SYSTEM, PORTABLE TERMINAL DEVICE, HEADSET, SENSOR SYSTEM AND METHOD FOR MONITORING A MINE

Abstract: System, portable terminal device, headset, sensor system and method for monitoring a mine is disclosed. A system for monitoring a mine tunnel comprises a sensor network including one or more fixed sensors which are attached to a wall of the mine tunnel, the fixed sensor being configured to sense environment in the mine tunnel and generate a sensor signal, and a transmitter being configured to receive the sensor signal and transmit a signal to a head office. The system also comprises a mobile sensor portable by a worker, the mobile sensor being configured to sense the environment in the mine tunnel, and a portable terminal device portable by the worker, the portable terminal device being configured to receive a signal from the mobile sensor and communicate with the head office. The system allows for real-time monitoring of the tunnel environment and the location of workers.
Description

Title of Invention: SYSTEM, PORTABLE TERMINAL DEVICE, HEADSET, SENSOR SYSTEM AND METHOD FOR MONITORING A MINE

Technical Field

[1] The present invention relates to a system for monitoring a mine and, more particularly, to a system for monitoring a mine which allows for monitoring the environment in the mine and the location of worker(s) in realtime.

Background Art

[2] The environment in a mine tunnel is very harsh. The light in the tunnel is insufficient because it is located underground. Further, certain toxic materials which may be emitted from minerals or soils threaten human body. Under such environment, in case the tunnel collapses or toxic gas is emitted, the life of the workers in the tunnel is in danger. In fact, only a single accident in a mine tunnel may result in many victims. Moreover, because workers would be completely buried underground when a tunnel collapses, it is difficult to locate and rescue the workers. However, as the demand for fossil fuels increases in the developing countries, the underground resources continue to be developed and workers are still exposed to the dangerous environment.

Disclosure of Invention

Technical Problem

[3] An object of the invention is to provide a system that allows for monitoring the environment in the mine tunnel from outside the tunnel or on the ground so as to quickly respond to the possible danger in the tunnel. Another object of the invention is to provide a system that enables locating workers in real time so that the workers can be quickly rescued in case of accident.

Solution to Problem

[4] According to one aspect of the invention, a system for monitoring a mine tunnel, comprising: a sensor network including one or more fixed sensors which are attached to a wall of the mine tunnel, the fixed sensor being configured to sense environment in the mine tunnel and generate a sensor signal; a transmitter being configured to receive the sensor signal and transmit a signal to a head office; a mobile sensor portable by a worker, the mobile sensor being configured to sense the environment in the mine tunnel; and a portable terminal device portable by the worker, the portable terminal device being configured to receive a signal from the mobile sensor and communicate with the head office is provided.
The portable terminal device is preferably configured to communicate with the head office via the transmitter.

The portable terminal device may be configured to transmit to the head office information on a location of the worker.

It is preferred that the system further comprises: a location marker being capable of communicating a tag within a coverage; and a location tag which is configured to communicate with the location marker, wherein the location marker is configured to notify the portable terminal device of information on the communication between the location marker and the location tag, and wherein the portable terminal device is configured to transmit to the head office the information on the location of the worker based on a signal from the location marker.

The location marker is preferably configured to periodically communicate with the location tag within the coverage thereof.

The location tag may be embedded in a headset, the headset being wearable by a worker.

The headset may include a microphone and a speaker, and the portable terminal device is configured to transmit to the head office a audio signal received from the microphone and transmit to the headset a signal to be output via the speaker.

The mobile sensor may be embedded in the headset.

The fixed sensor and/or the mobile sensor may be configured to sense at least one of methane, LPG (liquefied petroleum gas), carbon monoxide (CO), carbon dioxide (CO2), volatile organic compound (VOC), vibration, temperature, humidity and lightness.

The sensor network is preferably USN (ubiquitous sensor network) or WSN (wireless sensor network).

A signal from the sensor network may employ a first communication protocol or frequency, said first communication protocol or frequency being different from a second communication protocol or frequency which is receivable by the transmitter, and the system may further comprise a relay which is configured to receive the sensor signal, transform the received sensor signal into a signal of said second communication protocol or frequency, and transmit the transformed signal to the transmitter.

According to another aspect of the invention, a portable terminal device portable by a worker in a mine tunnel, configured to receive a signal from a mobile sensor and communicate with a head office, the mobile sensor being configured to sense environment in the mine tunnel is provided.

The terminal may be further configured to transmit to the head office information on a location of the worker.

Preferably, the terminal is further configured to transmit to the head office the in-
formation on the location of the worker based on a signal from a location marker, wherein the location marker is configured to communicate with a location tag within a coverage and notify the portable terminal device of information on the communication between the location marker and the location tag.

[18] The location marker is preferably configured to periodically communicate with the location tag within the coverage thereof.

[19] The location tag may be embedded in a headset, the headset being wearable by a worker.

[20] Also preferably, the headset includes a microphone and a speaker, and the portable terminal device is configured to transmit to the head office a audio signal received from the microphone and transmit to the headset a signal to be output via the speaker.

[21] The mobile sensor may be configured to sense at least one of methane, LPG (liquefied petroleum gas), carbon monoxide (CO), carbon dioxide (CO2), volatile organic compound (VOC), vibration, temperature, humidity and lightness.

[22] The terminal may be further configured to display information regarding the environment sensed by the mobile sensor based on the signal from the mobile sensor.

[23] The terminal may be further configured to communicate with the head office via Internet.

[24] In still another aspect, the inventor provides a headset wearable by a worker, comprising a location tag which is configured to communicate with a location marker, the location marker being capable of communicating a tag within a coverage, wherein the location marker is configured to notify a portable terminal device of information on the communication between the location marker and the location tag, and wherein the portable terminal device is configured to transmit to a head office information on a location of the worker based on a signal from the location marker.

[25] The location marker is preferably configured to periodically communicate with the location tag within the coverage thereof.

[26] Preferably, the headset further comprises a microphone and a speaker, wherein the portable terminal device is configured to transmit to the head office a audio signal received from the microphone and transmit to the headset a signal to be output via the speaker.

[27] The headset may further comprise a sensor being configured to sense environment in a mine tunnel, wherein the headset is configured to transmit to the portable terminal device a sensor signal generated by the sensor.

[28] In another aspect, the invention provides a sensor system, comprising: a sensor network including one or more fixed sensors which are attached to a wall of a mine tunnel, the fixed sensor being configured to sense environment in the mine tunnel; and a transmitter being configured to receive a signal from the sensor network and transmit
a signal to a head office, wherein the signal from the sensor network employs a first communication protocol or frequency, said first communication protocol or frequency is different from a second communication protocol or frequency which is receivable by the transmitter, and wherein the transmitter communicates with the sensor network via a relay, the relay being configured to transform the signal from the sensor network into a signal which is receivable by the transmitter.

It is preferable that the transmitter transmits the signal to the head office using wireless communication, and the system further comprises a repeater configured to receive a signal from the transmitter and transfer the received signal to the head office.

In yet another aspect, the invention provides a method for monitoring environment in a mine tunnel, comprising: receiving from a transmitter installed in the mine tunnel a sensor signal of a sensor network, the sensor network including one or more fixed sensors attached to a wall of the mine tunnel and configured to sense environment in the mine tunnel; receiving, through the transmitter, a sensor signal of a mobile sensor from a portable terminal device portable by a worker, the mobile sensor being portable by the worker and configured to sense environment in the mine tunnel; and transmitting to the portable terminal device a warning message when at least one of said sensor signal of the sensor network and said sensor signal of the mobile sensor indicates abnormal environment.

The method may comprise receiving from the portable terminal device information regarding a location of the worker.

**Advantageous Effects of Invention**

According to the embodiments of the invention, it is possible to quickly respond to accidents in a mine tunnel by monitoring the environment in the mine tunnel from outside the tunnel or on the ground. Further, because the location of a worker is detected in real time, workers can be quickly rescued in case of accident.

**Brief Description of Drawings**

Features, aspects and advantages of the present invention will become more apparent from reading the following description of non-limiting embodiments with the aid of appended drawings, in which:

- Fig. 1 shows a schematic diagram of a mine tunnel monitoring system according to an embodiment of the invention;
- Fig. 2 shows a portable terminal device according to an embodiment of the invention;
- Fig. 3 shows a block diagram of a portable terminal device according to an embodiment of the invention;
- Fig. 4 shows a headset according to an embodiment of the invention; and
- Fig. 5 shows a flowchart illustrating a mine tunnel monitoring method according to
an embodiment of the invention.

**Best Mode for Carrying out the Invention**

[39] Now, specific embodiments of the present invention will be described in reference to the drawings. However, the embodiments are only exemplary and the present invention is not limited thereto.

[40] Fig. 1 shows a schematic diagram of a mine tunnel monitoring system according to an embodiment of the invention. A mine tunnel comprises a safe zone 10 where mining has been completed and a danger zone 20 where mining is being carried out. A worker OP usually works in danger zone 20. On the walls in the safe zone 10, a sensor network 200, which includes one or more fixed sensors 210, is attached. The fixed sensor 210 senses the environment in the mine tunnel. The sensor network 200 may be attached to the wall after mining in the safe zone 10 is completed.

[41] The sensor 210 may be a sensor for sensing at least one of methane, LPG (liquefied petroleum gas), carbon monoxide (CO), carbon dioxide (C02), volatile organic compound (VOC), vibration, temperature, humidity and lightness. Methane, LPG, CO, C02, and VOC are toxic materials, which may harm worker's health when he/she is exposed thereto. Accordingly, the sensor 210 may sense such materials in order to warn the worker of the existence of such materials. Further, by sensing vibration, temperature, humidity and lightness, workers may be aware of vibration, collapsing and etc., occurring in the tunnel in advance and respond thereto quickly.

[42] On the floor or walls in the safe zone 10, a transmitter 110 may be installed. The sensor network 200 transmits the signal, which the sensor 210 generates based on its sensing, to the transmitter 110, and the transmitter 110 in turn transmits the received signal to the head office 600. The term "head office" as used herein includes, but not limited to, a desktop computer, a laptop computer, a PDA (personal digital assistant), a smartphone, or other electric device, which is located on the ground or outside the tunnel and provides users with the information on the environment in the tunnel. In one embodiment, the transmitter 110 may be connected to the Internet network via a cable such as a Ethernet cable. Such cable may be extended into the safe zone by worker(s).

[43] In one embodiment, the communication protocol or frequency used by the sensor network 200 may be different from that the transmitter 110 is capable of receiving. In one embodiment, the sensor network 200 may be USN (ubiquitous sensor network) or WSN (wireless sensor network), and communicate using the communication protocol such as 6L0WPAN, ROLL, CoRE, ZigBee, Wireless HART, ISA 100, and etc. On the other hand, the transmitter 110 may receive a signal using WiFi technique and transmit a signal to the head office 600 via Ethernet cable. In such situation, the sensor network 200 transmits a signal to a relay 120, and the relay 120 transforms the signal from the
sensor network 200 (e.g., a ZigBee signal) into a signal of the format used by the
transmitter 110 (e.g., a WiFi signal) and transmits the transformed signal to the
transmitter 110.

[44] In another embodiment, the protocol or frequency used in the sensor network 200
may be the same as that the transmitter 110 is capable of receiving. For example, each
of the sensors in the sensor network 200 may transmit a sensor signal to the transmitter
110 using WiFi technique and the transmitter 110 may receive the signal without trans-
formation. In this situation, the relay 120 as described above is not necessary and the
entire system may be simplified.

[45] The sensor network 200 may include one or more sensors for sensing the en-
vironment in the tunnel; the sensor network 200 is not to be construed to exclude a
single sensor network.

[46] As discussed above, because the environment in the safe zone 10 is sensed and
reported to the head office 600 by the sensor network 200 and the transmitter 110 as
well as the relay 120, if necessary, a user can monitor the environment in the safe zone
10 in real time.

[47] However, in the danger zone 20 where mining is ongoing, it is hard to install fixed
sensors. Accordingly, a mobile sensor 410 and a portable terminal device 400 are
provided to the worker OP, which are portable by the worker OP and able to sense the
environment in the tunnel. The sensor 410 may be a sensor for sensing at least one of
methane, LPG (liquefied petroleum gas), carbon monoxide (CO), carbon dioxide
(CO2), volatile organic compound (VOC), vibration, temperature, humidity and
lightness. The portable terminal device 400 receives a signal from the mobile sensor
410 and passes the receives signal to the head office 600. Further, the portable terminal
device 400 may communicates with the head office 600 to receive a signal from the
head office 600 and present it to user.

[48] In one embodiment, the mobile sensor 410 is connected to the portable terminal
device 400 via a cable so that the sensor signal generated by the mobile sensor 410 is
sent to the terminal 400. However, the present invention is not limited thereto, and the
mobile sensor 410 may transmit a signal to the portable terminal device 400 using
wireless communication.

[49] In one embodiment, the portable terminal device 400 may communicate with the
head office 600 via the transmitter 110 or via the relay 120 (which transforms the
signal from the portable terminal into the signal receivable by the transmitter) and the
transmitter 120. Alternatively or additionally, an repeater may be used to receive and
amplify the signal from the transmitter and forward the amplified signal to the head
office so that the signal can be reliably received by the head office. Accordingly, in
case the transmitter 110 is connected to the Internet, the portable terminal device 400
may also communicate with the head office 600 via the Internet.

In one embodiment, the mobile sensor 410 may be integrated into a headset 500 which is provided to the worker OP. In this case, by wearing the headset 500, the worker OP effectively attaches a sensor to his/her body and is free to use his/her hands. The headset 500 is described in more detail below.

Accordingly, in the danger zone 20, the mobile sensor 410 can detect the environment in the tunnel and send the detection result to the head office 600. Further, the information from the mobile sensor 410 may be displayed in the portable terminal device 400 so that the worker can be aware of the possible presence of toxic gas or dangerous accidents based on the information displayed on the terminal 400. Moreover, the head office 600 may also send a warning or instruction message to the portable terminal device 400 if necessary, and the terminal 400 may notify the user of such message by, for example, displaying the message or generating voice or warning sound to prompt, from the outside the tunnel, the user to properly react to the detected environment in the tunnel.

In one embodiment, the portable terminal device 400 further transmits the information regarding the location of a worker to the head office 600. Because it may be impossible to receive the GPS (Global Positioning System) signal from a satellite in the tunnel, a location marker 310 is provided in the tunnel in order to locate the worker. The location marker 310 maintains the information about its location, and is configured to communicate with a location tag 510 within a coverage C. In one embodiment, the tag 510 may be passive tag, and, in such case, the location marker 310 sends a interrogation signal and the tag 510 is activated by the interrogation signal to send a response signal to the marker 310. In order to maintain the list of tags within the coverage C to be current, the location marker 310 periodically sends the interrogation signal to communicate with the tag 510. In another embodiment, the tag 510 may be an active tag, and, in such case, is able to send a signal to the location marker 310 without the interrogation signal from the marker 310. Accordingly, the tag 510 may periodically send a signal to the marker 310. For communication between the location marker 310 and the tag 510, conventional RFID (Radio Frequency Identification) technique or USN technique may be employed.

The portable terminal device 400 is configured to receive a signal from the location marker 310. The location marker 310 notifies the portable terminal device 400 of the information regarding its communication with the location tag 510. In one embodiment, the location marker 310 sends to the portable terminal device 400 the information on the tag 510 present in the coverage C together with its identification or its location information. Accordingly, the portable terminal device 400 may have the information as to which tag is present in the coverage C of the marker and in which
marker's coverage a tag is present, and the terminal 400 sends such information to the head office 600. In one embodiment, the location information which the portable terminal device 400 sends to the head office 600 may include the information received from the location marker 310. In another embodiment, the location information may be the information indicating the location of a tag, which is generated by the portable terminal device 400 based on the information received from the location marker 310. Individual location tag 510 may be provided to a worker OP, and contain the information identifying the worker OP. Thus, it is possible to locate the workers in real time in the head office 600 so that the head office, in case of an accident, can quickly rescue the worker. In one embodiment, the location marker 310 may periodically send a signal to the portable terminal device 400.

Worker OP may wear the headset 500 for voice communication with the head office 600, and the location tag 510 may be integrated into the headset. The headset 500 is described in reference to Fig. 4 below.

As described above, according to one embodiment of the present invention, the environment in the tunnel can be readily monitored from outside the tunnel and the location of workers can be detected, allowing proper response to the change of environment. Further, if the transmitter is connected to the Internet, the environment in the tunnel can be monitored from outside the tunnel by simply connecting to the Internet.

Now the portable terminal device according to one environment is described in reference to Fig. 2. The portable terminal device 400 in the present embodiment comprises a display part 420 and an input part 404. The portable terminal device 400 communicates with the head office (in one embodiment, via the transmitter) using its internal communication module while communicating with the mobile sensor using a separate or identical communication module. The display part 402 displays at least one of the information detected by the mobile sensor, the information received from the location marker and the information received from the head office. For example, Fig. 2 shows the display part 402 displays the location of worker generated based on the information received from the location marker. The content displayed in the display part 420 may be selected by instruction from the input part 404. Additionally, the information to be transmitted to the head office may be input via the input part 404.

Fig. 3 shows a block diagram of a portable terminal device 400 according to an embodiment of the invention. The portable terminal device 400 comprises a controller part 420, which processes signal and controls the devices connected thereto. The controller part 420 may be connected to a memory 422 to execute the instructions stored in the memory 422 and/or store the result of such execution in the memory 422. In one embodiment, the portable terminal device 400 should be able to support three
type of communications, i.e., the communications with the transmitter, the location marker and the mobile sensor. In one embodiment, the portable terminal device 400 comprises an Internet communication module 424 for communicating with the transmitter. The Internet communication module may be an WiFi module and comprise an antenna for receiving and transmitting a signal. However, the module for communicating with the transmitter is not limited to the Internet communication module 424 but includes a module supporting at least one of the variety of wireless protocols such as Bluetooth, Zigbee, UWB, and etc. Further, in case the transmitter is not connected to the Internet, the module for communicating with the transmitter need not be the Internet communication module 424.

In one embodiment, the portable terminal device 400 includes a RF communication module 426 for communicating with the location marker, which includes an antenna for receiving and transmitting signal. As the worker can move in the tunnel along with the portable terminal device 400, the communication between the portable terminal device 400 and the location marker is preferably carried out in a wireless manner. In one embodiment, the portable terminal device 400 may employ the same protocol in communicating with both the location marker and the transmitter, and, in such case, the Internet communication module 424 and the RF communication module 426 may be integrated into a module.

A cable communication module 428 is provided for communication with the mobile sensor. The cable communication module 428 is provided when the mobile sensor is connected to the portable terminal device 400 with a cable, and may include at least one of an USB (universal serial bus) port, a connector for connecting a coaxial cable and a pin connector. When the mobile sensor is in wireless communication with the portable terminal device 400, the cable communication module 428 may not be included in the terminal 400 and RF communication module 426 may support the communication with the mobile sensor.

The portable terminal device 400 may comprise a speaker 406 for outputting sounds to a user and a microphone 408 for receiving voice from the user. The speaker 406 and the microphone 408 allow the worker to have a conversation or to communicate information with a user outside the tunnel via the portable terminal device 400. In one embodiment, the speaker 406 and the microphone 408 are embedded in the portable terminal device 400. In another embodiment, the speaker 406 and the microphone 408 are not included in the portable terminal device 400 but integrated into a headset as discussed below. In this case, the headset may be connected to the portable terminal device 400 via I/O module 432. In another embodiment, the headset may be in wireless communication with the portable terminal device 400 using a near field wireless communication protocol such as Bluetooth, Zigbee, UWB and etc. In such case, the
portable terminal device 400 may comprise a communication module supporting a relevant communication protocol, and when such relevant protocol is the same as the protocol for communication with the transmitter or for communication with the location marker, the Internet communication module 424 or the RF communication module 426 may be responsible for the communication with the headset.

In one embodiment, the mobile sensor may be integrated into the headset. In such case, a separate communication module for the mobile sensor is not necessary, and the sensor signal generated by the mobile sensor may be sent during the communication between the portable terminal device 400 and the headset. Accordingly, the portable terminal device 400 may comprise only the I/O module 432 without the RF communication module 426 (when the headset is wire-connected to the portable terminal device), or only the RF communication module 426 without the I/O module 432 (when the headset is in wireless communication with the portable terminal device).

Fig. 4 shows a headset 500 according to an embodiment of the invention. The headset 500 comprises a speaker part 506 and a microphone part 508 to provide a user with means for inputting and outputting. The headset 500 is configured to be wearable by a worker, e.g., in one embodiment, holdable on an ear of the worker with a hook 502 formed thereon. In the body 520 of the headset 500, a variety of elements and/or circuits are embedded for the functionality of the headset. In one embodiment, as the mobile sensor is included in the body 520, the user need not grasp the mobile sensor with his/her hands, and may be free to use his/her hands. The microphone part 508 may be extendible from and/or pivotable around the body 520 so that the worker can adjust its position near his/her mouth.

In one embodiment, a communication module for communication with the portable terminal device may be embedded in the body 520. In the embodiment shown in Fig. 4, as the headset 500 is in wireless communication with the portable terminal device, a module for wireless communication is embedded in the body 520, which may be any of a Bluetooth module, a Zigbee module, a UWB module, other known near field communication module and combination thereof. In another embodiment, the headset 500 may be connected to the portable terminal device via a cable, and, in such case, a module for wire communication is embedded in the body 520. If the headset 500 comprises the mobile sensor, the communication module in the body 520 also causes the sensor signal generated by the mobile sensor to be sent to the portable terminal device.

The body 520 may comprise the location tag that communicates with the location marker. Because the location tag is for locating a worker, the location tag is preferably embedded in the headset 500 that is wearable by the worker. However, in another embodiment, the location tag may be, instead of being embedded in the headset 500,
attached to the worker’s helmet or clothe and/or provided to the user in a card-like form.

Fig. 5 shows a flowchart illustrating a mine tunnel monitoring method according to an embodiment of the invention. The method shown in Fig. 5 may be implemented in the head office. First, in step S510, a sensor signal is received from the sensor network via the transmitter in the tunnel. As discussed above, the sensor network may send a signal to the head office via the transmitter using WiFi protocol. Next, in step S520, a signal from the portable terminal device is received via the transmitter. The signal from the portable terminal device may include at least one of a sensor signal which the portable terminal device receives from the mobile sensor, location information from the location marker, and user input from the headset.

In step S530, determination is made as to whether abnormality is detected based on the received signal. In one embodiment, based on the received sensor signal from the sensor network or the mobile sensor, if the detected amount of toxic material or vibration exceeds a predetermined threshold, it is determined that an abnormality is present. In another embodiment, if the amount of change in the sensor signal from the sensor network or the mobile sensor exceeds a predetermined threshold, it is determined that an abnormality is present.

If it is determined in step S530 that an abnormality is present, the method proceeds to step S540 to send a warning signal to the portable terminal device of a worker. The warning signal may be sent to the transmitter via the Internet network, and the transmitter sends the received signal to the portable terminal device. Upon receiving the warning signal, the portable terminal device displays a warning message on the display or outputs a warning sound through the speaker. In another embodiment, the portable terminal device may send the warning signal to the headset so that the headset outputs a warning sound.

In one embodiment, if an abnormality is detected in step S530, a rescue request to the emergency rescue center may be issued, and the request may be sent along with the location information contained in the signal received from the portable terminal device in step S520. Accordingly, rapid rescue is possible.

On the other hand, an abnormality is not detected in step S530, the method returns to step S510 and monitoring continues.

Although the present invention has been described in reference to certain specific embodiments, the present invention is not limited thereto but those skilled in the art would appreciate that various change or modification can be made within the scope of the present invention. For example, communication technique referred to herein may be replaced by known communication technique, and wired communication may be replaced by wireless communication, and vice versa. Each of the functional
components or elements referred to herein may be implemented as a single component or a combination of two or more components. Accordingly, as long as the functionalities referred to herein are implemented, even if the functionality is implemented by different component from that described herein, such implementation is within the scope of the present invention. A reference to a component or element by describing its functionality should not be construed to limit its functionality thereto. For example, the transmitter described herein may transmit a signal not only from an antenna to a portable terminal device but also from the terminal device to the antenna. Thus, the scope of the invention is intended to be defined only by the following claims and the equivalents thereof.
Claims

[Claim 1] A system for monitoring a mine tunnel, comprising:
a sensor network including one or more fixed sensors which are
attached to a wall of the mine tunnel, the fixed sensor being configured
to sense environment in the mine tunnel and generate a sensor signal;
a transmitter being configured to receive the sensor signal and transmit
a signal to a head office;
a mobile sensor portable by a worker, the mobile sensor being
configured to sense the environment in the mine tunnel; and
a portable terminal device portable by the worker, the portable terminal
device being configured to receive a signal from the mobile sensor and
communicate with the head office.

[Claim 2] The system claimed in claim 1, wherein the portable terminal device is
configured to communicate with the head office via the transmitter.

[Claim 3] The system claimed in claim 1, wherein the portable terminal device is
configured to transmit to the head office information on a location of
the worker.

[Claim 4] The system claimed in claim 3, further comprising:
a location marker being capable of communicating a tag within a
coverage; and
a location tag which is configured to communicate with the location
marker,
wherein the location marker is configured to notify the portable
terminal device of information on the communication between the
location marker and the location tag, and
wherein the portable terminal device is configured to transmit to the
head office the information on the location of the worker based on a
signal from the location marker.

[Claim 5] The system claimed in claim 4, wherein the location marker is
configured to periodically communicate with the location tag within the
coverage thereof.

[Claim 6] The system claimed in claim 4, wherein the location tag is embedded in
a headset, the headset being wearable by a worker.

[Claim 7] The system claimed in claim 6, wherein the headset includes a mi-
crophone and a speaker, and
wherein the portable terminal device is configured to transmit to the
head office a audio signal received from the microphone and transmit
6. the headset a signal to be output via the speaker.

[Claim 8] The system claimed in claim 6, wherein the mobile sensor is embedded in the headset.

[Claim 9] The system claimed in claim 1, wherein the fixed sensor and/or the mobile sensor is configured to sense at least one of methane, LPG (liquefied petroleum gas), carbon monoxide (CO), carbon dioxide (CO2), volatile organic compound (VOC), vibration, temperature, humidity and lightness.

[Claim 10] The system claimed in claim 1, wherein the sensor network is USN (ubiquitous sensor network) or WSN (wireless sensor network).

[Claim 11] The system claimed in claim 1, wherein a signal from the sensor network employs a first communication protocol or frequency, said first communication protocol or frequency being different from a second communication protocol or frequency which is receivable by the transmitter, and wherein the system further comprises a relay which is configured to receive the sensor signal, transform the received sensor signal into a signal of said second communication protocol or frequency, and transmit the transformed signal to the transmitter.

[Claim 12] A portable terminal device portable by a worker in a mine tunnel, configured to receive a signal from a mobile sensor and communicate with a head office, the mobile sensor being configured to sense environment in the mine tunnel.

[Claim 13] The terminal claimed in claim 12, further configured to transmit to the head office information on a location of the worker.

[Claim 14] The terminal claimed in claim 13, further configured to transmit to the head office the information on the location of the worker based on a signal from a location marker, wherein the location marker is configured to communicate with a location tag within a coverage and notify the portable terminal device of information on the communication between the location marker and the location tag.

[Claim 15] The terminal claimed in claim 14, wherein the location marker is configured to periodically communicate with the location tag within the coverage thereof.

[Claim 16] The terminal claimed in claim 14, wherein the location tag is embedded in a headset, the headset being wearable by a worker.

[Claim 17] The terminal claimed in claim 16, wherein the headset includes a mi-
crophone and a speaker, and
wherein the portable terminal device is configured to transmit to the
head office a audio signal received from the microphone and transmit
to the headset a signal to be output via the speaker.

[Claim 18] The terminal claimed in claim 12, wherein the mobile sensor is
configured to sense at least one of methane, LPG (liquefied petroleum
gas), carbon monoxide (CO), carbon dioxide (C02), volatile organic
compound (VOC), vibration, temperature, humidity and lightness.

[Claim 19] The terminal claimed in claim 12, further configured to display in-
formation regarding the environment sensed by the mobile sensor based
on the signal from the mobile sensor.

[Claim 20] The terminal claimed in claim 12, further configured to communicate
with the head office via Internet.

[Claim 21] A headset wearable by a worker, comprising a location tag which is
configured to communicate with a location marker, the location marker
being capable of communicating a tag within a coverage,
wherein the location marker is configured to notify a portable terminal
device of information on the communication between the location
marker and the location tag, and
wherein the portable terminal device is configured to transmit to a head
office information on a location of the worker based on a signal from
the location marker.

[Claim 22] The headset as claimed in claim 21, wherein the location marker is
configured to periodically communicate with the location tag within the
coverage thereof.

[Claim 23] The headset as claimed in claim 21, further comprising a microphone
and a speaker,
wherein the portable terminal device is configured to transmit to the
head office a audio signal received from the microphone and transmit
to the headset a signal to be output via the speaker.

[Claim 24] The headset as claimed in claim 21, further comprising a sensor being
configured to sense environment in a mine tunnel, wherein the headset
is configured to transmit to the portable terminal device a sensor signal
generated by the sensor.

[Claim 25] A sensor system, comprising:
a sensor network including one or more fixed sensors which are
attached to a wall of a mine tunnel, the fixed sensor being configured to
sense environment in the mine tunnel; and
a transmitter being configured to receive a signal from the sensor network and transmit a signal to a head office,
wherein the signal from the sensor network employs a first communication protocol or frequency, said first communication protocol or frequency is different from a second communication protocol or frequency which is receivable by the transmitter, and
wherein the transmitter communicates with the sensor network via a relay, the relay being configured to transform the signal from the sensor network into a signal which is receivable by the transmitter.

[Claim 26] The system as claimed in claim 25, wherein the fixed sensor is configured to sense at least one of methane, LPG (liquefied petroleum gas), carbon monoxide (CO), carbon dioxide (CO2), volatile organic compound (VOC), vibration, temperature, humidity and lightness.

[Claim 27] The system as claimed in claim 25, wherein the sensor network is USN (ubiquitous sensor network) or WSN (wireless sensor network).

[Claim 28] The system as claimed in claim 25, wherein the transmitter transmits the signal to the head office using wireless communication, and wherein the system further comprises a repeater configured to receive a signal from the transmitter and transfer the received signal to the head office.

[Claim 29] Method for monitoring environment in a mine tunnel, comprising:
receiving from a transmitter installed in the mine tunnel a sensor signal of a sensor network, the sensor network including one or more fixed sensors attached to a wall of the mine tunnel and configured to sense environment in the mine tunnel;
receiving, through the transmitter, a sensor signal of a mobile sensor from a portable terminal device portable by a worker, the mobile sensor being portable by the worker and configured to sense environment in the mine tunnel; and
transmitting to the portable terminal device a warning message when at least one of said sensor signal of the sensor network and said sensor signal of the mobile sensor indicates abnormal environment.

[Claim 30] The method as claimed in claim 29, further comprising receiving from the portable terminal device information regarding a location of the worker.
[Fig. 5]

SS10: Receive sensor signal from sensor network via transmitter in tunnel

SS20: Receive signal from portable terminal device via transmitter in tunnel

SS30: Abnormality detected?

Y: Send warning message to portable terminal device and/or rescue request

N: Continue

SUBSTITUTE SHEET (RULE 26)
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

**G06Q 50/00(2006.01):**

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)

G06Q 50/00; H04W 84/20; G06F 19/00; H04W 84/10; H04B 7/24; H04L 12/28; H04B 1/40

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

- Korean utility models and applications for utility models
- Japanese utility models and applications for utility models
- Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
  - eKOMPASS(KIPO internal) & Keywords: mine, gallery, pit*, sens*, USN, sensor network, detect*, headset, portable, mobile, position*, RFID, tag, transponder, marker, WIFI

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>KR 10-2011-0057439 A (LUCIS CO., LTD.) 01 June 2011</td>
<td>12, 18-20</td>
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- [ ] Further documents are listed in the continuation of Box C.
- [x] See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search

27 MARCH 2012 (27.03.2012)

Date of mailing of the international search report

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