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(54) **Title:** METHOD AND APPARATUS FOR A LOW-POWER RADIO BROADCAST ALERT FOR MONITORING SYSTEMS

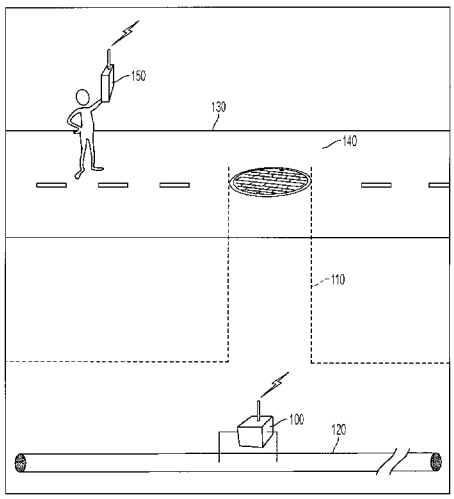

FIG. 1

(57) **Abstract:** Methods and apparatuses for instrumentation to broadcast an alert or status condition which solves the problems of close proximity or a hard-wired connection are presented. One method uses a low-power radio broadcast transmitter to broadcast a message during an alert or status condition.

WO 2009/015201 A1

TITLE OF THE INVENTION

METHOD AND APPARATUS FOR A LOW-POWER RADIO BROADCAST ALERT FOR MONITORING SYSTEMS

RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application S.N. 60/951,893, filed July 25, 2007 and entitled "METHOD AND APPARATUS FOR A LOW-POWER RADIO BROADCAST ALERT FOR MONITORING SYSTEMS" and U.S. Provisional Application S.N. 60/951,921, filed July 25, 2007 and entitled "METHOD AND APPARATUS FOR AN ELECTRICAL CONDUCTOR MONITORING SYSTEM", the entire contents of which are hereby incorporated by reference.

BACKGROUND

[0002] Due to advances in electronics and manufacturing, electronic instrumentation is increasingly deployed to monitor equipment and infrastructure. For example, electric utilities monitor transformers, relays, and even individual cables and fuses. Although these monitors are able to measure many parameters and detect failure conditions, the problem remains of getting these indications back to the user.

[0003] Existing methods include LED or other visual annunciators, contact closures, modem dial-out, LAN connection, etc. These methods either require very close proximity to the monitor, present an attractive nuisance, or an expensive data connection.

SUMMARY

[0004] In various embodiments, methods and apparatuses for instrumentation to broadcast an alert or status condition of an electrical device which solves the problems of very close proximity or a hard-wired connection are presented. In one embodiment, the method uses a low-power radio broadcast transmitter (e.g., an AM or FM transmitter) to broadcast a message during an alert or status condition related to the electrical device.

[0005] Additional features and advantages are described herein, and will be apparent from the following Detailed Description and the figures.

BRIEF DESCRIPTION OF THE FIGURES

[0006] Fig. 1 is a diagram of an underground alert system in accordance with one embodiment.

[0007] Fig. 2 is a diagram of an above ground alert system in accordance with one embodiment.

[0008] Fig. 3 is a block diagram of one process of broadcasting alerts in accordance with one embodiment.

DETAILED DESCRIPTION

[0009] In one embodiment, a system uses a low-power radio (LPR) transmitter, using the standard U.S. FM broadcast band or the standard U.S. AM broadcast band (e.g., 540kHz – 1610kHz) to broadcast alerts or status signals. The power is low enough to enable unlicensed operation, i.e. 100 mW or less. In one embodiment, the LPR transmitter can be connected to (e.g., by a physical hardwired connection or a wireless connection), or incorporated inside, a piece of electronic instrumentation (e.g. a general or special purpose computer) for measuring operating characteristics of any suitable device (e.g., an electrical device or non-electrical device). It should also be appreciated that the frequency broadcast used can be selected based on frequencies that are not being used by local radio stations or other entities.

[0010] The use of the LPR transmitter has several advantages in various embodiments. The modulation technique is very simple, allowing for low-cost devices. FM and AM receivers are inexpensive, ubiquitous, and available as commercial-off-the-shelf products in a large variety of forms (e.g., consumer products like car stereos, handheld radio receivers, etc.). The US broadcast frequency band has good propagation properties in otherwise inaccessible locations (e.g. in a vault or manhole shaft). FCC regulations for unlicensed transmission are more relaxed compared to other commonly used bands. However, it should be appreciated that other modulation schemes and frequency bands are also possible, and may be more suitable in certain situations.

[0011] In one embodiment, an LPR transmitter is coupled to at least one underground current monitor. The monitor is used in an electrical network grid system, and detects open circuit conditions due to current limiter operations or conductor failures (e.g., the monitor can detect conditions of any suitable device in the electrical network grid system). The monitor sends an alert through the LPR transmitter upon detection of a conductor failure (e.g., an open circuit condition). In one embodiment, the alert can be a generic voice message indicating a cable failure. In alternative embodiments, the alert can also be constructed by the monitor to indicate specifically which location, monitor serial number, etc. and ancillary

information such as peak current load, number of remaining conductors, date of failure, etc., or can have any other suitable message information and type.

[0012] In one embodiment, a broadcast-band transmitter which transmits to standard off-the-shelf receivers, is coupled with a piece of electronic instrumentation (e.g., a monitor) for the use of alert or status signaling. In one such embodiment as illustrated in Fig. 1, a monitor 100 with an integrated LPR transmitter connected to an underground power grid network is provided. It should be appreciated that a plurality of monitors 100, each having an LPR transmitter (integrated with, connected to, or in communication with the monitors 100), can be connected to a plurality of locations and devices of the power grid network to provide adequate monitoring coverage. The monitor 100 having an integrated LPR transmitter is located within or near manhole shaft 110. The monitor 100 is configured to measure at least one characteristic of power line cable 120. In one embodiment, monitor 100 comprises a PC or any other suitable specialized computer with any suitable operating system. Thus, monitor 100 can collect, store, analyze, or be configured to do any suitable processing/computation task. In one such embodiment as illustrated in Fig. 1, monitor 100 determines if an open circuit condition occurs in power line cable 120; however it should be appreciated that monitor 100 can be configured to detect any suitable condition of power line cable 120 (e.g., peak voltage/current, ambient temperature, humidity/moisture conditions of the ambient surroundings, etc.). In one embodiment, if monitor 100 detects a predetermined condition of power line cable 120, monitor 100 generates an appropriate alert and broadcasts the alert over a predetermined FM or AM band using the integrated LPR transmitter. In one embodiment, the monitor 100 transmits one of a plurality of pre-recorded voice messages based on the determined condition of the power line cable 120 (e.g., “Open Circuit Detected”, “Maximum Temperature Exceeded”, “Cable Operating Within Parameters”, or any other suitable message).

[0013] In the example embodiment illustrated in Fig. 1, a user on the street 130 located near manhole cover 140 is carrying an FM receiver 150. If the user has tuned the FM receiver 150 to the predetermined FM band that monitor 100 used when broadcasting the alert, FM receiver 150 will receive and playback the alert regarding the condition of power line cable 120. It should be appreciated that with such a broadcast, any standard FM receiver tuned to the predetermined band used by the monitor 100 to broadcast the alert will receive the alert if the standard FM receiver is within the broadcast range. Thus, the FM receiver does not need to be within a very close proximity of, or have a wired connection to, the

monitor 100 to receive the broadcast alerts regarding the monitored power line cable 120. However, it should be understood that the above features are optional and/or can be accomplished with any other suitable components in any suitable manner.

[0014] It should also be appreciated that in one embodiment, where security is a factor in broadcasting alerts, the LPR transmitter may be configured to broadcast encrypted or encoded messages that require a decoding device to playback/interpret the encoded broadcast alert. Thus, a user may need a decoding device in addition to the FM receiver to receive and playback the alert regarding the condition of the power line cable.

[0015] In an alternative embodiment as illustrated in Fig. 2, an LPR transmitter connected to an above ground power grid network is provided. A monitor 200 having an integrated LPR transmitter is located on or near power line pole 210. The monitor 200 is configured to measure at least one characteristic of transformer 220; however, it should be appreciated that the monitor 200 may be configured to measure any suitable power device. In one example, monitor 200 determines if a power surge condition occurs in transformer 220; however it should be appreciated that monitor 200 can be configured to detect any suitable condition of transformer 220 (e.g., peak voltage/current, transformer temperature, humidity/moisture conditions of the ambient surroundings, etc.). In one embodiment, if monitor 200 detects a predetermined condition of transformer 220, monitor 200 generates an appropriate alert and broadcasts the alert over a predetermined FM band (it should be appreciated that the AM band or any other suitable unlicensed or licensed band may be used) using the integrated LPR transmitter (e.g., like a voice alert described in connection with Fig. 1). In this embodiment, a vehicle 230 on the street 240 located near power pole 210 includes a standard radio receiver capable of receiving the FM band. In this embodiment, the FM receiver is tuned to the predetermined FM band that monitor 200 used to broadcast the alert. Thus, the FM receiver in vehicle 230 receives and is configured to play back the alert regarding the condition of transformer 220. However, it should be understood that the above features are optional and/or can be accomplished with any other suitable components in any suitable manner.

[0016] In one embodiment, upon a detected alert condition, a monitor (e.g., with integrated/connected LPR transmitter) can continuously broadcast the alert. The monitor can also be configured to broadcast the alert repeatedly on a periodic basis or in any other suitable manner. Alternatively, the monitor can be programmed to only broadcast during certain times (e.g. only during the day, weekends, at night, at one or more predetermined times, etc.).

In one embodiment, electric utility workers can routinely tune their FM radios to known broadcast frequencies of the monitors to listen for alerts. Thus, as the electric utility workers drive (or travel by any other suitable methods) by various locations, broadcasted alerts can easily be heard on an FM radio in their vehicle. Alternatively, if the electric utility workers' vehicles are not equipped with an FM radio, the electric utility workers' can carry an inexpensive, separate, dedicated, or multifunction FM radio for this purpose.

[0017] In one embodiment, one process for broadcasting an alert is illustrated in Fig. 3. A monitor is configured with a predetermined period in which the monitor determines the status of a monitored device and broadcasts an alert regarding the detected status. At step 300, a monitor is configured to determine if the time and date is equal to a predetermined time and date. If the time and date are not equal to the predetermined time and date, the monitor returns to step 300. If the time and date are equal to the predetermined time and date, the monitor determines the present status of the monitored device in step 310. At step 320, the monitor generates an appropriate alert message based on the detected status of the monitored device (e.g., "System Failure Detected", or any other suitable message). At step 330, the monitor broadcasts the generated message over a predetermined FM frequency using the LPR transmitter. At step 340, if an FM radio receiver is positioned within the broadcast range of the monitor's alert broadcast and tuned to the predetermined FM frequency, the FM radio receiver can receive and play back the alert broadcast.

[0018] In one embodiment, under normal operating conditions (e.g., no problems are detected), the monitor may be configured to not broadcast any alert/signal. That is, the monitor does not broadcast any alerts if the monitored device is working within standard operating conditions. In one such embodiment, if the monitor detects an alert condition, the monitor generates and broadcasts the alert. Thus, the monitor conserves power and reduces the amount of broadcast traffic that could occur if a plurality of monitors operated in the same broadcast range and were simultaneously broadcasting alerts that confirmed that each of the monitored devices were operating properly. However, it should be appreciated that in some embodiments, one or more monitors may still be configured to broadcast the general status of a monitored device. That is, in some embodiments, in addition to alerts, general status messages of conditions of the monitored device may also be transmitted as described above in connection with Figs. 1 and 2 (e.g., peak voltage/current, ambient temperature, humidity/moisture conditions of the ambient surroundings, etc.). In some embodiments, the monitor can broadcast the general conditions continuously, or on a periodic basis or in any

other suitable manner. The transmitted message can include measured parameters or equipment status, as determined by the monitor

[0019] In one embodiment, the timing of a monitor's broadcast alerts may be configured based on other monitors that are located in the same broadcast range (e.g., the same geographic area). For example, if a plurality of monitors in communication with (or connected/integrated to) LPR transmitters are connected to the same or different pieces of equipment within the same broadcast area, the broadcasted alerts could interfere with each other and prevent a listener from determining the status of the different pieces of monitored equipment. In one embodiment, the plurality of monitors in the same broadcast range are configured with a staggered broadcast timing configuration so that the plurality of monitors do not broadcast alerts at the same time. Thus, interference between the plurality of monitors in the same broadcast range is reduced or eliminated. It should also be appreciated that any other suitable timing configuration may be used to reduce or eliminate broadcast interference between the plurality of monitors in the same broadcast range. In an alternative embodiment, the plurality of monitors in the same broadcast range can be configured to broadcast alerts on different FM frequencies to prevent simultaneous broadcast alert interferences. In another embodiment, the plurality of monitors can be configured to broadcast alerts on different FM frequencies and in a staggered timing configuration. Thus, in one such embodiment, an FM radio can be configured to scan through different FM frequencies at a predetermined rate to efficiently distinguish between monitors broadcasting alerts in the same broadcast range. In another embodiment, some monitors can be configured to broadcast over FM frequencies, while other monitors in the same area can be configured to broadcast over AM frequencies. In some embodiments, a monitor can be configured to broadcast over FM and AM frequencies simultaneously, in a predetermined order, or in any other suitable manner.

[0020] In one embodiment, a monitor can be configured with a broadcast receiver (e.g., an FM or AM broadcast receiver). In one such embodiment, the broadcast receiver enables the monitor to determine whether another monitor is broadcasting on a specific/selected band before broadcasting on the same band (alternatively, the broadcast receiver enables the monitor to determine if excessive interference is present on a specific/selected band and would prevent the alert from being received). If the monitor detects that another monitor is broadcasting on the specific/selected band, the monitor can be configured to wait until the band is clear or the monitor can be configured to select a different band to broadcast the alert. In one embodiment, the monitoring device can include a

predetermined number of bands to select for broadcasting the alert; however it should be appreciated that any suitable number of bands can be used.

[0021] In one embodiment, a monitor in communication with an LPR includes fully programmable parameters such as transmitting frequency, transmission power, alert broadcast schedule, canned messages and message construction rules, etc. It should be appreciated that these parameters may also depend on the specific alert.

[0022] In one embodiment, an LPR transmitter can be configured to connect to existing monitoring devices (i.e., the LPR transmitter is retrofitted to existing monitoring devices that lack the ability to broadcast alerts via a radio). In one such embodiment, equipment monitors may already be installed or connected to devices requiring monitoring. To prevent or reduce a redundant expenditures for similar monitoring equipment, an LPR transmitter to convert the existing monitor into a monitor that can broadcast alerts over an FM frequency (or other suitable radio frequency) is provided. In one embodiment, the LPR transmitter is configured with hardware and/or software (e.g., a PC or other suitable specialized computer with any suitable operating system) that enables the LPR transmitter to be connected to the exiting monitor. The retrofitted LPR is configured to receive alerts from the existing monitor and convert the alerts to broadcast alerts over FM frequencies (e.g., such as voice alerts). In one such embodiment, an existing monitor includes an Ethernet interface that is used to communicate alert conditions to a remote monitoring system. To retrofit an LPR transmitter to the existing monitoring device, the LPR transmitter includes an Ethernet interface that allows the LPR to receive the alerts (e.g., codes) transmitted by the existing monitor. Thus, the LPR can be configured to receive the Ethernet communication based alerts and convert the alert into a suitable LPR broadcast alert. In another embodiment, the LPR can be configured to connect to a monitor that includes an LED alert code (e.g., a visual alert display) and convert the visual alert display into radio broadcast alerts. However it should be appreciated that the LPR can be configured with any suitable interface to connect to existing monitors and be programmed to receive and convert any known or proprietary alerts or alert codes into broadcast alerts as described above.

[0023] Although various embodiments are described as using voice messages through the LPR transmitter, digital or analog data may also or alternatively be sent using the invention. For example, touch-tone or other signaling may be sent through the modulation scheme to transmit digital data, or analog means may be used further modulate the radio

carrier. Thus, in some embodiments, the broadcast alerts can include ID, location identifiers, or the like.

[0024] Other transmission schemes may be used in place of the LPR or in conjunction with the LPR in various embodiments. In one embodiment, the SCA subcarrier in US broadcast FM can be used alone to send an alert. This channel is available with commercial FM radios with SCA decoding. In an alternative embodiment, an alert transmitted via the SCA subcarrier can be used in addition to an alert transmitted over the standard US broadcast FM band. In another embodiment, the Radio Broadcast Data System (RBDS) or Radio Data System (RDS) can be used to send an alert as small amounts of digital information. Thus, it should be appreciated that the LPR transmitter can be configured to transmit both analog and digital alerts as audio and text. It should be appreciated that any other suitable broadcast bands can be used where appropriate in various other embodiments.

[0025] Although any instrumentation may benefit from this invention to allow status or alert broadcasts, equipment in hazardous or difficult-to-access locations is especially suitable. For example, power quality monitors installed in underground vaults, arc-flash hazard areas, or power quality monitors connected to high voltages present special challenges for basic alert signaling. The broadcast alert system is especially suitable for these situations where frequent access is expensive and hazardous to diagnostic and repair crews. Other equipment located on towers, embedded in other equipment, or otherwise inaccessible are also well suited for this system.

[0026] It should be understood that various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art. Such changes and modifications can be made without departing from the spirit and scope of the present subject matter and without diminishing its intended advantages. It is therefore intended that such changes and modifications be covered by the appended claims.

CLAIMS

The invention is claimed as follows:

1. An alert system comprising:

at least one monitor configured to detect at least one alert condition of at least one device;

a low-power radio transmitter in communication with the at least one monitor, wherein the at least one monitor is configured to cause the low-power radio transmitter to transmit at least one of a plurality of alert signals upon the detection of the at least one alert condition; and

a commercially available radio receiver configured to receive the at least one transmitted alert signal.

2. The alert system of Claim 1, wherein the low-power radio transmitter is physically coupled to the at least one monitor.

3. The alert system of Claim 1, wherein the commercially available radio receiver is an FM receiver configured to receive the transmitted alert signal.

4. The alert system of Claim 3, wherein the alert signal is an audio message and the FM receiver is capable of playing back the received audio message.

5. The alert system of Claim 4, wherein the audio message comprises one of the following: a human understandable message or a computer message.

6. The alert system of Claim 1, wherein the at least one transmitted alert signal is based on the detected at least one alert condition.

7. The alert system of Claim 1, wherein a status signal is transmitted on a periodic basis without detection of the at least one alert condition.

8. The alert system of Claim 1, wherein the at least one monitor and the low-power FM transmitter are located in a hazardous location.

9. The alert system of Claim 1, wherein the at least one monitor is connected to a device on a power grid network.

10. A method of operating an alert system comprising:

detecting at least one alert condition with at least one monitor; and

transmitting at least one alert signal upon the detection of the alert condition from a low-power radio transmitter in communication with the at least one monitor.

11. The method of Claim 10, wherein the low-power radio transmitter is an FM transmitter.

12. The method of Claim 11, further comprising receiving the transmitted alert signal on an FM receiver.

13. The method of Claim 12, wherein the alert signal is an audio message and further comprises playing back the received audio message on the FM receiver.

14. The method of Claim 10, further comprising generating the alert signal based on the detected at least one alert condition.

15. The method of Claim 10, further comprising transmitting the alert signal at a predetermined time.

16. The method of Claim 10, further comprising placing the at least one monitor and the low-power FM transmitter in a hazardous location.

17. The method of Claim 10, further comprising connecting the at least one monitor to a device on a power grid network.

18. An alert system comprising:

a plurality of monitors, wherein each of the monitors is configured to detect at least one alert condition; and

a plurality of low-power radio transmitters, each in communication with at least one of the plurality of monitors, wherein at least one of the plurality of monitors is configured to cause the radio transmitter to transmit at least one alert signal upon the detection of the alert condition.

19. The alert system of Claim 18, wherein at least one of the monitors and at least one of the low-power radio transmitters is located in a hazardous location.

20. The alert system of Claim 18, wherein at least one of monitors is connected to a device on a power grid network.

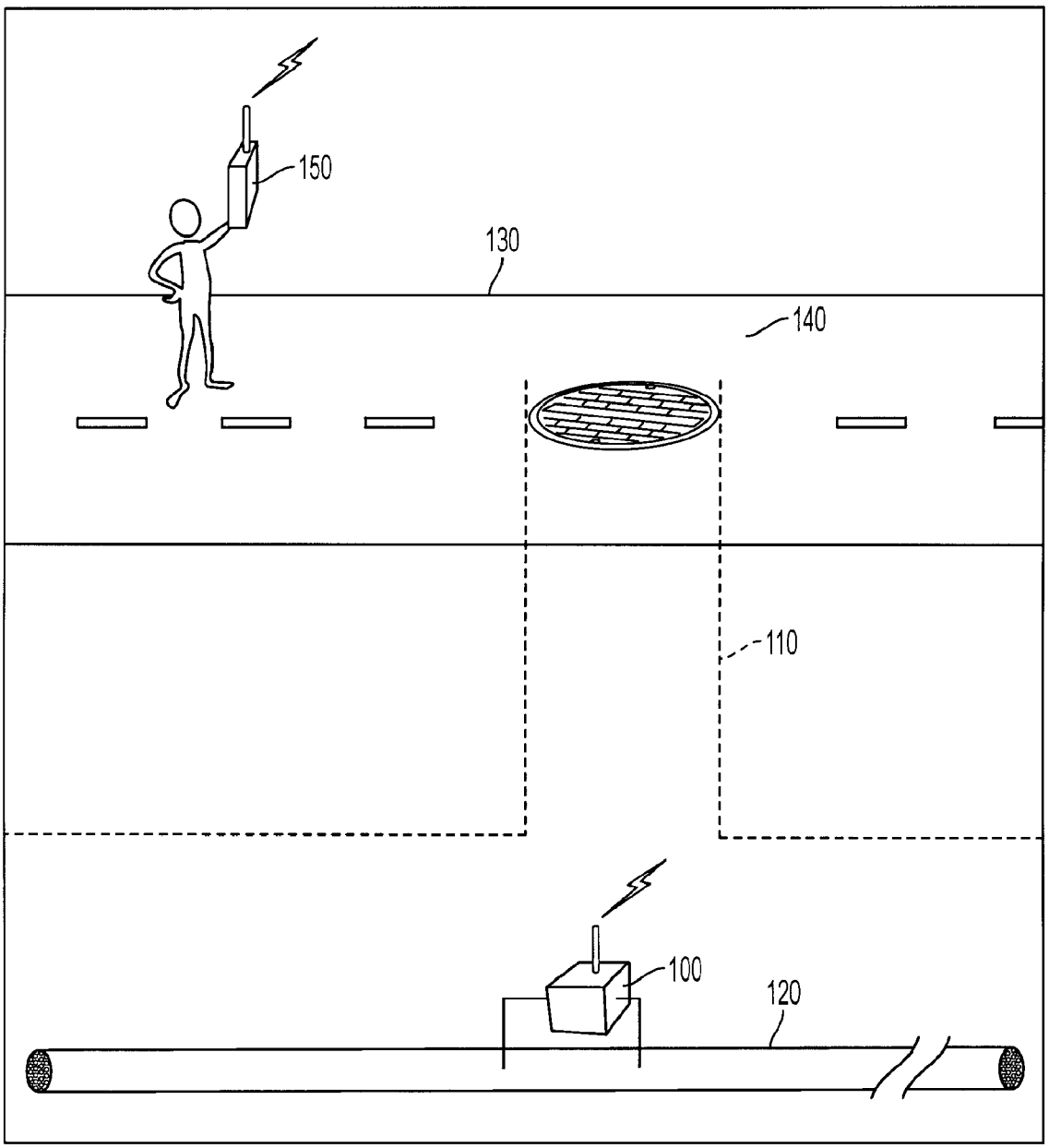

FIG. 1

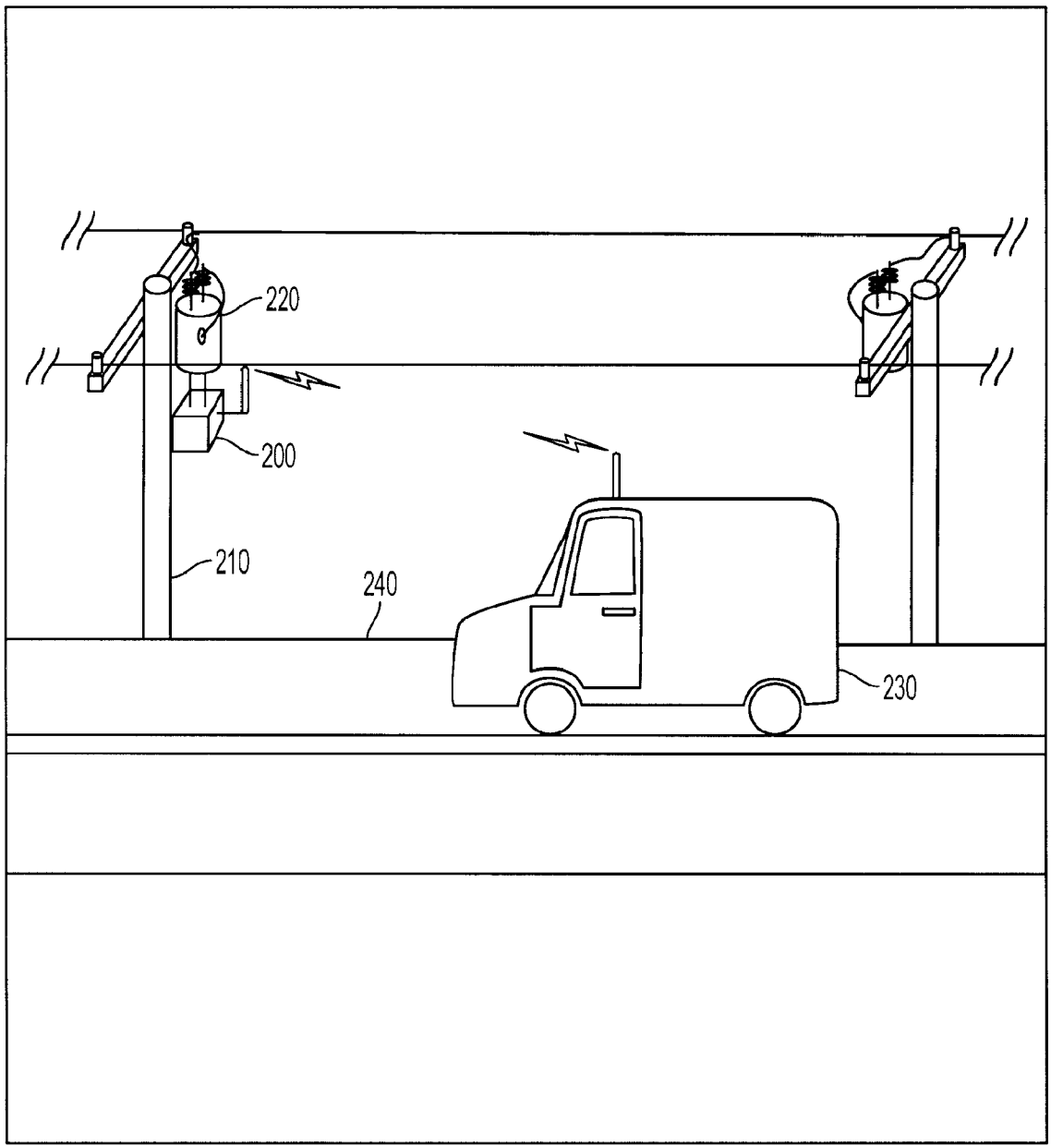

FIG. 2

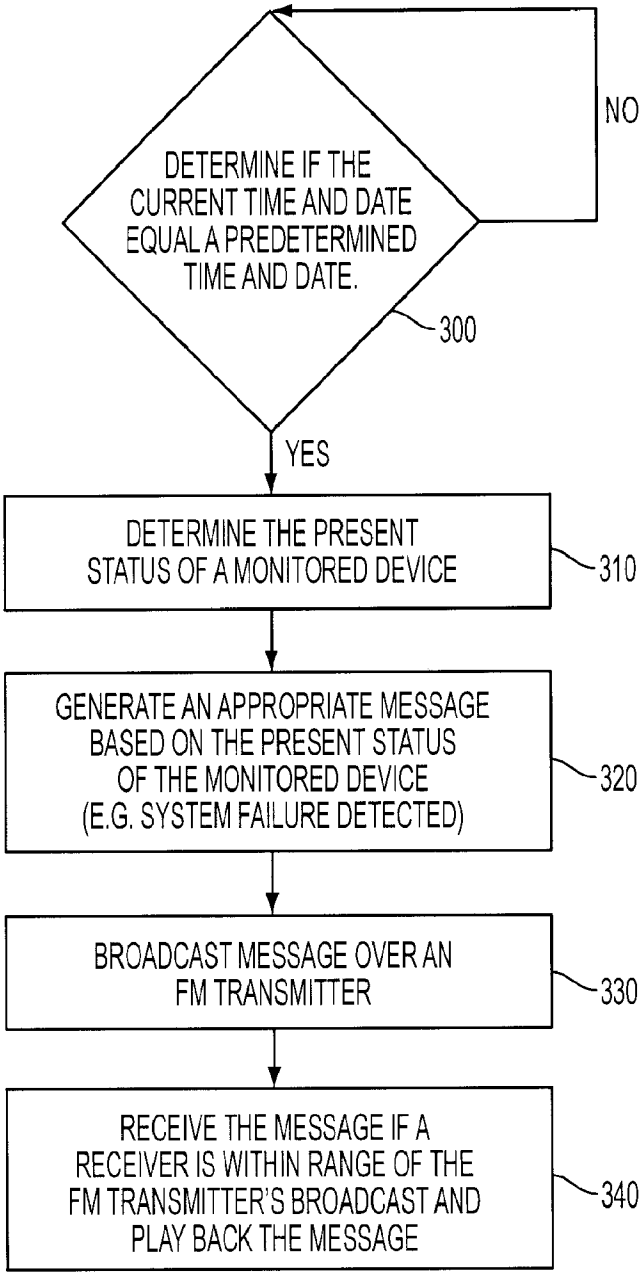
DETERMINE IF THE CURRENT TIME AND DATE EQUAL A PREDETERMINED TIME AND DATE.
300
NO
YES
DETERMINE THE PRESENT STATUS OF A MONITORED DEVICE
310
GENERATE AN APPROPRIATE MESSAGE BASED ON THE PRESENT STATUS OF THE MONITORED DEVICE (E.G. SYSTEM FAILURE DETECTED)
320
BROADCAST MESSAGE OVER AN FM TRANSMITTER
330
RECEIVE THE MESSAGE IF A RECEIVER IS WITHIN RANGE OF THE FM TRANSMITTER'S BROADCAST AND PLAY BACK THE MESSAGE
340

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/070881

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H04Q 7/00 (2008.04)
USPC - 340/539.11
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) - H04Q 7/00 (2008.04)
USPC - 340/539.11

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2002/0112250 A1 (KOPLAR et al) 15 August 2002 (15.08.2002) entire document	1-7, 10-15, 18 --- 8,9,16,17,19,20
Y	US 2006/0111040 A1 (JENKINS et al) 25 May 2006 (25.05.2006) entire document	8,16,19
Y	US 2005/0154499 A1 (ALDRIDGE et al) 14 July 2005 (14.07.2005) entire document	9,17,20

☐ Further documents are listed in the continuation of Box C. ☐

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

Date of the actual completion of the international search	Date of mailing of the international search report
26 September 2008	03 OCT 2008
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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