system 50 that includes antennas 52, a receiver 54, and a mobile unit 56. The mobile unit 56 broadcasts triangulation signals 58 to the antennas 52, which in turn provides them to receiver 54. The receiver 54 will use the signals received by the antennas 52 to calculate the position of the mobile unit 56. The position of the mobile unit 56 can be compared against the boundary coordinates 16 to determine whether the mobile unit is within or without the range 18. This system could find use, for example, where, the application of a stimulus was not desired, but the location of the mobile unit was, such as when the mobile unit would be worn by a small child playing outside. FIGS. 4 and 5 represent embodiments that can be employed for situations where GPS signals are not available, such as within a dwelling.

As explained previously, one of the deficiencies in prior art animal confinement systems is that they either were not portable, or if they were portable, they were unable to function with anything other than a substantially circular confinement perimeter. The present invention overcomes that prior art deficiency by including apparatus and method for "teaching" the preferred boundaries to the system, the coordinates of the preferred boundary being stored in memory in either the reference unit or the mobile unit. The vertices of the boundary are taught to the particular unit where the coordinates are stored by walking the boundary and entering the coordinates thereof into the unit and storing them therein, the coordinates being determined with reference to the globally broadcast GPS signals. With the present invention, it is also possible to define internal boundaries or "islands" from which it is desired to keep the animal away. Such an area may be new yard plantings, for example.

With reference to FIGS. 6 and 7, then, a schematic of the reference unit and a mobile unit useful in association therewith is seen. FIG. 6 shows the components of a reference unit 70. Unit 70 will include a GPS antenna 72 capable of receiving signals broadcast by GPSS. Antenna 72 transmits the received GPS signals via an appropriate connector 74, which may be coaxial cable, to a reference GPS receiver 76, which may be of the type designated as "Oncore"™ and manufactured by Motorola. Receiver 76 is connected by an appropriate connector 78, which may be a bus, to a transmitter 80, which is capable of providing digital radio frequency signals in one embodiment of the present invention, though in other embodiments the transmitter 80 may be capable of broadcasting ultrasonic signals. The radio frequency signals are provided by an appropriate connector 82, which may advantageously be coaxial cable, to an antenna 84 for broadcasting.

A mobile unit useful with the reference unit shown in FIG. 6 is shown in FIG. 7. Thus, FIG. 7 illustrates a mobile unit 90 that also includes a GPS antenna 92 connected by an appropriate connector 94 to a GPS receiver 96, which like GPS receiver 76 may be of the type designated as "Oncore"™ and manufactured by Motorola. Receiver 96 is connected by an appropriate connector 98, which may be a NEMA bus, to a device 100 including a microprocessor, random access memory (RAM), and an input/output apparatus. Device 100 will be explained in greater detail below. Device 100 is connected by an appropriate connector 102 to a high voltage correction circuit 104 and by an appropriate connector 106, which may be a serial bus of known type and construction, to a receiver 108, which in turn is connected by an appropriate connector 110, which may again be coaxial cable, to a radio frequency antenna 112. Antenna 112

receives radio frequency signals, such as those transmitted by antenna 84 of reference unit 70, and provides them via connector 110, receiver 108 and connector 106 to device 100.

Device 100, as noted, would include a microprocessor, random access memory, and an input/output apparatus, which may be as simple as some touch buttons on the exterior of the mobile unit 90. In this particular embodiment of the present invention, reference unit 70 and mobile unit 90 will function substantially as follows. Each unit will receive GPS signals via their respective antenna 72, 92, from the GPSS network. These signals, as noted earlier, provide an indication of the position of the particular unit. A signal, indicating the calculated position coordinates of the reference unit is transmitted from the reference unit 70 to the mobile unit 90. The mobile unit 90 will receive the transmitted reference unit signals via its antenna 112 and will convey those received reference unit signals to device 100 via receiver 108 and connector 106. Device 100 will then calculate the position of the mobile unit with respect to the position of the reference unit and compare it with the preestablished boundary stored in RAM. If it is determined that a stimulus is warranted, the microprocessor of device 100 will direct the application of a stimulus. As noted, this could be an auditory signal, such as a beep of some predetermined volume and tone emitted by speaker 114, which is connected to device 100 by an appropriate connector 116. Or it could be an electrical shock administered through the electrode 118 via a connection to the device 100 through an appropriate electrical connector 120. Both units 70 and 90 will be powered by the appropriately sized electrical power source 122, 124 respectively. Power source 122 will appropriately be standard alternating current (ac) available through the local power grid or an appropriately sized rechargeable battery. Power source 124 will preferably be an electrically rechargeable battery.

An external view of a reference unit 70 in accord with the present invention is shown in FIG. 8. Unit 70 includes a casing or housing 130 having antenna 84 extendible therefrom and ac/battery recharger plug-in 132. Casing 130 can also contain several light emitting diode (LED) indicators thereon, such as a battery status LED 134 to provide an indication of a need to replace or recharge a battery used therewith. Casing 130 can in addition include a mode status LED 136 to provide an indication of the mode of operation selected by the user using a mode select switch 138. With switch 138 the operator can select between the following modes of operation: off, manual, or automatic. A manual stimulus switch 140 is also provided to so that the operator can manually apply a stimulus to an animal during a training phase in teaching the animal the operation of the system and the location of the boundary beyond which the animal is not to pass.

FIG. 9 illustrates in a side elevation view a mobile unit, such as unit 90, in accord with the present invention. Reference unit 90 includes a casing 150 from which antenna 92 extends. Casing 90 can have an ac/battery recharger plug-in 152 for providing recharging of a battery used to power the unit 90. Mobile unit 90 advantageously includes at least a pair of LEDs for indicating the operation of the mobile unit 90, including, for example, an on/off LED 154 and a teach mode LED 156. A pair of electrodes 118 extend outwardly from the casing 150 to provide an electrical stimulation to the animal as warranted while a speaker such as speaker 114 is contained internally within casing 150. An input button 158 is provided to provide inputs to device 100.

Input button 158 and device 100 cooperatively function to provide a variety of functions useful with the present

invention, such functions including on/off, external teach mode, and internal teach mode. For example, button 158 can function as an on/off switch where a brief push turns the unit 90 on or off. When held in for a longer period of time, such as three seconds, the mode of "teaching" the unit 90 and thus the system of the present invention the external boundaries can be initiated with subsequent brief pushes on the button 158 storing external boundary coordinates in RAM of device 100. The teaching mode for the external boundary coordinates can be ended by pushing the input button 158 for, say, another three seconds.

Similarly, "internal" boundary coordinates can be input into the mobile unit 90. It will be recalled that while a pet may generally be allowed to roam freely the "ocean" of a yard, there may be "islands" within that ocean where it is desired to keep the pet from going. Such islands may comprise a garden or new plantings, for example. Thus, the present invention provides apparatus and method for preventing encroachment upon such islands by the animal. The input button 158 can be held for a predetermined period of time, say six seconds to initiate the teach mode for the internal boundary coordinates. As with the external boundary coordinates, the vertices of the boundary of any internal islands can be stored in the random access memory of the device 100 with subsequent brief pushes on the button 158. This mode can be repeated as often as desired to store the boundaries of additional islands.

In operation, both units 70 and 90 will be switched on. The first time the mobile unit is switched on, the "external" boundary coordinates will be placed in the RAM of device 100 of unit 90. This inputting of the boundary coordinates is accomplished by carrying the unit to a boundary vertex and pushing on the input button 158 to store the boundary vertex coordinate in RAM. The unit is then carried to an adjacent vertex and the input button 158 is again pushed to store the coordinate in RAM. It will be understood that the unit is carried similarly around the entire boundary with the external boundary vertices being input into the RAM of unit 90. The external boundary perimeter is then determined by device 100 by creating straight lines between consecutively input coordinates and the first and last coordinates input therein.

Similarly, the boundary perimeter of any internal islands will be formulated by creating straight lines between the consecutively input coordinates and then forming a line between the first and last input coordinates by device.

The position of the mobile unit, and hence the boundary, internal or external, and any person or animal associated therewith, can be determined according to the illustration shown in FIG. 10. As seen there, both the reference unit 70 and the mobile unit 90 receive GPS signals 160 broadcast from a plurality of GPS satellites 170, 172, 174. The position of each unit receiving the signals, such as ground based units 176 and 178, which could be reference unit 70 and mobile unit 90, respectively, can be determined according to commercially available devices, such as the aforementioned Motorola Oncore™ device. As noted previously, however, the position information available from these satellites is intentionally not sufficiently accurate for use in a pet confinement system or for the other applications previously mentioned herein. Such accuracy is presently limited to approximately 30 meters (100 feet). The inherent inaccuracy provided by a single unit receiving such signals, however, can be eliminated by the use of two relatively close receivers that receive signals from the same satellites and under the same atmospheric conditions. That is, the inaccuracy of the position of the reference and mobile unit as determined by

their own calculations will be substantially the same in terms of distance and direction. Thus, by subtracting the relative positions of the two units with respect to each other, the inaccuracy of a single receiver can be eliminated. This is otherwise known as differential position determination.

Thus, as illustrated in this Figure, the unit 176 will broadcast its position $X_1=(x_1, y_1, z_1)$ as determined by the received signals 160 to the unit 178, whose position has been determined to be $X_2=(x_2, y_2, z_2)$. The relative position of the unit 178 will then be the difference between the global positions of the units 176-178. This relative position, which will be free of the inherent inaccuracy provided by the present GPSS signals, can be expressed as

$$[X]_{relative}=[X]_1-[X]_2 \quad (1)$$

where the brackets indicate a vector. Because of the need to substantially reduce, and preferably to eliminate, the error inherent in GPS signals, the embodiment shown in FIG. 2 is preferred for use in such an application as a pet confinement system.

Stated otherwise, and still in reference to FIG. 10, an SATPS mobile station carries an SATPS signal antenna and associated SATPS signal receiver/processor and a mobile station receiver and associated processor in one embodiment of the invention. An SATPS reference station includes an SATPS signal antenna and associated SATPS signal receiver/processor and a reference station transmitter and associated processor. The reference station receives SATPS signals from M SATPS satellites (M is greater than or equal to 3). Receipt of these signals allows the reference station to compute the present location $(x,y,z)_{ref}$ of the reference station's SATPS antenna in a selected coordinate system. The spatial location coordinates (x,y,z) may be expressed in any coordinate system and are not limited to the Cartesian Coordinate System. The reference station transmitter and antenna transmit the location coordinates and satellite tags ("satellite tags" refer to identification of which SATPS satellite signals were used to compute the spatial location coordinates of the reference station) to a SATPS mobile station that is spaced apart from the reference station. The true location of the reference station need not be known to any degree of accuracy.

The mobile station receiver/processor receives the transmission from the reference station which includes coordinate information and the associated satellite tags. The mobile station SATPS antenna and receiver/processor receive SATPS signals from the same M satellites as used by the SATPS reference station, and compute the spatial location coordinates of the SATPS mobile station. These coordinates are expressed using the same coordinate system as was used by the reference station. The mobile station processor computes the location of the mobile station SATPS antenna relative to the reference station SATPS antenna by subtracting the location coordinates of the reference station from the mobile station location coordinates using equation (1) above.

Similarly, in a second embodiment of the invention, an SATPS mobile station carries an SATPS signal antenna and associated SATPS signal receipt/processor and a mobile station transmitter and associated processor. An SATPS reference station includes an SATPS signal antenna and associated processor. The mobile station receives SATPS signals from M SATPS satellites (M is greater than or equal to 3). Receipt of these signals allows the mobile station to compute the present location $[X_{ref}]= (x,y,z)_{ref}$ of the mobile station's SATPS antenna in a selected coordinate system.

The mobile station transmitter and antenna transmit the location coordinates and satellite tags to a SATPS reference station that is spaced apart from the mobile station. The true location of the reference station need not be known to any degree of accuracy.

The reference station receiver/processor receives the transmission from the mobile station which includes coordinate information and the associated satellite tags. The reference station SATPS antenna and receiver/processor receive SATPS signals from the same M satellites as used by the SATPS mobile station, and compute the spatial location coordinates of the SATPS reference station. These coordinates are expressed using the same coordinate system as was used by the mobile station. The reference station processor computes the location of the mobile station SATPS antenna relative to the reference station SATPS antenna by subtracting the location coordinates of the reference station from the mobile station location reference coordinates (equation (1)).

The microprocessor of device 100 may be programmed to operate in accordance with the foregoing description of operation. A flowchart for such programming is shown in FIGS. 11A-11F. Thus, to begin operation, the input button 158 is pushed in to turn the mobile unit 90 on as indicated at 200. Reference unit 90 will then determine whether it is acquiring a transmitted signal from the reference unit 70 as indicated at 202. If a signal is not acquired from the reference unit 70, then as will be noted below in reference to FIG. 12, the reference unit will be in the manual mode and the manual mode indicator on the reference unit will indicate that the unit 70 is in manual mode, such as when the LED 136 blinks, as indicated at 204. The mobile unit, that is the microprocessor of device 100, will then check to see if the input button 158 is activated, such as by depressing it, as indicated at 206. If the button 158 has been depressed as at 206, the mobile unit 90 will have been turned off as at 208.

If the mobile unit is on and functioning, the mobile unit will check to see if it is receiving a signal from the reference unit indicating that a stimulus is to be applied as indicated at 210. If a signal to administer a manual stimulus is received, indicating that manual stimulus trigger 140 has been activated, then a stimulus will be administered, as indicated at 212. If no such signal indicating a stimulus is to be applied, no stimulus will be applied, as indicated at 214. The unit will then cycle and once again check to see if the input button has been pushed to turn the unit on.

If the mobile unit does acquire a signal from the reference unit and the unit is in the automatic mode, then the LED indicating the unit is on will be lit steadily as indicated at 220. The mobile unit will be receiving a transmission indicative of the reference unit position at preselected time intervals, which could be fractions of seconds or at minutes as desired and as indicated at 222. This received position indicating data will be stored in memory as shown at 224.

Also while the mobile unit is turned on, it will determine whether it is receiving an input from the operator, such as having the input button 158 pushed as indicated at 226. If the input button 158 or some other input is not being provided, the mobile unit will analyze the position indicating signals received from the external position indicating source, such as the GPSS to arrive at its own global position at 228. This global position will be converted to a relative coordinate position using the position indicating data provided by the reference unit at 230.

Once the relative coordinate position of the mobile unit is determined, that position will be compared with the predetermined boundary to determine if the mobile unit is within or without the allowed range of motion of the mobile unit at

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232. The results of this determination will be compared with the stimulus criteria to determine if a stimulus is warranted at 234. For example, if a dog wearing a mobile unit on a collar approaches within five feet of the predetermined boundary, the stimulus criteria may require that an audible warning be sounded as at 236. If the dog is within one foot of the boundary, the stimulus criteria may direct the application of an electric shock, as at 238, through apparatus such as electrodes 118. Or, if the dog is not within the stimulus application range, then no stimulus will be applied as at 240. It will be understood that other forms of stimulus may be applied, as previously mentioned, depending upon the particular application of the present invention. Thus, the mobile unit may contain a vibration producing means as found in many current pagers or it may provide a visual display. The logic employed at 234 may also include steps to determine if the dog is returning from a foray outside the boundary. If so, then no stimulus may be employed until the animal has returned to the allowed area and is once again within the stimulus producing area.

As indicated at 232, the mobile unit will employ an algorithm to determine whether the mobile unit is within or without the predetermined boundary conditions. While there are many different analyses performed to make such a determination in accord with the present invention, herein follows one such method.

Thus, as shown at 250, initially the boundary coordinate vectors are calculated based upon the stored boundary coordinates, which will be stored as relative coordinates with respect to the reference unit. Thus for a total of i boundary coordinates, the boundary vectors for boundary coordinates $i=1$ to $i-1$, the boundary vectors $[BC]_i$ would be given by:

$$[BC]_i = [(X_{i+1} - X_i), (Y_{i+1} - Y_i)] = [BC_x, BC_y]_i \quad (2)$$

In essence the foregoing equation provides that a boundary vector is drawn from the first boundary coordinate entered to the second, from the second to the third, and so on. For the last boundary coordinate i the boundary vector is drawn from the last coordinate entered to the first, thereby providing a completely enclosed boundary. This last boundary vector is given by:

$$[BC]_i = [(X_1 - X_i), (Y_1 - Y_i)] = [BC_x, BC_y]_i \quad (3)$$

As shown at 252, then, the object vectors of the mobile unit are calculated for each of the i stored boundary coordinates. That is, the position of the mobile unit relative to the boundary is determined by calculating vectors from the relative coordinate position of the mobile unit to each of the boundary coordinates. Thus these object vectors $[OV]_i$ are determined, for 1 to i boundary coordinates (X_i, Y_i) , and mobile coordinate (X_m, Y_m) and are given by:

$$[OV]_i = [(X_m - X_i), (Y_m - Y_i)] = [OV_x, OV_y]_i \quad (4)$$

After having determined the object vectors, the magnitude or amplitude of each of the object vectors is calculated and is given by

$$OVM_i = (OV_x^2 + OV_y^2)^{1/2} \quad (5)$$

where x_i and y_i indicate the magnitudes of the x and y coordinates of the respective vector.

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Referring now to 254, the scalar multipliers of the boundary vectors i are calculated as at 254. Each scalar multiplier identifies the point along the boundary vector heading at which a normal vector originating from the object coordinates, will intersect the boundary vector heading. For a scalar multiplier <0 or >1 , the normal vector originating from the object coordinates will intersect the boundary vector heading at an imaginary point beyond the vectors determined length.

$$SM_i = ([BC]_i \cdot [OV]_i) / ([BC]_i \cdot [BC]_i)$$

where " $\cdot$ " represents a dot product.

Another step in determining the position of the mobile unit relative to the boundary is to calculate the vector normal $[N]_i$ as at 256 for each of the boundary vectors, the vector normal being given by

$$[N]_i = (SM_i \cdot BC_{xi}) - X_m, (SM_i \cdot BC_{yi}) - Y_m = [N_x, N_y]_i \quad (6)$$

After the vector normals $[N]_i$ are determined, the vector normal magnitudes or amplitudes N_i for each of the boundary coordinates is calculated as at 256 and are given by:

$$N_i = (N_x^2 + N_y^2)^{1/2} \quad (7)$$

As another step, the range R_i from the object coordinates to each i boundary vector is determined. First, the scalar multiplier for each coordinate is evaluated according to the following rules at 258:

$$\text{if } SM_i < 1 \text{ and } > 0, \text{ then } R_i = N_i \quad (8)$$

as indicated at 260. Otherwise as indicated at 262.

$$R_i = OVM_i \quad (9)$$

As a further step, the included angle θ_i is determined for each boundary vector as at 264. That is, θ_i is the angle between adjacent object vectors. So for boundary vector $[BC]_i$, its included angle is that which is formed by object vectors $[OV]_i$ and $[OV]_{i+1}$. Thus,

$$\theta_i = \arcsin(\text{ARC-COSINE}(N_i / OVM_i)) = \text{ARC-COSINE}([N]_i \cdot [OV]_{i+1} / (N_i \cdot OVM_{i+1})) \quad (10)$$

where $+$ is used if SM_i is <1 and >0 , and $-$ is used otherwise.

As another step, a sign convention must be applied to the calculated included angle, θ_i for each boundary vector. To assign the proper sign convention to the included angle θ_i , the cross products of the boundary coordinate vectors $[BC]_i$ and the corresponding object vectors $[OV]_i$ is calculated as at 266 and as given by

$$[BC]_i \times [OV]_i \quad (11)$$

The results of each cross product calculation are examined and a sign convention is assigned as at 268 based upon the following rules:

$$+ \text{ if the cross product of } [BC]_i \times [OV]_i \text{ is } > 0 \quad (12)$$

$$- \text{ if the cross product of } [BC]_i \times [OV]_i \text{ is } < 0 \quad (13)$$

As another step in determining whether the mobile unit is within or without the allowed range, the minimum distance

and the boundary vectors is the minimum value of the range set as indicated at 270. This number indicates the distance to the nearest boundary.

By determining whether the object coordinates are within the boundary perimeter, the included angles are determined as indicated at 272. The within/without status is then determined according to the following:

If the sum of the object coordinates (and thus the mobile unit) is within the boundary perimeter as indicated at 274:

If the sum of $\theta = 2\pi$, where n is an integer, the object coordinates (and thus the mobile unit) are within the boundary perimeter as indicated at 276.

In summary, the included angles are determined and summed. If the result of the summation is 0, the mobile unit is outside the allowed area. If the result of the summation is a multiple of 2π then the mobile unit is within the allowed area. The stimulus application condition will be based upon whether the mobile unit is in or out of the containment area or boundary, and the minimum distance of the range set as calculated earlier. One example for stimulus may be that audible tones are emitted if the angles θ sum to a value other than 0, meaning the unit is still within the boundary and the minimum value of the range set is greater than 1 but less than 5 feet as an example only. An electric shock may be administered if the mobile unit is being worn by an animal and if the minimal value of the range set is less than one foot, for example. The appropriate ranges can be set as desired in accord with the present invention.

Referring back to 226 and to FIG. 11B now, if the input button is pushed, the built in logic of the microprocessor will compare the length of time that the button is pushed in with internal parameters. The length of time that the button 158 is depressed will determine the appropriate function to be executed. For example, where the button 158 is held in only briefly as at 300, the microprocessor of 100 will recognize that the power to the unit is to be turned off and will do so as at 302. Depressing the button 158 for longer time periods will indicate that a function relating to the stored boundary coordinates is to be performed. Thus, where the button is depressed for approximately three seconds as shown at 304, the microprocessor of 100 will be programmed to recognize that the teaching of external boundary coordinates is to follow as at 306. In such a circumstance and with the exemplary devices of FIGS. 8 and 9, the LED 156 can be lit steadily to provide an indication of that particular mode of operation.

Where the input button 158 is depressed for a longer period of time, such as for approximately 6 seconds, then the microprocessor of 100 will recognize that a programming of internal coordinates for internal islands is to occur as indicated at 308. Again, such a teaching function can be represented to the user by an external signal, visual (or auditory), such as by having LED 156 blink steadily as at 310.

Where the input button 158 is depressed for a longer period of time, such as nine seconds as indicated at 312, the microprocessor will remove previously stored coordinates from memory as at 314, thereby allowing the programming of new coordinates.

Where a "teaching function" is indicated as at 306 for external boundary coordinates or at 310 for internal boundary coordinates, a subsequent press of the button as at 316 will either allow various coordinates to be acquired and stored in the memory of the mobile unit or will cause the

teaching function to be exited. Thus, where the button 158 is pushed briefly as at 318, mobile unit will acquire its global coordinate as from a GPS at 320 and will also receive the global position coordinate of the reference unit 70 from the reference unit as a 322. The differential position of the boundary co-ordinate will then be calculated using equation (1) given above as at 324. This relative position will then be stored in a non-volatile memory as at 326. A second and subsequent coordinates can then be entered following the same procedure. When the coordinates have all been entered, the input button 158 can then be depressed and held for the requisite length of time, three seconds if an external boundary is being programmed and six seconds if an internal boundary for an "island" is being programmed as at 328. The mobile unit 90 will then exit the "teach mode" as at 330 and the unit will substantially ready to function in accord with the present invention.

It will be understood that the mobile unit will be carried or otherwise transported to the vertices of the boundary and at each vertex the coordinates thereof will be entered into the mobile unit or other memory device. While the foregoing description of the operation of the mobile unit is an exemplary example of a device in accord with the present invention, the present invention and the following claims are not so limited. Thus, the present intention contemplates any device wherein the coordinates of a boundary are recorded and the position of a mobile unit is later checked relative thereto to determine whether the unit is within the predetermined boundary.

Referring now to FIG. 12, the functioning of a reference unit in accord with the present invention will now be described. The reference unit 70 will preferably have an indicator such as an LED to indicate whether the unit is powered as at 350. The mode is determined as at 352. If the unit is in manual operation mode, then the built in logic in the unit will determine whether the manual trigger button has been activated as by pushing it as at 354. If the manual trigger button has been activated, then a signal to apply a stimulus via the mobile unit will be transmitted thereto as at 356. This allows for manual training of a pet. If the manual trigger button is not activated or has been activated and then reactivated, the program will again check the mode to see if the operator has selected automatic mode at 352. If the automatic mode has been switched, the reference unit will acquire its position indicating data as at 358 and then transmit data indicating its position to the mobile unit as at 360. At preselected intervals the reference unit will check to see if the mode has again been switched from automatic to manual mode.

As noted, the reference unit will transmit position indicating data to the reference unit. Such data could be the actual GPS signals received by it or other position indicating signals. In addition, the reference unit could itself calculate its position based upon such signals and then transmit the actual calculated position coordinates.

An example of a boundary with "allowed areas," prohibited areas, and stimuli administering distances is shown in FIG. 13. FIG. 13 illustrates residential property 400 having a boundary or property line indicated at 402, and including a house 404. Boundary 402 includes a plurality of vertices, here labeled as 406-414. In the manner just described, these vertices could be taught to the mobile unit as an external boundary. If desired, however, because of the unique and advantageous flexibility of the present invention, a boundary line distinct from that of the actual property line could be designated since the input of the boundary coordinates is within the control of the operator of the mobile unit and does

not depend upon the location of the property line. Thus, a boundary inside of the actual property line could be arbitrarily designated by the operator.

Also shown in FIG. 13 is a garden 420 and a new planting (or other prohibited area) 422. The garden 420 has vertices 424-430 which can be taught to the mobile unit as hereinbefore described. The other area 422 has a very irregular shape, the vertices of which can also be taught to the mobile unit. For simplicity, however, many operators will choose to define a regular geometrical boundary about such irregular shaped areas, as indicated by the dashed line rectangle 432 having vertices 434-440. The flexibility and utility of the present invention flows from the ability of the operator to define at will allowed and prohibited areas of movement and to provide stimulus to the wearer of the mobile unit, or, if being worn by a person or small child, for example, to enable the tracking of the person or child relative to the allowed range of movement.

Also shown in FIG. 13 are various stimulus application range. Thus, a first stimulus application range 450 is defined as a distance d_1 from the boundary 402. A second stimulus application range 452 is defined as a distance d_2 from the boundary 402. The distances d_1 and d_2 can be arbitrarily determined. Thus, if the mobile unit moves within a distance d_1 of the boundary 402, for example, then a particular stimulus, such as a vibration or audible tone may be applied to the wearer of the mobile unit. If the mobile unit is moved within a distance d_2 of the boundary, then a stronger stimulus may be applied. If desired, the present system is flexible so as to accommodate defining a third or more ranges such as d_3 along boundary segment 406-414, which may front a street for example, for application of a stronger stimulus immediately. It will be understood that similar stimulus application areas may be defined around prohibited areas 420 and 422 also, such areas being omitted here for the sake of clarifying the figure. It will be understood further that the example of a use of the present invention relative to FIG. 13 is meant to be illustrative only and that the present invention may be used with any other boundary geometries, external and internal.

It will be understood in reviewing FIG. 13, however, the many advantages of the present invention over the prior art. For example, if the garden 420 is removed in a subsequent year or if at the end of the harvesting season it is desired to return the area to the animal's use, then the internal boundaries can be retaught to the mobile unit. Furthermore, assuming friendly relations between neighbors, the boundary can be expanded beyond the actual property line to allow the pet the full use of the yard before a harsh stimulus such as an electric shock is applied to the animal. In such a circumstance, the actual property line may form the range at which the harsh stimulus is administered. If the family takes the pet on a vacation, a boundary can be defined as hereinbefore described at the vacation location and when the family returns, the old values for the external and internal boundaries can be entered back into the mobile unit. All of these "resettlings" of the boundaries can occur without the need to bury or dig up a transmitter wire or in reliance on a device providing only a uniform boundary having a circular configuration.

More generally, the present invention can be described relative to FIG. 14. FIG. 14 shows a system 500 in accord with the present invention that includes a mobile unit 502 and a reference unit 504 both including receivers and receptive to position indicating signals broadcast by a remote transmitter 506. One of the units 502, 504 will include a processor 508 that determines the position of the

mobile unit 502 and will compare it with the predetermined boundary coordinates. The processor 508 can be programmed to function in a desired manner dependent upon the results of the position determination. For example, it could cause the position to be displayed on a display device 510, which may be a computer monitor for example, and thus show the location of the mobile unit relative to the boundary. Or, as previously described, it could cause the application of a stimulus as at 512 to a person or animal wearing the mobile unit. The stimulus could be an auditory stimulus, such as a "beep" or a voice, a vibratory stimulus, a chemical stimulus, such as an odor, or an electrical shock.

It will be understood that the present invention has been described in relation to the teaching function occurring relative to the mobile unit. The present invention is not so limited however. The teaching function could also occur relative to the reference unit. The mobile unit would then transmit its position indicating data signals to the reference unit, which would process them and determine whether a stimulus was warranted. When the application of a stimulus was warranted the reference unit would transmit the appropriate signal to the mobile unit directing the application of the stimulus. Thus, a system and method in accord with the present invention could include a processor in either or both of the units. Typically, the reference unit will be permanently positioned at a single location once the teaching function is completed for a particular boundary. As another variation on the present invention, the system could include multiple taught boundaries. Thus, where a homeowner had two or more homes, the present invention could include sufficient memory and appropriate apparatus to switch as desired between the differing boundaries.

Furthermore, it will be understood that the present invention has been advantageously described with reference to use of GPSS. Any other position indicating broadcast signal such as GLOSNASS or LORAN could also function in accord with the present invention. It will also be understood that the signals exchanged between the reference and mobile or remote units could be the actual signals received by the units or calculated coordinate positions or any other signal indicating the position of the broadcasting unit.

Additionally, with regard to the embodiments of the present invention shown and described in the various figures, it will be understood that many different input devices for the mobile and reference units could be used with the present invention and that alternative indicators or additional indicators beyond the LEDs illustrated and shown herein could be used. For example, but without limitation, LEDS could be added that would be lit only when a particular mode of operation, such as manual, automatic, teaching external coordinates, or teaching internal coordinates LEDS to simplify the use of the inventive apparatus for the user, particularly the home user.

The present invention having thus been described, other modifications, alterations, or substitutions may now suggest themselves to those skilled in the art, all of which are within the spirit and scope of the present invention. It is therefore intended that the present invention be limited only by the scope of the attached claims below.

What is claimed is:

1. A method for locating an object relative to a predetermined external boundary and at least one internal boundary, said external boundary defining an allowed area of movement therewithin and said internal boundary defining at least one excluded area of movement within said allowed area of movement, said external and internal boundary each having a plurality of vertices, said method for locating using a

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reference unit, a mobile unit attached to and movable with the object, and position indicating data signals broadcast by a remote transmitter and receivable by the reference and mobile units, said method comprising:

receiving the position indicating data signals;
determining the respective global positions of the reference and mobile units;
determining the differential coordinate position of the mobile unit;
determining the respective global positions of a plurality of external boundary coordinates of the external boundary including at least the vertices of the external boundary;
determining the differential coordinate positions of at least the vertices of the external boundary;
determining the respective global positions of a plurality of internal boundary coordinates of the internal boundary including at least the vertices of the internal boundary;
determining the differential coordinate positions of at least the vertices of the internal boundary;
determining whether the mobile unit is within the allowed area by comparing the differential coordinate position of the mobile unit with the differential external and internal boundary coordinate positions.

2. The method of claim 1 wherein the mobile unit is worn by an animal and includes apparatus for administering a stimulus from the group including auditory, visual, chemical, vibratory, or electrical shock stimuli and said method further comprises:

determining a sequence of allowable distances within which the animal may approach the external boundary;
determining the distance of approach by the animal to the external boundary; and
applying a stimulus to the animal in accord with the predetermined sequence.

3. The method of claim 1 wherein the mobile unit is worn by a person and includes apparatus for administering a stimulus from the group including auditory, visual, chemical, and vibratory stimuli and said method further comprises:

determining a sequence of allowable distances within which the person may approach the external boundary;
determining the distance of approach by the person to the external boundary; and
applying a stimulus to the person in accord with the predetermined sequence.

4. The method of claim 1 and further including:

determining the distance of the mobile unit from the external boundary.

5. The method of claim 4 and further including administering a stimulus based upon the distance of the mobile unit from the external boundary.

6. The method of claim 1 and further including:

determining the distance of the mobile unit from the at least one internal boundary.

7. The method of claim 6 and further including:

determining the distance of the mobile unit from the external boundary.

8. The method of claim 6 and further including administering a stimulus based upon the distance of the mobile unit from the internal boundary.

9. The method of claim 1 and further including providing a system comprising the mobile unit, reference unit and

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remote transmitter comprise a system, wherein at least one of the reference or mobile units includes a processor, the processor converting said position indicating signals to global positions of the reference and mobile units and further determining a differential coordinate position for the units.

10. The method of claim 9 wherein the processor includes a memory, the memory storing the differential boundary coordinates of the external and internal boundaries.

11. The method of claim 10 and further including continuously determining the relative differential coordinates of the mobile unit.

12. The method of claim 10 wherein the processor compares said relative differential coordinates of the mobile unit with said relative differential external boundary coordinates to determine whether the mobile unit is with said predetermined external boundary.

13. The method of claim 12 wherein the processor determines the distance of the mobile unit from said predetermined external boundary and provides a stimulus application signal to the mobile unit directing the application of a stimulus to the wearer of the mobile unit.

14. The method of claim 10 and further including providing the differential boundary coordinates based upon the boundary vertices of the external and at least one internal boundary and determining the global position of the boundary vertices by determining the global position of the mobile unit.

15. The method of claim 14 and further including calculating the external and internal boundaries based upon the global positions of the external and internal boundary vertices respectively.

16. A system for relating the position of a mobile unit to a predefined external boundary defining an area of allowed movement and at least one predefined internal boundary defining an area of excluded movement within said area of allowed movement, said system comprising:

a mobile unit;

a reference unit; and

at least one remote transmitter provided for transmitting position indicating signals by which the positions of the mobile and reference units may be determined relative to the external and the at least one internal boundary;

wherein said mobile unit and said reference unit each include a receiver for receiving said position indicating signals and wherein said system further includes at least one processor for converting said position indicating signals into global coordinate positions of said reference and mobile units and for determining the distance of said mobile unit from said predetermined external boundary.

17. The system of claim 16 wherein said processor further determines the relative differential positions of said reference and mobile units.

18. The system of claim 16 wherein at least one of said reference or mobile units includes a said processor, said processor converting said position indicating signals to global converting positions of said reference and mobile units and further determining a differential coordinate position for said units.

19. The system of claim 18 wherein said processor includes a memory, said memory storing the differential boundary coordinates of the external and internal boundaries.

20. The system of claim 19 wherein said processor continuously determines the relative differential coordinates of said mobile unit.

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21. The system of claim 20 wherein said processor compares said relative differential coordinates of said mobile unit with said relative differential external boundary coordinates to determine whether said mobile unit is with said predetermined external boundary.

22. The system of claim 21 wherein said processor determines the distance of said mobile unit from said predetermined external boundary and provides a stimulus application signal to the mobile unit directing the application of a stimulus to the wearer of the mobile unit.

23. The system of claim 19 wherein the differential boundary coordinates of the external and internal boundaries

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are provided to said memory by moving the mobile unit to the boundary vertices of the external and at least one internal boundary and determining the global position of the boundary vertices by determining the global position of the mobile unit.

24. The system of claim 23 wherein said processor calculates the external and internal boundaries based upon the global positions of the external and internal boundary vertices respectively.

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Flach et al.

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[54] **ARCHITECTURE FOR TDMA MEDICAL
TELEMETRY SYSTEM**

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[52] **U.S. Cl.** 600/300; 128/903

[58] **Field of Search** 128/630, 903,
128/904, 637, 638, 670, 671, 731-733,
739-741

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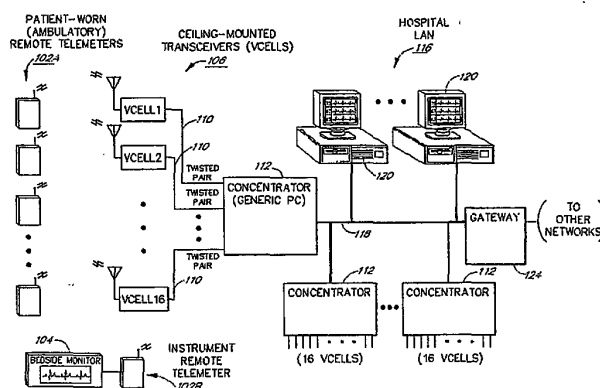
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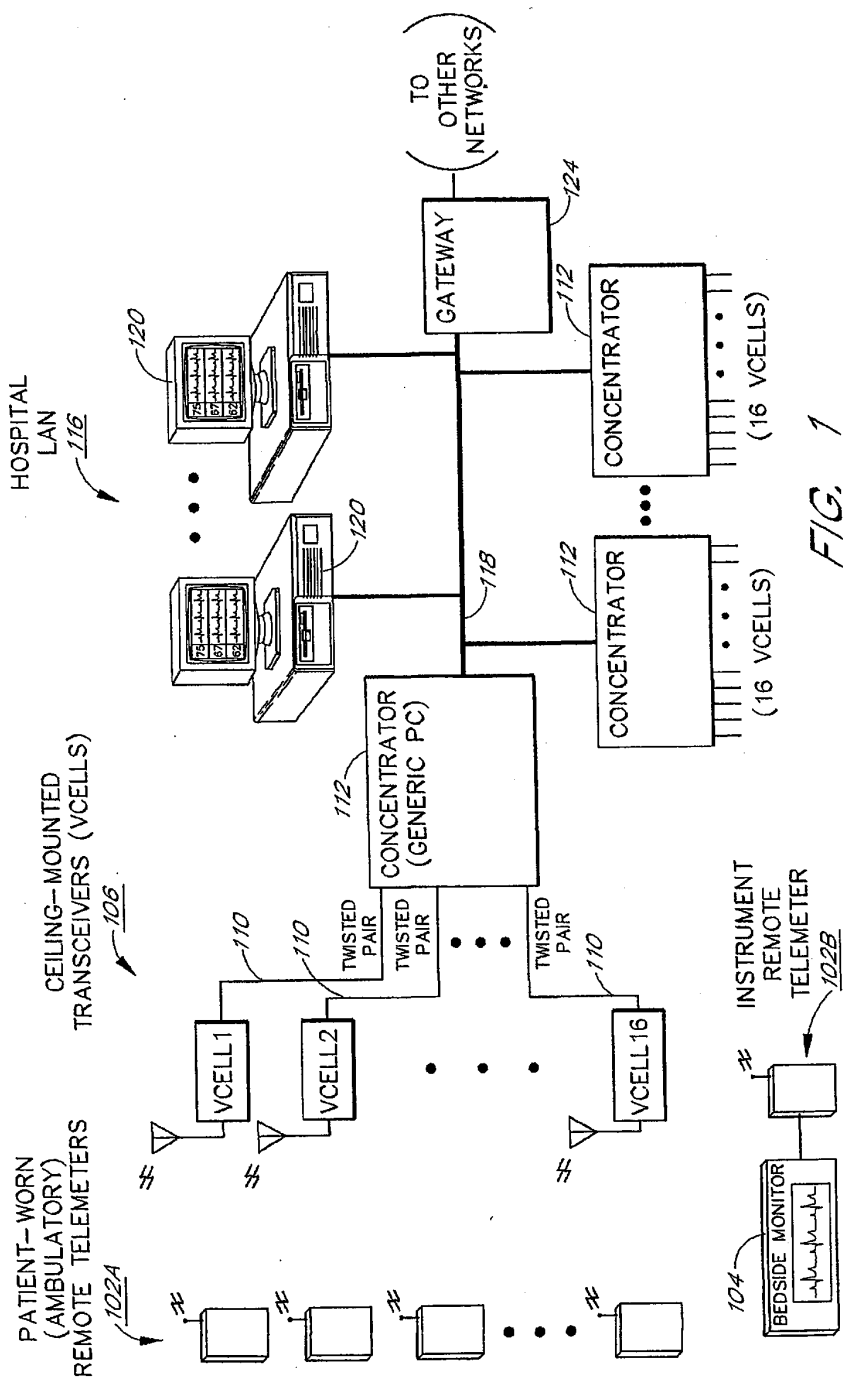
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LLP

[57] **ABSTRACT**

A medical telemetry system is provided for collecting the real-time physiologic data of patients (including ambulatory patients) of a medical facility, and for transferring the data via RF to a real-time data distribution network for monitoring and display. The system includes battery-powered remote telemeters which attach to respective patients, and which collect and transmit (in data packets) the physiologic data of the patients. The remote telemeters communicate bi-directionally with a number of ceiling-mounted RF transceivers, referred to as "VCELLs," using a wireless TDMA protocol. The VCELLs, which are hardwire-connected to a LAN, forward the data packets received from the telemeters to patient monitoring stations on the LAN. The VCELLs are distributed throughout the medical facility such that different VCELLs provide coverage for different patient areas. As part of the wireless TDMA protocol, the remote telemeters continuously assess the quality of the RF links offered by different nearby VCELLs (by scanning the frequencies on which different VCELLs operate), and connect to those VCELLs which offer the best link conditions. To provide a high degree of protection against multi-path interference, each remote telemeter maintains connections with two different VCELLs at-a-time, and transmits all data packets (on different frequencies and during different timeslots) to both VCELLs; the system thereby provides space, time and frequency diversity on wireless data packet transfers from the telemeters. The telemeters and VCELLs also implement a patient location protocol for enabling the monitoring of the locations of individual patients. The architecture can accommodate a large number of patients (e.g., 500 or more) while operating within the transmission power limits of the VHF medical telemetry band.

36 Claims, 11 Drawing Sheets





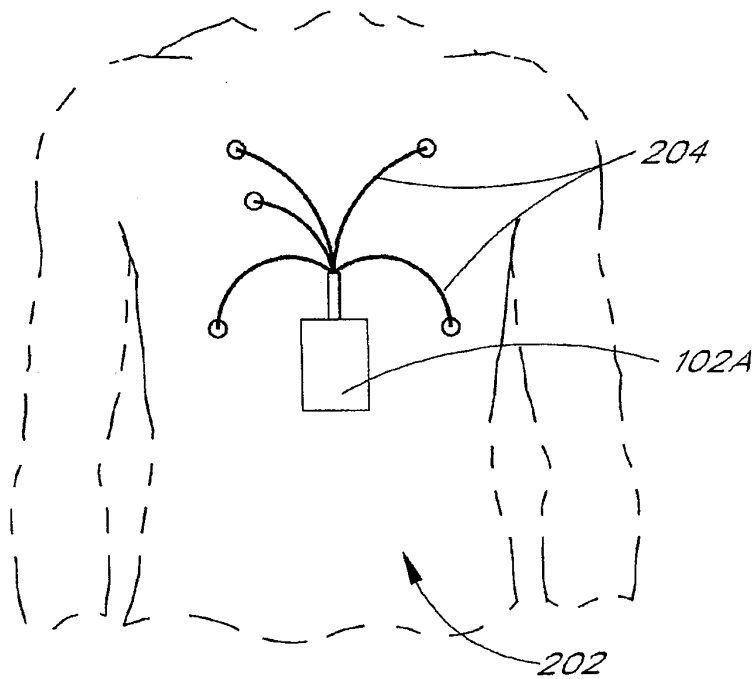
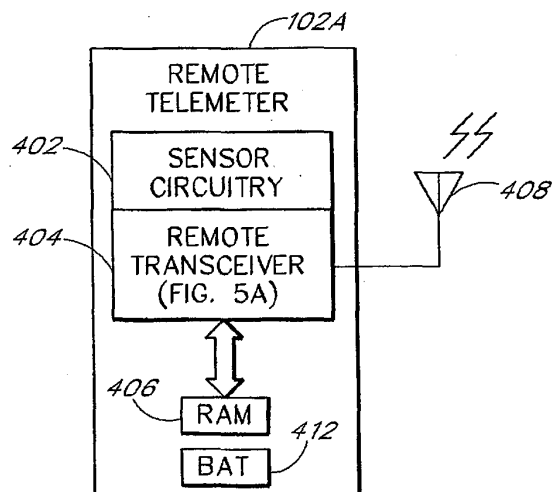
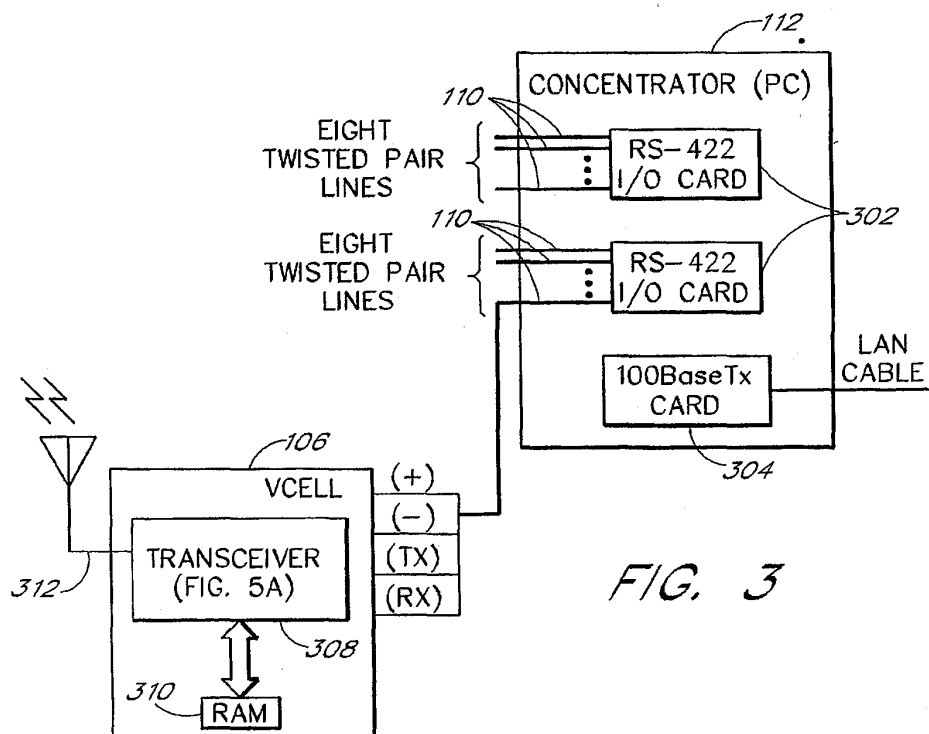


FIG. 2



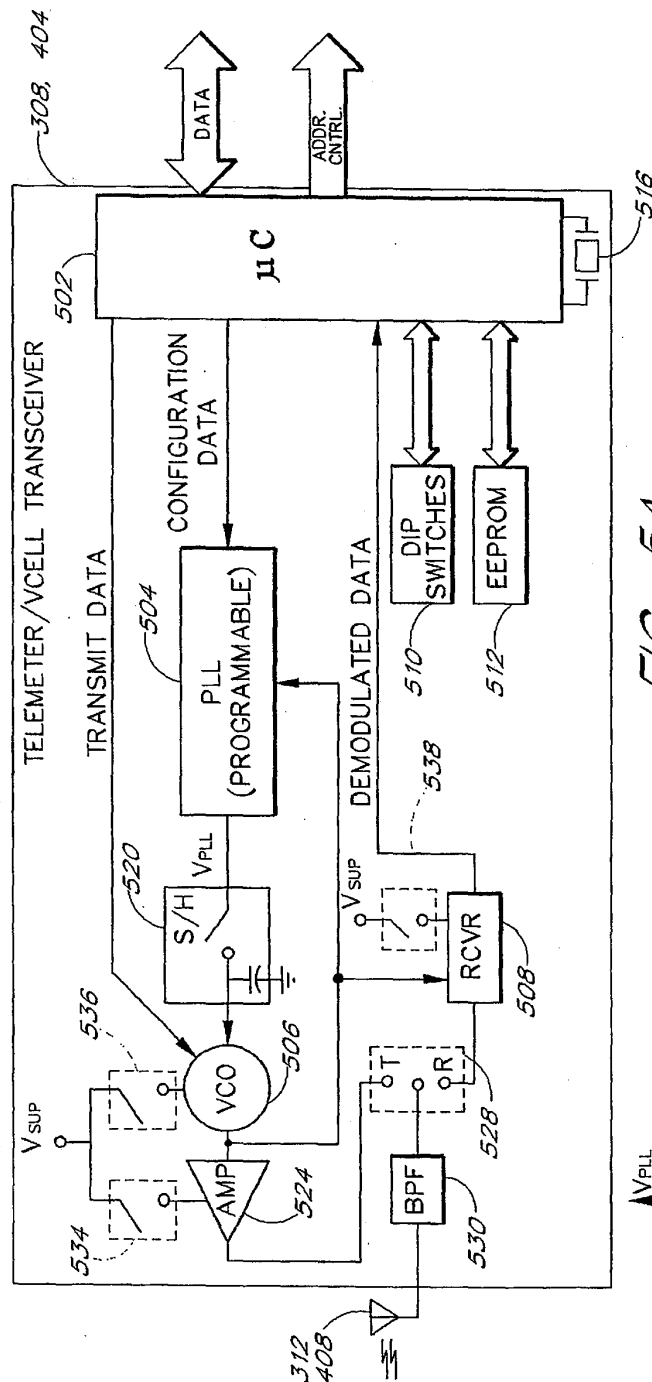


FIG. 5A

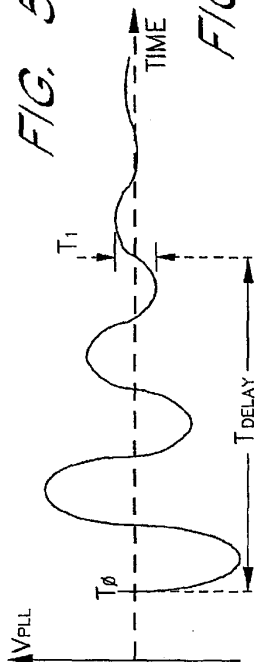


FIG. 5B

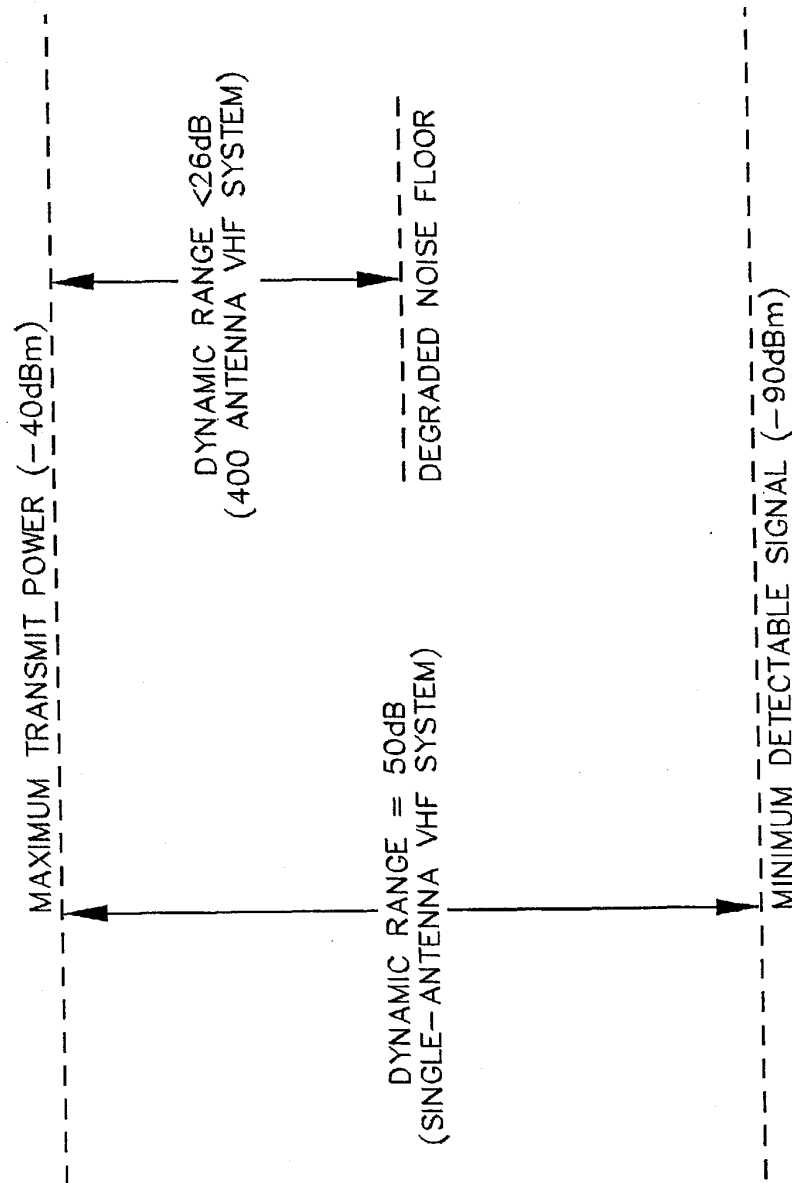


FIG. 6

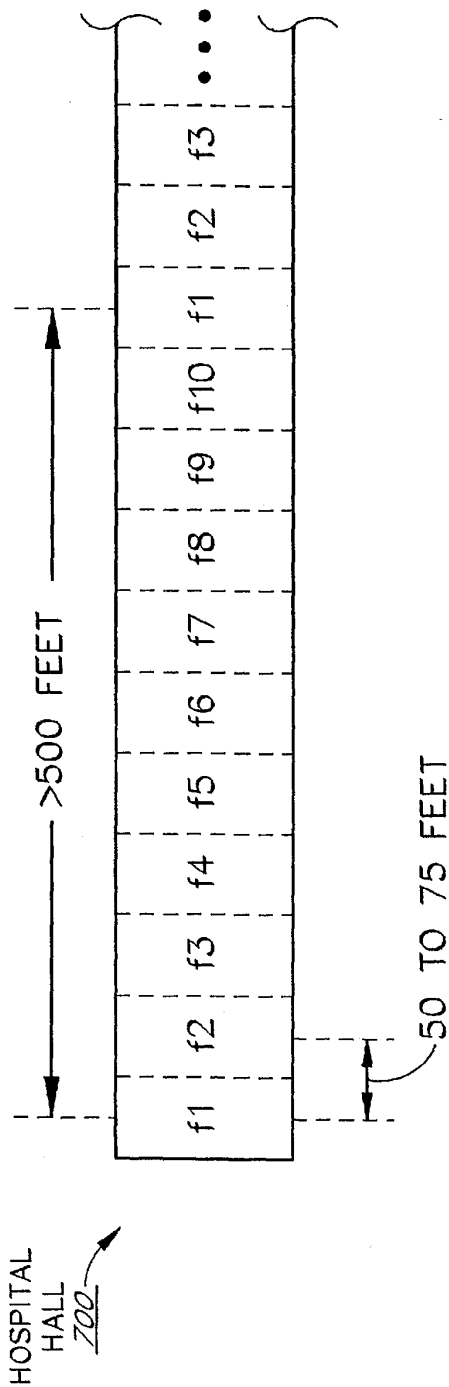


FIG. 7

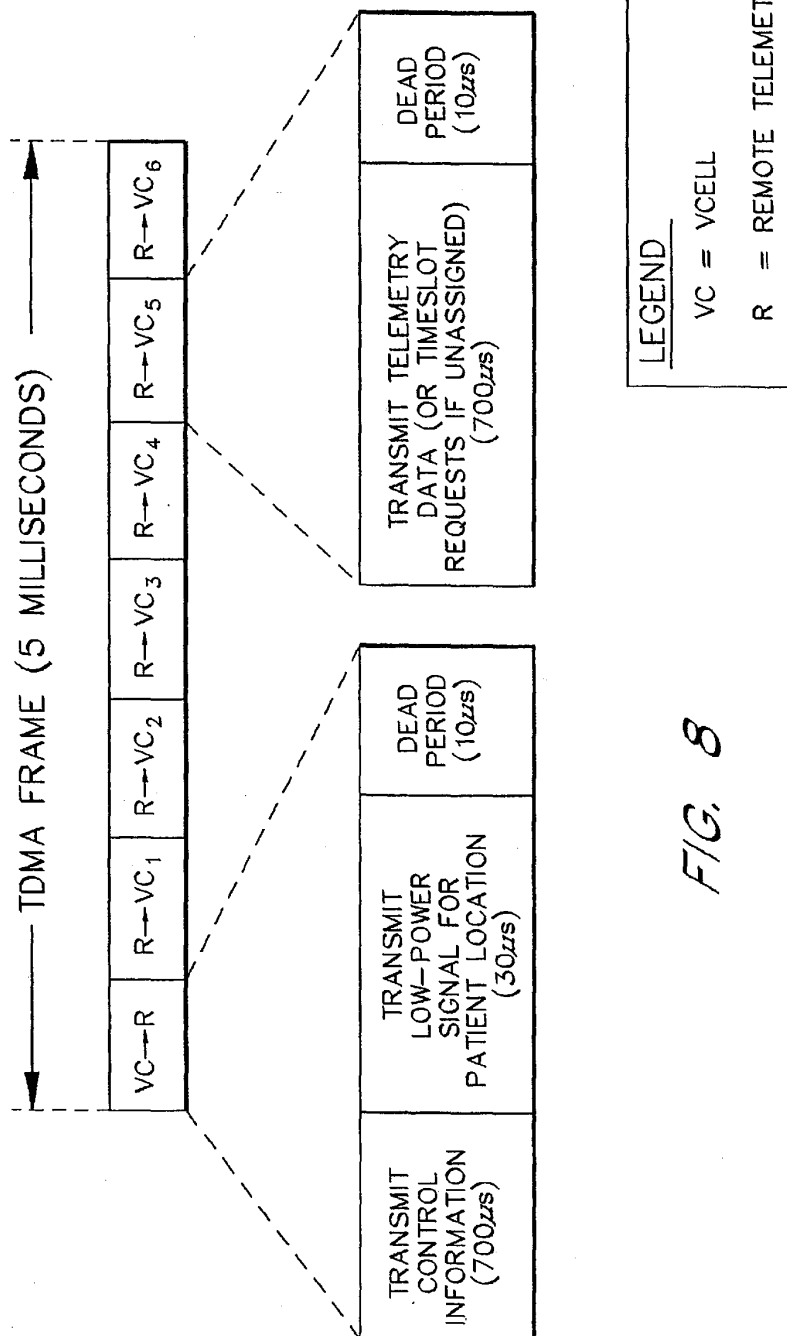


FIG. 8

TIMESLOT STATUS TABLE

900

	SLOT 1	SLOT 2	SLOT 3	SLOT 4	SLOT 5	SLOT 6
ASSIGNED	✓	✓		✓	✓	
FRAMES SINCE LAST PACKET	0	0	(NA)	3	0	(NA)

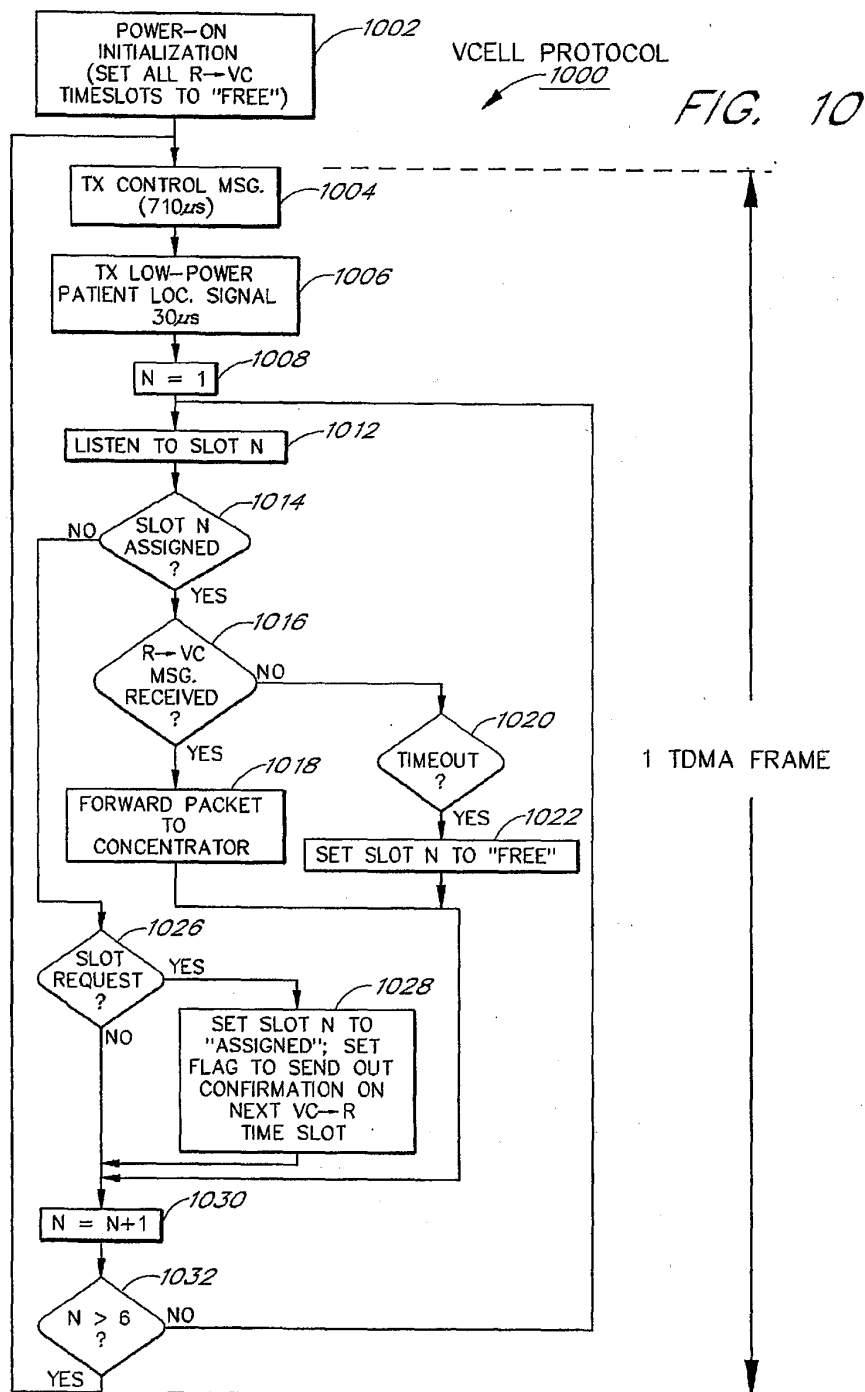
FIG. 9

VCELL CATALOG

1100

	RATING	CONNECTED TO	LOW-PWR. SIGNAL STRENGTH
VCELL1 (f1)	7		1
VCELL2 (f2)	8	✓	9
VCELL3 (f3)	8		6
VCELL4 (f4)	8	✓	6
VCELL5 (f5)	6		1
VCELL6 (f6)	2		0
VCELL7 (f7)	0		0
VCELL8 (f8)	0		0
VCELL9 (f9)	3		0
VCELL10 (f10)	5		1

FIG. 11



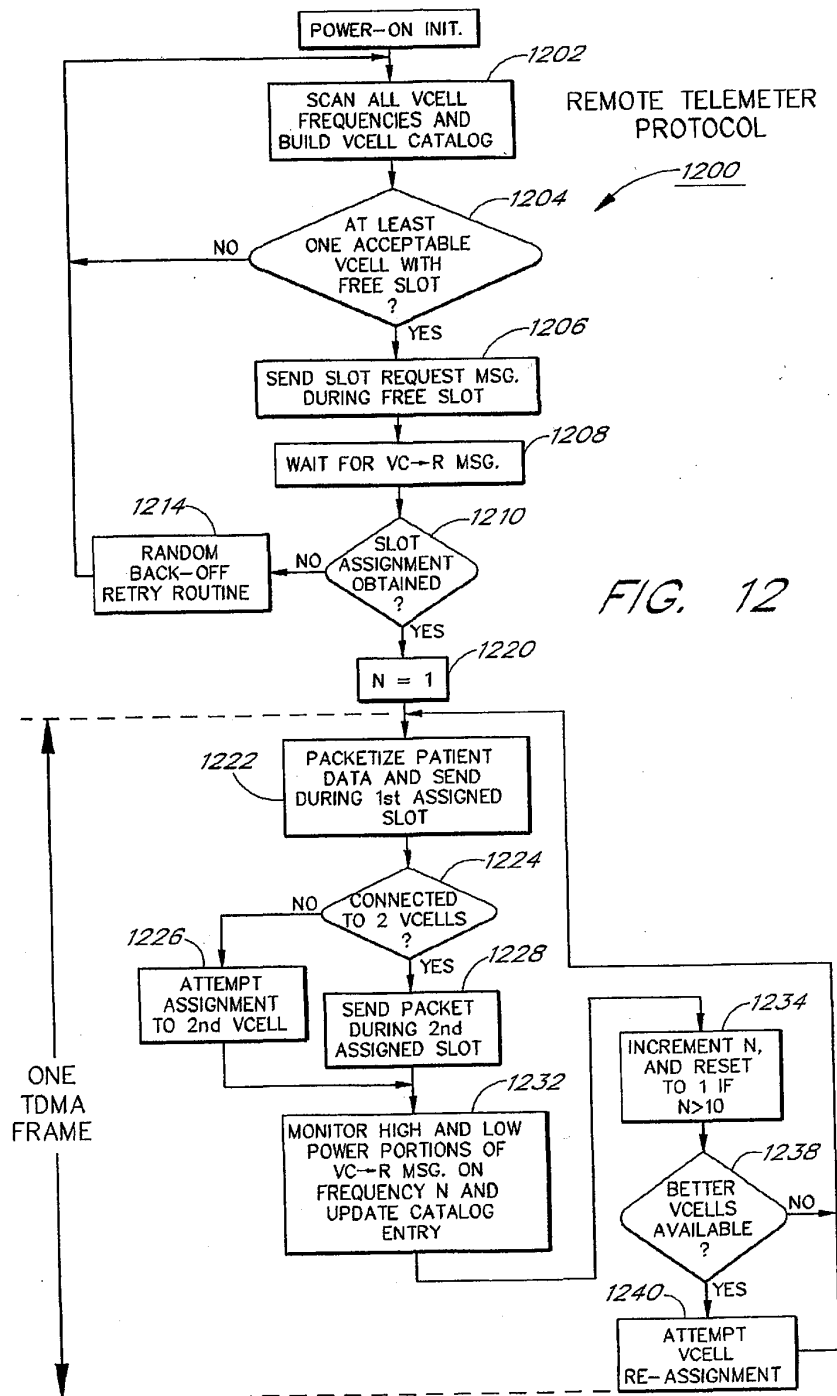
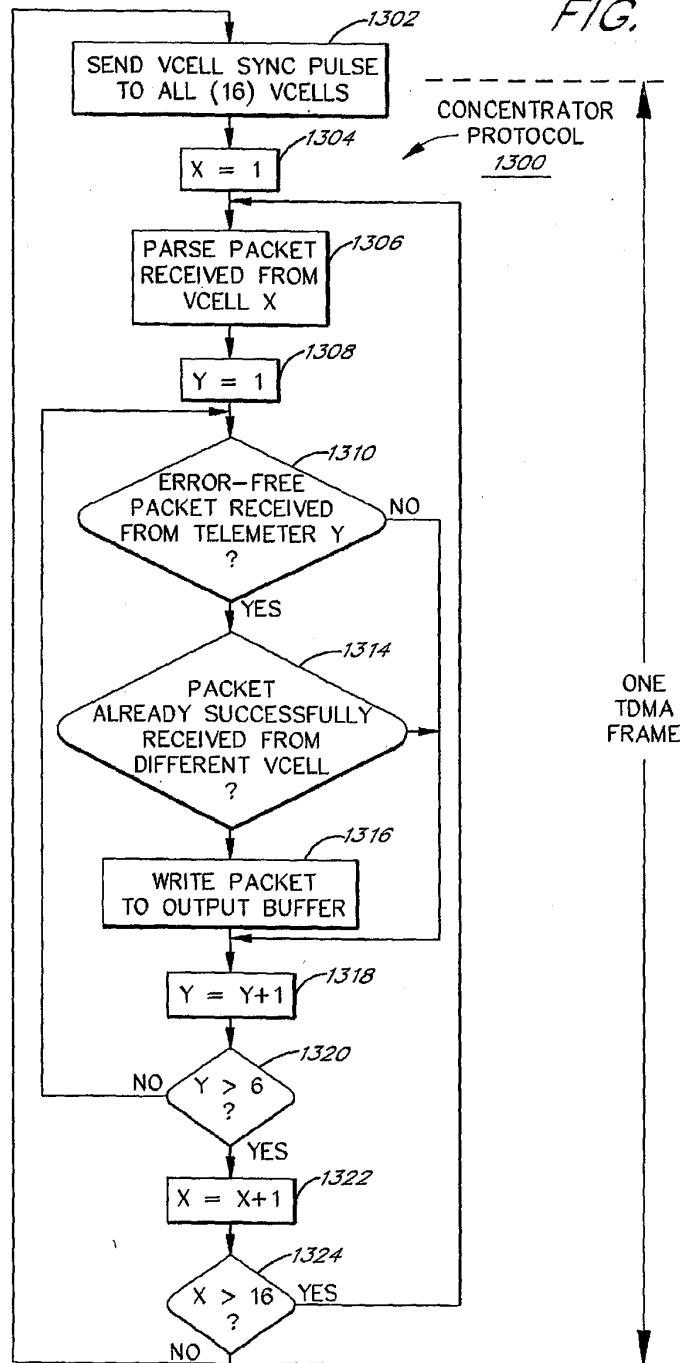


FIG. 13



ARCHITECTURE FOR TDMA MEDICAL TELEMETRY SYSTEM

PRIORITY CLAIM

This application claims the benefit of U.S. Provisional Appl. No. 60/006,600 titled TWO-WAY TDMA TELEMETRY SYSTEM, filed Nov. 13, 1995.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to digital wireless communications systems of the type which employ portable, battery-powered communications devices, such as remote telemeters worn by ambulatory hospital patients for monitoring purposes. More particularly, the present invention relates to a network architecture, and an associated TDMA (time division multiple access) communications protocol, for facilitating the efficient and reliable exchange of information between portable wireless devices and centralized monitoring stations.

2. Description of the Related Art

Medical telemetry systems that allow the physiologic data of multiple, remotely-located patients to be monitored from a central location are known in the art. These systems typically comprise remote telemeters that remotely collect the physiologic data of respective patients and transmit the data over a wireless link to a centralized monitoring station. This physiologic data may include, for example, real-time electrocardiograph (ECG) waveforms, CO₂ levels, and temperature readings. From the centralized monitoring station, a clinician can visually monitor the physiologic status, in real time, of many different patients. The central station may also run automated monitoring software for alerting the clinician whenever a predetermined physiologic event occurs, such as a cardiac arrhythmia condition.

Remote telemeters of medical telemetry systems are generally of two types: instrument remote telemeters and ambulatory remote telemeters. An ambulatory remote telemeter is a portable, battery-powered device which permits the patient to be monitored while the patient is ambulatory. The ambulatory telemeter attaches to the patient by a strap or other attachment device, and receives the patient's physiologic data via ECG leads (and/or other types of sensor leads) which attach to the patient's body. The physiologic data is continuously transmitted to the central monitoring station by the telemeter's RF (radio frequency) transmitter to permit real-time monitoring. (A design of a remote transceiver which may be used in a two-way, ambulatory telemeter is described in the above-referenced provisional application.) Instrument remote telemeters operate in a similar manner, but receive the patient's physiologic data from a bedside monitor (or other instrument) over a hardwired link, such as an RS-232 connection. Instrument remote telemeters that transfer the physiologic data to the central station over a hardwired connection are also common.

SUMMARY OF THE INVENTION

One problem that is commonly encountered in the field of medical telemetry involves signal loss caused by multi-path interference. Multi-path interference is a well-known phenomenon which occurs when a signal takes two or more paths (as the result of signal reflections) from the transmitter to the receiver such that the multi-path components destructively interfere with each other at the receiver's antenna. To reduce the effects of multi-path interference, some telemetry

equipment manufactures have included multiple antenna/receiver pairs on each remote telemeter. With this technique, known as spacial diversity, when one of the antennas experiences multipath fading, the other antenna (and the corresponding receiver) is used to receive the signal. One problem with this method is that it adds to the cost, size and complexity of the remote telemeter. In addition, in at least some implementations, a loss of data may occur when a "switch-over" is performed from one antenna/receiver pair to the other.

Another problem that has been encountered in the field of medical telemetry relates to the ability to monitor a large number of patients over a coverage area that extends to all patient areas of the hospital. A common solution to this problem involves installing a large number of antennas (e.g., 200 or more) throughout the hospital (with different antennas positioned in different patient areas), and interconnecting the antennas using signal combiners to form a single, distributed antenna system. One problem with this "distributed antenna system" approach is that each antenna and its associated preamplifier (or preamplifiers) contributes to the noise floor of the antenna system, and thereby increases the minimum transmit power at which the transmitting components of the system can operate. (The reasons for this noise floor degradation are discussed below.) Consequently, unless the transmission power of the system's transmitters is increased, a practical limitation is imposed on the number of antennas that can be included in the system, and on the coverage area provided by the system.

Although the noise floor degradation problem can potentially be overcome by increasing the transmission power of the telemetry equipment, there are at least two problems associated with increasing the transmit power. The first problem is that under existing Federal Communications Commission (FCC) regulations, medical telemetry equipment is only permitted to operate within certain frequency bands, and must operate within certain prescribed power limits within these bands. Under FCC Part 15.241, for example, which governs the protected VHF (174-216 MHz) medical telemetry band (a band which is generally restricted to VHF television and medical telemetry), telemetry devices are not permitted to transmit at a signal level which exceeds 1500 microvolts/meter at 3 meters. To operate at power levels which exceed this maximum, frequency bands which offer less protection against interference must be used. The second problem is that increasing the transmit power of an ambulatory telemeter will normally produce a corresponding reduction in the telemeter's battery life.

Another problem with distributed antenna systems is that they are typically highly vulnerable to isolated sources of electromagnetic interference ("EMI"). Specifically, because the signals received by all of the antennas are combined using RF signal combiners, a single source of interference (such as a cellular phone or a faulty preamplifier) at or near one of the antennas can introduce an intolerable level of noise into the system, potentially preventing the monitoring of all patients. One consequence of this problem is that antennas generally cannot be positioned near known intermittent sources of EMI such as X-ray machines, CAT (computerized axial tomography) scanners, and fluoroscopy machines, preventing patient monitoring in corresponding diagnostic areas.

In light of these and other problems with existing medical telemetry systems, the present invention seeks to achieve a number of performance-related objectives. One such objective is to provide an architecture in which the coverage area and patient capacity can be increased without degrading the

noise floor. This would allow the telemetry system to be expanded in size and capacity without the need to increase the transmit power of the battery-powered remote telemeters, and without the need to operate outside the protected VHF medical telemetry band. A related objective is to provide an architecture which is highly scalable, so that the capacity and coverage area of the system can easily be expanded through time.

Another goal of the invention is to provide extensive protection against signal drop-outs caused by multi-path interference. The present invention seeks to achieve this objective without the need for multiple antennas or receivers on the telemeters, and without the loss or interruption of physiologic data commonly caused by antenna/receiver switch-overs. A related goal is to provide a high degree of protection against isolated sources of EMI, and to allow patients to be remotely monitored while near known intermittent sources of interference.

Another goal of the invention is to provide an architecture in which a large number of patients (e.g., 500 to 800 or more) can be monitored using a relatively narrow range of RF frequencies (such as the equivalent of one or two VHF television channels). This would allow the RF communications components of the system to be optimized for narrow-band operation, which would in-turn provide a performance advantage over wide-band systems.

In accordance with these and other objectives, a medical telemetry system is provided which includes multiple remote telemeters (which may include both ambulatory and instrument telemeters) which transmit the real-time physiologic data of respective patients via RF to multiple ceiling-mounted transceivers, referred to as "VCELLs." The VCELLs are hardwire-connected to a real-time data distribution network which includes at least one centralized monitoring station. (In a preferred implementation, each group of 16 VCELLs is connected via twisted pair lines to a respective "concentrator PC," and the concentrator PCs and monitoring stations are interconnected as part of a hospital local area network.)

The VCELLs are distributed throughout the hospital such that different VCELLs provide coverage for different patient areas, and are spaced such that the coverage zones provided by adjacent VCELLs overlap with one another. Different VCELLs within the same general area communicate with the remote telemeters on different respective RF frequencies (i.e., frequency channels), so that a remote telemeter can selectively communicate with a given VCELL by selecting that VCELL's frequency. As described below, however, VCELL frequencies are reused by VCELLs that are spaced sufficiently apart from one another to avoid interference, allowing the system to be implemented as a narrow-band system which uses a relatively small number of frequencies (e.g., 10) to provide coverage for an entire hospital facility.

In a preferred embodiment, the remote telemeters communicate with the VCELLs using a wireless time division multiple access (TDMA) protocol in which each VCELL can concurrently receive the real-time physiologic data of up to six remote telemeters (corresponding to six patients). As part of this protocol, the remote telemeters implement a VCELL "switch-over" protocol in which the telemeters establish wireless connections with different VCELLs based on periodic assessments (made by the telemeters) of the wireless links offered by the different VCELLs. Thus, as a patient moves throughout the hospital, the patient's remote telemeter may connect to (and disconnect from) many different VCELLs.

In operation, the remote telemeters send data packets (during assigned timeslots) to the respective VCELLs with which the telemeters have established wireless connections. (As described below, each remote telemeter preferably remains connected to two different VCELLs at-a-time to provide extensive protection against multi-path interference.) These data packets include the real-time physiologic data of respective patients, and include ID codes which identify the remote telemeters. The VCELLs in-turn forward the data packets to the real-time data distribution network to permit the real-time monitoring of the patients of the system.

To provide protection against multi-path interference and other causes of data loss, each remote telemeter maintains wireless connections with two different VCELLs at-a-time, and transmits each data packet to both of the VCELLs. These duplicate packet transmissions to the two different VCELLs take place on different frequencies during different TDMA timeslots. The two VCELLs forward the data packets to a centralized node (which may be a monitoring station or a concentrator PC in the preferred embodiment), which performs error correction by selecting between the corresponding packets based on error detection codes contained within the packets. Thus, the patient's physiologic data is sent from the remote telemeter to the centralized node over two separate data paths. Because the two VCELLs are spaced apart, and because the duplicate packets are transferred to the VCELLs on separate frequencies at different times, the packet transfers benefit from the protection offered by spacial diversity, frequency diversity and time diversity.

The architecture of the above-described medical telemetry system provides numerous advantages over prior art systems. One such advantage is that the system can be expanded in patient capacity and coverage area, by the addition of VCELLs, without increasing the noise floor of the system beyond the natural thermal noise floor. (This is because the data signals received by the VCELLs are multiplexed digitally at baseband, rather than being combined by RF analog signal combiners.) Thus, unlike distributed antenna telemetry systems, the noise floor does not impose an upper limit on the size of the system. Moreover, the architecture can accommodate a large number of patients (e.g., 500 to 800 or more) using a low maximum transmission power, such as the maximum transmit power permitted by the FCC for operation within the VHF medical telemetry band.

Another advantage is that the architecture is highly immune to isolated sources of EMI. A source of EMI (such as a cellular phone), for example, will typically contaminate the signals received by no more than one or two nearby VCELLs, as opposed to introducing noise into the entire system. (Because the remote telemeters connect to two VCELLs at-a-time, and automatically switch to different VCELLs when bad link conditions are detected, the contamination of one or two VCELLs will typically result in little or no loss of telemetry data.) One benefit of this immunity is that VCELLs can be installed within X-ray rooms and other radiological diagnostic rooms which contain intermittent sources of EMI, allowing patients to be monitored in such areas.

Another advantage of the architecture is that it permits the reuse of RF frequencies by VCELLs that are sufficiently spaced apart (by about 500 feet in a VHF implementation) to avoid interference with each other. By extending this concept, the present invention provides coverage for the entire facility using a relatively small number of frequencies

which fall within a relatively narrow frequency band. In a preferred VHF implementation, for example, it is estimated that a typical hospital can be covered using only 10 to 12 VCELL frequencies which fall within a frequency band that is equal in width to about two adjacent VHF television channels. This characteristic of the architecture advantageously allows the telemetry transceivers to be optimized (through the appropriate selection of transceiver components) for a relatively narrow band of frequencies, which in-turn improves performance.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention are described below with reference to the drawings of a preferred embodiment, which is intended to illustrate and not to limit the invention:

FIG. 1 is an architectural drawing of the hardware components of a medical telemetry system in accordance with the present invention.

FIG. 2 illustrates the attachment of an ambulatory remote telemeter to a patient of the system.

FIG. 3 illustrates the basic hardware components of the concentrator PCs and the ceiling-mounted transceivers (VCELLs) of FIG. 1.

FIG. 4 illustrates the basic hardware components of the ambulatory remote telemeters of FIG. 1.

FIG. 5A is a generalized circuit diagram of a transceiver which may be used in the VCELLs and remote telemeters of the telemetry system.

FIG. 5B illustrates the output of the phase-locked loop (PLL) chip of FIG. 5A during the locking of the transmit frequency of a remote telemeter.

FIG. 6 illustrates an increase in dynamic range achieved by the present system over prior art telemetry systems.

FIG. 7 illustrates how VCELLs operating on different frequencies may be arranged within a hospital hallway in accordance with the invention.

FIG. 8 illustrates a TDMA frame of a wireless TDMA protocol used for the transfer of information between the remote telemeters and the VCELLs of the system.

FIG. 9 illustrates the basic timeslot status information stored by each VCELL as part of the wireless TDMA protocol.

FIG. 10 is a flowchart of a protocol followed by each VCELL as part of the wireless TDMA protocol.

FIG. 11 illustrates the basic VCELL status information stored by each remote telemeter as part of the wireless TDMA protocol.

FIG. 12 is a flowchart of a protocol followed by each remote telemeter as part of the wireless TDMA protocol.

FIG. 13 is a flow chart of a protocol followed by the concentrators PCs for processing packets received from the VCELLs.

In the drawings, the left-most digit (or digits) of each reference number indicates the figure in which the item first appears. For example, an element with the reference number 310 first appears in FIG. 3, and an element with reference number 1100 first appears in FIG. 11.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

To facilitate a complete understanding of the invention, the description of the preferred embodiment is arranged within the following sections and subsections:

1. OVERVIEW

(i) GENERAL OPERATION

(ii) HARDWARE COMPONENTS

(iii) PATIENT CAPACITY AND DATA THROUGHPUT

(iv) NOISE FLOOR IMPROVEMENT

(v) PROTECTION AGAINST ISOLATED EMI SOURCES

(vi) VCELL SPACING AND FREQUENCY REUSE

2. COMMUNICATIONS BETWEEN REMOTE TELEMETERS AND VCELLS

(i) OVERALL WIRELESS TDMA PROTOCOL

(ii) VCELL PROTOCOL

(iii) REMOTE TELEMETER PROTOCOL

3. COMMUNICATIONS BETWEEN VCELLS AND CONCENTRATORS

(i) PROCESSING OF TELEMETER COMMANDS

4. DATA TRANSFERS OVER LAN

5. VCELL LOAD MONITORING

6. TRANSCEIVER CIRCUIT AND OPERATION

7. CONCLUSION

1. Overview (FIGS. 1-7)

FIG. 1 illustrates the general architecture of a two-way medical telemetry system which operates in accordance with the present invention. The system, referred to herein as the "VCELL system," includes a number of wireless remote telemeters 102A, 102B which collect, packetize and transmit the physiologic data of respective hospital patients. (As used herein, the term "wireless" means that data is transferred to and/or from the device over a wireless medium.) The remote telemeters 102 may include both patient-worn (ambulatory) remote telemeters 102A which connect directly to the patient (as generally illustrated in FIG. 2), and instrument remote telemeters 102B which connect to a bedside or other patient monitor 104. The physiologic data transmitted by the remote telemeters may include, for example, real-time ECG signals, blood pressure readings, CO₂ levels, and temperature readings. The remote telemeters 102 may additionally sense and transmit various types of non-physiologic data, such as battery-level status data, ECG loose-lead status data, and patient location data. (The term "patient data" is used herein to refer collectively to the physiologic and non-physiologic data captured by the remote telemeters 102.)

The remote telemeters 102 communicate bi-directionally with a number of ceiling-mounted radio transceivers 106, referred to as "VCELLs," using a time division multiple access (TDMA) protocol. In one mode of operation, each VCELL 106 can communicate with up to six remote telemeters 102 at-a-time at a rate of 10 kilobaud (Kbaud) per telemeter. The VCELLs 106 are spaced apart from one another (typically by about 50 to 75 feet, depending upon expected patient density) throughout the hospital to provide a "cell-like" coverage area which consists of overlapping zones of coverage.

Different VCELLs 106 of the system operate (i.e., transmit and receive data) on a different RF frequency channels ("frequencies") within the VHF medical telemetry band (174-216 MHz). However, VCELLs that are sufficiently spaced apart to avoid interference with one another may operate on like frequencies, as described below. The VCELLs 106 and telemeters 102 of the preferred embodiment operate in compliance with the spectrum utilization and transmission power limitations of FCC Part 15.241. Although the system preferably operates within the VHF medical telemetry band, other suitable frequency bands may be used. In addition, although the system uses frequency

division multiplexing to separate the data transmissions to and from different VCELLs 106, other channel separation techniques can be used.

Although the remote telemeters 102 and VCELLs 106 shown in FIG. 1 are of the type which communicate by radio frequency (RF), the system may also include "hardwired" remote telemeters and VCELLs which communicate over hardwire connections. For purposes of this description, however, it may be assumed that the terms "remote teleme-
ter" and "VCELL" refer to RF devices, except where indicated otherwise.

With further reference to FIG. 1, the VCELLs 106 are connected by conventional shielded twisted pair lines 110 to concentrator PCs 112 ("concentrators"). In the preferred embodiment, each concentrator 112 can accommodate up to sixteen VCELLs 106. In a typical hospital installation, one concentrator 112 will service a single floor of the hospital. The concentrators 112 provide connectivity between the VCELLs 106 on a hospital local area network (LAN) 116. The LAN 116 serves as a real-time data distribution system for distributing the physiologic data of the patients with a known latency. The LAN 116 includes a 100 Mbit/second backbone 118 which is based on the 100BaseTx (Ethernet) protocol. (The term "backbone" refers generally to the transmission medium and the networking cards of the LAN.) Alternative LAN protocols which could be used include ATM (Asynchronous Transfer Mode) and FDDI (Fiber Distributed Data Interface) and others.

The LAN 116 includes multiple monitoring stations 120 for allowing hospital personnel to remotely view and otherwise monitor the real-time physiologic data of the patients of the system. Each monitoring station 120 is preferably in the form of a standard 486 or Pentium based PC (personal computer) which runs conventional patient monitoring software, such as the VCOM (MPC 1100) patient monitoring software package available from VitalCom Incorporated. The patient monitoring software can also be loaded onto the concentrator PCs 112 so that the concentrators double as monitoring stations. The LAN 116 may also include one or more gateway computers 124 for connecting the LAN 116 to other networks, such as the Internet, to permit the exchange of patient information with other medical facilities and patient sites.

As will be apparent, the architecture illustrated in FIG. 1 provides for a high degree of scalability. The system can initially be installed, for example, as a single concentrator PC 112 which serves as the sole monitoring station for a set of 16 (or fewer) VCELLs, which may include both RF and hardwired VCELLs. With the addition of a LAN, new VCELLs 106 and concentrators 112 can be added to increase the patient capacity and/or coverage area of the system. (As described below, the architecture allows new VCELLs to be added to the system without a corresponding degradation in performance caused by noise.) Monitoring stations 120 can be added to the LAN 116 as needed to permit the remote viewing and monitoring of patient data from various locations within the hospital.

(i) General Operation

In operation, the remote telemeters 102 send data packets to individual VCELLs 106 using a wireless TDMA protocol. These packets include the patient data collected by the remote telemeters 102 (or by patient monitors connected to the remote telemeters), along with the ID codes of the respective telemeters 102. The VCELLs 106 forward these data packets to the corresponding concentrators 112, which in-turn broadcast the patient data on the LAN 116 (in real

time) for viewing and automated monitoring by the monitoring stations 120. The wireless TDMA protocol includes control timeslots for allowing the VCELLs to pass control information (e.g., synchronization information, commands, and timeslot assignments) to the remote telemeters 102. In addition, the protocol supports a patient location method (described below) for monitoring the remote location of each patient.

To support patient mobility, the VCELLs 106 and remote telemeters 102 implement a "switch-over" protocol in which the telemeters 102 continuously attempt to establish connections with those VCELLs which offer the best link performance. As part of this protocol, each remote teleme-
ter continuously assesses the quality of the RF link to each VCELL that is within range. The telemeters store this link assessment information within respective VCELL "cata-
logs" (described below), and periodically evaluate these catalogs to determine whether a switch-over to a new VCELL is desirable. When a remote teleme-
ter 102 determines that a VCELL is available (i.e., has an open timeslot) which offers better link performance than a current VCELL (i.e., a VCELL to which the teleme-
ter is currently connected), the remote teleme-
ter attempts to connect to the new VCELL. (As described below, this involves sending a timeslot request message to the selected VCELL 106, and then waiting for confirmation message from the VCELL.) If the connection is successfully established, the remote teleme-
ter 102 drops its connection to the current VCELL 106. Thus, a remote teleme-
ter 102 will normally connect to many different VCELLs 106 (including VCELLs of different concentrators 112) as the patient moves throughout the hospital. Transitions between VCELLs occur without interruption or loss of data, and are thus seamless from the viewpoint of the monitoring clinician.

To provide protection against dropouts caused by multi-path interference (and other types of interference), each remote teleme-
ter 102 attempts to maintain a connection with two VCELLs 106 at all times. (In other implementations, the remote telemeters 102 may connect to three or more VCELLs 106 to provide even greater protection against multi-path interference.) Whenever two VCELL connections are established, the remote teleme-
ter 102 transmits each of its data packets to both of the VCELLs. These redundant transfers take place on different frequencies during different TDMA timeslots. Thus, each wireless data path benefits from the protection offered by space, time, and frequency diversity. Upon receiving the redundant packets, the concentrator 112 to which the two VCELLs 106 are connected (assuming the VCELLs are connected to the same concentrator) uses error detection codes contained within the packets to discard bad packets, and to discard duplicate packets when both packets are successfully received.

In one implementation of the system, the remote telemeters 102 can only connect to the VCELLs 106 of one concentrator 112 at-a-time. In this implementation, each remote teleme-
ter 102 attempts to stay connected to the VCELLs of the current concentrator 112, and switches over to a different concentrator only when deemed necessary. In another implementation, the concentrators 112 of the system are maintained sufficiently synchronized with one another to allow each remote teleme-
ter to connect to VCELLs of two different concentrators 112. When this situation occurs, the task of discarding duplicate packets automatically shifts to the monitoring stations 120.

The operation of the system is described in further detail in the following sections.

(ii) Hardware Components (FIGS. 3-5A)

FIG. 3 illustrates the basic components of the concentrators 112 and VCELLs 106 of the system. Each concentrator

112 comprises a generic PC having two RS-422 input-output (I/O) cards 302 and a 100BaseTx LAN card 304. The PC may, for example, be a Pentium-based PC with 16 megabytes of memory. (Additional memory and a display monitor will normally be provided if the concentrator 112 is to double as a monitoring station.) The RS-422 and 100BaseTx cards 302, 304 are standard AT size components which can be purchased off-the-shelf at computer stores.

Each RS-422 card 302 includes eight external (full duplex) I/Os which connect, respectively, to eight standard twisted pair lines 110. Each twisted pair line 110 connects to a respective VCELL 106. The twisted pair lines 110 are preferably shielded 140 Kbaud lines with RJ-45 connectors. As is conventional, each twisted pair line includes four wires: a transmit (TX) wire, a receive (RX) wire, a positive voltage (+) wire, and a negative voltage (-) wire. The (+) and (-) wires are used to provide power to the VCELLs 106, and the (RX) and (TX) wires are used for the transfer of data.

Each VCELL 106 is in the form of a microcontroller-based transceiver 308 coupled to an antenna 312. The specifications of a transceiver which may be used in the preferred embodiment are listed in Table 1. (A transceiver circuit which may be used within the VCELLs is illustrated in FIG. 5A, and is described below.) The transceiver 308 is coupled to random access memory (RAM) 310 for buffering packet data and storing various status information.

TABLE 1

VCELL TRANSCEIVER SPECIFICATIONS	
Operating Frequency	204-216 MHz
Frequency Tuning	100 KHz
Transmit Power	1500 μ V/meter @ 3 meters
Modulation Type	FSK
Modulation Rate	80 Kbaud
Deviation	$\pm$ 50 KHz
Receive Sensitivity	-90 dBm (BER < .001)
Tx/Rx Switching Time	<10 μ s
Antenna	1/2 Wave Turnstile
Power Supply	6 to 12 VDC, <100 ma

As depicted in FIG. 4, each remote telemeter 102A includes conventional sensor circuitry 402 for sensing and digitizing the patient data of a respective patient. (In instrument remote telemeters 102B of the type shown in FIG. 1, the sensor circuitry normally resides primarily within the patient monitor 104.) The sensor circuitry 402 is coupled to a microcontroller-based remote transceiver 404, which is in-turn coupled to a RAM 406 and an antenna 408. The sensor circuitry 402, remote transceiver 404 and RAM 406 are powered by one or more batteries 412. The specifications of a remote transceiver 404 which may be used in the preferred embodiment are listed in Table 2.

TABLE 2

REMOTE TELEMETER TRANSCEIVER SPECIFICATIONS	
Operating Frequency	204-216 MHz
Frequency Tuning	100 KHz
Transmit Power	1500 μ V/meter @ 3 meters
Modulation Type	FSK
Deviation	$\pm$ 50 KHz
Modulation Rate	80 Kbaud
Receive Sensitivity	-90 dBm (BER < .001)
Tx/Rx Switching Time	<10 μ s
Antenna	1/2 Wave Turnstile
Power Supply	2 Alkaline Batteries, <25 ma

Although the architecture of FIG. 1 is not tied to any particular transceiver implementation, the remote trans-

ceiver circuit disclosed in the above-referenced provisional application (diagram reproduced as FIG. 5A) is well-suited for use as both the VCELL transceiver 308 and the remote transceiver 404. With reference briefly to FIG. 5A, the circuit includes a microcontroller 502 (preferably a 17C42) coupled to an EEPROM 512 which includes a firmware program stored therein. In the remote telemeters 102, the firmware program implements the remote telemeter side of the wireless TDMA protocol (described below). Likewise, in the VCELLs 106, the firmware program implements the VCELL side of the wireless TDMA protocol (also described below). An overview of the transceiver circuit of FIG. 5A is provided below under the heading TRANSCIVER CIRCUIT AND OPERATION.

(iii) Patient Capacity and Data Throughput

Each VCELL 106 can receive the patient data of six patients (i.e., six remote telemeters 102) at a sustained maximum data rate of 10 Kbaud per patient. (This data rate corresponds to one timeslot per TDMA frame using a simple FM transmitter, as described below.) In addition, the architecture supports increased data rates at the expense of reduced patient capacity. For example, a VCELL 106 could receive the patient data of three patients (i.e., three remote telemeters 102) at a data rate of 20 Kbaud per patient.

The total patient capacity of the system is limited primarily by the throughput of the LAN 116. In the preferred embodiment, the system design supports approximately 900 patients at a data rate of 10 Kbaud per patient 102. This results in a backbone throughput requirement of 900 $\times$ 10 Kbaud=9 megabaud (Mbaud) at the network level. The use of 100BaseTx for the backbone supports this data rate while providing a margin of over 90% for overhead processing (such as synchronization, signaling, and background status keeping tasks). The patient capacity of the system can be increased by adding a second backbone 118 to the LAN 116 to provide dual 100 Mbaud data paths.

(iv) Noise Floor Improvement (FIG. 6)

One significant benefit of the VCELL architecture is that it overcomes the above-described noise-floor degradation problem encountered with distributed antenna systems, and thus allows the system to be expanded in capacity (through the addition of VCELLs) without a corresponding reduction in signal quality. To illustrate the noise-floor degradation problem encountered with distributed antenna systems, reference will be made to FIG. 6, which illustrates example dynamic range values for a single-antenna system (left-hand side) and a 400 antenna system with preamplifiers (right-hand side) operating within the VHF medical telemetry band.

In general, telemetry systems operate between two limits of transmitted signal strength: (i) the minimum signal that the receiver can detect above the thermal noise floor (which is the "natural" noise floor created by the normal movement of charged particles), and (ii) the maximum signal that the transmitter can provide at very close range (as experienced when the transmitter resides directly below the receiver's antenna.) As illustrated in FIG. 6, the minimum detectable signal level (based on the thermal noise floor) in the single-antenna telemetry system will typically be about -90 dBm. The maximum allowed signal level within the VHF medical telemetry band is 1500 microvolts/meter at 3 meters (as specified by FCC Part 15.241), which corresponds to a signal level of about -40 dBm with the transmitter located directly below a ceiling-mounted telemetry antenna. Thus, a

single-antenna medical telemetry system will have a dynamic range of about 50 dB.

As indicated above, the process of combining the RF signals of the antennas of a distributed antenna system has a loss associated with it. This loss results from the need for signal combiners, and from the large amount of coaxial cable required to interconnect the various antennas. To compensate for this loss, distributed antenna systems use preamplifiers, typically at the antenna sites, to boost the RF signal. One problem with this approach is that each preamplifier contributes to the noise level of the antenna system in excess of the noise actually received by the corresponding antenna. Thus, although only a few of the antennas typically receive a usable signal of a particular telemeter at any given time, all of the antennas (preamplifiers) contribute to the noise floor.

Consequently, each time the number of antennas of the distributed-antenna system is doubled, the minimum detectable signal level increases by about a factor of 2, or 3 dB. Thus, for example, a system with 400 antennas and 400 preamplifiers will suffer from a noise floor degradation of more than 24 dB (corresponding to over 8 doublings of the noise floor), producing a degraded dynamic range of less than 26 dB (FIG. 6). (A distributed antenna system of this size is currently installed at Barnes Hospital in St. Louis.) To reclaim this lost dynamic range, the remote telemeters could potentially be operated at a higher transmission power. However, the use of a higher transmission power would reduce the average battery life of remote telemeters. Moreover, an increase in power beyond the limits imposed by FCC Part 15.241 would require operation outside the protected medical telemetry band, exposing the system to new forms of RF interference.

In contrast to distributed antenna systems, the VCELL system combines the outputs of the VCELLs at baseband using digital multiplexing techniques. As a result, virtually no degradation of the noise floor occurs as VCELLs are added to the system, and the system enjoys the full 50 dB dynamic range regardless of the number of VCELLs. This has the effect of increasing the perceived transmitted power by about 24 dB (a 200 fold increase) over the 400 antenna system in the example above.

(v) Protection Against Isolated EMI Sources

Another benefit of the VCELL architecture is that it inherently offers a high degree of immunity against isolated sources of EMI (electromagnetic interference). In the above-described distributed antenna system, a single source of interference (such as an X-ray machine or a faulty copying machine) near one of the antennas can introduce an intolerable level of noise to the entire system, and prevent the monitoring of all patients of the system. In contrast, in the VCELL system, the interference source will only effect the operation of the VCELLs 106 that are sufficiently close to the source. Moreover, the contamination of one or two VCELLs by an isolated interference source will often have little or no impact on the ability to monitor patients in the area, since each remote telemeter 102 normally maintains data connections to two VCELLs 106, and automatically connects to a new VCELL source when a drop in the quality of a VCELL link is detected.

One benefit of this interference immunity is that it allows patients to be monitored near known intermittent sources of interference. For example, patients can be monitored within x-ray, fluoroscopy, and CAT-scan rooms by simply placing VCELLs in these areas.

(vi) VCELL Spacing and Frequency Reuse (FIG. 7)

The VCELLs are preferably mounted sufficiently close to one another such that each patient of the system will normally be within range of multiple VCELLs 106 at any given time. (For operation at maximum power within the VHF medical telemetry band, spacings of 50 to 75 feet are suitable.) Such an arrangement allows the remote telemeters 102 to maintain connections with two VCELLs at-a-time, as is desirable for mitigating the effects of multi-path interference.

One benefit of the architecture, however, is that it allows the VCELLs to be spaced as closely together as necessary to accommodate different patient densities. For example, a relatively large number of VCELLs (each operating on a different frequency) can be placed within a hospital cafeteria to accommodate the high patient densities which may occur during meal times. Because the remote telemeters 102 only attempt to connect to the VCELLs 106 that have open timeslots (as described below), the telemetry load during such high-density events is automatically distributed among the VCELLs.

Although it is possible to configure the system such that every VCELL 106 operates (i.e., transmits and receives data) on its own unique frequency, considerable performance benefits (described below) can be realized by re-using the same set of frequencies in different regions of the hospital. In general, two VCELLs can operate on the same frequency provided that they are sufficiently spaced apart to avoid interference with one another. For operation within the VHF medical telemetry band (at the maximum allowed signal strength), a separation of 500 feet between such VCELLs is more than adequate. By assigning like frequencies during the installation process to VCELLs that are spaced 500 feet (or greater) apart, it is estimated that 10 to 12 frequencies will be sufficient to provide coverage for a typical hospital.

FIG. 7 illustrates how a set of ten frequencies can be re-used in different sections of a hospital hall 700. As illustrated, a set of ten frequencies, 61-610, can be used to cover a 500 foot section of the hall using ten corresponding VCELLs. (Each frequency symbol in FIG. 7 represents one VCELL.) The same ten frequencies can then be used to cover the next 500 foot section of the hallway. With appropriate staggering of frequencies between hospital floors, the same 10 frequencies can be used to provide coverage of an entire multi-floor hospital. (While ten frequencies may be adequate for many installations, the actual number of frequencies will depend upon such factors as the hospital floor plan, the telemeter transmission power, and the expected patient densities in the various patient areas.)

The ability to reuse frequencies provides several advantages over conventional frequency division multiplexed systems. One advantage is that a reduced number of clear frequencies need to be identified during the installation process. Another advantage is that the transmitters, receivers and antennas of the system can be optimized to operate over a much narrower band of frequencies. For a system which operates within the VHF medical telemetry band, for example, the VCELL frequencies can be selected to fall within a band of one or two VHF television channels (such as channels 12 and/or 13, which tend to have the lowest ambient noise), rather than spanning the entire 174 to 216 MHz range. It is estimated that such optimization will add a performance margin of 6 to 10 dB over existing telemetry equipment which operates over the entire 174 to 216 MHz range.

2. Communications Between Remote Telemeters and VCELLS (FIGS. 8-12)

(i) Overall Wireless TDMA Protocol (FIG. 8)

FIG. 8 illustrates a single frame of the wireless TDMA protocol used between the remote telemeters 102 and the VCELLs 106. The frame repeats every 5 milliseconds, and consists of seven timeslots: a 740 microsecond (μ s) VC→R (VCELL to remote teleme- 5 ter) timeslot and six 710 μ s R→VC (remote teleme- ter to VCELL) timeslots. The VC→R timeslots are used to broadcast information to the remote telemeters 102. (As described below, all VCELLs of the system are synchronized, and thus transmit at the same time.) The R→VC timeslots are assigned by the VCELLs 106 to individual telemeters 102, and are used to transfer information from the assigned telemeters to the VCELLs. All timeslots terminate with a 10 μ s dead period, which is sufficient to allow the devices to switch between transmit and receive modes.

In the preferred embodiment, the remote telemeters 102 and VCELLs 106 transmit at a raw data rate of 80 Kbaud, which corresponds to a bit time of 12.5 μ s. At this data rate, a total of $(700 \mu\text{s/slot}) / (12.5 \mu\text{s/bit}) = 56$ bits are transmitted during the data portion of each R→VC timeslot. The first six of the 56 bit times are used for synchronization of the receiver, leaving 50 bits for the transfer of telemetry data (including error detection codes). Because this 50 bit mes- 10 sage repeats every 5 milliseconds, or 200 times per second, the total teleme- ter-to-VCELL throughput for a single timeslot assignment is $200 \times 50 = 10,000$ bits/second, or 10 Kbaud. This throughput rate is obtained in the preferred embodiment using simple FM transceivers in the VCELLs and telemeters. As will be recognized by those skilled in the art, higher throughput rates can be achieved, at a greater expense, by using transceivers which use more sophisticated modulation techniques, such as BPSK and QPSK.

With further reference to FIG. 8, the VCELLs broadcast respective control messages to the remote telemeters 102 during the first 700 μ s of each VC→R timeslot. (Because all VCELLs within range of one another transmit on different frequencies, each teleme- 15 ter 102 can listen to the control message of only one VCELL at-a-time.) The control mes- sages are used to transmit the following information to the telemeters:

Synchronization Sequences.

The telemeters use these sequences to initially become synchronized and to maintain synchronization with the VCELLs 106.

VCELL-Specific Timeslot Assignment Status Data.

For a given VCELL, this status data indicates which of the six R→VC timeslots (if any) are unassigned, and thus available for use. The telemeters use this information to formulate timeslot request messages to the VCELLs.

Telemeter-Specific Timeslot Assignment Messages.

A timeslot assignment message (or "confirmation" message) is transmitted in response to a timeslot request message from a specific teleme- 20 ter, and serves as an acknowl- edgement to the teleme- ter that it has successfully acquired the requested timeslot.

Telemeter-Specific Commands.

This is an optional feature which may be supported by certain remote telemeters 102. A command may be sent, for example, to instruct a teleme- 25 ter to take a blood pressure reading, or to enter into special mode of operation.

VCELL ID Codes.

Each VCELL transmits a unique ID code which is used for patient location.

During the last 30 μ s of each VC→R timeslot, each VCELL transmits a low-power ($\frac{1}{4}$ -power in the preferred embodiment), unmodulated signal to allow each remote teleme- 30 ter 102 to estimate the location of the respective patient. (The use of a low-power, unmodulated signal for this purpose produces a more accurate VCELL-teleme- ter distance measurement.) Each remote teleme- ter 102 mea- sures the signal strengths of the low-power transmissions of the various VCELLs (by listening to different VCELL frequencies during different TDMA frames), and maintains a table (discussed below) of the detected signal strengths. As a low duty cycle task (e.g., once every 5 seconds), each teleme- 35 ter 102 evaluates its respective table to estimate the closest VCELL (i.e., the VCELL with the greatest signal strength). Whenever a change occurs in the closest VCELL, the teleme- ter transmits the ID of the new VCELL to the hospital LAN 116 (FIG. 1). The monitoring stations 120 use this information to keep track of the locations of the patients of the system. In other embodiments of the invention, patient location may be accomplished by having the VCELLs periodically attach VCELL identification codes to the data packets received from the remote telemeters 102.

With further reference to FIG. 8, the six R→VC timeslots are used by the remote telemeters 102 to transmit data packets to individual VCELLs 106. (As described below, each teleme- 40 ter 102 transmits to only one VCELL at-a-time.) These data packets are generally of two types: (i) telemetry data packets which include the patient data (including patient location data) of individual patients, and (ii) timeslot request messages for requesting timeslot assignments. Once a R→VC timeslot has been assigned by a VCELL to a remote teleme- 45 ter, the remote teleme- ter has exclusive use of the timeslot until the teleme- ter disconnects. Once the teleme- ter disconnects, the VCELL modifies its control message (transmitted on the VC→R timeslot) to indicate that the timeslot is available for use.

During normal operation, each R→VC timeslot of a given VCELL 106 will be assigned, if at all, to a different remote teleme- 50 ter 102. Thus, when all six R→VC timeslots of the VCELL are assigned, the VCELL receives the telemetry data of six different remote telemeters 102. In other modes of operation, multiple timeslots of a single VCELL can be assigned to the same teleme- ter to allow the teleme- ter to achieve a higher data throughput rate.

(ii) VCELL Protocol (FIGS. 9 and 10)

The VCELL side of the above-described wireless TDMA protocol is implemented via a firmware program which is executed by the microcontroller of each VCELL 106. With reference to FIG. 9, this program maintains a timeslot status table 900 in VCELL RAM 310 to keep track of the assign- 55 ment status of each R→VC timeslot. As illustrated in FIG. 9, the information stored within the table 900 includes, for each timeslot, whether or not the timeslot is currently assigned or unassigned. In addition, for the timeslots that are assigned, the table indicates the number of consecutive frames that have passed without receiving an error-free data packet from the assigned teleme- 60 ter; each VCELL uses this information to implement a timeout procedure to determine whether the assigned teleme- ter 102 has disconnected.

FIG. 10 is a flow chart which illustrates the VCELL portion of the wireless protocol. With reference to block 1002, during a power-on initialization sequence, the VCELL 106 updates its timeslot status table 900 to set all of the R→VC timeslots to the "free" (unassigned) state. The VCELL then enters into a primary program loop which corresponds to a single TDMA frame. Referring to blocks

1004 and 1006 of this loop, during the VC→R timeslot the VCELL transmits the 710 μs control message followed by the 30 μs patient location signal, as illustrated in FIG. 8. This control message includes the timeslot assignment data (for all six R→VC slots) stored in the timeslot status table 900. On the first pass through this loop following power-on, the control message will indicate that all six R→VC timeslots are available for use. With reference to block 1008, the VCELL 106 then sets a slot counter (N) to one (corresponding to the first R→VC timeslot), and enters into a sub-loop (blocks 1012–1032) for processing the data packets transmitted by the telemeters.

During each R→VC timeslot, the VCELL attempts to receive any telemetry data packet transmitted during the timeslot (block 1012), and checks the timeslot status table 900 to determine whether the slot is assigned (block 1014). With reference to blocks 1016–1022, if the timeslot is assigned and a data packet was successfully received, the VCELL forwards the packet to the concentrator 112, and clears the corresponding “missed packets” counter in the status table 900. (The data packet is actually sent to the concentrator 112 following the TDMA frame as part of a larger “VCELL packet” which represents the entire frame.) If, on the other hand, the timeslot is assigned but no packet was successfully received, the VCELL 106 updates the timeslot status table 900 to indicate that a packet was missed; in addition, the VCELL determines whether the number of consecutive missed packets has exceeded a timeout threshold (e.g., 64 packets). If the threshold is exceeded, the status table 900 is updated to set the timeslot to the “free” state.

With reference to blocks 1026 and 1028, if the timeslot is unassigned, the VCELL 106 determines whether it received a valid timeslot request message. If a valid timeslot request was received, the VCELL updates its status table to indicate that the slot has been assigned; in addition, the VCELL sets a flag to indicate that a timeslot confirmation message should be transmitted to the requesting telemeter 102 during the next VC→R timeslot.

With reference to blocks 1030 and 1032, once all processing of the received telemeter packet (if any) is performed, the VCELL increments its timeslot counter. If the incremented counter is 6 or less, the program loops back to block 1012 to begin receiving any data transmitted during the next timeslot. If the incremented counter has exceeded 6, the program loops back to block 1004 to transmit the next control message.

Although the FIG. 10 flowchart illustrates the above-described operations in sequential order, it will be recognized that some of these operations can (and normally will) be performed concurrently or out-of order. For example, the step of forwarding the data packets to the concentrator (block 1018) is preferably performed as a separate task, with all of the telemeter packets received during the TDMA frame transferred together within a larger VCELL packet.

(iii) Remote Telemeter Protocol (FIGS. 11 and 12)

The telemeter side of the wireless TDMA protocol generally mirrors the VCELL protocol 1000, and is similarly implemented by a firmware program which is executed by the microcontroller of each remote telemeter 102. As part of this protocol, each remote telemeter 102 maintains a VCELL catalog within its respective RAM 406. The general format of this catalog is illustrated in FIG. 11, which is representative of a system which uses a total of 10 VCELL frequencies. As illustrated in FIG. 11, the catalog 1100 includes one

set of entries for each of the ten VCELL frequencies. The telemeter thus stores status information for up to ten nearby VCELLs at-a-time. The entries stored with respect to each VCELL frequency include the following:

Rating.

A rating of the quality of the RF link to the VCELL 106, as assessed by the individual telemeter 102. The RF links are assessed by the telemeters one frequency at-a-time during the control message portions of the VC→R timeslots. (In other embodiments, the task of assessing the available RF links may alternatively be performed by the VCELLs.) In one embodiment, the VCELL ratings are based on a combination of signal strength (as measured by the telemeters) and bit error rate. Specifically, if an error is detected in a VCELL's transmission, the VCELL's rating is set to a zero or null entry to indicate that the VCELL should not be used; and if no error is detected, the rating is set to a value which is proportional to the measured signal strength. The ratings are periodically compared (as described below) to determine whether to attempt a connection to a new VCELL.

Connected To.

A flag indicating whether or not the telemeter is connected to a VCELL on the frequency. During normal operation, each telemeter will be connected to two different VCELLs (on two different frequencies) at-a-time.

Low-Power Signal Strength.

A measurement of the signal strength taken during the low-power (patient location) portion of the VC→R timeslot. The low-power signal strengths stored in the catalog 1100 are periodically compared to estimate which of the VCELLs the patient is closest to. When the outcome of this comparison changes, the telemeter transmits the new location (i.e., the VCELL ID, which is obtained from the VCELL during the high-power message portion) to the hospital LAN 116 in a subsequent data packet.

The remote telemeters 102 also keep track of the unique IDs of the VCELLs that are within range.

The protocol followed by the remote telemeters 102 generally consists of the following steps:

1. Scan all VCELL operating frequencies and construct the VCELL catalog 1100. Remain in this mode until at least one VCELL 106 is identified which has an acceptable rating and an unassigned timeslot.
2. Send a timeslot request message to the VCELL identified in step 1 during one of the available timeslots. Perform this task using a random back-off algorithm in case other remote telemeters attempt to connect to the VCELL during the same timeslot. Remain in this operating mode (including step 1) until a timeslot assignment message is received from the selected VCELL.
3. Once connected to a first VCELL (“VCELL 1”), attempt to connect to the “next best” VCELL (“VCELL 2”) in the catalog which has an acceptable rating and a free timeslot (other than the timeslot being used to communicate with VCELL1), to provide a second (diversity) data path. Send telemetry data packets to VCELL1 during this process.
4. Monitor the catalog entries to determine whether any of the other VCELLs offer better link performance than VCELLs 1 and 2. When a better VCELL is available (i.e., has an open, nonconflicting timeslot), send a timeslot request message to the “new” VCELL. Drop the connection with the current VCELL once a timeslot assignment message is received.
5. As a background task, scan the VCELL frequencies and update the catalog. This can be done as a low priority, low duty cycle task (such as once per second).

FIG. 12 illustrates this protocol in greater detail for a system which uses 10 VCELL frequencies. With reference to

block 1202, the remote telemeter 102 initially scans the ten VCELL frequencies and builds the VCELL catalog 1100. This involves monitoring different VCELL frequencies during different TDMA frames. With reference to blocks 1204-1210, once an acceptable VCELL 106 with an open timeslot has been identified, the telemeter 102 transmits a timeslot request message to the selected VCELL, and then monitors the selected VCELL's frequency during the following VC→R timeslot to determine whether the slot has been successfully acquired. With reference to block 1214, if the connection attempt is unsuccessful, a random back-off algorithm (such as the binary exponential back-off algorithm used by Ethernet) is used to retry the connection attempt. If the retry is unsuccessful (after, for example, 2 retry attempts), or if it is determined that the requested timeslot has been assigned to a different telemeter 102, the telemeter repeats the above process to identify another potential VCELL.

With reference to blocks 1220-1226, once a timeslot assignment has been obtained from a first VCELL, the protocol enters into a loop (blocks 1222-1240) which corresponds to a single TDMA frame. Within this loop, the telemeter 102 sends telemetry data packets to the first VCELL (block 1222) during the assigned timeslot while attempting to connect to a second VCELL (block 1226). The process of connecting to the second VCELL is generally the same as the above-described process for connecting to the first VCELL, with the exception that the timeslot used to communicate with the second VCELL must be different from the timeslot used to communicate with the first VCELL. With reference to block 1228, once a second VCELL connection has been established, the telemeter sends all data packets to both VCELLs.

With reference to blocks 1232 and 1234, the remote telemeter 102 monitors the high-power and low-power transmissions of the VCELLS 106 (during the VC→R timeslots) and updates the rating and low-power signal strength entries of the VCELL catalog 1100. Although this process is shown in FIG. 12 as occurring during every TDMA frame (one VCELL per frame), this function can alternatively be performed as a low duty cycle task.

With reference to blocks 1238 and 1240, as a background task the telemeter 102 monitors the VCELL catalog 1100 to determine whether a VCELL 106 with a higher rating exists. If a VCELL with a higher rating and an available (nonconflicting) timeslot is identified, the telemeter attempts to connect to the new VCELL (as described above), and if successful, drops the existing connection to one of the two "current" VCELLs.

As a background, low priority task, the telemeter 102 also monitors the VCELL catalog 1100 to determine whether a change has occurred in the VCELL 106 with the greatest low-power signal strength. (This process is omitted from FIG. 12 to simplify the drawing.) When such a change occurs, the telemeter transmits the VCELL ID of the new "closest" VCELL in a subsequent telemetry packet. As described above, this information is used by the monitoring stations 120 to track the location of each patient.

3. Communications Between VCELLs and Concentrators (FIG. 13)

The VCELLS 106 and concentrators 112 communicate bi-directionally over the shielded twisted pair lines 110 in accordance with the RS-422 specification. (RS-422 is an Electronic Industries Association interface standard which defines the physical, electronic and functional characteristics of an interface line which connects a computer to communications equipment.) The RS-422 interface supports an

overall data transfer rate of 140 Kbaud, which corresponds to 20 Kbaud per TDMA timeslot.

In operation, each VCELL 106 sends one packet to its respective concentrator 112 for every TDMA frame; this VCELL packet includes all of the telemeter packets (up to six) received during the corresponding TDMA frame. (The terms "VCELL packet" and "telemeter packet" are used in this description to distinguish between the two types of packets based on their respective sources.) The concentrator 112 in-turn parses the VCELL packet to extract the individual telemeter packets, and performs error checking on the telemeter packets using the error detection codes contained within such packets. As part of the error checking protocol, the concentrator 112 discards all telemeter packets which include errors (or uncorrectable errors if error correction codes are used), and discards all telemeter packets that are redundant of packets already received from a different VCELL. All other packets are written to an output buffer for subsequent broadcasting over the LAN 116.

FIG. 13 is a flow chart which illustrates the concentrator side of the VCELL-to-concentrator protocol in further detail. With reference to block 1302, the concentrator 112 sends a VCELL synchronization pulse to its 16 VCELLs once per TDMA frame. The concentrator then initializes a loop counter (block 1304), and enters into a loop (blocks 1306-1324) in which the concentrator processes the 16 VCELL packets (one per loop) received from the 16 VCELLs. Within this loop, the concentrator 112 parses each VCELL packet (block 1306) to extract the individual telemeter packets contained therein, and then enters into a sub-loop (blocks 1310-1320) in which the concentrator performs error checking (as described above) on the individual telemeter packets (one telemeter packet per sub-loop).

With reference to blocks 1310-1316, error free telemeter packets which have not already been successfully received (from other VCELLs) are written to an output buffer of the concentrator 112. (As described below, a separate concentrator task reads these packets from the buffer and broadcasts the packets on the LAN 116 during patient-specific timeslots of the LAN protocol.) With reference to blocks 1320-1324, once all of the telemeter packets within a given VCELL packet have been processed, the protocol loops back to block 1306 (unless all 16 VCELL packets have been processed, in which case a new synchronization pulse is transmitted), and the concentrator 112 begins to process the next VCELL packet.

As indicated by the foregoing, the concentrators 112 only place error-free telemeter packets on the LAN backbone 118, and do not place duplicate error-free telemeter packets (from the same telemeter) on the backbone 118. Nevertheless, the duplicate (error-free) packets transmitted by a telemeter will normally appear on the LAN backbone 118 when the remote telemeter connects to VCELLs of two different concentrators 112 (as permitted in one implementation of the invention). In this situation, the monitoring stations 120 simply ignore the extra telemeter packets.

(i) Processing of Telemeter Commands

In system implementations which support the sending of commands to the remote telemeters 102, the concentrators 112 additionally implement a simple task (not illustrated in FIG. 13) for receiving commands from the monitoring stations 120 and forwarding these commands to the VCELLS 106. As part of this task, each concentrator 112 maintains a list of all of the remote telemeters 102 to which the concentrator is currently connected. (This list is gener-

ated by monitoring the telemetry ID codes contained within the telemetry data packets.) When a monitoring station 120 places a telemetry-addressed command on the LAN 116, each concentrator 112 of the system receives the command and checks its respective list to determine whether a connection exists with the target telemetry. If a concentrator determines that such a connection currently exists, the concentrator 112 sends the command to all 16 of its VCELLs 106. The sixteen VCELLs in-turn transmit the telemetry command during a subsequent VC→R timeslot. To increase the probability of receipt, the VCELLs are preferably configured to re-transmit the telemetry command over several TDMA frames. In other embodiments, an acknowledgement protocol can be implemented in which the telemeters embed an acknowledgement message within a subsequent data packet.

4. Data Transfers Over LAN

Data transfers over the LAN backbone 118 are accomplished using a real-time TDM (time division multiplexing) protocol which makes use of the 100BaseTx protocol. Among other things, this protocol distributes the telemetry data from the concentrators 112 to the monitoring stations 120 with a known latency, permitting the real-time monitoring of patient data.

Each 50 millisecond frame of the TDM protocol includes 1000, 50 μ s timeslots. Every remote telemetry 102, VCELL 106, concentrator 112, monitoring station 120, and gateway 124 of the system is uniquely assigned one of the 1000 backbone timeslots. The backbone timeslots that are uniquely assigned to respective remote telemeters 102 are used to transfer telemetry data packets (containing patient-specific physiologic data) from the concentrators 112 to the monitoring stations 112. All other entities that are connected to the LAN backbone 118 also have access to this telemetry data. The remaining backbone timeslots are used for the transfer of synchronization and control information between the various LAN entities.

The 100BaseTx backbone 118 has the capacity to transfer up to 5000 bits in each 50 μ s backbone timeslot. Thus, each remote telemetry (and other entity which is assigned a backbone timeslot) is effectively allocated a LAN bandwidth of 5000 bits/slot $\times$ 20 frames/second=100 Kbaud. This more than satisfies the 20 Kbaud data rate per telemetry which is required when a telemetry connects to VCELLs of two different concentrators.

Upon initialization of the system, a "master" concentrator 112 transmits a synchronization packet to all other concentrators of the LAN 116. This synchronization packet defines the starting point of the backbone TDM frame. Thereafter, the frame repeats at a rate of 20 frames per second. As indicated above, a task which runs on each concentrator moves telemetry packets from the concentrator's output buffer to the LAN during the appropriate patient-specific (50 μ s) timeslots. This task waits for a patient (telemetry) timeslot, and then transmits all corresponding telemetry packets which have been written to the output buffer since the same timeslot of the immediately preceding backbone frame. When a telemetry is connected to VCELLs of two different concentrators, the 50 μ s patient timeslot is divided equally between the two concentrators. This is accomplished by passing control messages between the concentrators.

5. VCELL Load Monitoring

As a background task, each concentrator 112 maintains a statistical log or "histogram" of the loads carried by each of the concentrator's VCELLs 106. This histogram can periodically be examined by network administrators to evaluate the current positioning of the VCELLs. When, for example,

the histogram indicates that a VCELL in a particular patient area reaches its capacity (i.e., all six timeslots assigned) on a frequent basis, another VCELL (which operates on a different frequency) can be installed in the area to reduce the load on the heavily-loaded VCELL.

6. Transceiver Circuit and Operation (FIGS. 5A and 5B) The transceiver circuit illustrated in FIG. 5A will now be described. As indicated above, this general circuit can be used in both the remote telemeters 102 and the VCELLs 106 of the system. When included within a remote telemetry 102, the transceiver will typically be powered by battery. When included within a VCELL 106, the transceiver will be powered by the corresponding concentrator 112 over a twisted pair line 110 (as illustrated in FIG. 3).

The transceiver 112 comprises a microcontroller (preferably a 17C42) which is connected, via appropriate port lines, to a programmable phase-locked loop chip 504 ("PLL chip"), a voltage controlled oscillator (VCO) 506, a receiver (RCVR) 508, a set of DIP (dual in-line package) switches 510, an EEPROM 512, and a sample-and-hold (S/H) device 520. (The sample-and-hold 520 is preferably omitted in the VCELL transceivers 308.) The PLL chip 504 is preferably a Motorola MC 145192 which can be placed, via appropriate commands, into a low-power state when not in use. The microcontroller 502 is clocked by an 8 MHz high stability ($\pm 0.001\%$) crystal oscillator 516. The output of the amplifier 524 and the signal input of the receiver 508 are connected to respective terminals of a transmit/receive switch 528, which is connected to the antenna 312, 408 via a band-pass filter (BPF) 530.

As illustrated in FIG. 5A, the PLL chip 504 is coupled to the VCO 506 to form a phase lock loop circuit. Via the PLL chip 504, the phase lock loop circuit can be programmed to generate a carrier signal of a selected frequency. Within the transceivers of the telemeters 102, the sample-and-hold device 520 is connected so as to allow the microcontroller 502 to programmatically interrupt the phase-lock process and hold the carrier frequency at a steady frequency value within a preselected margin of frequency error. This allows the carrier frequency to be locked rapidly, at low power, without waiting for a phased-locked state to be reached. In a preferred embodiment, this feature is used to lock the transmit frequency of each telemetry just prior to each R→VC timeslot to which the telemetry is assigned.

As illustrated in FIG. 5A, the VCO 506, amplifier 524, and receiver 508 are coupled to the power supply (V_{SUP}) via respective microcontroller-controlled switches 534, 536, 538 such that the microcontroller 502 can selectively turn these components ON and OFF to conserve power. (In the VCELLs, the switches 534, 536, 538 can be omitted since battery life is not a concern.) To utilize this power-conservation feature, the firmware program (stored within the EEPROM 512) of the remote telemeters 102 includes code for maintaining these active transceiver components in an OFF state when not in use. For example, the receiver is maintained in an OFF state during TDMA timeslots for which the remote telemetry 102 is not receiving data, and the amplifier is maintained in an OFF state during timeslots for which the remote telemetry 102 is not transmitting. This feature of the transceiver circuit significantly increases the average battery life of the remote telemeters 102.

In operation within a remote telemetry, the microcontroller 502 maintains the PLL chip 504 in its low-power state, and maintains the amplifier 524, VCO 506 and receiver 508 in respective OFF states, during timeslots for which the telemetry is neither transmitting nor receiving data. Shortly before the next R→VC timeslot which is assigned to the

telemeter 102, the microcontroller 502 initiates a frequency lock operation which involves initiating a phase-lock process, and then interrupting the process (by opening the sample-and-hold 520) once the carrier frequency has settled to within an acceptable margin of error. This process is illustrated in Figure 5B, which is an approximate graph of the output (V_{PLL}) of the PLL chip 504 following power-up at T_0 .

With reference to FIG. 5B, just prior to T_0 , the VCO 506 is turned on, the sample-and-hold 520 is in the closed (or "sample") position, and the PLL chip 504 is in the low-power state. At T_0 , the PLL chip 504 is taken out of the low-power state, causing its output V_{PLL} to ring, and thus causing the output of the VCO to oscillate above and below the programmed transmit frequency. Following T_0 , the output of the PLL is in the general form of a damped sinusoid, which approaches the voltage that corresponds to the programmed frequency. (Because the voltage V_{PLL} controls the VCO 506, the amplitude of the voltage signal in FIG. 5B corresponds to the frequency.) Once this oscillation is sufficiently attenuated such that the frequency error is within a predetermined tolerance (e.g., ± 5 KHz), the sample-and-hold 520 is opened (at T_1 in FIG. 5) to hold the input voltage to the VCO 506. (This is accomplished by waiting a predetermined delay, T_{DELAY} , before opening the sample-and hold 520, as described in the above-referenced priority application.) This holds the output frequency, and ensures that the remote telemeter's subsequent data transmission will not be contaminated by any oscillation in the PLL's output. Immediately following T_1 , the amplifier 524 is turned on, the PLL 504 is placed in the low-power state, and the T/R switch 528 is placed in the transmit position. The microcontroller 402 then begins sending its transmit data to the VCO, to thereby FSK-modulate the carrier signal. Following the transmission of the telemeter packet, the amplifier 524, and VCO 506 are turned off.

In one embodiment, the telemeter firmware is written such that the telemeters 102 only use non-adjacent (i.e., non-consecutive) R $\rightarrow$ VC timeslots. This ensures that each telemeter will have at least a 720 μ s "dead period" between transmissions during which to lock the new transmit frequency using the above-described process.

The process of receiving data (during VC $\rightarrow$ R timeslots) is generally analogous to the above-described transmit process, with the exception that the sample-and-hold 520 is left in the closed (sample) position throughout the VC $\rightarrow$ R timeslot.

7. Conclusion

While the present invention has been described herein with reference to a preferred embodiment of a medical telemetry system, the invention is not so limited, and should be defined only in accordance with the following claims.

What is claimed is:

1. A medical telemetry system for permitting real-time monitoring of patients, including ambulatory patients, of a medical facility from a centralized monitoring station, comprising:

- at least one monitoring station which displays real-time physiologic data of multiple patients;
- a plurality of battery-powered wireless remote telemeters, the remote telemeters configured to attach to, and configured to collect and transmit real-time physiologic data of, respective patients; and
- a plurality of transceivers which communicate bi-directionally with the plurality of remote telemeters using a plurality of wireless radio frequency (RF) channels, the transceivers connected to the at least one

monitoring station and being distributed throughout the medical facility such that different transceivers provide data-reception coverage for different areas of the medical facility, at least some of the transceivers receiving physiologic data on different RF channels, the transceivers configured to receive the physiologic data transmitted by the remote telemeters and to forward the physiologic data over a wired connection to the at least one monitoring station;

wherein at least some of the remote telemeters automatically switch between different RF channels of the plurality of RF channels in response to patient movement throughout the medical facility to connect to and disconnect from individual transceivers of the plurality of transceivers.

2. The medical telemetry system according to claim 1, wherein at least some of the remote telemeters evaluate wireless link conditions offered by different transceivers and establish wireless connections with individual transceivers based at least upon said wireless link conditions.

3. The medical telemetry system according to claim 2, wherein at least one remote telemeter of the plurality of remote telemeters maintains wireless connections with at least two different transceivers at-a-time, and transmits the physiologic data of a respective patient to the at least two different transceivers to provide at least spacial diversity.

4. The medical telemetry system according to claim 2, wherein the remote telemeters communicate with the transceivers using a TDMA protocol, and the at least one remote telemeter transmits the physiologic data to the at least two different transceivers during different respective TDMA timeslots to thereby additionally provide time diversity.

5. The medical telemetry system according to claim 4, wherein the at least one remote telemeter transmits the physiologic data to the at least two different transceivers on different RF frequencies, the different RF frequencies spaced sufficiently apart to provide frequency diversity.

6. The medical telemetry system according to claim 1, wherein the transceivers forward the physiologic data to the at least one monitoring station over a local area network.

7. The medical telemetry system according to claim 1, wherein at least two of the transceivers communicate with the remote telemeters on the same RF channel.

8. The medical telemetry system according to claim 7, wherein the at least two transceivers which communicate on the same RF channel are sufficiently spaced apart to avoid interference with one another.

9. The medical telemetry system according to claim 1, wherein at least some of the transceivers of the plurality of transceivers are synchronized with one another.

10. The medical telemetry system according to claim 1, wherein different subsets of the plurality of transceivers are connected to respective concentrator computers, each concentrator computer receiving physiologic data from a respective subset of transceivers and forwarding the physiologic data to the at least one monitoring station.

11. The medical telemetry system according to claim 10, wherein the concentrator computers are interconnected by a local area network.

12. The medical telemetry system according to claim 11, wherein the local area network comprises a plurality of monitoring stations which display the real-time physiologic data of the patients.

13. The medical telemetry system according to claim 1, wherein the remote telemeters communicate with the transceivers using a TDMA protocol, and at least one of the transceivers broadcasts timeslot availability messages to the

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remote telemeters, the timeslot availability messages indicating available and unavailable TDMA timeslots for communicating with the at least one transceiver.

14. The medical telemetry system according to claim 13, wherein different transceivers of the plurality broadcast timeslot availability messages to the remote telemeters on different RF frequencies.

15. The medical telemetry system according to claim 1, wherein the plurality of transceivers communicate with the plurality of remote telemeters within a VHF medical telemetry band.

16. The medical telemetry system according to claim 1, wherein at least one of the remote transceivers maintains wireless connections with multiple remote telemeters at-a-time.

17. The medical telemetry system according to claim 1, wherein at least one of the remote transceivers is positioned proximate to a known intermittent source of electromagnetic interference.

18. The medical telemetry system according to claim 17, wherein the at least one remote transceiver is positioned within a patient X-ray room.

19. The medical telemetry system according to claim 1, wherein at least some of the transceivers transmit patient location signals to the remote telemeters.

20. The medical telemetry system according to claim 1, wherein at least one remote telemeter of the plurality of remote telemeters includes a processor which executes a control program to implement a wireless communications protocol in which the remote telemeter transmits data packets to different transceivers during different timeslots, the control program configured to maintain wireless connections with at least two different transceivers at-a-time on at least two different RF channels, and to transmit data packets that contain like physiologic data to the at least two different transceivers to provide multiple simultaneous transmission paths for the transfer of the physiologic data between the remote telemeter and the monitoring station.

21. A method of transferring real-time physiologic data of a patient from a wireless remote telemeter to a receiving node of a network so as to provide protection against multi-path interference, the remote telemeter configured to attach to the patient, the method comprising:

providing first and second transceivers that are positioned within respective first and second patient areas of a medical facility, the patient areas being sufficiently close to one another so that the transceivers provide overlapping first and second coverage zones, each transceiver positioned remotely from and being connected to the receiving node;

transmitting a first data packet from the remote telemeter to the first transceiver during a first timeslot, the first data packet containing at least the real-time physiologic data;

transmitting a second data packet from the remote telemeter to the second transceiver during a second timeslot which is different from the first timeslot, the second data packet containing at least the real-time physiologic data;

forwarding the first and second data packets, respectively, from the first and second transceivers to the receiving node; and

selecting between the first and second data packets at the receiving node.

22. The method according to claim 21, wherein the first and second data packets contain respective error detection

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codes, and the step of selecting comprises evaluating the error detection codes at the receiving node to determine whether the first and second data packets were successfully received by the first and second transceivers.

23. The method according to claim 22, wherein the error detection codes comprise error correction codes.

24. The method according to claim 21, wherein the step of transmitting the first data packet is performed on a first frequency channel and the step of transmitting the second data packet is performed on a second frequency channel, the first and second frequency channels sufficiently different to provide frequency diversity.

25. The method according to claim 24, wherein the first and second frequency channels fall within a VHF medical telemetry band.

26. The method according to claim 21, further comprising sending either the first data packet or the second data packet from the receiving node to a patient monitoring station over a wired local area network.

27. The method according to claim 21, wherein the step of forwarding the first and second data packets to the receiving node comprises transmitting the packets over different respective wired connections.

28. The method according to claim 21, wherein the steps of transmitting first and second packets from the remote telemeter are repeated periodically to transmit the patient's ECG waveform data in real-time to the receiving node.

29. The method according to claim 21, further comprising:

positioning a third transceiver within a third patient area to provide a third coverage zone which overlaps with the first and second coverage zones, the third transceiver positioned remotely from and being connected to the receiving node; and

in response to patient movement away from the first patient area towards the third patient area, automatically establishing a connection between the remote telemeter and the third transceiver and terminating a connection between the remote telemeter and the first transceiver.

30. The method according to claim 29, wherein the step of establishing a connection with the third transceiver comprises sending a timeslot request message from the remote telemeter to the third transceiver.

31. The method according to claim 29, wherein the step of establishing a connection with the third transceiver comprises:

broadcasting a timeslot availability message from the third transceiver, the timeslot availability message indicating available and unavailable timeslots for communicating with the third transceiver; and

receiving the timeslot availability message with the remote telemeter, and evaluating the timeslot availability message to identify an available timeslot.

32. The method according to claim 29, wherein the first, second and third transceivers communicate with the remote telemeter on different respective frequency channels.

33. A medical telemetry system for monitoring patients of a medical facility, the system comprising:

a plurality of transceivers distributed throughout the medical facility such that different transceivers provide data reception coverage for different areas of the medical facility, the plurality of transceivers connected to a common data receiving node, at least some of the transceivers of the plurality operating on different radio frequency (RF) channels; and

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a wireless remote telemeter that is configured to be worn by an ambulatory patient, the remote telemeter including sensing circuitry for sensing physiologic data of the patient, the remote telemeter implementing a wireless communications protocol in which the remote telemeter transmits data packets to different transceivers of the plurality during different timeslots, and in which the remote telemeter maintains wireless connections with at least two different transceivers at-a-time on at least two different RF channels and transmits like physiologic data to the at least two different transceivers to provide multiple concurrent transmission paths for the transfer of the physiologic data from the remote telemeter to the receiving node.

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34. The medical telemetry system according to claim 33, wherein the remote telemeter implements a switch-over protocol in which the remote telemeter automatically connects to and disconnects from different transceivers of the plurality based on assessments of RF link conditions.

35. The medical telemetry system according to claim 33, wherein the physiologic data comprises ECG waveform data, and the remote telemeter transmits the ECG waveform data to the at least two different transceivers in real-time.

36. The medical telemetry system according to claim 32, wherein each transceiver is configured to concurrently receive the physiologic data of multiple patients from multiple telemeters.

* * * * *



United States Patent [19]

Fan et al.

[11] Patent Number: 5,959,577

[45] **Date of Patent:** Sep. 28, 1999

[54] METHOD AND STRUCTURE FOR DISTRIBUTION OF TRAVEL INFORMATION USING NETWORK

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[73] Assignee: Vectorlink, Inc., Fremont, Calif.

[21] Appl. No.: 08/924,042

[22] Filed: **Aug. 28, 1997**

[51] Int. Cl.⁶ G01S 5/02

[52] U.S. Cl. 342/357.13; 701/208

[58] **Field of Search** 342/357, 357.13;
701/208, 213

[56] **References Cited**

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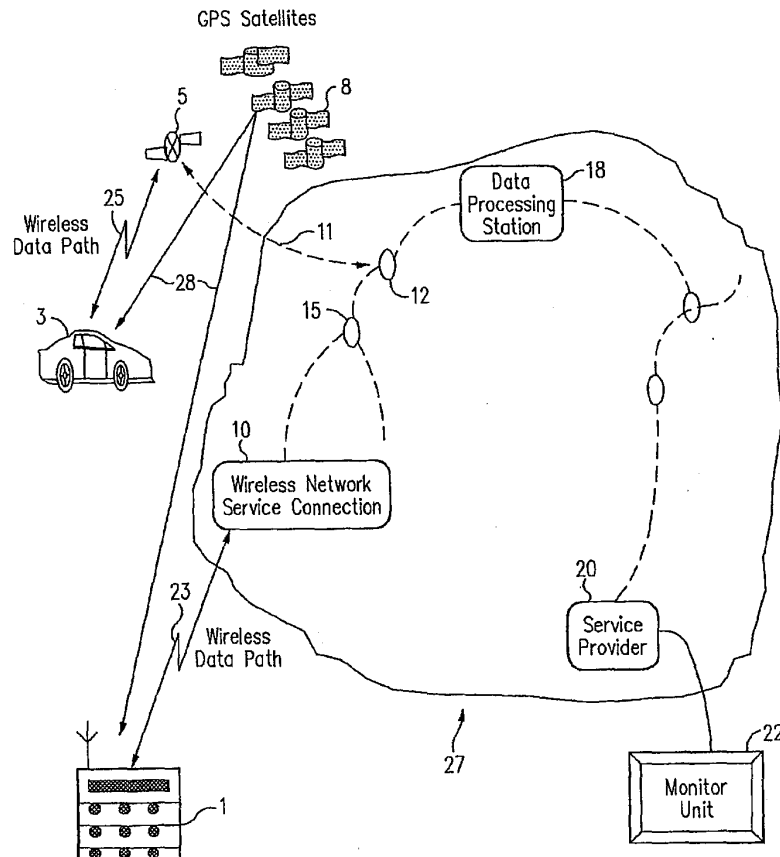
Primary Examiner—Mark Hellner

Attorney, Agent, or Firm—Skjerven, Morrill, MacPherson, Franklin, Friel LLP; Edward C. Kwok

[57] **ABSTRACT**

A method is provided for processing position and travel related information through a data processing station on a data network. In one embodiment, a GPS receiver is used to obtain a measured position fix of a mobile unit. The measured position fix is reported to the data processing station which associates the reported position to a map of the area. Typically, the measured position of the mobile unit is marked and identified by a marker on the map. The area map is then stored in the data processing station and made available for access by authorized monitor units or mobile units. An authorized monitor unit may request for a specific area map by sending a request through the data network. Upon receiving a request, the data processing unit sends the area map to the monitor unit. Data processing station may also perform a database search for travel-related information, such as directions to a gasoline station.

44 Claims, 8 Drawing Sheets



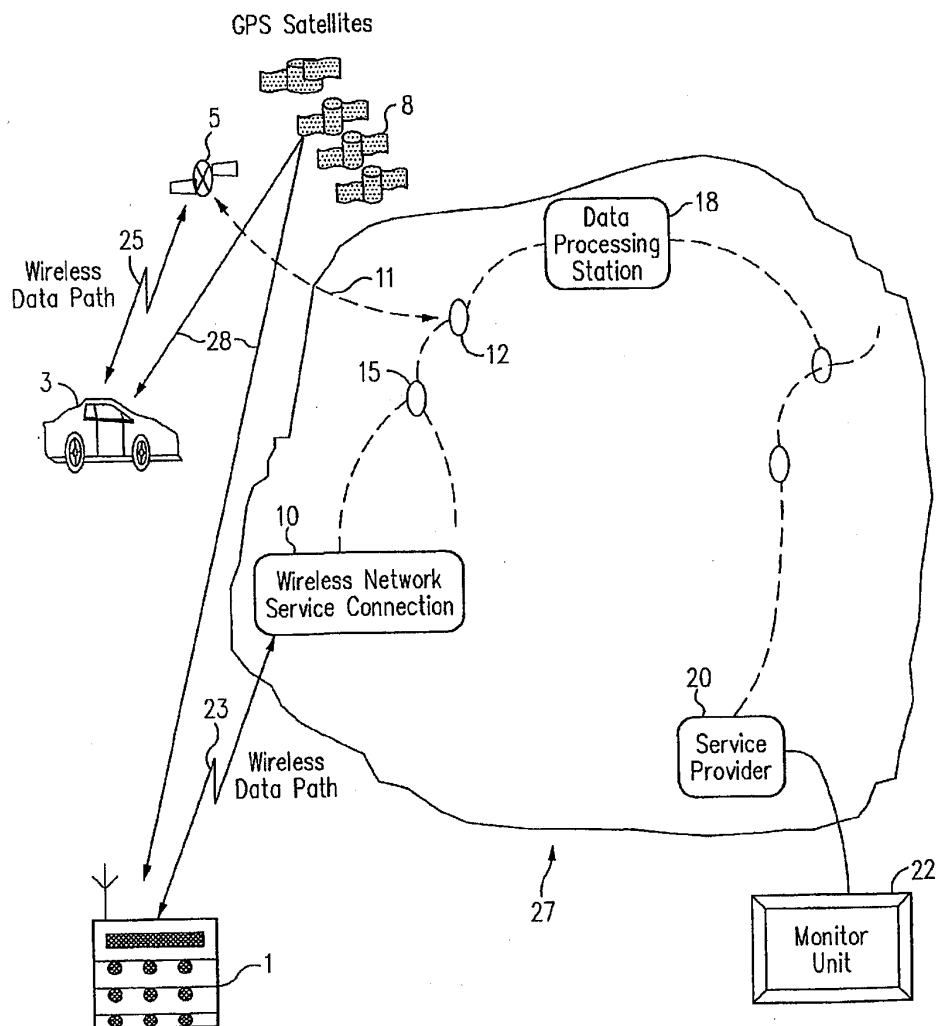


FIG. 1

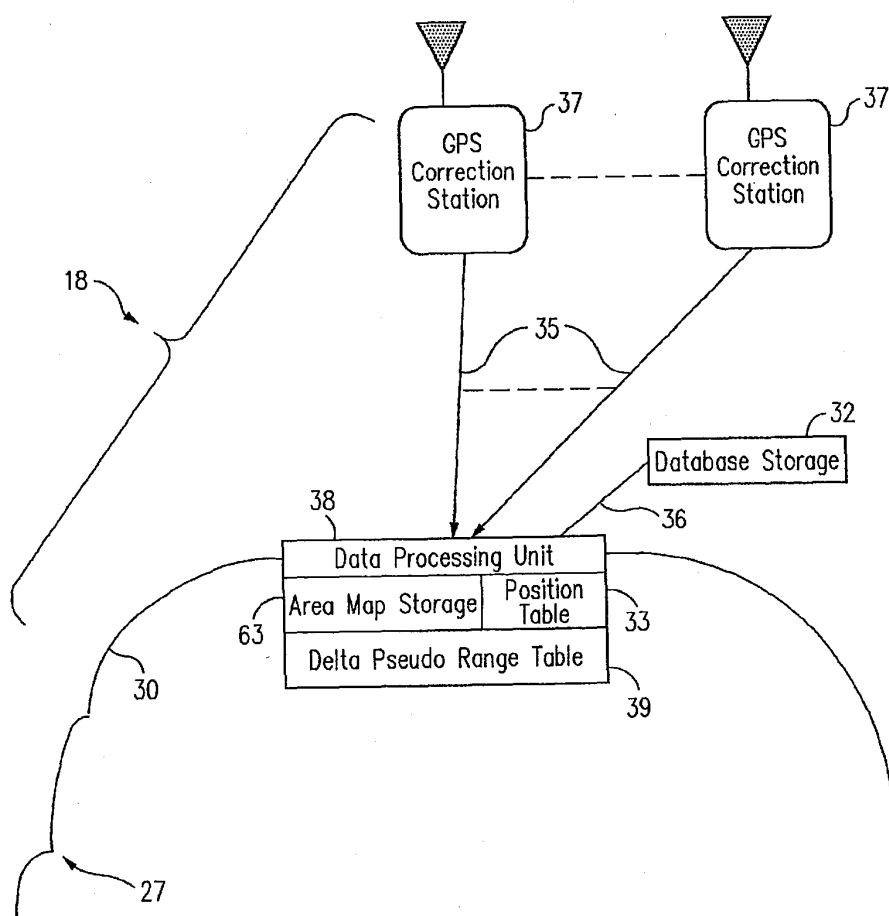


FIG. 2

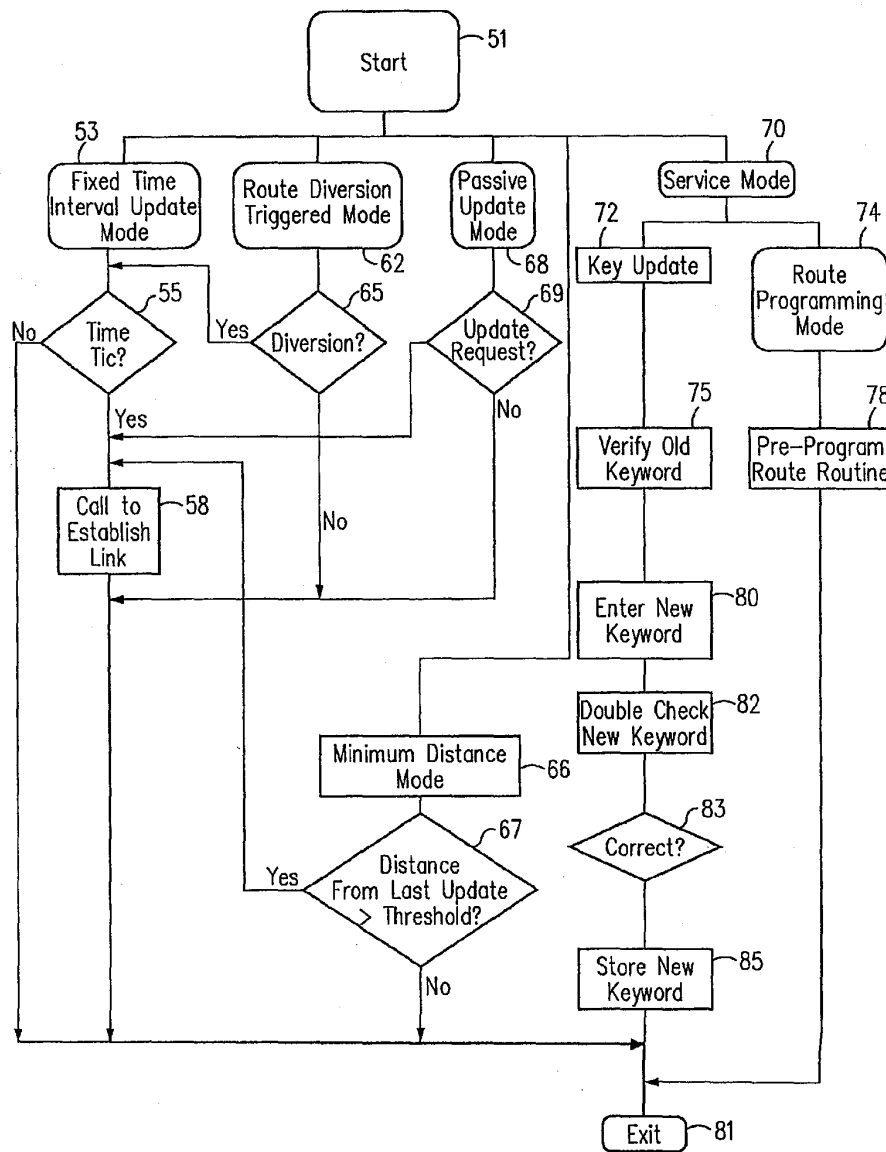


FIG. 3

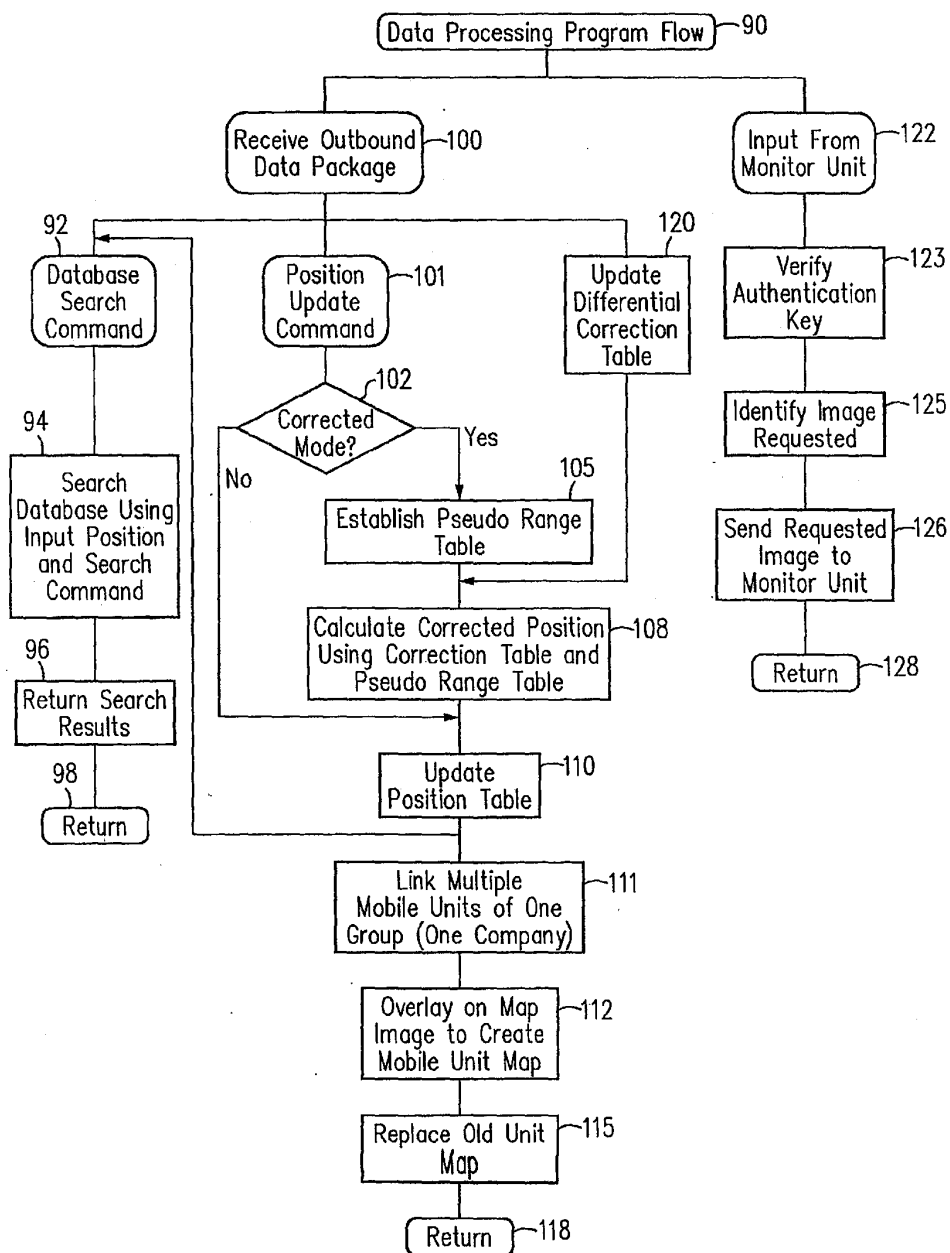


FIG. 4

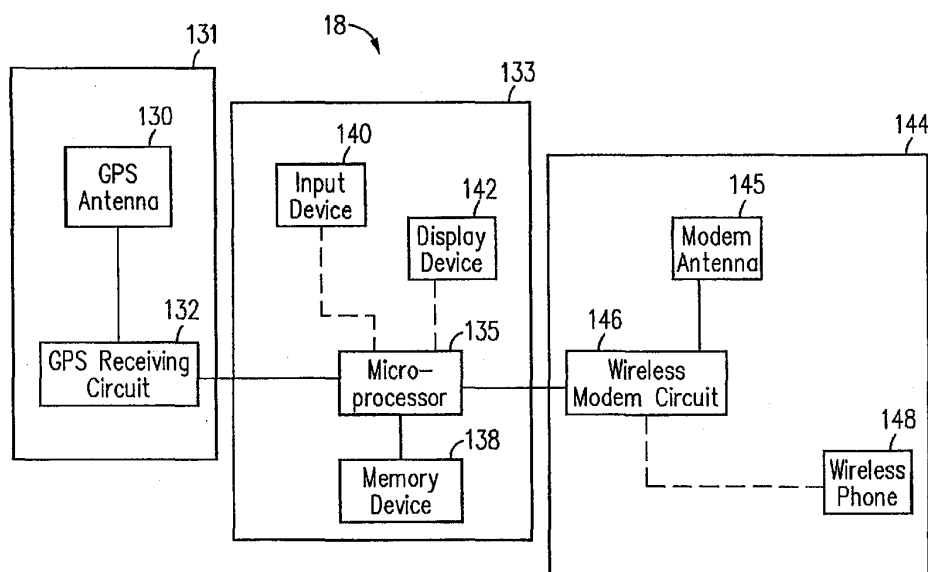


FIG. 5

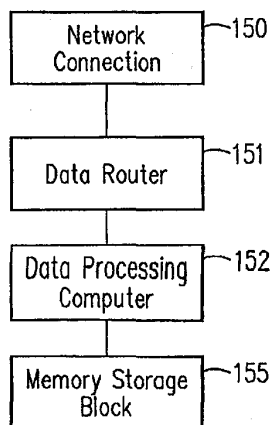


FIG. 6

160 ID	162 Time	165 Latitude	168 Longitude	170 Velocity
XX	XXX	XXXX	XXXX	XXX
**	*	**	**	*
	*	**	**	*

FIG. 7

172 ID	175 PR1, PR2, PR3, PR4, PR5, PR6, PR7, PR8							178 Time
MU1	X	X	X	X	X	X	X	1:00.00
MU1	-	X	X	X	X	-	X	1:00.10

FIG. 8

180 Area	186 DPR1, DPR2, DPR3, DPR4, DPR5, DPR6, DPR7, DPR8							188 Time
A	X	X	X	X	X	X	X	1:00.00
A	X	X	-	X	X	-	-	1:00.10
A	X	-	X	X	X	-	-	1:00.50

FIG. 9

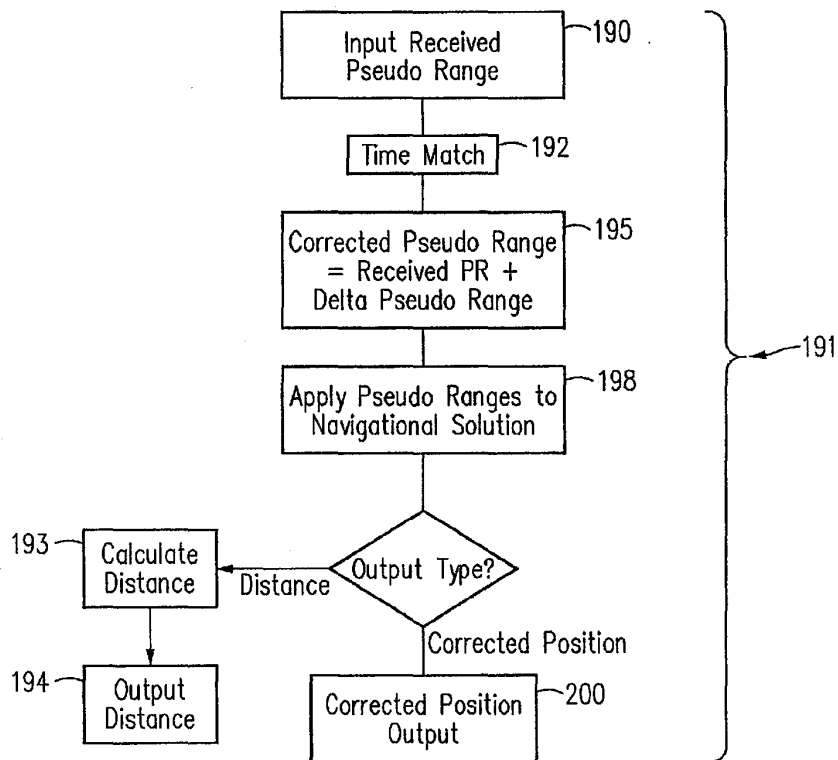


FIG. 10

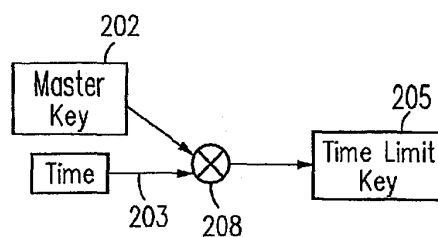


FIG. 11

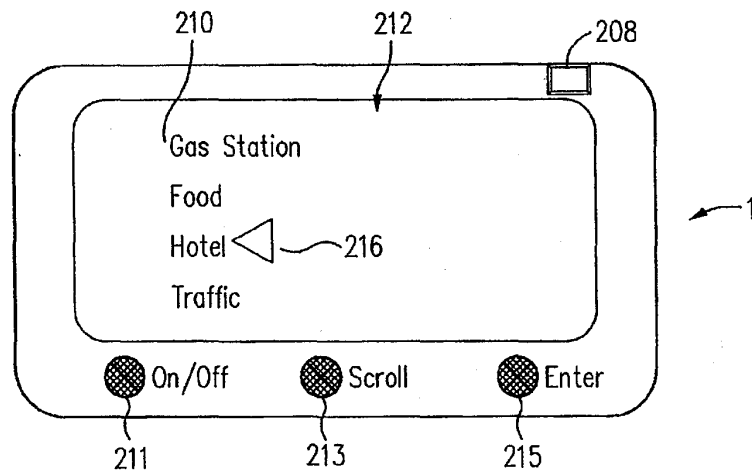


FIG. 12

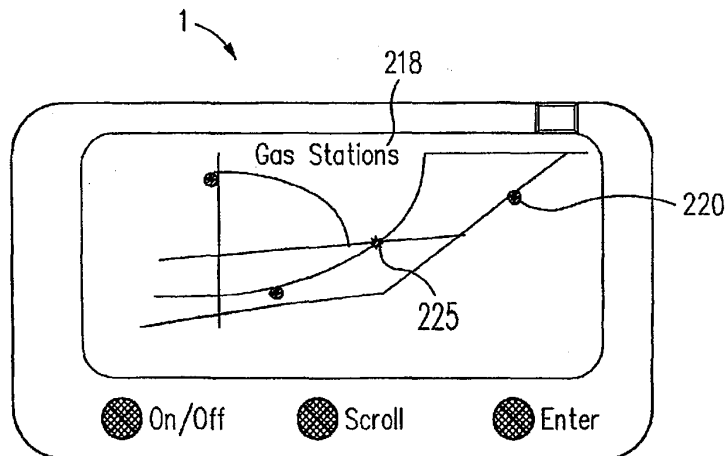


FIG. 13

METHOD AND STRUCTURE FOR DISTRIBUTION OF TRAVEL INFORMATION USING NETWORK

BACKGROUND OF THE INVENTION

1. Field of Invention

This invention relates to a system and a method for locating vehicles, and more particularly to a system and a method which use a data network, such as the Internet, to monitor vehicle movements and to transmit travel-related information to vehicles.

2. Description of the Related Art

The global position system ("GPS") is used for obtaining position information. A GPS receiver receives ranging signals from several GPS satellites, and triangulates these received ranging signals to obtain the measured position of the receiver. A more detailed discussion of a GPS receiver is found in U.S. patent application ("Copinging Application"), Ser. No. 08/779,698, entitled "Structure of An Efficient Global Positioning System Receiver," attorney docket no. M-4578, assigned to the present assignee. The Copending Application is hereby incorporated by reference.

One application of GPS is vehicle location. A conventional vehicle locating system typically includes one or more ground stations and many mobile units installed on the vehicles. In such a system, each mobile unit is equipped with a GPS receiver and a wireless transmitter. Using the GPS receiver, a mobile unit determines the position of the vehicle and then transmits the position directly to a ground station. The ground station receives the positions of all vehicles, and displays these positions on a digital map on a display device. The ground station of a conventional vehicle locating system normally also includes a map database search system, a media reader (e.g., a CD-ROM drive) and media (e.g., CD-ROMs) that store digital maps and travel-related information. Using the stored digital maps and positioning information received from the GPS satellites, the operator of the ground station can determine a present position for the vehicle.

The conventional vehicle locating system described above has several limitations. First, a direct wireless communication link between a vehicle and the ground station is required. Such a communication link is expensive, especially for long-distance communication. Further, special software must be installed on each ground station which adds to time and money costs. Thus a conventional vehicle locating system is impractical for a small company that has only a small number of vehicles.

Secondly, conventional vehicle location systems are not standardized. Typically, a company using a vehicle locating system must devise its own map software and create its own digital maps. The amount of information that is available on a conventional vehicle locating system is limited by the capacity of the storage system. In addition, information in such a system is often updated by creating a new CD-ROM. Statistical information, such as traffic condition and traffic patterns of the routes, is typically not available because each operation is independent and isolated from the other.

SUMMARY OF THE INVENTION

According to the present invention, a data network, such as the Internet, is involved in locating mobile units. In one embodiment of the present invention, using a GPS receiver, position information of a mobile unit is determined from positioning signals received from GPS satellites and pseudo-

ranges derived from the positioning signals. The GPS receiver triangulates the pseudo-ranges to obtain a measured position of the mobile unit. The measured position is then transmitted via a data network to a data processing station. The data processing station organizes the measured position and generates an area map which indicates by a position marker the position of each mobile unit. This area map is made available to one or more monitor units connected to the data network.

In another embodiment, using a GPS receiver, the mobile unit receives ranging signals from GPS satellites and calculates the pseudo-ranges to these satellites. These pseudo-ranges are then transmitted to the data processing station, where the measured position of the mobile unit is obtained through triangulation. Alternatively, the pseudo-range information is encrypted before transmission to the data processing unit to prevent unauthorized use. In another embodiment, the measured position is also corrected at the data processing station using differential correction data collected from a differential correction station installed in the same area where the mobile unit is located. A mobile unit may also send a request for a database search through the data network to the data processing station to obtain an area map or travel-related information.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a vehicle locating system which includes a data network 27, according to the present invention.

FIG. 2 illustrates a data processing station 18 in a vehicle location system of the present invention.

FIG. 3 illustrates a program flow in a mobile unit of the present invention.

FIG. 4 illustrates a program flow in a data processing unit of the present invention.

FIG. 5 is a block diagram of a mobile unit of the present invention.

FIG. 6 is a block diagram of a data processing unit of the present invention.

FIG. 7 represents one implementation of position table 33.

FIG. 8 illustrates a pseudo-range table 40 for indicating the pseudo-ranges of a mobile unit over a period of time.

FIG. 9 represents one implementation of delta-pseudo-range table 39, containing delta-pseudo-ranges obtained from various service areas.

FIG. 10 illustrates the logic flow of a differential correction process according to the present invention.

FIG. 11 illustrates a process for generating a time-limited key from a master key and a specified duration.

FIG. 12 illustrates one display in a mobile unit according to the present invention.

FIG. 13 illustrates one display in a mobile unit according to the present invention, specifically displaying a map with travel information overlaid thereon.

DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 illustrates a system of the present invention which includes a data network. As shown in FIG. 1, a vehicle locating system according to the present invention includes GPS satellite constellation 8, data network 27 with nodes 5, 10, 12 and 15, data processing station 18, monitor unit 22, and mobile units 1 and 3. Mobile unit 1 is a portable (e.g., handheld) device while mobile unit 3 is installed in a vehicle. Mobile units 1 and 3 each include a GPS receiver,

a transmitter for transmitting messages to the data network, and a microprocessor. Each mobile unit can also be provided a data receiver for receiving messages from the data network. Mobile units may fall into different groups, which requires different handling procedures. For example, it may be convenient to group moving companies separately from taxi companies. Monitor units perform system-wide or regional control and data-gathering functions. The following description uses mobile unit 1 as an example of the mobile units of the present invention.

The mobile unit of the present invention allows a user to report his/her position and to obtain travel-related information over a data network. Travel-related information includes such information as directions to reach a destination (e.g., a gas station, a hotel, or a restaurant), or traffic conditions in the immediate vicinities of concern. Using a GPS receiver, mobile unit 1 receives a positioning signal which contains code sequences from GPS satellite constellation 8 and converts the code sequences into pseudo-range information. When the operator of the mobile unit wishes to request the travel-related information, a query is sent in an outbound data package. The outbound data package includes the operator's query, the pseudo-ranges and a time-stamp indicating the time the pseudo-ranges were obtained. (In this detailed description, an outbound data package refers to a data package transmitted from a mobile unit.) A history showing the most recent positions of mobile unit 1 may also be included in the outbound data package. In this embodiment, data processing station 18 keeps track of the time since the last update. The outbound data package is then transmitted by the mobile unit's transmitter over wireless link 23 to a service connection 10 on data network 27, which relays the outbound data package to data processing station 18. Alternatively, instead of sending the pseudo-ranges as described above, mobile unit 1 obtains a "measured" position using a triangulation technique on the pseudo-ranges. This measured position of mobile unit 1 is then included in an outbound data package. The outbound data package also includes a position update request or query, together with the pseudo-ranges or the measured position. Mobile unit 1 reports its position either automatically, according to a predetermined schedule, or manually, through commands entered by an operator into the mobile unit. Wireless communication between the mobile unit and data network can be accomplished, for example, using a cellular digital packet data (CDPD) modem or via satellite.

FIG. 2 illustrates a data processing station 18 of the present invention, including a data process unit 38 which handles the computation at data processing station 18. If data processing station 18 receives an outbound data package which includes a measured position of the mobile unit (presumably the position of the vehicle), the measured position is entered into a position table 33 (FIG. 2). If the outbound data package includes pseudo-ranges, however, data processing station 18 obtains the measured position of the mobile unit for position table 33 by applying triangulation technique on the pseudo-ranges.

Alternatively, data processing station 18 can also use pseudo-ranges in conjunction with differential correction information, or delta-pseudo-ranges. The delta-pseudo-ranges, which are obtained by data processing unit 38 from correction stations (e.g., correction stations 37) and stored in a delta-pseudo-range table (e.g., delta-pseudo-range table 39 of FIG. 2), are correction factors for the geographical area in which the mobile unit is currently located. Data processing unit 38 can connect to correction stations 37 via wired or wireless communication links, or via a data network, such as

data network 27. The position of a differential correction station is precisely known. Typically, a differential correction station serves an area 200 miles in diameter. In the present embodiment, a differential correction station in each of the vehicle locating service's service areas is desired. The delta-pseudo-ranges are used in conjunction with the pseudo-ranges received from satellite constellation 8 to provide a corrected measured position of the mobile unit. The corrected measured position is then stored in position table 33 (FIG. 2).

A differential correction station receives code sequences from GPS satellite constellation 8 (FIG. 1) to obtain a first set of pseudo-ranges based on the received code sequences. The differential correction station then calculates a second set of pseudo-ranges based on its known position and the relative positions of the satellites in satellite constellation 8. Delta-pseudo-ranges are then computed using the two sets of pseudo-ranges. These delta-pseudo-ranges are provided to data processing unit 38, and stored in delta-pseudo-range table 39 for computing corrected measured positions of the mobile units. Alternatively, correction to the measured position can also be achieved using positional corrections, rather than delta-pseudo-ranges. To obtain a positional correction, a differential correction station receives GPS positioning code sequences, and obtains, based on the received code sequences, a measured position of its own position expressed in terms of the longitude and latitude. This measured position (called a "fix") is compared to the precisely known position of the differential correction station to obtain the positional correction expressed in a delta-longitude quantity and a delta-latitude quantity. To use these delta-longitude and delta-latitude quantities to find a corrected measured position of mobile unit 1, the pseudo-range obtained by mobile unit 1 is first used to triangulate a measured position to obtain a raw position expressed in a raw longitude and a raw latitude. The corrected longitude for the mobile unit is this raw longitude plus the applicable delta-longitude obtained by the differential correction station in the vicinity. Likewise, the corrected latitude is the raw latitude of the mobile unit plus the delta-latitude computed by the differential correction station in the vicinity.

In addition to computing the corrected measured position, data processing station 18 searches a database 32 and associated area map storage 63 to process the operator's query received in the outbound data package. Database 32 maintains such travel-related information as maps, traffic situation in a particular area, positions of service stations and destinations of interest. Storage for database 32 can be implemented using any mass storage media, such as hard disks, RAMs, ROMs, CD-ROMs, and magnetic tapes. For example, infrequently updated information (e.g., maps or destinations of interest) can be stored on CD-ROMs, while frequently updated information (e.g., current traffic conditions) can be stored on RAM. Database 32 is accessed by data processing unit 38.

Position table 33 stores the last known measured positions of the mobile units in the system. The measured position stored in positions table 33 can be used for compiling vehicle position maps by monitor units 22 (FIG. 1). FIG. 7 represents one implementation of position table 33. Position table 33 contains the measured positions of several mobile units, identified respectively by an identification number 160, at particular times 162. The measured position of each mobile unit is represented by a time-stamp 162, a measured latitude value 165, a measured longitude value 168, and a velocity 170.

Delta-pseudo-range table 39 stores the delta-pseudo-ranges of each service area. FIG. 9 represents one imple-

mentation of delta-pseudo-range table 39 used by data processing station 18 (FIG. 1). As shown in FIG. 9, delta-pseudo-range table 39 maintains the delta-pseudo-ranges 186 of each service area (indicated by identification 180) from each of a group of satellites at each of the specified times 188. Each value of the delta-pseudo-range data 186 indicates the delta-pseudo-range to a particular satellite. Area map storage 63 stores area maps with position markers indicating the mobile units and landmarks. The response to the query can be in text, graphical or audio form. If the query is for directions, for example, a map including the measured position or corrected measured position and the position of the destination is retrieved. Typically, a position marker is provided to identify the position of the requested destination. The map and a result of the database search (i.e., a response to the operator's query) are then packaged into an inbound data package, which is transmitted to mobile unit 1 through data network 27 via network connection 10 and wireless link 23. (In this detailed description, an inbound data package refers to a data package received by a mobile unit or a monitor unit.)

Instead of computing the corrected measured position at data processing station 18, a microprocessor in mobile unit 1 can also be used to compute a corrected measured position from pseudo-range information the mobile unit received from satellite constellation 8 and delta-pseudo-range information received from data processing station 18. Under this arrangement, instead of the measured corrected position, data processing station 18 includes in the inbound data package the delta-pseudo-ranges for the current position of mobile unit 1. In any event, upon receiving the inbound data package, mobile unit 1 displays on its screen the corrected measured position and the position of the destination, typically by overlaying the positions on the map received, along with the response to the query. For example, if the operator requests directions to a nearby gas station, a position marker identifying the gas station and a position marker identifying the mobile unit's current position are displayed on the map, together with the response to query (i.e., directions as to how to get to the gas station). The response to the query can be a text description or a graphical representation of the directions placed next to or overlaying the map. Alternatively, instead of sending the map the positions and the response to query in the inbound data package, data processing station 18 can provide in the inbound data package a picture file of the map, with the markers and the response to the query already embedded. Special markers can be used for indicating interesting conditions. For example, a mobile unit that has been stationary for a predetermined period of time can be marked by a special marker to signal monitor units of an exceptional condition. The picture file is then simply displayed by mobile unit 1.

Data network 27 can be a wide area data network, such as the Internet, or a telephone network, including wired or wireless communications, or both. Data network 27 can also be accessed via a satellite link. For example, in FIG. 1, satellite 5 provides access to data network 27, communicating with mobile unit 3 through a wireless communication channel 25. Satellite 5 allows the present invention to be used in a remote area where other forms of transceivers, such as cellular phone transceiver stations, are expensive to implement. In one embodiment, the inbound and outbound data packages are encrypted for security. One method of image encryption and decryption that can be used for this application is described in U.S. Pat. No. 5,541,993 by Eric Fan and Carey B. Fan, July 1996. This disclosure of U.S. Pat. No. 5,541,993 is hereby incorporated herein by refer-

ence. Service connection 10 can be a commercial transceiver station such as a cellular phone transceiver station. In another embodiment, service connection 10 is a dedicated transceiver station for the handling of communication related to the present invention.

In the embodiment shown in FIG. 1, another set of terminals (e.g., monitor 22) are provided in some applications to monitor the activities of the mobile units. For example, a monitor unit may send a request together with a mobile unit identification to data processing station 18 to obtain the measured position and speed of a specified mobile unit. One application for this capability can be found, for example, in a trucking company interested in tracking the positions of its fleet of trucks for scheduling and maintenance purposes. Monitor unit 22 can be a fixed unit or a portable unit. A portable monitor unit 22 is equipped with a wireless transceiver for accessing data network 27 via service provider 20 or wireless network service connection 10. Monitor unit 22 may also communicate with mobile unit 1 through data network 27 using a message exchange protocol. For example, monitor unit 22 may send a special command to mobile unit 1, and mobile unit 1 may send a message addressed to monitor unit 22. In one example the message communicated between mobile unit 1 and monitor unit 22 is in the form of an electronic mail message. Of course, the communication between monitor unit 22 and mobile unit 1 can be encrypted for security or to prevent unauthorized use. Monitor unit 22 also displays the elapsed time since the last position update graphically (data collected by data processing unit). The elapsed time can be represented graphically as a color code, grades of shade, a flashing interval, or any suitable symbolic representation.

When the Internet is used as data network 27, data processing station 18 is a node on the Internet and is assigned an Internet address. Monitor unit 22 can include a computer installed with a conventional web browser. The Internet address of data processing station 18 is used by the monitor unit for communicating with data processing unit 18.

A land based vehicle normally travels a limited distance during a short time period. On the other hand, an area map showing the location of the vehicle is only useful when the vicinity of the vehicle is also shown. Consequently, a vehicle is often located in the area covered by the same map for the period of several position updates. This principle can be utilized to reduce the amount of data transmitted and thus improve the efficiency of the system.

According to the present invention, a plugin program for a web browser can be installed in monitor unit 22. During each location update, the plugin program downloads the new location of the vehicle and compares the new location with the area map stored in monitor unit 22. If the new location of the vehicle is within the boundary of the area map, a new location marker representing the vehicle is overlaid on the area map. If the location of the vehicle is outside the boundary of the area map, a new area map is downloaded and the location of the vehicle is marked on the new area map. The plugin program can be downloaded over the Internet from the vehicle location service provider, or can be loaded directly from software storage media.

FIGS. 12 and 13 shows one implementation of mobile unit 1 adapted for allowing an operator to send a travel-related query under the present invention. As shown in FIG. 12, mobile unit 1 includes liquid crystal display (LCD) 212, transceiver/antenna assembly 208, power switch 211, a scroll key 213, and an "enter" key 215. Scroll key 213 and

enter key 215, in conjunction with a software-generated command menu 210 displayed on LCD 212, allow the user to enter simple commands, such as the travel-related query described above. For example, as shown in FIG. 12, command menu 210 shows selections "gas station," "food," "hotel", and "traffic". By pressing scroll key 213, an operator of mobile unit 1 causes a cursor 216 to step through the selections. When the operator presses enter key 215, an outbound data package including the query or command is transmitted by transceiver/antenna assembly 208 to processing station 18. In this embodiment, as shown in FIG. 13, the response from data station 18 is received in mobile unit 1 through transceiver/antenna assembly 208 and displayed on LCD 212. In this instance, the query sent to data station 18 corresponds to the selection of "gas station". In FIG. 13, data processing station 18 returns to mobile unit 1, in an inbound data package, a map which is displayed on LCD 212, showing the vicinity of mobile unit 1. Mobile unit 1's position is indicated on LCD 212 by a marker 225. The locations of several gas stations, indicated by markers 220 are also displayed.

FIG. 3 is a flow diagram showing the operation of mobile unit 1 (FIG. 1). At step 51, one of four modes of operation is selected: periodic update mode 53, route diversion triggered mode 62, passive update mode 68, minimum distance mode 66 and service mode 70. Under periodic update mode 53, mobile unit 1 periodically reports pseudo-ranges of its position to data processing station 18, so as to update the measured position of mobile unit 1 stored at data processing station 18. Under route diversion triggered mode 62, mobile unit 1 reports its position only upon a diversion from a pre-programmed route or a diversion from a predetermined time schedule. Under update mode 68, the position of mobile unit 1 is reported under an operator's control. Service mode 70 is not an operating mode, but is used to program mobile unit 1.

Under periodic update mode 53, at step 55, mobile unit 1 waits for the next scheduled position update. At the time of a scheduled update, i.e., at step 58, mobile unit 1 calls to establish network service connection 10 for accessing data network 27, and transmits to data processing station 18 an outbound data package. Upon receiving the outbound data package, data processing station 18 responds to the operator's query by searching database 32, updating a map retrieved from map storage 63, and transmitting the map to mobile unit 1 an inbound data package.

Under route diversion triggered mode 62, the measured position of mobile unit 1 is obtained at the mobile unit using pseudo-range data without differential correction. At step 65, this measured position is compared with a pre-programmed route and a schedule. If the current position is a substantial deviation from the pre-programmed route or from the schedule, mobile unit 1 branches to step 55 to create a service connection 10 for performing the update described above at the next scheduled reporting time.

Under passive update mode 68, a measured position update occurs when an operator issues an update request in an outbound data package. At step 69, when an operator initiates an update request, mobile unit 1 branches to step 58 to create network service connection 10. An outbound data package including the update request is transmitted via network service connection 10 to data processing station 18 over data network 27.

Under minimum distance mode 66, the distance traveled since the last update must exceed a threshold value before a new update is issued. Step 67 compares the distance traveled since the last update with the threshold value.

Under service mode 70, an operator of mobile unit 1 can effectuate two major functions: route programming function 74 and password update function 72. In route programming function 74, the operator of mobile unit 1 enters a new route to replace a pre-programmed route in mobile unit 1. In this description, a "route" connotes not only a series of physical coordinate sets marking the path of a vehicle, but also the time at which the vehicle is scheduled to arrive at or depart from each set of physical coordinates. In this embodiment, to operate mobile unit 1, an operator must first be verified by supplying a password. The password can be modified under user password update mode 72. At step 75, the operator provides the current password to identify himself/herself, and to obtain authorization to modify the password. Typically, mobile unit 1 requests the operator to enter the new password twice to ensure that the new password is correctly entered. At step 85, the successfully entered new password is written into storage, thereby superseding the old password.

FIG. 4 illustrates a flow diagram of a data processing program used by data processing station 18 (FIG. 1). Beginning at step 90, data processing station 18 receives either an outbound data package (step 100) or a command from a monitor unit (step 122), such as monitor unit 22. If the received outbound data package includes a position update request (step 101), the data processing program determines at step 102 whether a corrected measured position update is requested. If a corrected measured position update is requested (step 105), the data processing program obtains the pseudo-ranges from the outbound data package and enters them into a pseudo-range table. An example of a pseudo-range table is provided in FIG. 8. As shown in FIG. 8, pseudo-range table 40 includes one entry for each mobile unit. Each entry of pseudo-range table 40 includes an identification 172, pseudo-ranges (175) of the mobile unit to 8 satellites (PR1-PR8), and a time-stamp 178, indicating the time at which the pseudo-ranges are taken.

FIG. 10 is a flow diagram of one implementation of a differential correction process 191. As shown in FIG. 10, at step 190, the pseudo-ranges of a mobile unit are either received from an outbound data package or retrieved from pseudo-range table 40 of FIG. 8. At step 192, all delta-pseudo-ranges from delta-pseudo-range table 39 are examined to find the delta-pseudo-ranges from a differential correction station in the mobile unit's service area, and which have a time-stamp closest to the time-stamp of the pseudo-ranges of the mobile unit sending the query. At step 195, the corrected pseudo-ranges for the mobile unit are obtained by adding to the pseudo-ranges of the mobile unit corresponding delta-pseudo-ranges. The corrected measured position of the mobile unit is then calculated at step 198 using the corrected pseudo-ranges. At step 199, if it is decided that a corrected position is desired, the corrected position is provided at step 200. If it is decided at step 199, on the other hand, that a distance to a known position is desired, then the distance is calculated at step 193, and is provided as output at step 194.

Returning to FIG. 4, at step 120, data processing program retrieves from delta-pseudo-range table 39 a set of delta-pseudo-ranges for the mobile unit taken at the same time and in the same service area the pseudo-ranges of the requesting mobile unit were taken. At step 108, the data processing program computes the corrected measured position using the pseudo-range and delta-pseudo-range information obtained at steps 101 and 120. If a corrected measured position is not requested, steps 105 and 108 are skipped, and the data processing program enters the measured position of the mobile unit into position table 33.

At step 111, the data processing program links in database 32 the reporting mobile unit's updated measured position entry in position table 33 with the measured position entries of other mobile units in the reporting mobile unit's group. At step 112, in this embodiment, the measured positions of the mobile units in one linked group are associated with (or "overlaid on") a digital map, so that the positions and the identification of all vehicles of that group can be represented by position markers and text on the map. Such a map allows a manager of a group of vehicles to conveniently monitor the activities of the vehicles. At step 115, the updated position of the mobile unit and the newly created associations among the mobile units and the digital map are replaced in database 32. The data processing program then returns to step 90 to receive the next outbound data package or command.

As mentioned above, an outbound data package can contain a query for a database search, e.g. a request for directions to a nearby restaurant. When such a query is identified (step 92), database 32 is searched for formulating a response at step 94. To formulate the response, the data processing program uses the measured position of the requesting mobile unit and other relevant positional information. The response is returned in an inbound data package to the requesting mobile unit at step 96.

The data processing program can also receive a request from monitor unit 22. Typically, such a request is provided with an authentication key over data network 27 (FIG. 1). At step 123, the authentication key, hence the identity of the requesting monitor unit, is verified. The authentication key allows the requesting monitor unit access to the records of a specific mobile unit or a specific group of mobile units. To enhance security, authentication keys can be made time-limited, i.e., each authentication key is valid only for a specified duration. FIG. 11 shows a process for making a time-limited key. As shown in FIG. 11, using a mixing function represented by reference numeral 208, a master key 202 (which identifies the owner) is mixed with a value representing a time duration 203. The resulting value 205 serves as a time-limited authentication key over the specified time duration. Security is enhanced since forging a valid time-limited authentication key requires both knowledge of the master key and the value representing the time duration for which the key is valid.

At step 125, if the verification is successful, the data processing program responds to the request. In one embodiment, a digital map (e.g., the one created above at step 112) providing the positions of a group of vehicles is returned at step 126 to the requesting monitor unit.

FIG. 5 is a block diagram of a mobile unit, such as mobile unit 1. As shown in FIG. 5, mobile unit 1 has three functional sections: GPS receiving section 131, control section 133, and communication section 144. GPS receiving section 131 includes GPS antenna 130 for receiving and providing GPS ranging signals to receiving circuit 132, which processes the received GPS ranging signals to obtain a pseudo-range to each of the GPS satellites within mobile unit 1's line of sight. Control section 133 includes a microprocessor 135, input device 140, display device 142, and memory device 138. Input device 140 is an optional feature which allows commands and requests to be entered. Input device 140 can be a keyboard, a mouse, a track ball, a pressure sensitive display panel, or any combination of these and other input devices. Display device 142 is also an optional device, which is used to provide visual responses to entered commands and requests, and to display relevant information (e.g. query response from data processing unit 18, or a command from monitor unit 22). The pseudo-ranges from

GPS receiving section 131 are provided to control section 133, where the pseudo-ranges are combined with an update request or a query in an outbound data package for data processing station 18. The outbound data packages are transmitted to data processing station 18 by wireless transceiver section 144. Wireless transceiver section 144 includes a wireless modem circuit 146 with an antenna 145 or, alternatively, a wireless telephone network interface 148. Wireless modem circuit 146 receives an outbound data package from control section 133 for transmission to data network 27 through modem antenna 145 and a wireless network service connection, such as service connection 10 (FIG. 1). Alternatively, wireless modem circuit 146 provides the outbound data package to data network 27 over wireless telephone network interface 148 via service connection 10. Depending on the application, control section 133 may or may not be programmed for receiving an inbound data package from wireless transceiver 144. For example, if mobile unit 1 is used only for reporting position, control section 133 need not be programmed to receive inbound data packages.

FIG. 6 is a block diagram of a data processing unit, e.g. data processing unit 38 of FIG. 2. Data processing unit 38 includes a network interface 150 for interfacing data processing unit 38 with data network 27, a data processing computer 152 for providing the computational power for processing operator query and performing position update requests, and a memory system 155. A data router 151 can be provided between network interface 150 for connecting data processing computer 152 to a local area network.

The principles of the present invention can be applied to a wide variety of services. For example, a courier service company may provide a mobile unit to each of its delivery persons. A delivery person may use the mobile unit to obtain directions to a destination. A time-limited key may be issued to a customer, who can then use the time-limited key to track the delivery of his/her package through data processing station 18. In this instance, the customer plays the role of monitor unit 22 described above. As described above, monitor unit 22 may access data processing station 18 through the Internet. With the time-limited key, the customer can obtain the present position of the package, monitor the performance of the courier company, and estimate the expected arrival time of the package at the destination. Further, the customer may also send additional or alternative instructions to the delivery person (e.g., he/she may instruct the delivery person to abort the delivery, or to re-route the package to a new destination). The time-limited key issued to the customer expires when the package is delivered, or when a certain amount of time has passed.

The present invention allows even small companies with limited resources to have the benefits of a vehicle locating system, even when the vehicles tracked are few and scattered over a large geographical area. Since a data network, such as the Internet, is used in the present invention, the hardware investment for such use is minimal, as compared to prior art vehicle location systems.

As another example, a vehicle rental company may install mobile units on its vehicle fleet. The speeds and measured positions of these vehicles can thus be monitored using a monitor unit. In yet another example, a metropolitan bus company may install mobile units on its buses, and set the mobile units to route diversion triggered mode 62 discussed in conjunction with FIG. 3 above. When a bus is not running according to schedule, or deviates from a designated route, the mobile unit signals a dispatcher immediately. Timely remedial measures can thus be carried out.

In another application of the present invention, pseudoranges or measured position information transmitted from mobile units are used to calculate the speeds at which the vehicles travel. This information is compiled into database 32 at data processing station 18, and made available for access through monitor units, such as monitor 22. Such information allows shipping companies to route their vehicles away from traffic congestions and diversions. Radio stations or television stations can access this database from which to report traffic conditions. The information can also be used by municipal authorities in studying traffic patterns of selected vicinities to assist in planning new infrastructures.

When the Internet is used as data network 27 (FIG. 1), the necessary hardware and software for implementing a monitor unit are readily available. Most computers that have the ability to access the Internet, together with a standard web browser, can be used to access data processing station 18 to perform the functions of the monitor units described above. Since a monitor unit can receive a map from data processing station 18, such as the map displayed on LCD 212 in FIG. 13, which can be displayed using conventional graphics software, the monitor unit is not required to be equipped with any special map software or a map database. Because the cost of communication on Internet is inexpensive, a vehicle monitoring system according to the present invention can be deployed on a world-wide basis at minimum cost. With increased bandwidth in data network 27, the present invention can also be used in aircrafts, ships and other vessels for navigational purposes. Therefore, even though the present invention is described using the above examples, the scope of the invention is not limited by these examples. Numerous variations and modifications are possible within the scope defined by the following claims.

We claim:

1. A vehicle locating system comprising:
 - a data processing station connected to a data network accessible by wireless communication, said data processing station having a database including maps; and
 - a mobile unit including a global positioning system (GPS) receiver and a wireless transmitter, said receiver receiving positional information from GPS satellites and transmitting said positional information to said data processing station via said data network; wherein when said data processing station receives said positional information, said data processing station computes a measured position for said mobile unit, stores said measured position of said mobile unit in said database, associates said measured position of said mobile unit with a map in said database, creates from said map a second map embedded therein a marker indicating said measured position of said mobile unit, and provides said second map for display through a data network.
2. A vehicle locating system as in claim 1, further comprising a monitor unit accessing said data processing station via said data network for said positional information of said mobile unit.
3. A vehicle locating system of claim 1, wherein said mobile unit transmits said positional information to said data processing station using an encryption.
4. A vehicle locating system of claim 1, wherein said positional information includes a time-stamp indicating the time when the positional information was received.
5. A vehicle locating system of claim 2, wherein said data processing station associates said measured position of said mobile unit with a map in said database.
6. A vehicle locating system of claim 1 further comprising a monitor unit, wherein said second map is provided to said monitor unit for display.

7. A vehicle locating system of claim 6, said mobile unit further including a display device, said mobile unit displaying graphically an elapsed time since its last transmission of said positional information to said data processing unit.

8. A vehicle locating system of claim 7, wherein monitor unit displays said elapsed time using a symbolic representation.

9. A vehicle locating system of claim 1, wherein said data processing unit receives correctional data from a differential correction data source, wherein said data processing station computes a corrected measured position of said mobile unit using said correctional and said positional information received from said mobile unit.

10. A vehicle locating system of claim 1, wherein said mobile unit transmits said positional information to said processing data station at predetermined time intervals.

11. A vehicle locating system of claim 1, wherein said data processing station marks in said map a mobile unit that remains stationary over a predetermined time period with a symbol indicating an exceptional condition.

12. A vehicle locating system of claim 2, wherein said data processing station verifies communication from a monitor unit by an authentication scheme.

13. A vehicle locating system of claim 1, wherein said mobile unit is assigned a route, wherein said mobile unit transmits said positional information to said data processing station when said mobile unit deviates from said assigned route.

14. A vehicle locating system of claim 1, wherein said data network comprises a publicly shared network such as the Internet.

15. A vehicle locating system of claim 14, wherein said data processing station receives said positional information from a plurality of mobile units, and wherein said data processing station compiles statistical data from said positional information received from said mobile units.

16. A vehicle locating system of claim 15, wherein said statistics includes traffic condition statistics compiled from said positional information.

17. A vehicle locating system of claim 15, wherein said data processing station compiles statistics relating to vehicle usage and drivers habit.

18. A vehicle locating system of claim 15, wherein said statistics relates to traffic pattern on a particular route.

19. A vehicle locating system of claim 15, wherein said data processing station compiles a travel history for a vehicle on which said mobile unit is placed to establish a report on said vehicle.

20. A vehicle locating system of claim 19, wherein said data processing stations schedules vehicle maintenance according to travel history information provided by said positional information.

21. A vehicle locating system of claim 14, wherein said mobile unit automatically initiates a position update when a distance traveled since last update exceeds a pre-determined value.

22. A vehicle locating system of claim 14 further comprises a monitor unit connected to said network, wherein said monitor unit causes said mobile unit to initiate a position update.

23. A vehicle locating system of claim 14 further comprising:

- a monitor unit connected to said network; and
- a message exchange protocol implemented on said network to allow digital data message exchange between said monitor unit and said mobile unit.

24. A vehicle locating system of claim 9, wherein said data processing station further computes a distance of said mobile unit to a designated location.

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25. A vehicle locating system in claim 14, wherein said wireless communication comprises communicating using a cellular digital packet data (CDPD) protocol.

26. A vehicle locating system in claim 14, wherein said wireless communication comprises communication via a cellular telephone modem.

27. A vehicle locating system in claim 14, wherein said wireless communication comprises communication over a satellite data link.

28. A vehicle locating system in claim 14 further comprises a monitor unit, wherein said monitor unit is installed on a moving vehicle and is connected to said data network through a wireless data communication link.

29. A vehicle locating system in claim 14 further comprises a monitor unit connected to said data network, wherein said data processing station provides a monitor unit a key valid for a limited time to allow said monitor unit access to said data processing station for a limited time.

30. A vehicle locating system of claim 28, wherein (a) said database further comprises travel-related information and said mobile unit having a receiver for receiving wireless communication, (b) said mobile unit transmits to said data processing station a query for travel-related information; and (c) in response to said query, said data processing station retrieves said travel-related information from said database and transmits said travel-related information to said mobile unit.

31. A vehicle locating system of claim 16, wherein, said traffic condition statistics are organized by geographical areas.

32. A vehicle locating system of claim 31, wherein said data processing station causes said traffic condition statistics to be transmitted to said mobile unit in a form that can be played as an audio message.

33. A vehicle locating system of claim 30, wherein said data processing station provides, in response to said query, a map showing a route including the measured position of said mobile unit.

34. A vehicle locating system of claim 30, wherein said data processing station provides said travel-related information in the form of a map relating to the positional information of said mobile unit, said data processing station providing on said map markers indicating locations of interest.

35. A method for locating a mobile unit, comprising the steps of:

receiving in a mobile unit global positioning signals transmitted by global positional system (GPS) satellites to derive a set of positional data representing the position of said mobile unit relative to said satellites; transmitting said positional data to a data processing station through a data network;

receiving in said processing data station said positional data and storing said positional data in a database for later retrieval;

retrieving said positional data in said processing station and computing a measured position of said mobile unit; creating a map embedded therein a marker indicating said measured position of said mobile unit; and

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providing said map by said processing station for display through said data network.

36. A method as in claim 35, wherein said positional data comprises pseudo-ranges.

37. A method as in claim 36, further comprising the steps of:

converting said pseudo-range data into a measured position for said mobile unit; and

storing said measured position in said database.

38. A method as in claim 37, further comprising the steps of:

receiving differential correction data from a differential correction station,

using said differential correction data and said pseudo-range data received from said mobile unit to calculate a corrected measured position of said mobile unit; and storing said corrected measured position of said mobile unit in said database.

39. A method as in claim 35, wherein said data network comprises the Internet.

40. A method for calculating a corrected measured position of a mobile unit at a data processing station, comprising the steps of:

at said mobile unit, receiving global positioning system (GPS) data signals from GPS satellites;

sending said positional information to said data processing station;

at said data processing station, receiving differential correction data corresponding in time to said positional information from a differential correction station;

sending said differential correction data to said mobile unit; and

at said mobile unit, calculating said corrected measured position of said mobile unit; based on said positional information and said differential data.

41. A method as in claim 40, further comprising the step of calculating a distance between the corrected measured position of the mobile unit and a pre-determined geographical position.

42. A vehicle locating system of claim 14, further comprising a monitor unit accessing said data processing station through said data network for said positional information and said maps associated with said mobile unit, wherein said monitor unit further comprises an Internet browser program and a plugin program interfaced with said Internet browser program, said plugin program is used for managing positional and map data.

43. A vehicle locating system of claim 42, wherein said monitor unit further having an area map on which location of said mobile unit is marked, said Internet browser program downloads an updated location of said mobile unit, said plugin program compares said updated location with said area map to determine whether or not a new area map needs to be downloaded from said data processing station.

44. A vehicle locating system of claim 23, wherein said digital data message is in the form of an electronic mail message.

* * * * *

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2000

Application or Docket Number

09753178

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	19	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	19 minus 20=	* 0
INDEPENDENT CLAIMS	7 minus 3 =	* 4
MULTIPLE DEPENDENT CLAIM PRESENT ☐		

* If the difference in column 1 is less than zero, enter "0" in column 2

CLAIMS AS AMENDED - PART II

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	* 18	Minus ** 20	=
Independent	* 7	Minus *** 7	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐			

SMALL ENTITY TYPE ☐ OR

OTHER THAN SMALL ENTITY

RATE	FEE
BASIC FEE	355.00
X\$ 9=	—
X40=	160.00
+135=	—
TOTAL	515.00

RATE	FEE
BASIC FEE	710.00
X\$18=	
X80=	
+270=	
TOTAL	

SMALL ENTITY OR

OTHER THAN SMALL ENTITY

RATE	ADDITIONAL FEE
X\$ 9=	
X40=	
+135=	
TOTAL	
ADDITIONAL FEE	

RATE	ADDITIONAL FEE
X\$18=	
X80=	
+270=	
TOTAL	
ADDITIONAL FEE	

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	* 18	Minus ** 20	=
Independent	* 7	Minus *** 7	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐			

RATE	ADDITIONAL FEE
X\$ 9=	
X40=	
+135=	
TOTAL	
ADDITIONAL FEE	

RATE	ADDITIONAL FEE
X\$18=	
X80=	
+270=	
TOTAL	
ADDITIONAL FEE	

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT C	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	*	Minus **	=
Independent	*	Minus ***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐			

RATE	ADDITIONAL FEE
X\$ 9=	
X40=	
+135=	
TOTAL	
ADDITIONAL FEE	

RATE	ADDITIONAL FEE
X\$18=	
X80=	
+270=	
TOTAL	
ADDITIONAL FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

ISSUE SLIP STAPLE AREA (for additional cross references)

POSITION	INITIALS	ID NO.	DATE
FEE DETERMINATION			
O.I.P.E. CLASSIFIER		10	1-31-01
FORMALITY REVIEW	MTB	954	2/15/01
RESPONSE FORMALITY REVIEW			

INDEX OF CLAIMS

✓ Rejected N Non-elected
 = ... Allowed I Interference
 - (Through numeral)... Canceled A Appeal
 ÷ Restricted O Objected

Claim	Final	Original	Date
1	1	1	10/29/01
2	2	2	10/29/01
3	3	3	10/29/01
4	4	4	10/29/01
5	5	5	10/29/01
6	6	6	10/29/01
7	7	7	10/29/01
8	8	8	10/29/01
9	9	9	10/29/01
10	10	10	10/29/01
11	11	11	10/29/01
12	12	12	10/29/01
13	13	13	10/29/01
14	14	14	10/29/01
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46	46	46	10/29/01
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50	50	50	10/29/01

Claim	Final	Original	Date
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Claim	Final	Original	Date
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150	150	150	

If more than 150 claims or 10 actions
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CLASSIFICATION NOTES			
Examiner/ Classifier	Class	Date	Initials

Petitioner Uber Ex-1004, 0473

ATTACH
DISK/FICHE/CD-ROM
ENVELOPE
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(RIGHT INSIDE)



SEARCHED			
Class	Sub.	Date	Exmr.
340	988	10/18/02	~
	989	↓	↓
	993	↓	↓
	573.1	↓	↓
	573.3	↓	↓
	573.4	↓	↓
	573.7	↓	↓
	7.27	↓	↓
	7.28	↓	↓
	992	↓	↓
342	357.07	10/18/01	~
	465	↓	↓
	357.1	↓	↓
455	429	10/18/01	~
	440	↓	↓
	441	↓	↓
		↓	↓
UPDATE	SEARCH	1/30/02	~
UPDATE	SEARCH	3/29/02	~

INTERFERENCE SEARCHED			
Class	Sub.	Date	Exmr.
340	988	5/7/02	~
	989	↓	↓
	992	↓	↓
		↓	↓

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	Date	Exmr.
EAST	10/18/01	~
EAST	1/30/02	~
EAST	3/29/02	~

(RIGHT OUTSIDE)

CLAIMS ONLY

SERIAL NO.

09753178

FILING DATE

APPLICANT(S)

CLAIMS

	AS FILED		AFTER 1st AMENDMENT		AFTER 2nd AMENDMENT	
	IND.	DEP.	IND.	DEP.	IND.	DEP.
1	/					
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TOTAL DEP.	12	←		←		←
TOTAL CLAIMS	19					

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TOTAL CLAIMS						

* MAY BE USED FOR ADDITIONAL CLAIMS OR ADMENDMENTS

PATENT APPLICATION



09753178

10853 U.S. PTO

09/753178



12/30/00

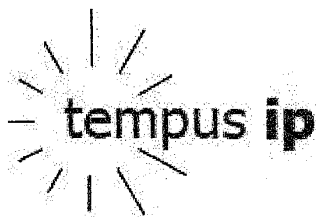
JAN 31 01 34

INITIALS

CONTENTS

	Date Received (Incl. C. of M.) or Date Mailed	Date Received (Incl. C. of M.) or Date Mailed
1. Application _____ papers.		
2. <i>IDS</i>	12-30-00	
3. <i>Rep 3 months</i>	10-23-01	
4. <i>Interview Summary (12-30)</i>	12-17-01	
5. <i>Amdt A</i>	1/23/02	
6. <i>Suppl. Amdt B</i>	3/4/02	
7. <i>Final Rep 3 months</i>	4-2-02	
8. <i>Amdt C</i>	5-2-00	
9. <i>Amdt D</i>	5-2-02	
10. <i>Interview Summary</i>	5-10-02	
11. <i>Notice of Allowability</i>	5-16-02	
12. <i>1st petition 1.28C</i>	01/31/10	
13. <i>petition Granted</i>	03/04/10	
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Order Information

Order Number: 21692

General Order Information

Account : O'Melveny & Myers LLP (Newport Beach)
User : Kristin Godfrey (kgodfrey@omm.com) Tel : 949 823-6942
Order Number : 21692
Status : In Process
Reference/Client matter : Enovsys LLC v. Uber Technologies, Inc
OrderDate : Monday, October 23, 2023
Special Instructions :

Delivery Details

Document Type : File Histories
Delivery Method : Paper copy with free PDF download (Not available for certified copies)
Account Address : 610 Newport Center Drive
17th Floor
Newport Beach
CA
92660
United States

Delivery Address : 610 Newport Center Drive
17th Floor
Newport Beach CA 92660
United States

Shipment Method : Sent Via UPS Overnight

Requested Documents

Ctry.	Item	No. Copies	Cert	Search.	Book.	US ref.	Int ref.	NPL	Parent Files	Child Files
US	6441752	1	X	-	-	-	-	-	-	-
US	6756918 - to follow		X	-	-	-	-	-	-	-