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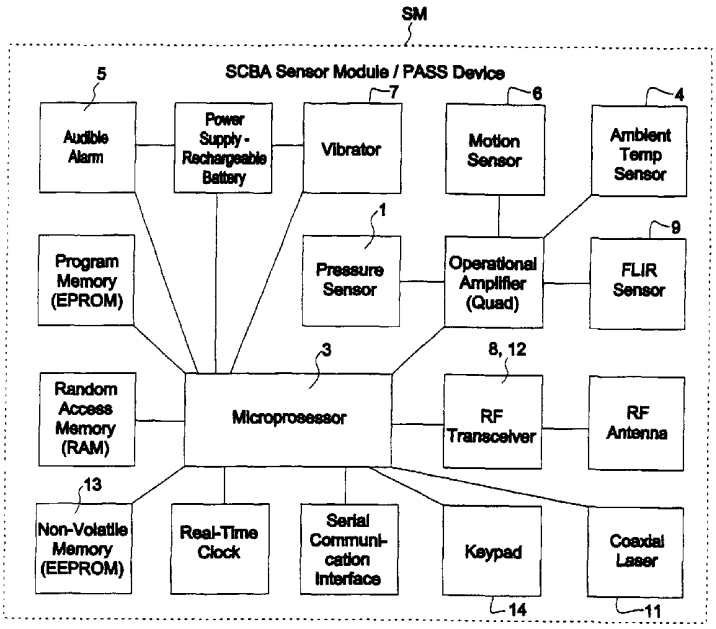

(57) Abstract: The present invention relates to a digital situation indicator, especially a personal monitoring and alarm system. The digital situation indicator according to the invention consist of three parts: sensor module (SM) for monitoring desired data, heads-up display module (HUD) mounted in a facemask (F) or helmet of the operating person, and incident commander module (ICM) at a distance from the operating person. The digital situation indicator can be used to monitor for example firefighter's heat stress, amperage in a welding machine or warfighter's dosage of chemical warfare agents.

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Digital situation indicator

Field of the invention

The present invention relates to a digital situation indicator, especially a personal monitoring and alarm system as defined in the preamble of claim 1.

Background of the invention

When entering a burning building, firefighters wear breathing apparatus consisting of an air tank, regulator, facemask and pressure gage. Typically, firefighters work in dense smoke, where the visibility may be only a few inches.

Firefighters carry a personal alert safety system (PASS) device, which activates an audible alarm, if they stop moving. The PASS device has a "Pre-Alert" stage, which allows the firefighter a pre-specified number of seconds to move or to shake the PASS device, before the alarm is activated. In addition to the PASS device, firefighters need to know certain information about their constantly changing situation in order to safely and efficiently perform their work.

At minimum, firefighters need to know at all times, how much air is remaining in their tank. The pressure of the air tank will only tell part of the story. Two firefighters with identical pressure gage readings may each have a different number of minutes of air time remaining, depending on their respective rates of air consumption. The rate of air consumption varies from firefighter to firefighter according to size, physical conditioning, and metabolic rate. The rate of air consumption also can change from minute to minute for an individual firefighter depending on the intensity of the physical work being performed, stress, and other factors. Therefore, the firefighter needs to know both the air pressure and its equivalent in number of minutes remaining, at any given time.

For safety reasons, the firefighter also needs to know the ambient temperature, its time-dependent effect on his or her cumulative heat stress level, and whether flashover conditions are impending. Before opening a door inside a burning building, the firefighter needs to know whether there is a raging fire on the other side. During so-called "mop-up" operations after the fire has been extinguished, firefighters typically have to use axes to inspect inside walls, to ensure that no hidden fires exist.

Firefighters wear thick gloves, carry axes and water hoses, and need their hands free to be able to perform their work. Gages that attach to the air hose and hang from the firefighter's side are inconvenient to continuously pick-up and, in dense smoke, are almost impossible to read. When brought up to the facemask, the gage is too close for the firefighter's eyes to focus. For this reason, an elementary display system has recently been invented, consisting of a series of Light Emitting Diodes (LEDs) mounted inside the facemask. The drawback to this approach is that the LEDs provide much less information than gages provide.

A helmet-mounted display system such as those used by military jet fighter pilots, which projects data onto the visor of the helmet, would offer firefighters a possible solution. However, the cost of a single helmet could absorb an annual budget. The cost to equip all firefighters worldwide would be staggering.

Another occupational group working with impaired visibility are welders. When welding certain types of material, such as stainless steel or aluminum, certain amperage settings for the welds may be specificated in the manufacturing drawings, and it is necessary to the welder from time to time to check the amperage gage. In many cases the welder has to work severeral meters away from the welding machine, and he has to flip up his helmet and walk back to read the gage. If the welder is working on a ladder or a scaffold, he has to climb down or ask someone else to read the amperage.

Remote controls for setting the amperage are available, and to save time welders sometimes try to set the amperage based on experience. If the amperage is set incorrectly with this method, the result can be a weld that is out of the specification or a rejected part.

Also warfighters suffer from impaired visibility when chemical warfare agents (CWA) are present and they have to wear gas masks and protective clothing. Sometimes warfighters have to work in even more impaired visibility conditions, for example after a bombardment the battlefield is covered with smoke.

Warfighters carry CWA detection instruments, which indicate the presence of any chemical warfare agent. When the CWA detection instrument detects the presence of CWA, it activates an audible alarm, and warfighters put on their gas masks and protective clothing. The CWA detection instrument continues to monitor the level of present CWA, and informs the warfighter when it is safe to take of the gas mask.

The CWA detection instrument also continuously measures the concentration of chemical warfare agents in the surrounding. To be all the time aware of the current concetration, warfighters need to look at the instrument frequently. Current instruments are handheld and warfighters need pick them up to read them, same time forcing him to release grip from his tools or weapon.

Displays of these current handheld instruments are small and they are not protected from mud and dirt. Also dense smoke can impaire the readability of the instrument. To improve the readability of these current CWA detection instruments their displays are often illuminated. This inturn can reveal the warfighter to the enemy. One detection instrument is also needed for each warfighter, which adds weight to the warfighter's gear and increases costs.

The incident commander (IC) is in charge of all firefighters at the scene of the fire. Each firefighter gives the IC a personal accountability tag (PAT) upon arrival at the scene. The IC keeps track of the firefighters by the use of a unit identification pad (UIP) and a large marker board. The drawback is that once the firefighters are inside the fire, the IC has no method of knowing how much air each firefighter has left, what temperature the firefighters are operating in, what is their heat stress level or PASS device status.

The commanding officer (CO) of a certain part of the battlefield is tracking the overall CWA concentration of that area. Warfighters report their instrument readings to the CO either using a radio or a courier. The drawback is that the CO can not keep track of the CWA concentration or the dosage of an individual warfighter in realtime.

Firefighters, welders and warfighters are just examples for possible users of digital situation indicator of the invention. This kind of indicators can be utilised in many fields where personal monitoring and alarming are essential.

Summary of the invention

A primary object of the present invention is to provide a digital situation indicator, especially a personal monitoring and alarm system that will overcome the shortcomings of the prior art devices. Another object of the invention is to provide a new digital situation indicator.

The invention is characterized by the features defined in claim 1. The dependent claims describe preferred embodiments of the invention.

The situation indicator SI of the invention offers a digital heads-up display HUD solution with a multitude of new features. The SI offers a truly digital, very easily legible HUD, at a cost no more expensive than the existing technology.

The SI system has three separate units:

- Sensor Module SM for monitoring desired data,
- Heads-Up Display HUD mounted in the facemask F of the operating person, and
- Incident Commander Module ICM at a distance from the operating person.

The sensor module may contain a pressure sensor, ambient temperature sensor, infrared (IR) temperature sensor, an "SOS" Button and an integrated PASS device. A microprocessor analyses the sensor data and computes air time remaining in minutes, heat stress level, and impending flashover danger. The sensor module transmits sensor and computed data to both the HUD and the ICM. The communication between the parts is preferably wireless such as radio frequency (RF) communication.

The sensor module may also contain a amperage sensor. The sensor module transmits sensor and computed data to the HUD using preferably wireless communication, such as RF communication.

The sensor module may also contain a chemical warfare agent sensor. A microprocessor analyses the sensor data and computes CWA concentration in the surrounding and the dosage of an individual warfighter.

The heads-up display incorporates a miniature, transflective LCD display unit with electro-luminescent panel backlighting, and optical enhancement means consisting of an achromatic doublet lens, optimized to correct for on-axis spherical and chromatic aberrations. The optics is designed for extra long eye relief, and the HUD is positioned in the facemask so that it does not restrict the firefighter's forward field of view.

With the SI system, before opening a door inside a burning building, the firefighter can point the IR sensor with a laser beam at the door, press the IR sensor button and read the temperature of the door on the HUD. During "mop-up" operations after the fire has been extinguished, the firefighter can scan the walls with the IR sensor to ensure that no hidden fires exist.

The incident commander module consists of a self contained, portable, one-piece computer module, with backlit LCD display, touch screen or flex-membrane keypad, and RF transceiver. The ICM receives data transmissions from the sensor module. The ICM can also transmit text messages to the fire- or warfighter. Once the firefighter is inside the fire, the ICM tracks each firefighter's situation, including elapsed time in the fire, air pressure, air time remaining in minutes, ambient temperature in the fire, heat stress level and PASS device status. It may also track each warfighter's situation, including time under exposure to CWA and dosage of CWA.

The advantages of the invention are, among the other things, the following:

- the SI system is a compact and versatile system for a user and,
- effective communication between different parts of the SI system,
- a user has clear and concise information for use,
- it is possible to follow a user with his/her sensor module inside the fire or equivalent work and communicate, if necessary.

Brief description of the drawings

A preferred embodiments of the invention are presented in the following with reference to the attached drawing in which:

Fig. 1 shows a schematic block diagram of the sensor module according to the first embodiment of the invention,

Fig. 2 shows a schematic block diagram of the sensor module according to another embodiment of the invention,

Fig. 3 shows a schematic block diagram of the sensor module according to another embodiment of the invention,

Fig. 4 shows a block diagram of the heads-up display,

Fig. 5 shows a block diagram of the incident commander module,

Fig. 6 shows a perspective view of the sensor module attached to an air tank,

Fig. 7 shows more closely the sensor module,

Fig. 8 shows a mask with the heads-up display,

Fig. 9 shows a welders helmet with the heads-up display,

Fig. 10 shows more closely the heads-up display as perspective view,

Fig. 11 shows examples of information which can be presented in the heads-up display according to the first embodiment of the invention,

Fig. 12 show example of information which can be presented in the heads-up display according to another embodiment of the invention,

Fig. 13 shows examples of information which can be presented in the heads-up display according to another embodiment of the invention,

Fig. 14 shows a perspective view of the incident commander module,

Fig. 15 shows a flow diagram of the Flashover Warning Alarm software according to the first embodiment of the invention,

Fig. 16 shows a flow diagram of the Cumulative Heat Stress Level calculating software according to the first embodiment of the invention, and

Fig. 17a and 17b show a flow diagram of the Motion Sensor software according to the first embodiment of the invention.

Description of the preferred embodiment

Digital situation indicator SI for firefighters - system highlights:

- Pressure sensor –senses pressure remaining in the air tank of the firefighter;
- Computes minutes of air time remaining at firefighter's current consumption rate;
- Ambient temperature sensor – senses ambient temperature;
- Flashover warning alarm – warns of impending flashover danger;
- Computes heat stress level, in "degree-minutes";
- Integrated Personal Alert Safety System PASS device;
- Infrared (IR) sensor, activated by the push of a button – detects fire and/or high temperatures behind closed doors and inside walls;
- Visible light LASER to show where IR sensor is pointed;
- "SOS" button – transmits emergency signal to ICM and activates audible alarm;

- Service records datalogger – records sensor module service and maintenance information in non-volatile memory.

The sensor module SM in accordance with one embodiment of the invention, as shown in Fig 1, has the following parts and features:

- Sensor module SM scans all sensor readings and transmits updated sensor data to both HUD and ICM, preferably every 3 seconds;
- Pressure sensor 1 – senses air pressure in the air tank 2 (Fig. 6);
- Control unit, such as microprocessor 3, tracks firefighter's rate of air consumption, then computes air time remaining in minutes at current consumption rate;
- Ambient temperature sensor 4 – senses ambient temperature;
- Flashover warning alarm – software analyses sensor data and detects, when ambient conditions are appropriate for impending flashover. Microprocessor 3 transmits flashover warning to both HUD and ICM, and/or activates audible alarm 5.

The operation of the flashover warning software is described in the flow chart of the Fig. 15. First the pre-specified alarm limits and the ambient temperature T_A are read and the real time clock is started. Then the ambient temperature is stored in to the memory as a function of time and the rate of increase of ambient temperature is calculated. After this the ambient temperature is compared to the pre-specified alarm limit and if the ambient temperature is lower than the limit, the program returns to the beginning.

If the ambient temperature is higher than pre-specified alarm limit, the rate of increase of ambient temperature is compared to the pre-specified alarm limit. If the rate of increase of ambient temperature is lower than the limit, the program returns to the beginning. If the rate of increase of ambient temperature is higher than the pre-specified alarm limit, a flashover warning is displayed in the HUD. A flashover warning is also transmitted to the incident commander module;

- Microprocessor 3 records firefighter's duration in high temperatures and computes cumulative heat stress level, in "degree-minutes". Software includes computation for rehabilitation (Rehab) time as well as multiple tank 2 usage. The operation of the cumulative heat stress level program is described in the flow chart of the Fig. 16. First the pre-specified alarm limits and the ambient temperature T_A are read and the real time clock is started. Then the ambient

temperature is stored in to the memory as a function of time and the cumulative heat stress level is calculated. After this the cumulative heat stress level is displayed in the HUD.

If the cumulative heat stress level is higher than the pre-specified alarm limit, a heat stress warning alarm is activated and an alarm message is transmitted to the incident commander module. If the cumulative heat stress level is lower than the pre-specified alarm limit program returns to the beginning;

- Integrated personal alert safety system "PASS" device, including:
  - Motion sensor 6 to detect absence of motion by firefighter;
  - Vibrator 7 and/or audible alarm 5 to alert firefighter of "Pre-Alert" condition;
  - Transmitter 8 to transmit "Pre-Alert" condition data to HUD and ICM;
  - Audible alarm 5, activated after a pre-specified number of seconds of absence of motion.

  The operation of the motion sensor program is described in the flow chart of the Fig. 17a and 17b. First the pre-specified alarm limits and the motion sensor are read and the real time clock is started. Then the motion is stored in to the memory as a function of time. If the motion stops, time period of zero motion is calculated.

  If the time period of zero motion is shorter than the pre-specified limit, program returns to the beginning. Otherwise a countdown timer and a vibrator alarm are activated. Simultaneously zero motion warning and countdown timer data is displayed in the HUD. A zero motion warning is also transmitted to the incident commander module.

  After this the motion sensor is read again. If motion is detected, the countdown timer is reset and a all clear message is transmitted to the incident commander module, and the program returns to the beginning. Otherwise the countdown timer is checked, and if there is still time left, motion sensor is read again. If countdown timer has reached zero, an audible alarm is activated and an alarm message is transmitted to the incident commander module.

- Infrared (IR) sensor 9, activated by the push of a button 10 (Fig. 9) – detects infrared radiation emitted from closed doors and walls (and therefore fire and/or high temperatures behind closed doors and inside walls);

- Visible wavelength coaxial LASER 11 (Fig. 7) to show with its beam 11a where IR-sensor 9 is pointed;
- SOS-button 20 – activates audible alarm and transmits signal to ICM;
- Radio frequency (RF) receiver 12 – receives text messages from ICM and forwards them to HUD;
- Service records datalogger – records sensor module service and maintenance information in non-volatile memory 13;
- "Automatic On" feature – activated upon opening of air tank regulator valve;
- Optional button(s) 14 to allow firefighter to input his/her identification code.;
- Optional "Black Box" datalogger – records all sensor data during fire, with automatic "Time Stamping",
- Optional emergency locator transmitter (ELT), activated by PASS device or SOS-button.

The sensor module SM is attached to the pressure gage hose 15 of the air tank 2 as shown in Fig. 4. The sensor module SM has a connector 16 to the pressure hose 15, a housing 17 for the electronic circuitry (shown in Fig. 1) of the sensor module SM , RF antenna 18, IR-sensor and ambient temperature sensor in their housing 19, a waterproof switch 10 for IR-sensor 9 (Fig. 1), a laser 11 and SOS-button 20.

Digital situation indicator SI for welders - system highlights:

- Amperage sensor - senses the amperage of a welding machine;

The sensor module SM in accordance with another embodiment of the invention, as shown in Fig 2, has the following parts and features:

- Sensor module SM scans all sensor readings and transmits updated sensor data to HUD, preferably every 3 seconds;
- Amperage sensor 31 – senses amperage of a welding machine;
- Service records datalogger – records sensor module service and maintenance information in non-volatile memory 13;
- "Automatic On" feature – activated upon turning the welding machine on;
- Optional "Black Box" datalogger – records all sensor data during welding, with automatic "Time Stamping",

The sensor module SM is attached to the welding machine. The sensor module SM has a connector to the amperage gage, a housing for the electronic circuitry (shown in Fig. 2) of the sensor module SM and RF antenna.

Digital situation indicator SI for warfighters - system highlights:

- Chemical warfare agent sensor – senses the amount of CWA in the surroundings.
- Computes warfighter's total dosage of CWA;
- Computes the remaining operating time at current CWA consentration;
- "SOS" button – transmits emergency signal to ICM and activates audible alarm;
- Service records datalogger – records sensor module service and maintenance information in non-volatile memory.

The sensor module SM in accordance with another embodiment of the invention, as shown in Fig 3, has the following parts and features:

- Sensor module SM scans all sensor readings and transmits updated sensor data to both HUD and ICM, preferably every 3 seconds;
- Chemical warfare agent sensor 32 – senses the amount of CWA in the surroundings;
- Control unit, such as microprocessor 3, tracks warfighter's CWA dosage, then computes remaining operating time with current CWA consentration;
- SOS-button – activates audible alarm and transmits signal to ICM;
- Radio frequency (RF) receiver 12 – receives text messages from ICM and forwards them to HUD;
- Service records datalogger – records sensor module service and maintenance information in non-volatile memory 13;
- "Automatic On" feature – activated upon turning on of the CWA sensor;
- Optional button(s) to allow warfighter to input his/her identification code.;
- Optional "Black Box" datalogger – records all sensor data during presence of CWA, with automatic "Time Stamping",
- Optional emergency locator transmitter (ELT), activated by SOS-button.

The sensor module SM is attached to the chemical warfare agent sensor. The sensor module SM has a housing for the electronic circuitry (shown in Fig. 3) of the sensor module SM , RF antenna, housing and SOS-button.

The heads-up display HUD is an optielectric, night-readable display which is mounted in a facemask F of the firefighter or warfighter, or to the helmet of the

welder as shown in Fig. 8 and Fig. 9 . The heads-up display module HUD, as shown in Fig. 4, has the following parts and features:

- Control unit such as a microprocessor 24, display 21, preferably electro-luminescent backlit 22, miniature digital LCD display or equivalent;
- Use of optical enhancement to create an easily legible digital display, which can be located inside the facemask as shown in Fig. 8 as an example – specifically, an achromatic doublet lens 22, optimized to correct for on-axis spherical and chromatic aberrations, with extra long eye relief, positioned so as not to restrict the firefighter's forward field of view;
- RF receiver 25 for receiving data from the sensor module SM;
- Housing 23 into which the display 21 and the lens 22 are fixed;

The display 21 in accordance with one embodiment of the invention is arranged to function as following indicators:

- Pressure indicator – indicates pressure remaining in air tank;
- Time remaining indicator – indicates air time remaining in minutes, at current consumption rate;
- Ambient temperature indicator – displays ambient temperatures (compare Fig. 11):
- Heat stress indicator – displays firefighter's cumulative heat stress level;
- Flashover warning indicator – alerts firefighter of impending flashover danger;
- Infrared temperature indicator – displays infrared temperature of object that IR-sensor is pointed towards, whenever IR-sensor button is pushed (compare Fig. 8);
- PASS device condition indicator – alerts firefighter of "Pre-Alert" PASS condition;

The display in accordance with another embodiment of the invention is arranged to function as following indicators:

- amperage indicator – indicates pressure remaining in air tank;

The display in accordance with another embodiment of the invention is arranged to function as following indicators:

- CWA indicator – indicates consentration of CWA in the surrounding and changes the color of the display depending the situation;
- Time remaining indicator – indicates remaining operating time in minutes at current CWA consentration;

Furthermore, the heads-up display module has:

- "Sleep mode" – provides "Automatic On" feature and prolonged battery life;
- Optional two-way RF voice communication between firefighter and incident commander.

The incident commander module ICM of one embodiment of the present invention provides the incident commander, who is commanding the operation, with real-time sensors data on all firefighters in the interior of the building or equivalent. The incident commander module ICM as shown in Fig. 5 and Fig. 14, has the following parts and features:

- Control unit such as a microprocessor 26;
- RF Transceiver 27, which receives continuous RF sensor data transmissions from up to 128 firefighters, specifically from the firefighter's sensor modules SM;
- Display 28 such as backlit LCD display, indicates the following for each firefighter:
  - Elapsed time inside the fire;
  - Pressure in air tank;
  - Air time remaining in minute;
  - Ambient temperature reading;
  - IR sensor reading;
  - Heat stress level;
  - Flashover warning;
  - PASS device status, including "Pre-Alert" condition;
- Receives "SOS" transmission and identifies firefighter in trouble;
- Transmits text messages by means of the RF transceiver 27 to any selected firefighter or to all firefighters;
- Illuminates "Service" icons, to indicate when upcoming service is due for ICM, HUDs or sensor modules;
- "Black Box" datalogger built into ICM;
  - records each firefighter's situation in real-time, as it occurs;
  - records any firefighter's "SOS" transmission in real-time, as it occurs;
  - records the ICM's text messages in real-time, as they occur;
  - records all service and maintenance records on each device;
  - automatically adds "Time/Date Stamp" to all records.

- Field programming capacity – enables ICM to download identification codes and other information to non-volatile memory in sensor modules and HUDs;
- Optional two-way RF voice communication between firefighter and incident commander.

The incident commander module ICM of another embodiment of the present invention provides the commanding officer, who is commanding certain part of the battlefield, with real-time sensors data on all warfighters in the area. The incident commander module ICM as shown in Fig. 5 and Fig. 14, has the following parts and features:

- Control unit such as a microprocessor 26;
- RF Transceiver 27, which receives continuous RF sensor data transmissions from up to 128 warfighters, specifically from the warfighter's sensor modules SM;
- Display 28 such as backlit LCD display, indicates the following for each firefighter:
  - Elapsed time under CWA ;
  - CWA concentration in the surrounding;
  - current dosage of CWA;
  - remaining operating time in minutes;
- Receives "SOS" transmission and identifies warfighter in trouble;
- Transmits text messages by means of the RF transceiver 27 to any selected warfighter or to all warfighters;
- Illuminates "Service" icons, to indicate when upcoming service is due for ICM, HUDs or sensor modules;
- "Black Box" datalogger built into ICM;
  - records each warfighter's situation in real-time, as it occurs;
  - records any warfighter's "SOS" transmission in real-time, as it occurs;
  - records the ICM's text messages in real-time, as they occur;
  - records all service and maintenance records on each device;
  - automatically adds "Time/Date Stamp" to all records.
- Field programming capacity – enables ICM to download identification codes and other information to non-volatile memory in sensor modules and HUDs;
- Optional two-way RF voice communication between warfighter and incident commander.

Claims

1. A digital situation indicator, especially a personal monitoring and alarm system, **characterized** in that the situation indicator (SI) has three separate units:

- sensor module (SM) for monitoring desired data,
- heads-up display module (HUD) mounted in a facemask (F) or helmet of the operating person, and
- incident commander module (ICM) at a distance from the operating person,

which modules are arranged to communicate with each other.

2. A digital situation indicator according to claim 1, **characterized** in that the sensor module has:

- a plurality of sensors for monitoring conditions around the operating person, air consumption and the pressure of the air tank,
- a control unit for analyzing the data collected, and
- a transceiver for sending and receiving data.

3. A digital situation indicator according to claim 1, **characterized** in that the sensor module has:

- a sensor for monitoring amperage of a welding machine,
- a control unit for analyzing the data collected, and
- a transceiver for sending and receiving data.

4. A digital situation indicator according to claim 1, **characterized** in that the sensor module has:

- a plurality of sensors for monitoring consentration of Chemican Warfare Agents in the surrounding,
- a control unit for analyzing the data collected, and
- a transceiver for sending and receiving data.

5. A digital situation indicator according to any of the preceding claim, **characterized** in that the heads-up display module has

- a miniature display unit,
- optical enhancement means,
- a control unit, and
- a receiver for receiving data from the sensor module.

6. A digital situation indicator according to any of the preceding claim, **characterized** in that the incident commander module (ICM) is a portable computer module having a display, a keypad and a transceiver.

7. A digital situation indicator according to any of the preceding claim, **characterized** in the sensor module has an infrared sensor and a visible wavelength laser to show where the infrared sensor is pointed.

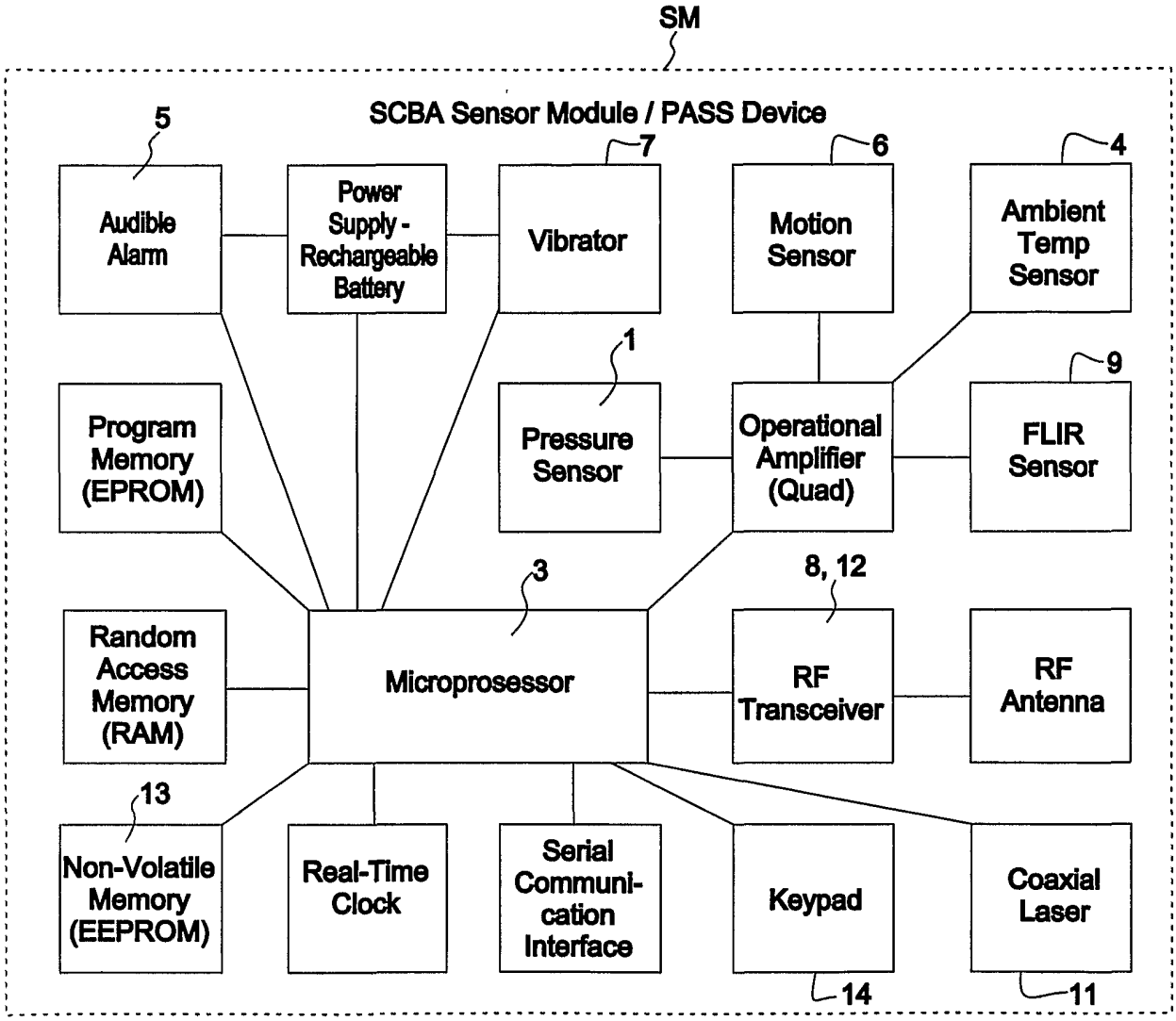

SM
SCBA Sensor Module / PASS Device
5
Audible Alarm
Power Supply - Rechargeable Battery
7
Vibrator
6
Motion Sensor
4
Ambient Temp Sensor
1
Pressure Sensor
Program Memory (EPROM)
Operational Amplifier (Quad)
9
FLIR Sensor
3
8, 12
Random Access Memory (RAM)
Microprosessor
RF Transceiver
RF Antenna
13
Non-Volatile Memory (EEPROM)
Real-Time Clock
Serial Communi-cation Interface
Keypad
14
Coaxial Laser
11

Fig. 1

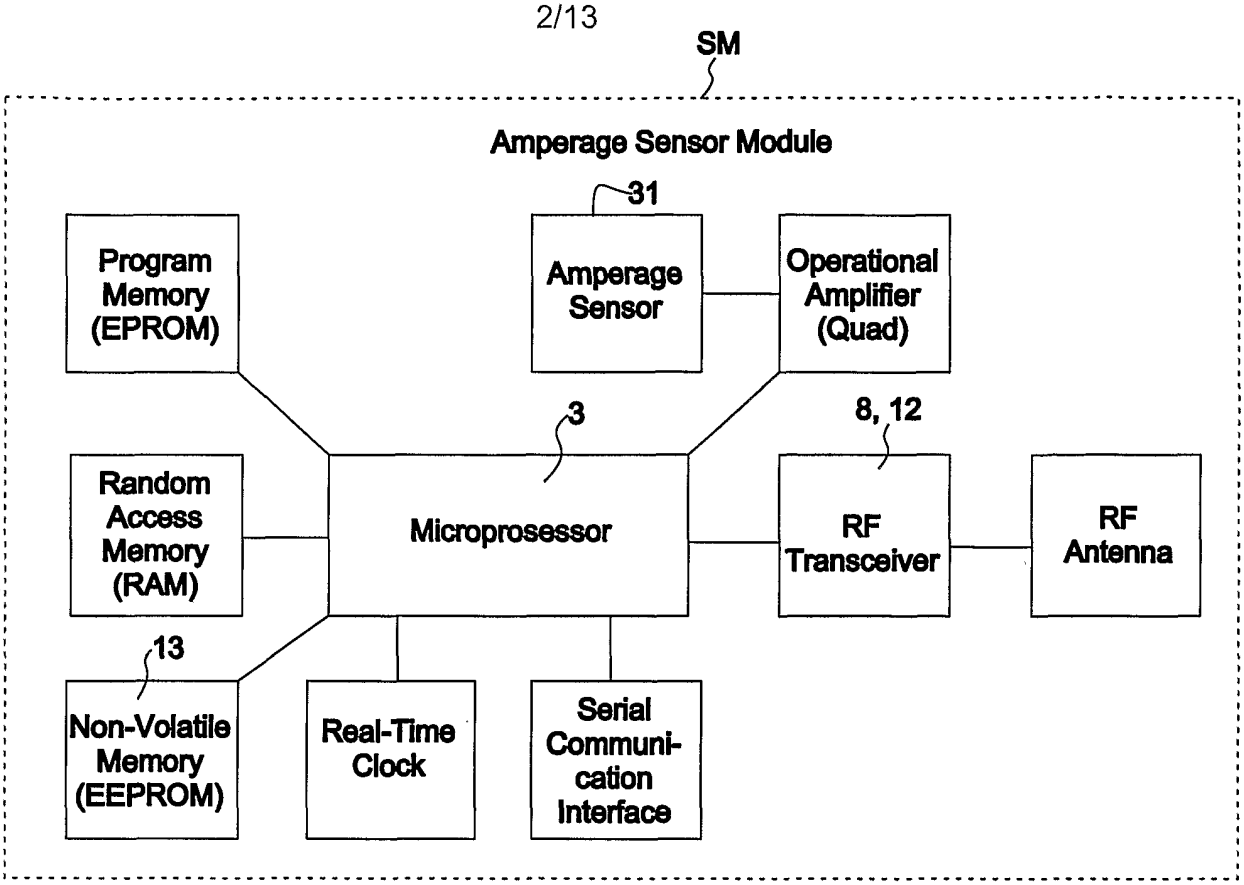

SM
Amperage Sensor Module
31
Program Memory (EPROM)
Amperage Sensor
Operational Amplifier (Quad)
3
8, 12
Random Access Memory (RAM)
Microprosessor
RF Transceiver
RF Antenna
13
Non-Volatile Memory (EEPROM)
Real-Time Clock
Serial Communi-cation Interface

Fig. 2

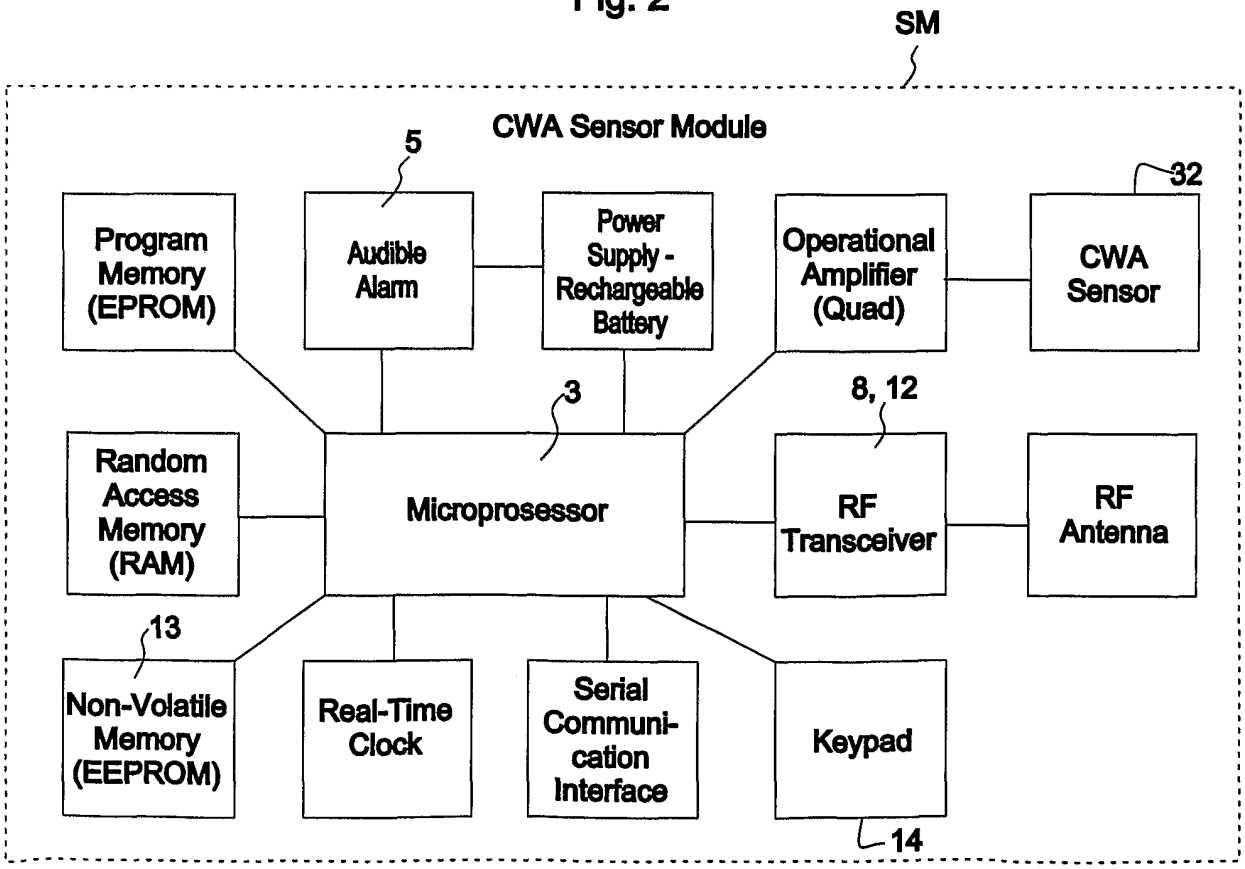

SM
CWA Sensor Module
5
32
Program Memory (EPROM)
Audible Alarm
Power Supply - Rechargeable Battery
Operational Amplifier (Quad)
CWA Sensor
3
8, 12
Random Access Memory (RAM)
Microprosessor
RF Transceiver
RF Antenna
13
Non-Volatile Memory (EEPROM)
Real-Time Clock
Serial Communi-cation Interface
Keypad
14

Fig. 3

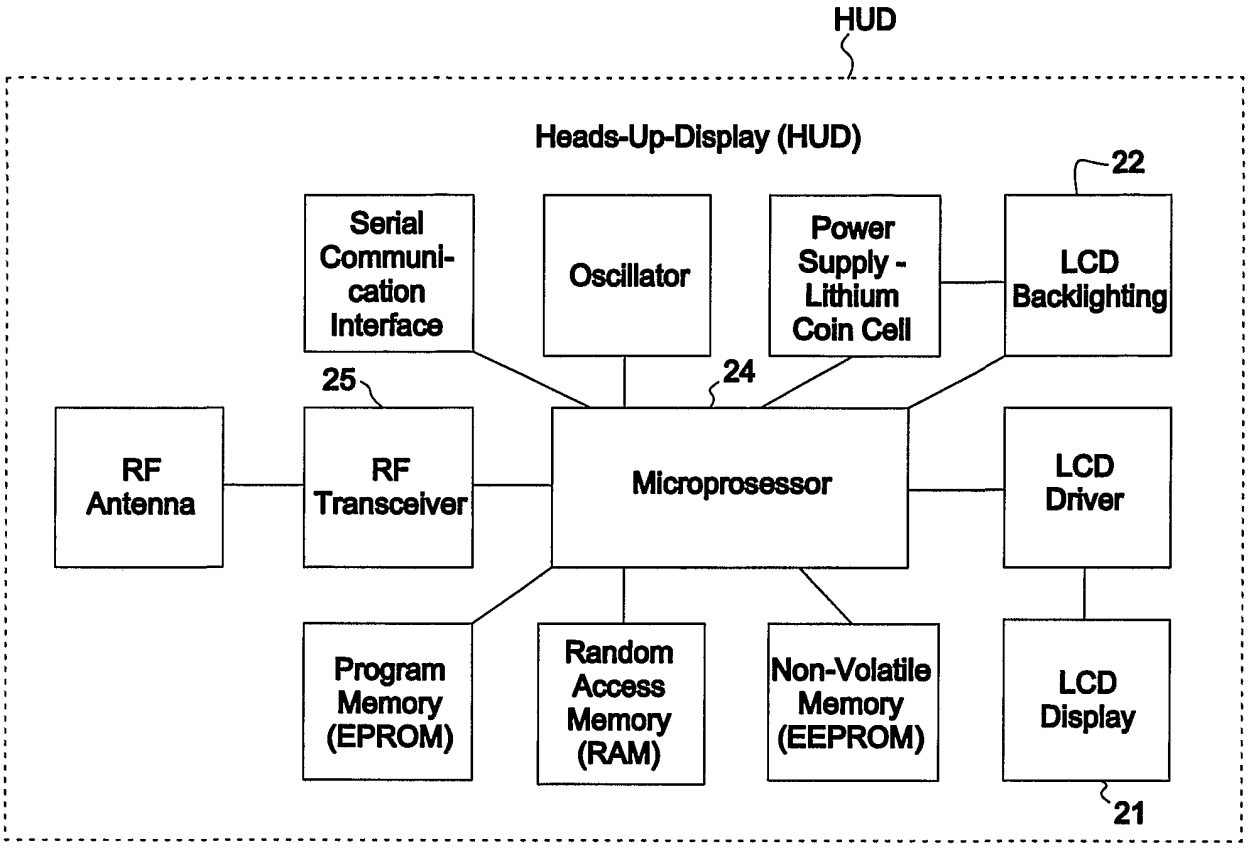

HUD
Heads-Up-Display (HUD)
22
Serial Communi-cation Interface
Oscillator
Power Supply - Lithium Coin Cell
LCD Backlighting
25
24
RF Antenna
RF Transceiver
Microprosessor
LCD Driver
Program Memory (EPROM)
Random Access Memory (RAM)
Non-Volatile Memory (EEPROM)
LCD Display
21

Fig. 4

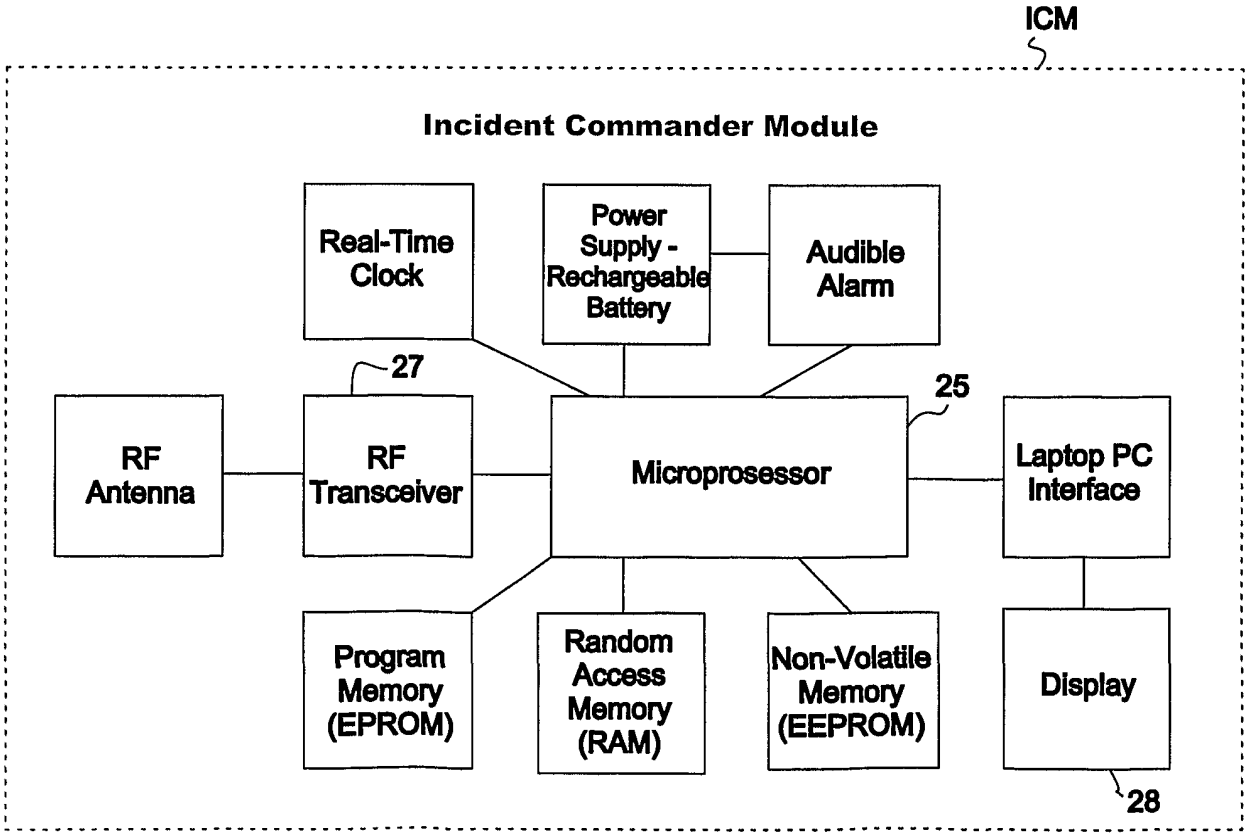

ICM
Incident Commander Module
Real-Time Clock
Power Supply - Rechargeable Battery
Audible Alarm
27
25
RF Antenna
RF Transceiver
Microprosessor
Laptop PC Interface
Program Memory (EPROM)
Random Access Memory (RAM)
Non-Volatile Memory (EEPROM)
Display
28

Fig. 5

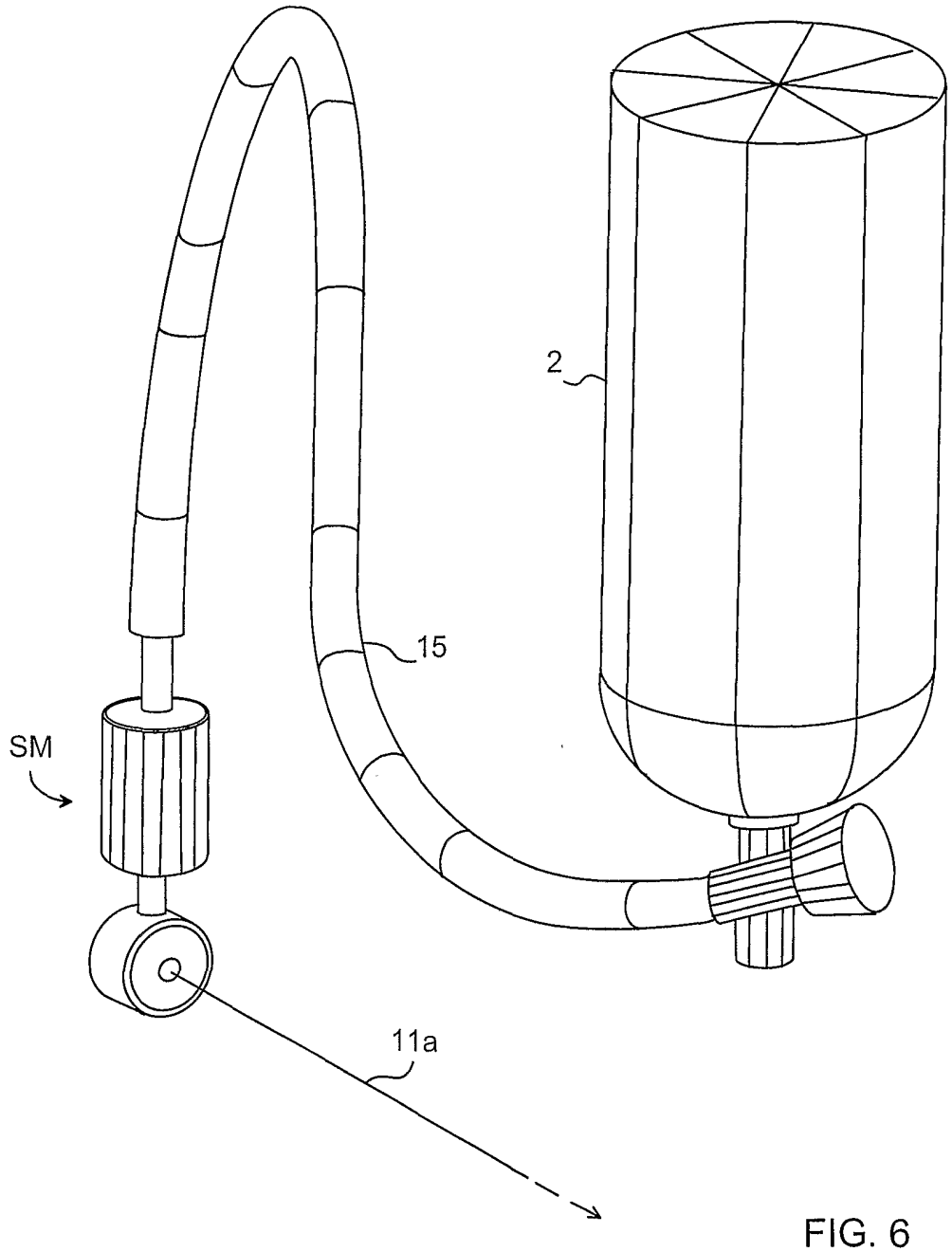


FIG. 6

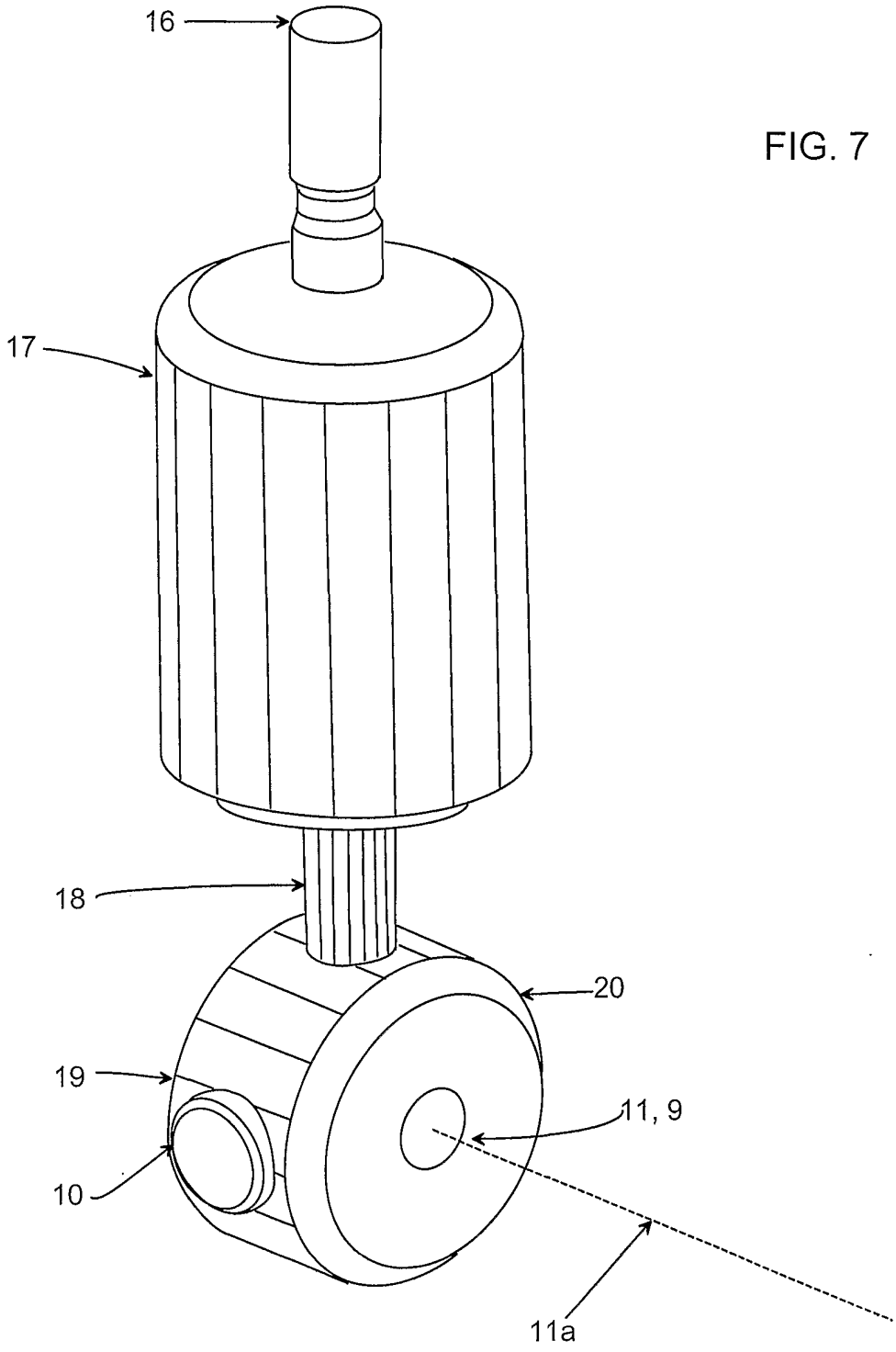


FIG. 7

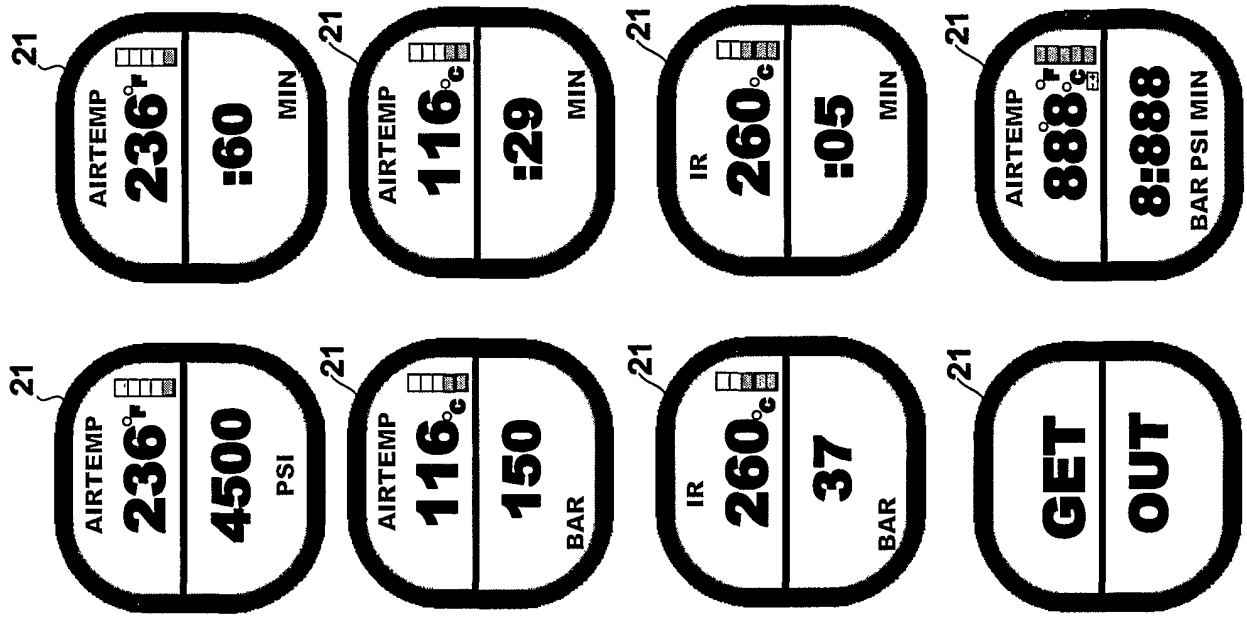

21
AIRTEMP
236°F
:60
MIN
21
AIRTEMP
116°C
:29
MIN
21
IR
260°C
:05
MIN
21
AIRTEMP
888°F
°C
8:888
BAR PSI MIN
21
AIRTEMP
236°F
4500
PSI
21
AIRTEMP
116°C
150
BAR
21
IR
260°C
37
BAR
21
GET
OUT

FIG. 11

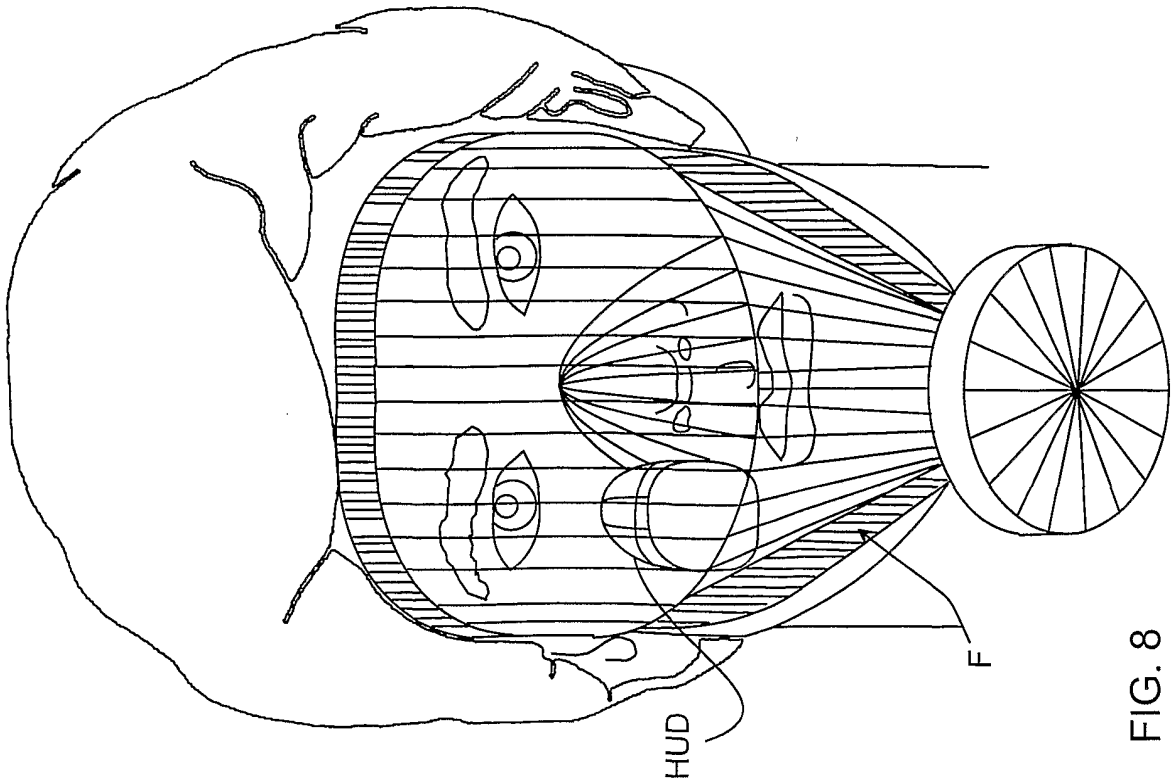

HUD
F

FIG. 8

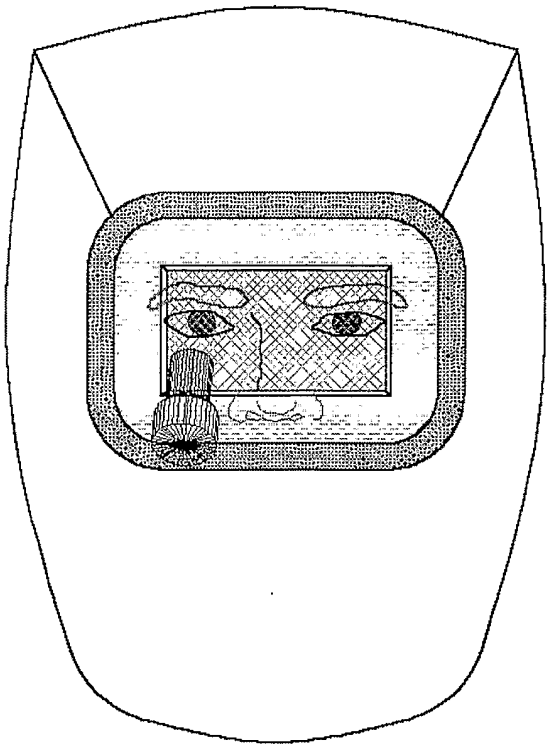


Fig. 9

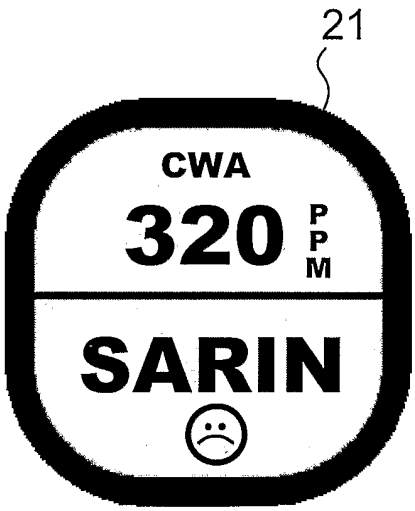


Fig. 13b

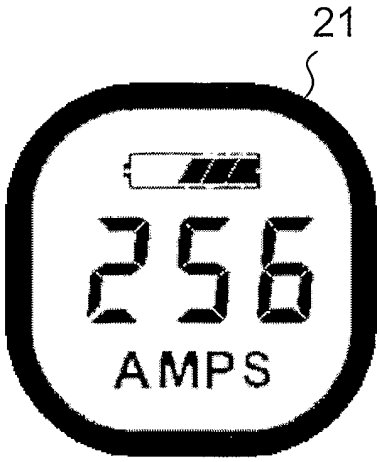


Fig. 12

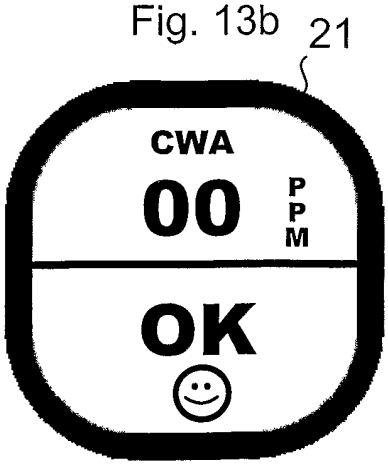
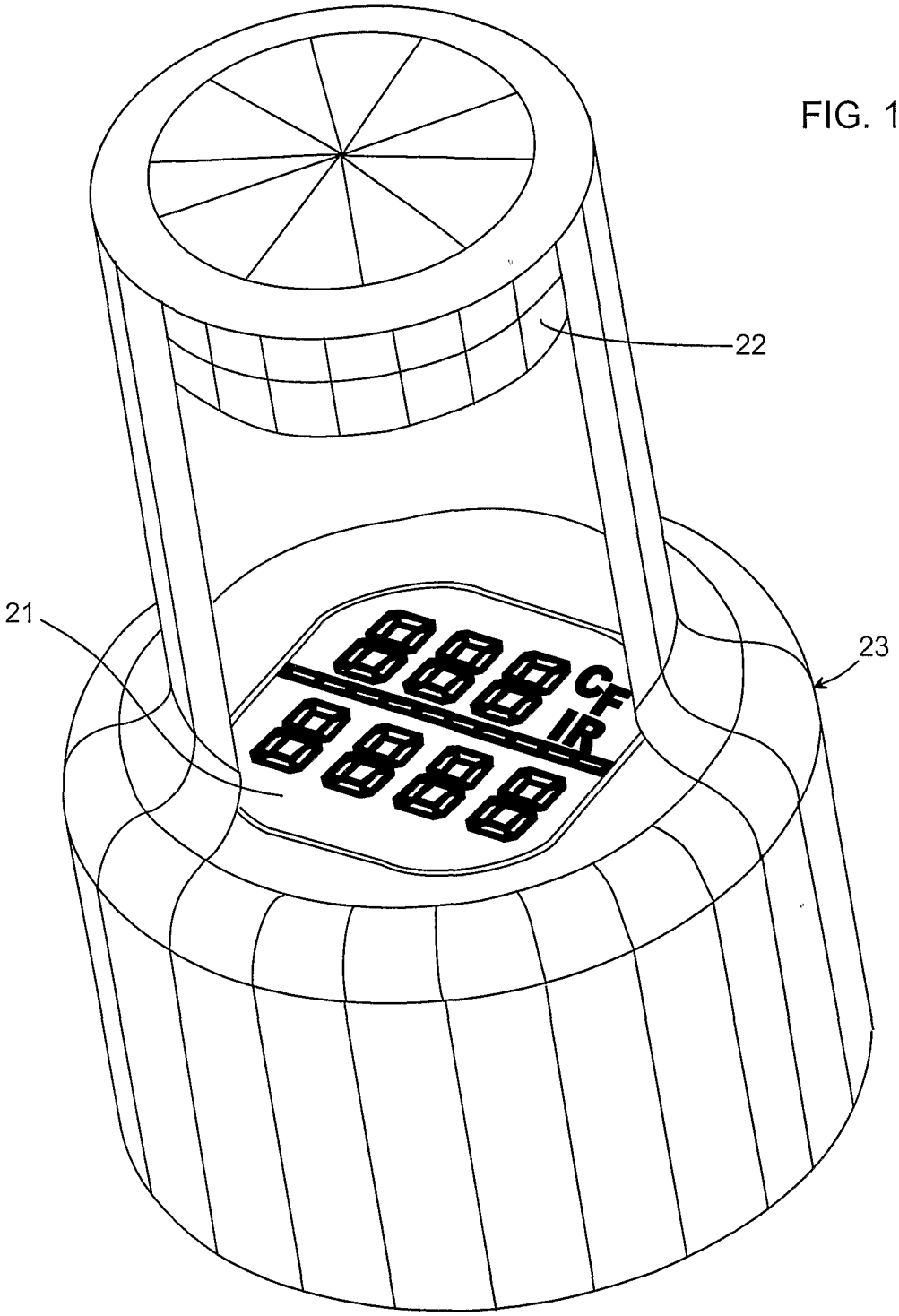


Fig. 13a

FIG. 10



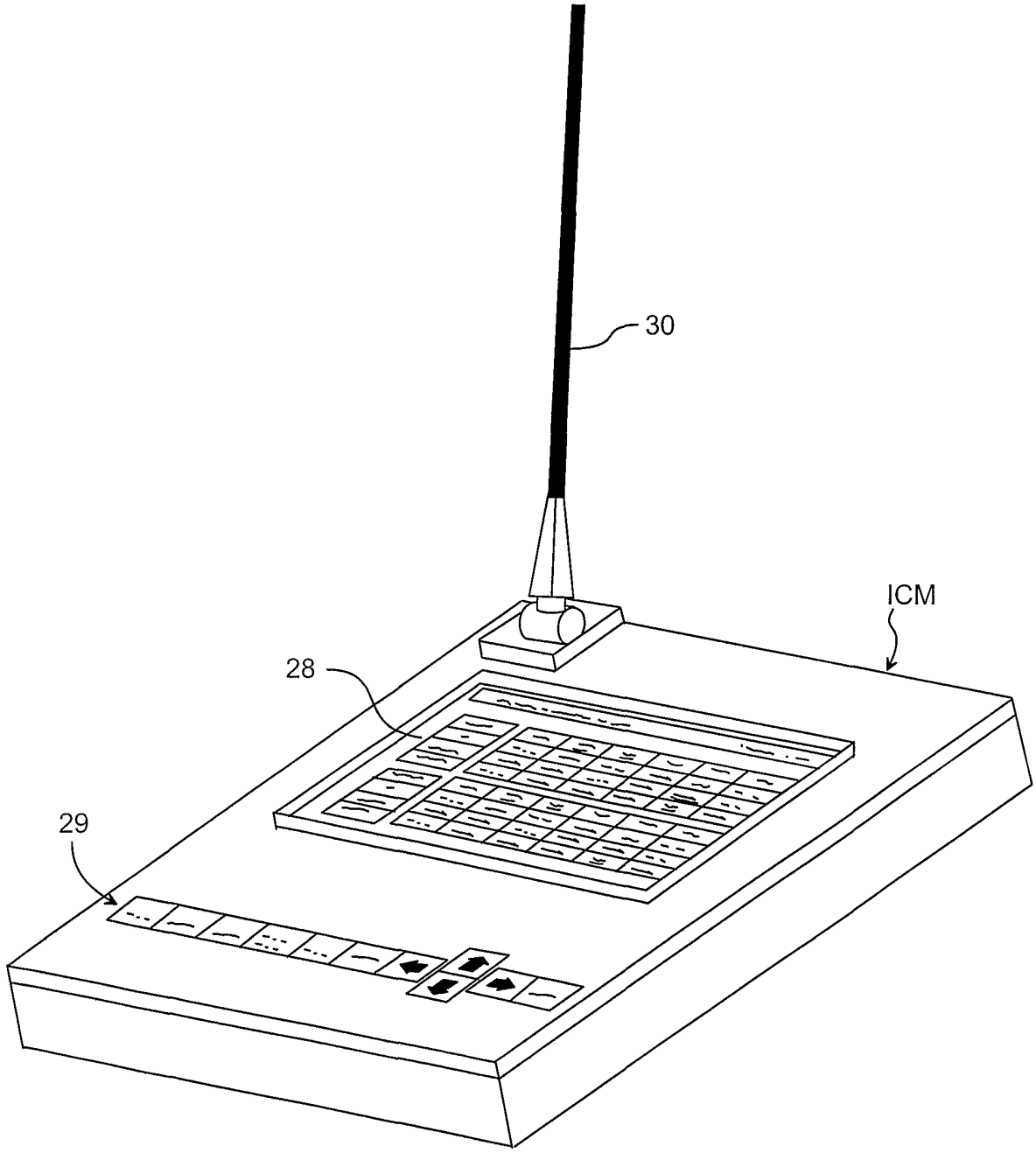


FIG. 14

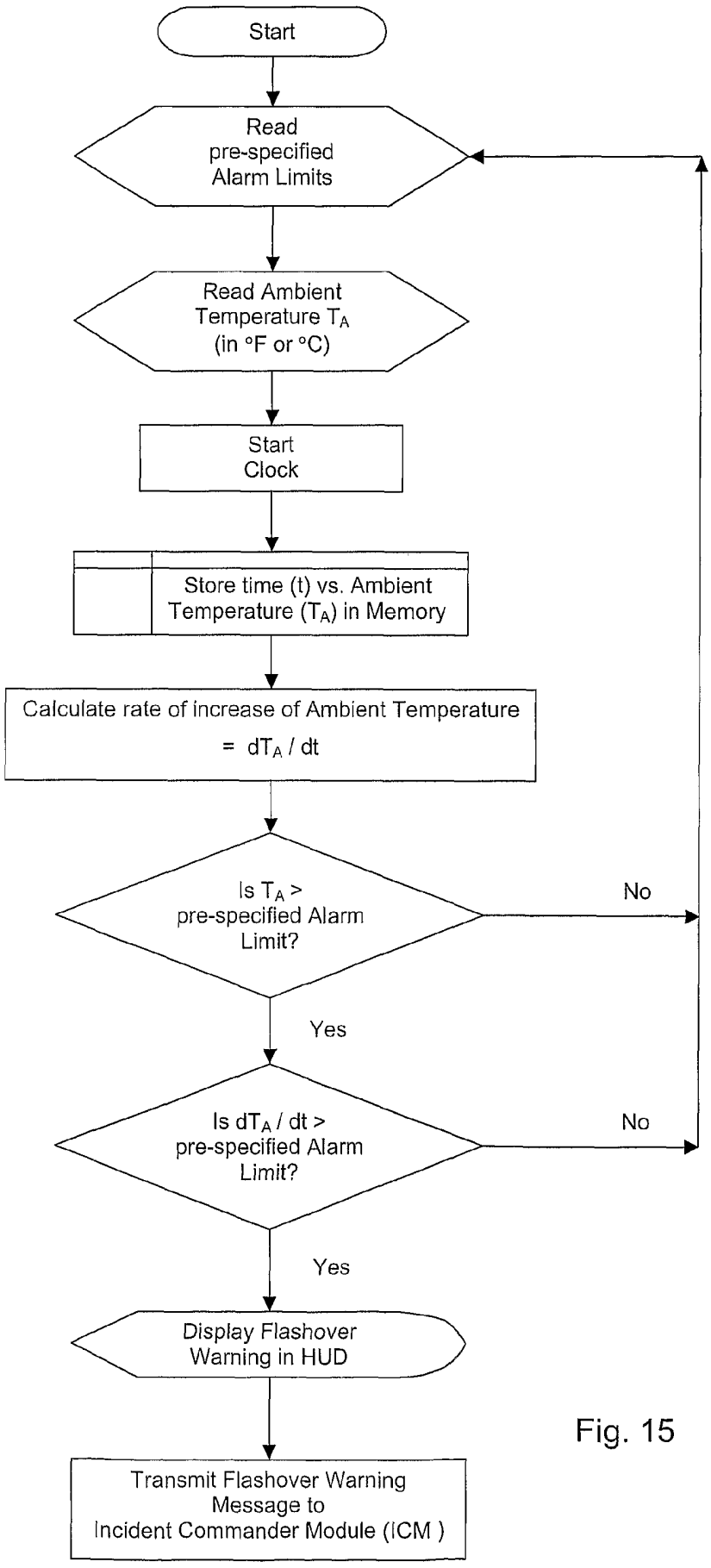

Start
Read pre-specified Alarm Limits
Read Ambient Temperature T_A (in °F or °C)
Start Clock
Store time (t) vs. Ambient Temperature (T_A) in Memory
Calculate rate of increase of Ambient Temperature = dT_A / dt
Is T_A > pre-specified Alarm Limit?
No
Yes
Is dT_A / dt > pre-specified Alarm Limit?
No
Yes
Display Flashover Warning in HUD
Transmit Flashover Warning Message to Incident Commander Module (ICM)

Fig. 15

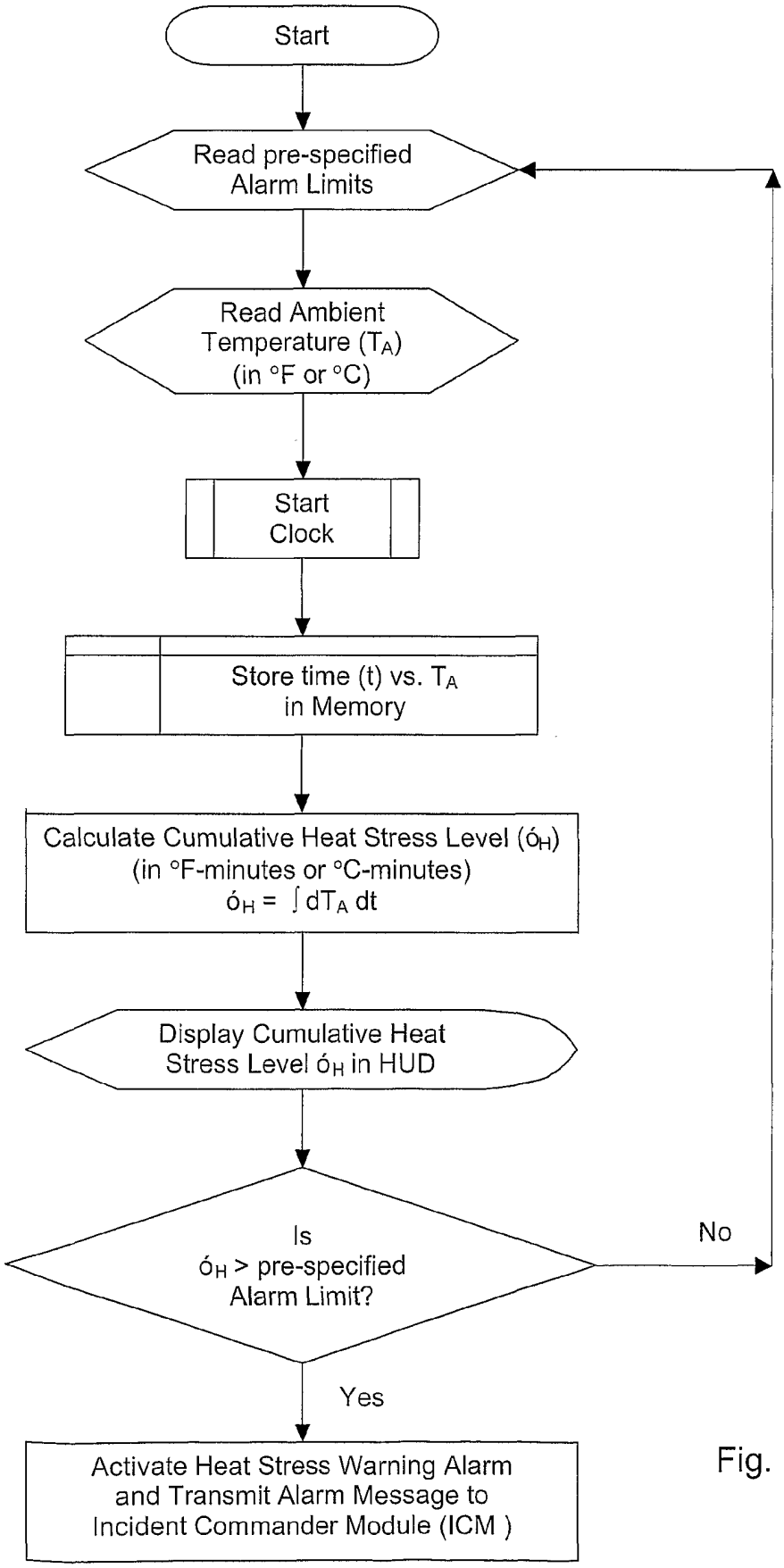

Start
Read pre-specified Alarm Limits
Read Ambient Temperature (T_A) (in °F or °C)
Start Clock
Store time (t) vs. T_A in Memory
Calculate Cumulative Heat Stress Level ($ó_H$) (in °F-minutes or °C-minutes) $ó_H = \int dT_A\, dt$
Display Cumulative Heat Stress Level $ó_H$ in HUD
Is $ó_H$ > pre-specified Alarm Limit?
No
Yes
Activate Heat Stress Warning Alarm and Transmit Alarm Message to Incident Commander Module (ICM)

Fig. 16

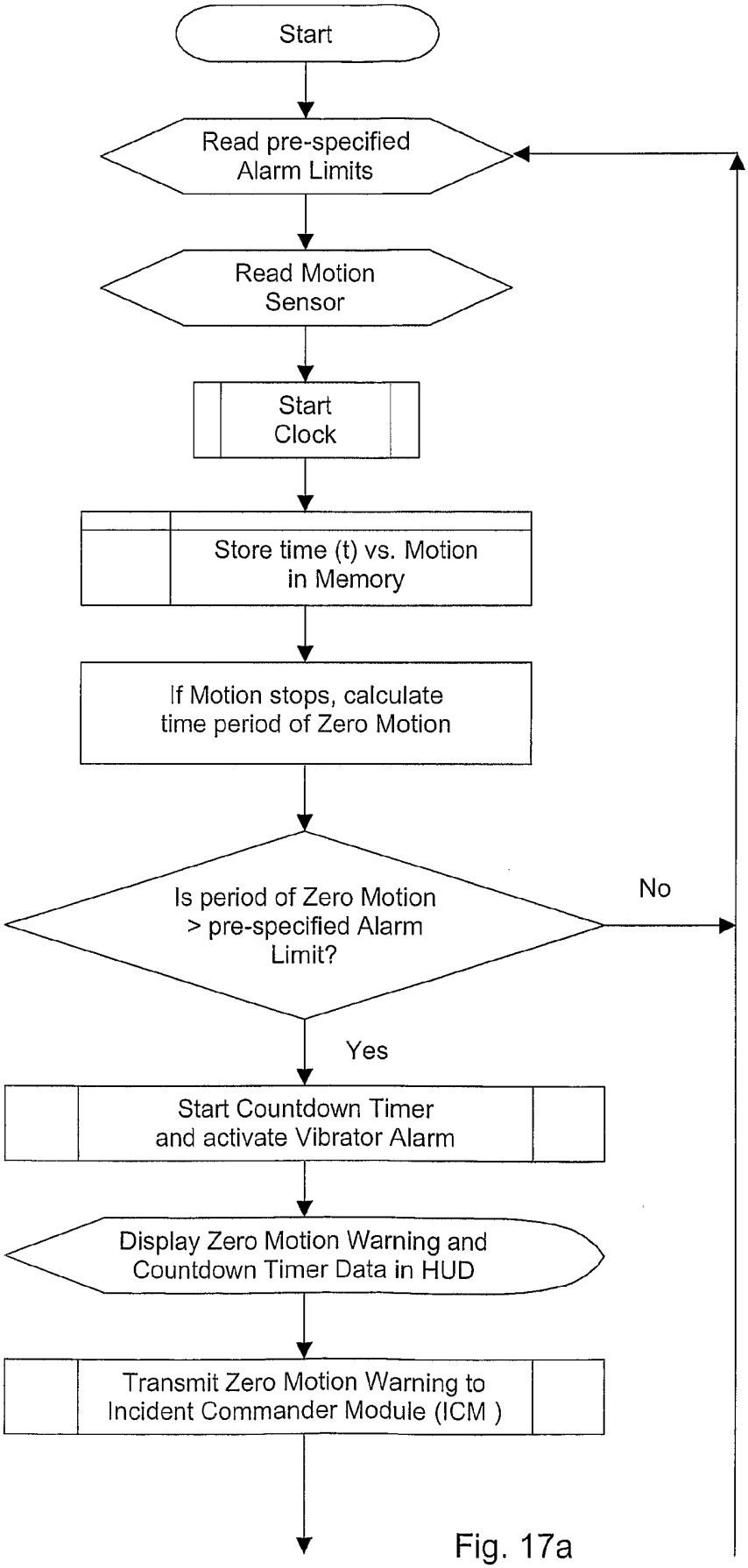

Start
Read pre-specified Alarm Limits
Read Motion Sensor
Start Clock
Store time (t) vs. Motion in Memory
If Motion stops, calculate time period of Zero Motion
Is period of Zero Motion > pre-specified Alarm Limit?
No
Yes
Start Countdown Timer and activate Vibrator Alarm
Display Zero Motion Warning and Countdown Timer Data in HUD
Transmit Zero Motion Warning to Incident Commander Module (ICM)

Fig. 17a

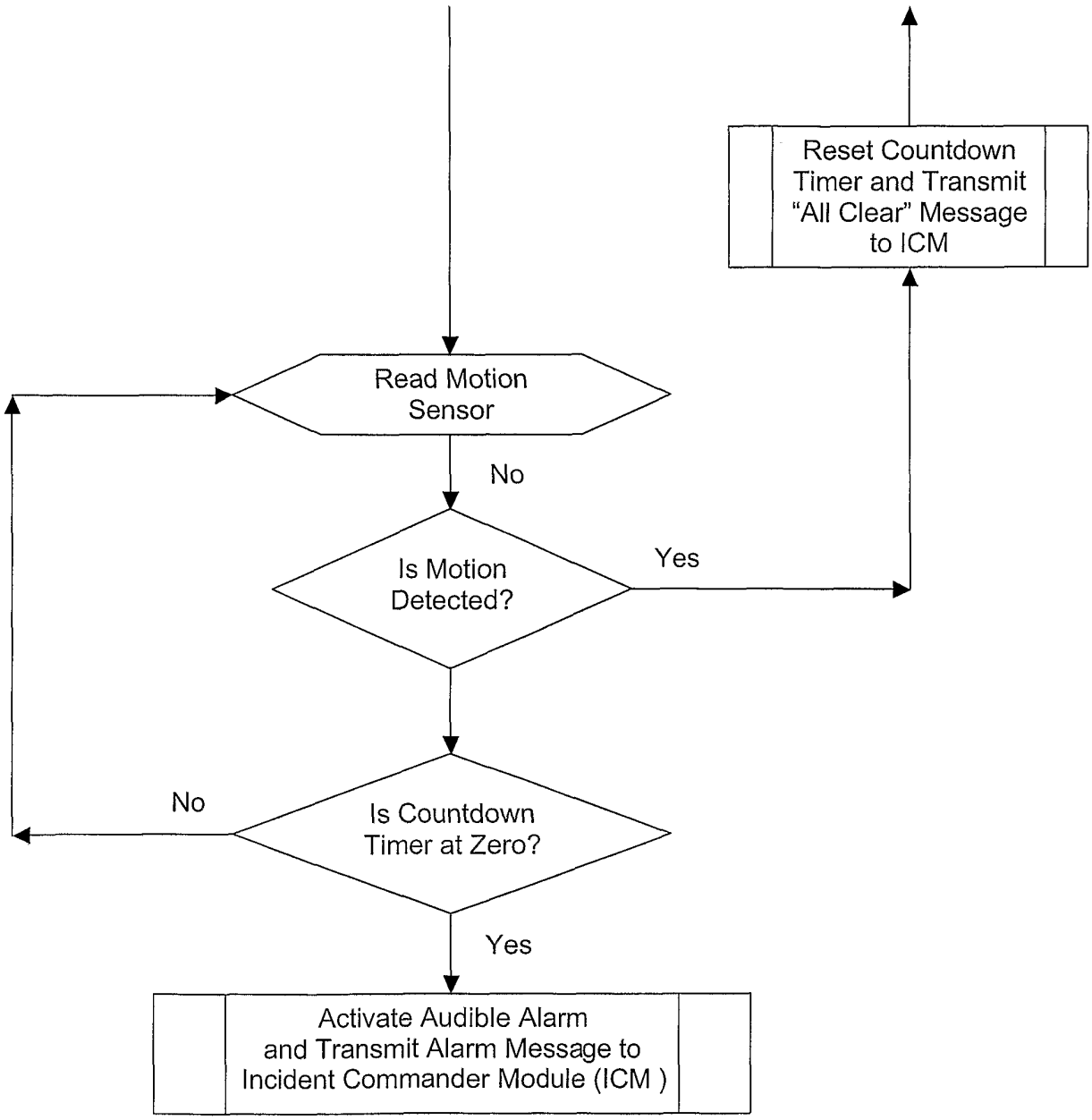

Reset Countdown Timer and Transmit "All Clear" Message to ICM
Read Motion Sensor
No
Is Motion Detected?
Yes
No
Is Countdown Timer at Zero?
Yes
Activate Audible Alarm and Transmit Alarm Message to Incident Commander Module (ICM)

Fig. 17b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/00626

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: A62B 18/08 // A62B 18/04, A61F 9/04, B63C 11/12
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)

IPC7: A62B, A61F, B63C

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5301668 A (L.B. HALES), 12 April 1994 (12.04.94) --	1-7
X	US 5503145 A (S. CLOUGH), 2 April 1996 (02.04.96) --	1-7
X	US 5617848 A (M.J. COCHRAN), 8 April 1997 (08.04.97) -- --------	1-7

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
6 November 2001	07 -11- 2001
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Sune Söderling / MRo Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 01/00626

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5301668 A	12/04/94	AU 2240392 A WO 9300134 A	25/01/93 07/01/93
US 5503145 A	02/04/96	NONE	
US 5617848 A	08/04/97	US 5794616 A US 5899204 A	18/08/98 04/05/99