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(54) **IGNITION INTERLOCK BREATHALYZER**

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(52) **U.S. Cl.** ..... **340/426.24**

(57) **ABSTRACT**

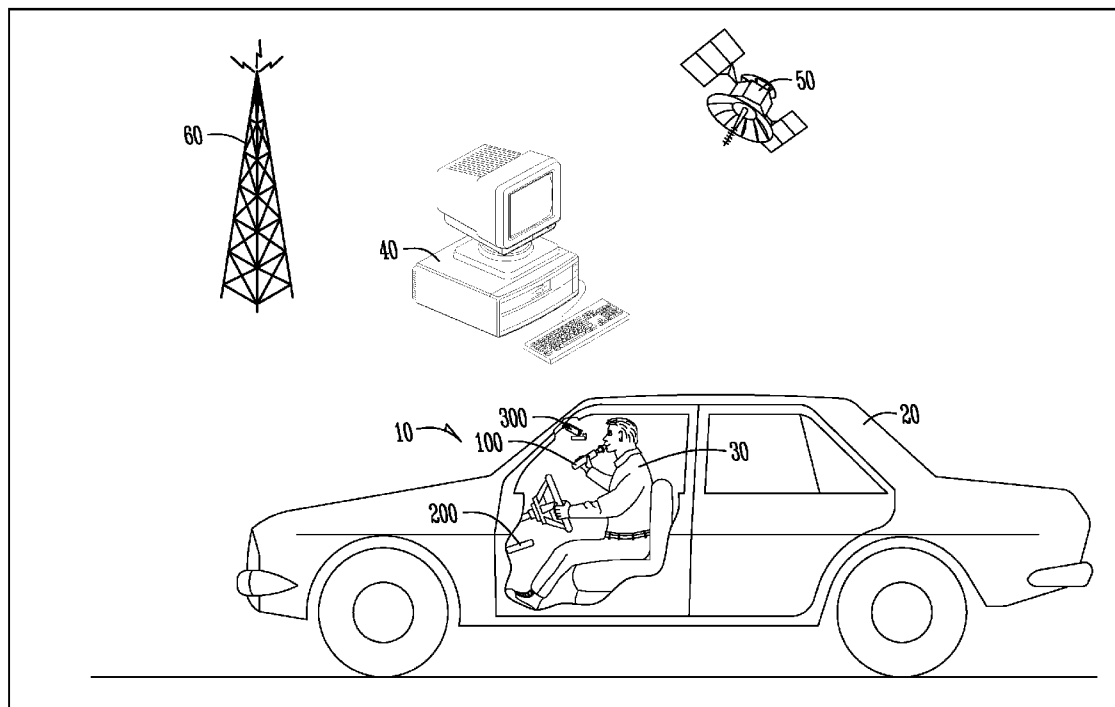
(21) Appl. No.: **12/973,550**

The invention relates to an improvement in a breath alcohol test devices includes within the handheld unit containing a fuel cell, a miniaturized self calibrating test device thereby avoiding the need for 30, 60 and 90 day calibration testing. It also relates to various tamper or circumvention improvements that may be used alone or in combination with the self calibration improvement, including cameras to record a driver providing a breath sample and to verify the location of the driver within a vehicle.

(22) Filed: **Dec. 20, 2010**

**Related U.S. Application Data**

(63) Continuation of application No. 12/504,714, filed on Jul. 17, 2009.



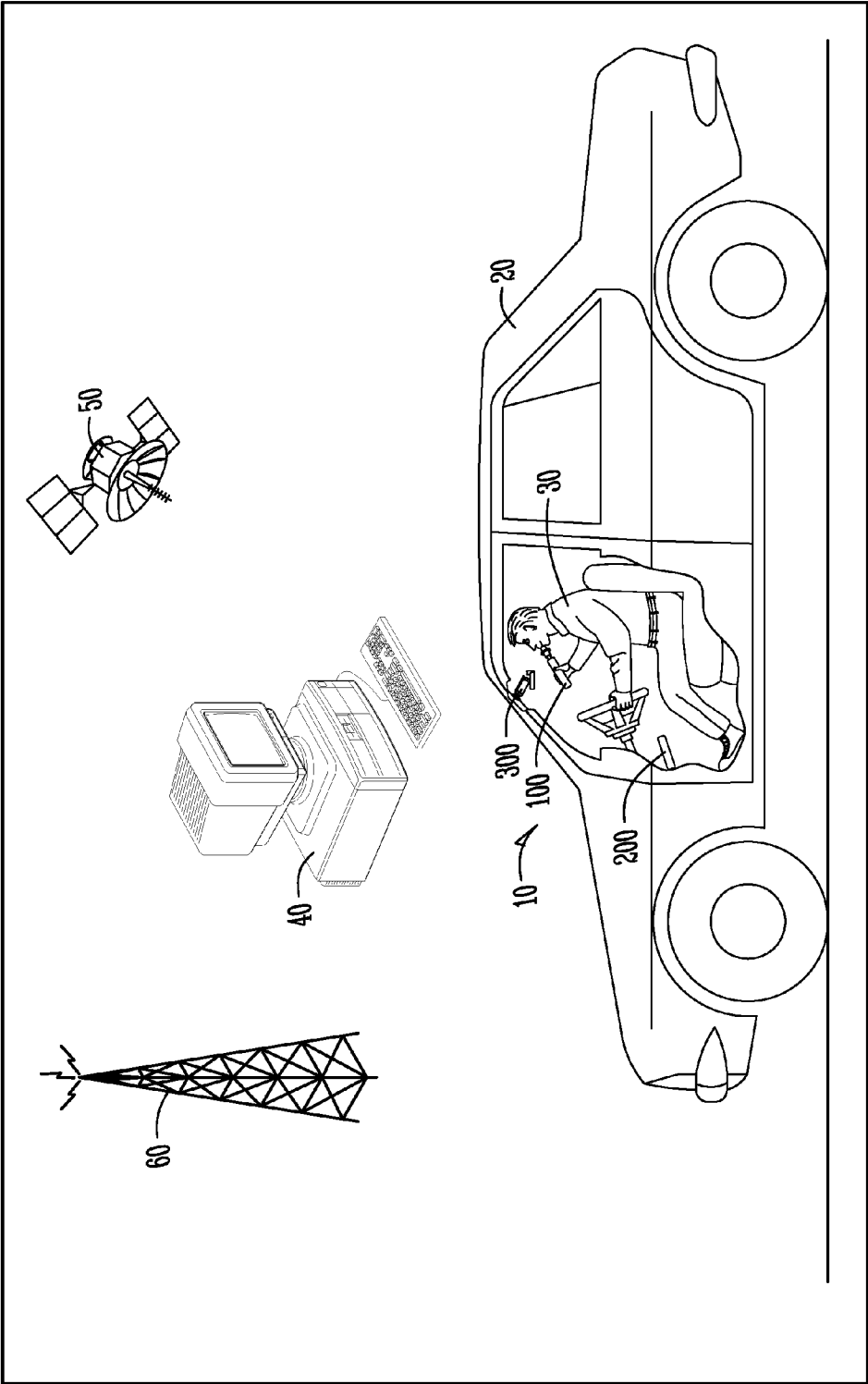


Fig. 1

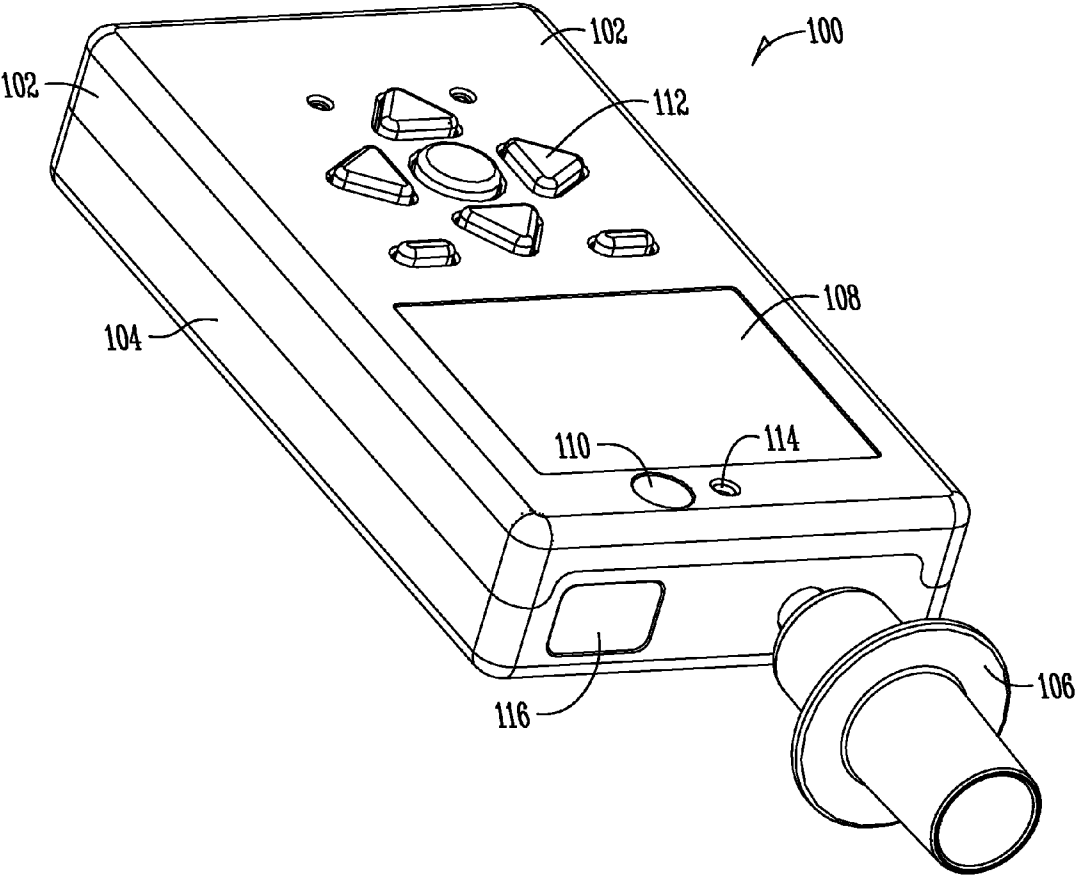
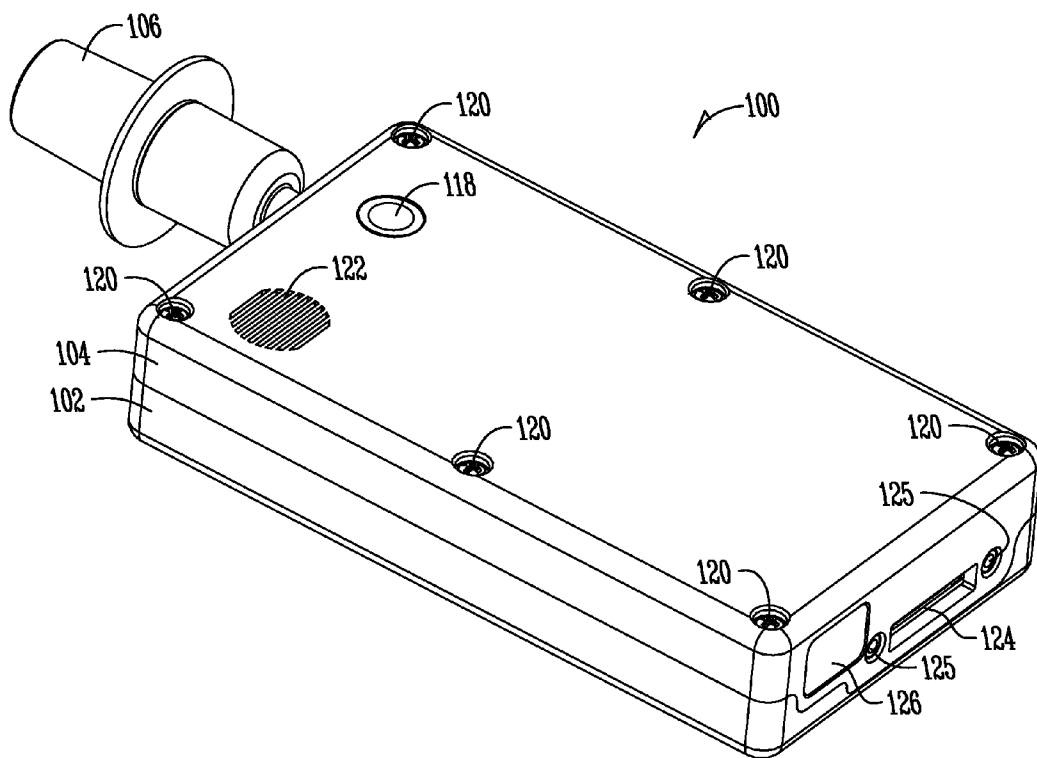


Fig. 2



*Fig. 3*

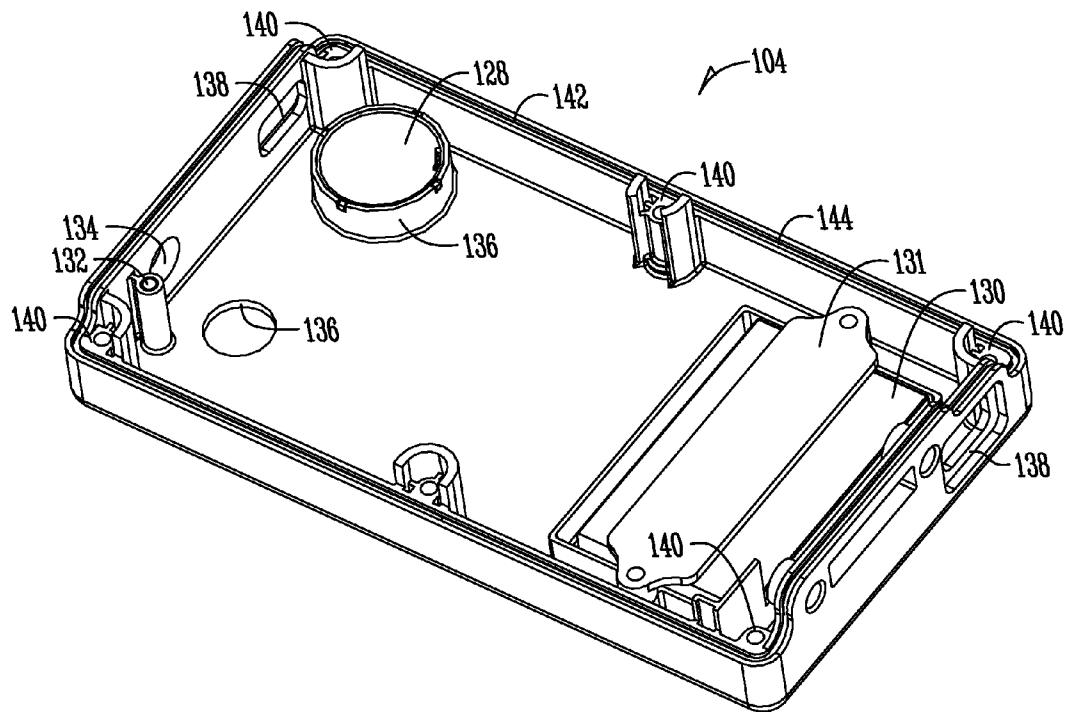


Fig. 4

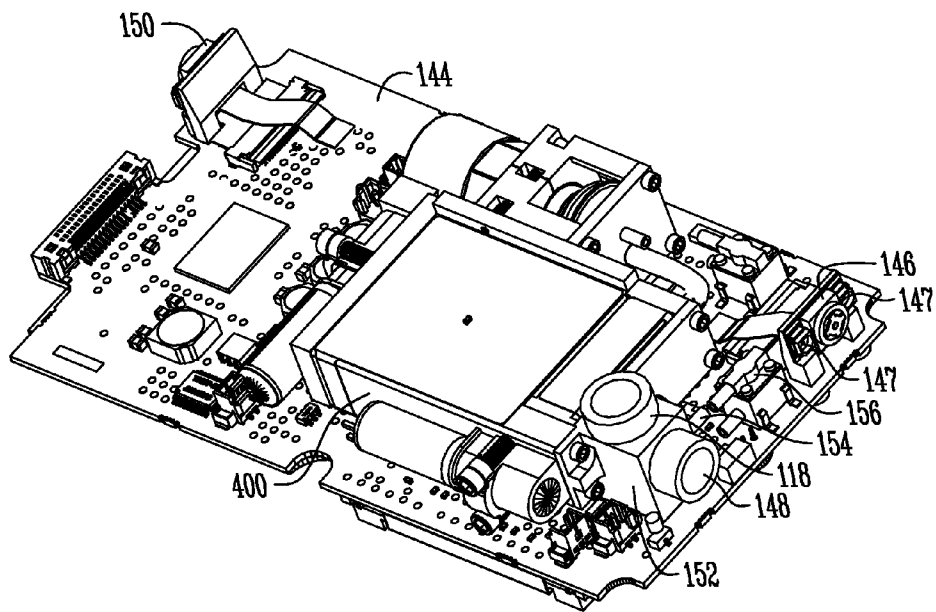
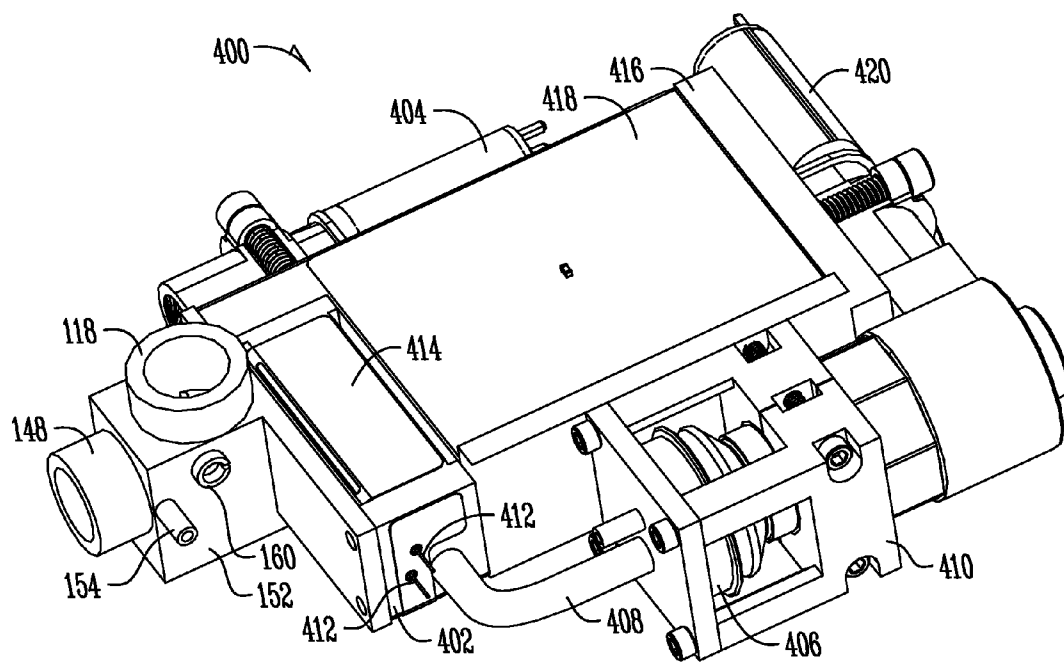


Fig. 5



*Fig. 6*

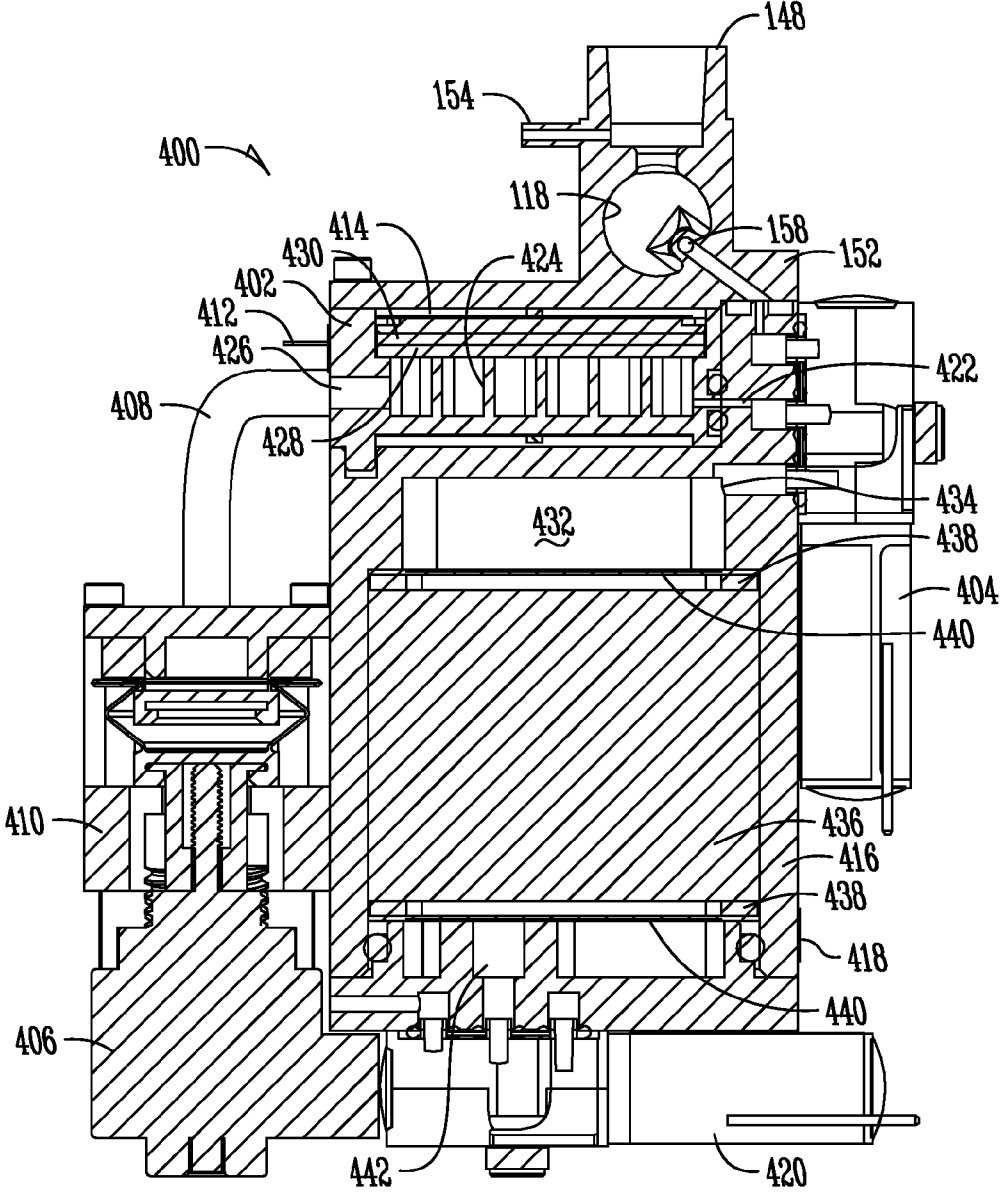


Fig. 7

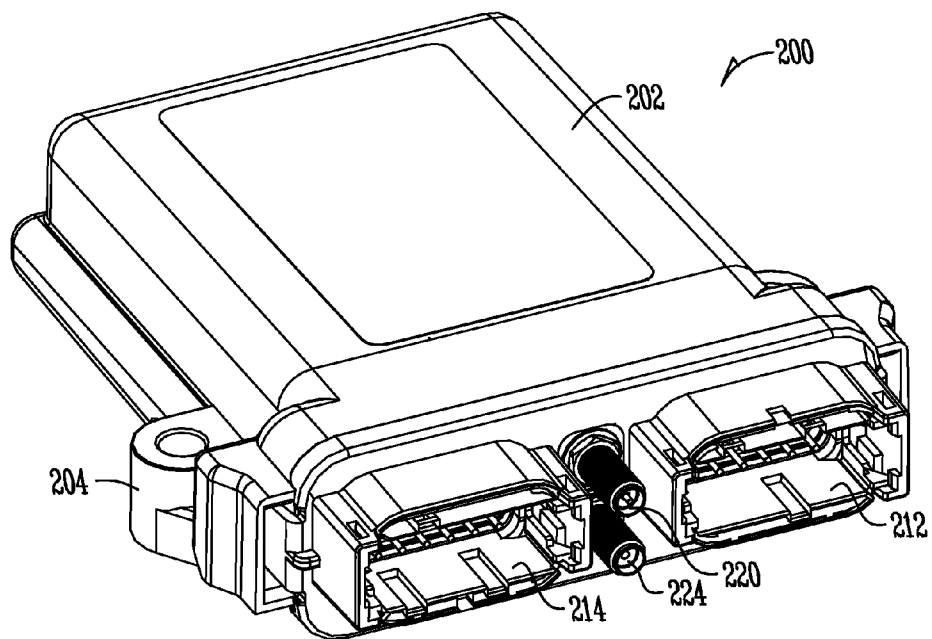


Fig. 8

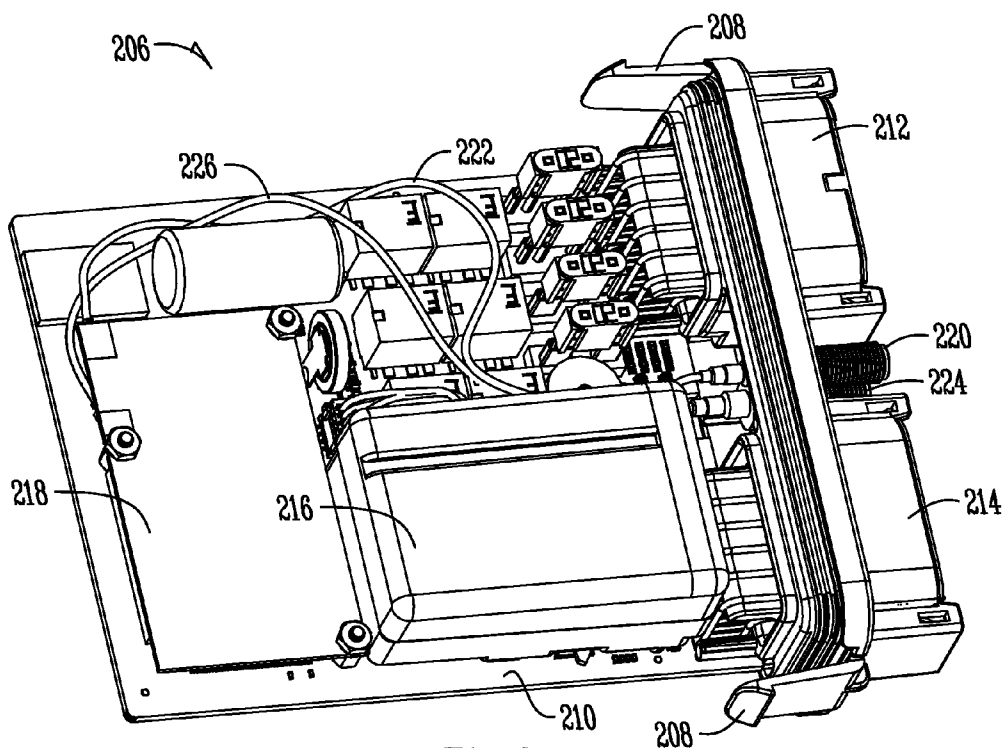


Fig. 9



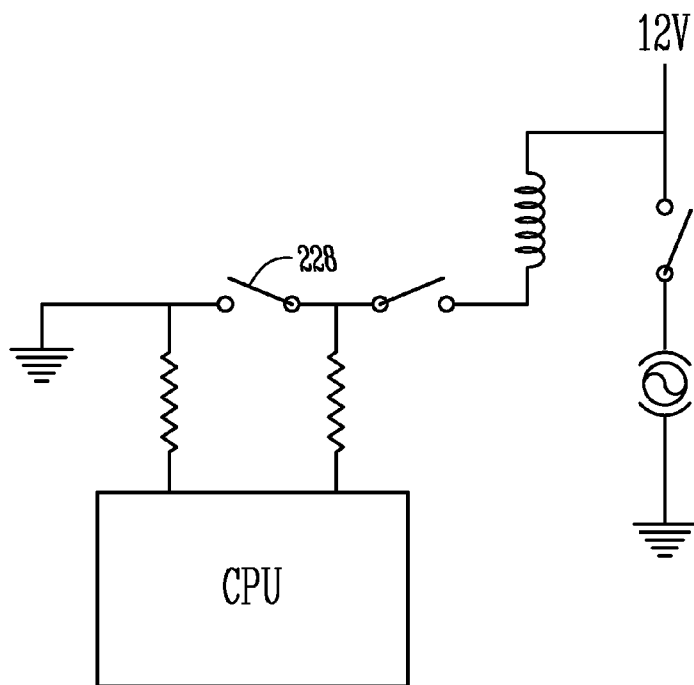


Fig. 10

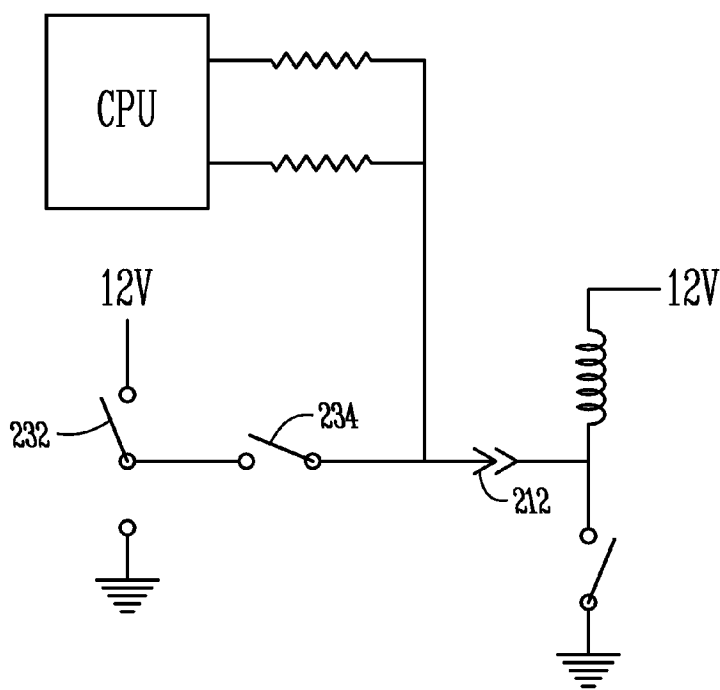
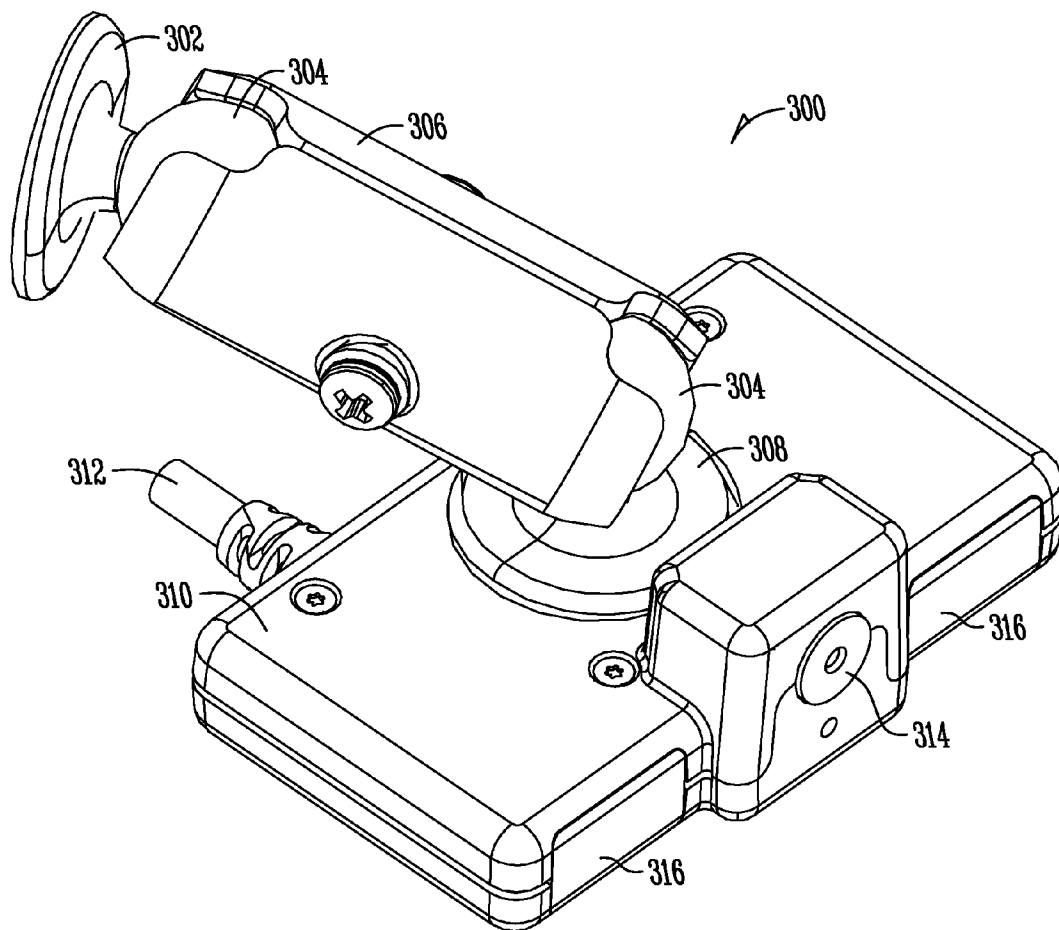


Fig. 11



*Fig. 12*

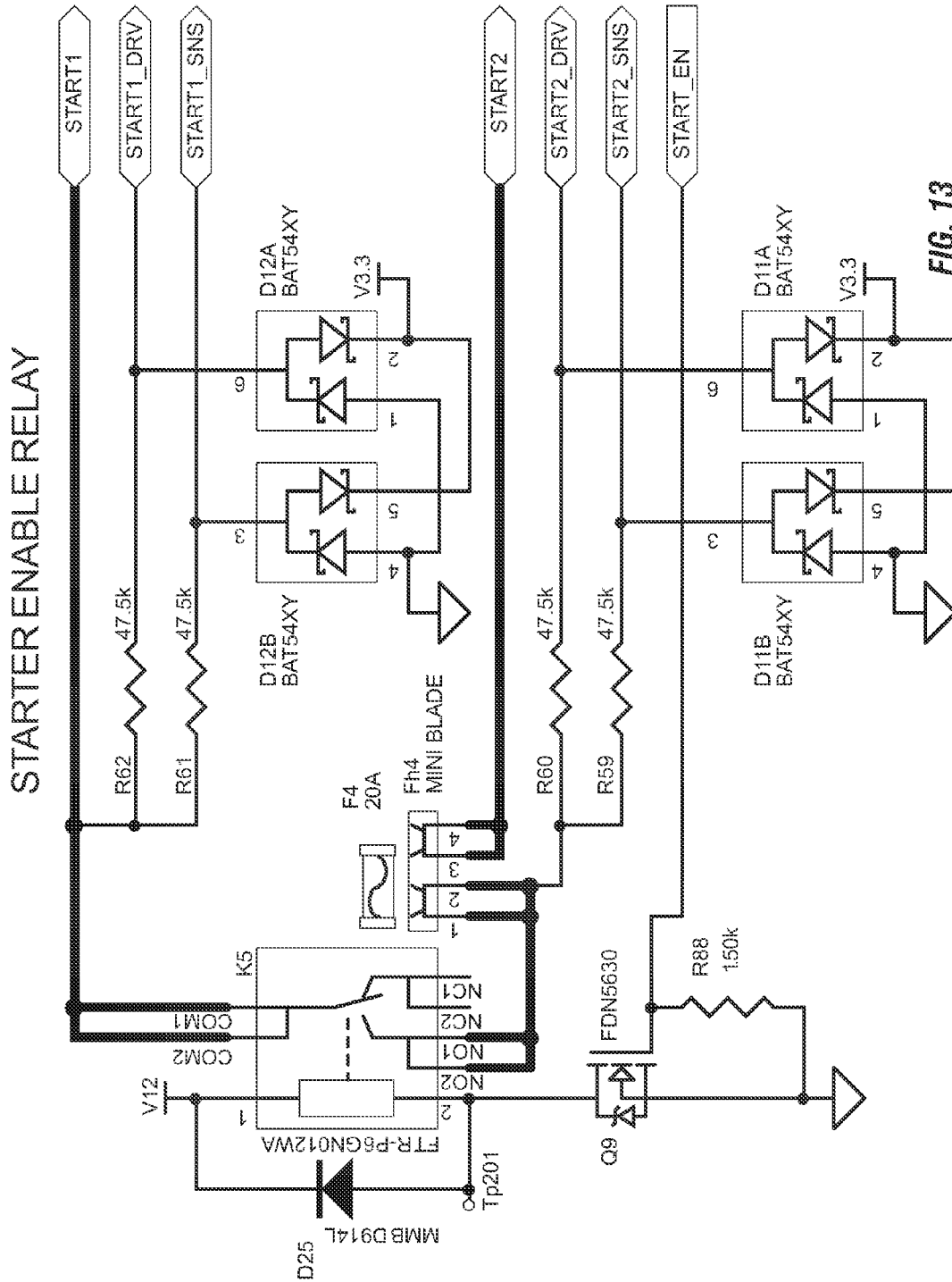


FIG. 13

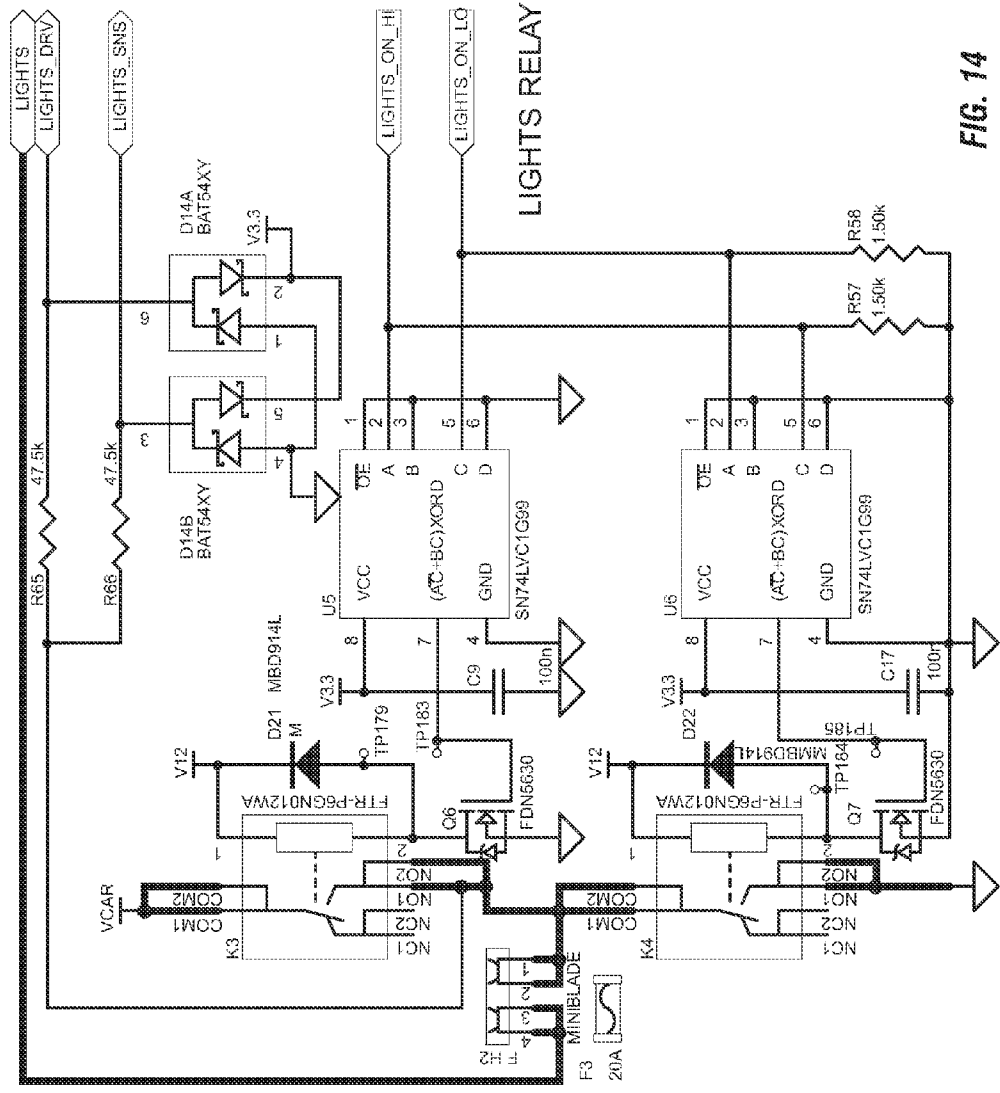


FIG. 14

**IGNITION INTERLOCK BREATHALYZER**

**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application is a continuation of U.S. Ser. No. 12/504,714 filed Jul. 17, 2009, which claims priority under 35 U.S.C. §120 to provisional application Ser. No. 61/081,594 filed Jul. 17, 2008, herein incorporated by reference in its entirety.

**FIELD OF THE INVENTION**

[0002] This invention relates to a breath alcohol ignition interlock device. Before the vehicle can be started, the driver must breathe into the device. If the analyzed blood alcohol result is over a programmed blood alcohol concentration, commonly 0.02% or 0.04%, the vehicle cannot be started.

**BACKGROUND OF THE INVENTION**

[0003] Analyzing devices, used to determine the blood alcohol content of those about to drive vehicles, are commonly available. They emanated from breathalyzers used by law enforcement to test whether or not a driver was intoxicated, i.e., over the legal limit. In more recent times this traditional use of breathalyzing devices has been enhanced by combining a breathalyzer and an ignition locking system to prevent known, problem intoxicated drivers from being able to start their vehicle. This has been used with habitual violators in order to allow driving for necessary reasons, for example, to work, after confirming they are not intoxicated.

[0004] Typically at random times after the engine has been started the ignition interlock device will require another breath sample. The purpose of this is to prevent a friend (imposter) from breathing into the device to pass the test, thus enabling the intoxicated person to get behind the wheel and then drive away. If the breath sample isn't provided, or the sample given exceeds the ignitions interlock set blood alcohol level, the device will log the event, warn the driver, send a command station warning and begin visible and auditory warnings such as lights flashing, horn honking, etc.

[0005] Modern ignition interlock devices use an ethanol specific fuel cell for a sensor. A fuel cell is an electrochemical device in which alcohol undergoes a chemical oxidation reaction at a catalytic electrode surface (often platinum) to generate an electrical current. This current is then measured and converted to an alcohol equivalent rating. If it exceeds safe limits, warnings are issued.

[0006] A device log keeps a record of the activity on the device in the interlock vehicle electrical system. This record, or log, is printed out or downloaded each time the device sensors are calibrated, commonly at 30, 60 or 90 day intervals. Authorities may even require periodic review of the log. If violations are detected, then additional sanctions can be implemented. The typical periodic calibrations performed use either a pressurized alcohol/gas mixture at known standard alcohol concentration to test accuracy, or an alcohol wet bath (Guth) arrangement that contains a known standard alcohol solution. Cost of installation, maintenance and calibration are generally paid by the offender, which typically can run \$100 a month or more.

[0007] A breath alcohol ignition interlock device is typically comprised of two components. One is a handheld component that contains the fuel cell to contain the electrochemical reaction and response after gathering the initial breath

data. The second component is a relay box that relays the information and data from the first hand held unit to a command station or to provide a warning alarm, such as lights flashing, horn honking, etc or both. Both parts of the device offer opportunities for mischief, if one is inclined to try and beat the device and forestall court penalty sanctions, etc. Put another way, for the devious user on whom courts have already imposed enforced use of an ignition interlock device, often there is a "match of wits" between the ignition interlock device manufacturer and the user.

[0008] Some obvious attempts at avoiding the consequences of use of an ignition interlock device include imposter fraud, i.e., someone else other than the intoxicated driver provides the breath sample or no breath sample at all, but simply use of stored fresh air. A third and perhaps more daring and reckless attempt by one under the influence is deactivation, simply by attempts at disconnecting or even destruction. A fourth and perhaps a more subtle evidentiary way of avoiding the consequences of detection of excess use of alcohol is simply to deny the accuracy of the device, i.e., a fuel cell that has gone "haywire".

[0009] Manufacturers have done some things over the years to try and eliminate the risk of each of these avoidance techniques. For example, co-owned and commonly assigned application of some of these current inventors is U.S. Pat. No. 5,426,415 issued Jun. 20, 1995, is a breath temperature sensor to measure temperature of the breath sample to ensure that is the same temperature as normal human breath, thereby avoiding use of other non-human air sources. The '415 patent also requires rolling retests to ensure that the driver is the one that was tested and remains sober. U.S. Pat. No. 6,748,792 relates to use of video camera surveillance to capture the identity of the person being tested. U.S. Pat. No. 6,026,674 teaches use of detectors to detect use of alcohol removing filter media, such as activated charcoal by detecting the resultant low pressure caused by the pressure drop across an alcohol filter.

[0010] From the above it can be seen there are many "wily ways" of seeking to circumvent a breath alcohol ignition interlock device. A reliable interlock device avoids as many of these as possible, and detects the fraud, sending a signal to a command station, etc. That is, a good interlock device records attempts to physically tamper with it, detects circumvention or retest fraud attempts including disconnect efforts, and reports non-human air samples or attempts to filter out the breath, or mask the amount of alcohol blown into the device, and finally records and logs for evidentiary purposes each use.

[0011] One of the properties associated with high integrity breath alcohol ignition interlock devices is a need for proof of calibration. Calibration is expensive, and depending on the device, it needs to occur every 30, 60 or 90 days. Calibration usually involves the wet chemistry of known standards or a Guth bath. While necessary problems with calibration involve time consumption, expense of distant travel that may be necessary, inconvenience discourages expense and the travel to maintain integrity and the user's knowledge that lack of an adequately calibrated machine may make the evidence it collects inadmissible in court discourages the effort. One way all of this could be avoided is to develop a machine that self calibrates. That is to say, it internally reports information that could be used as States evidence that it is constantly calibrated. This would save money, time and expense of all concerned.

**[0012]** Yet another problem with alcohol ignition interlock devices is constant user circumvention by imposter fraud. As mentioned there are a variety of existing state-of-the-art techniques that have been used to detect such fraud and also to detect artificial samples. Some detectors that are used detect attempts to filter out alcohol from the breath; others take a video of the person blowing into the breathalyzer. With the latter, this can be avoided by one person blowing into the breathalyzer and then a different person driving. A circumvention frustration technique that is used by this invention is using two video cameras, one to detect the person blowing into the breathalyzer and a second to detect the person driving. If different people are recorded on these two different videos, the system senses and keeps a video record of this. As far as the present Applicants know, no one has so far used two video cameras, one focusing on the person taking the test and the other focusing on the driver, in order to be sure they are the same.

**[0013]** Another device useful for the present invention to detect circumvention efforts is the use of an accelerometer both in the handheld unit and in the relay box to immediately sense attempts at destruction and send a warning to a command station that such activity is occurring. If desired, this may even be coupled with a GPS to report location.

**[0014]** While most circumvention detection systems focus on the handheld unit, this invention also makes use of detection systems on the relay unit. Therefore it even further frustrates circumvention efforts. In particular, it also uses an internal cell phone which calls back to a command station when there is a sobriety violation and it may use a wireless link (RFID technology) between the handheld unit and the relay box in order to avoid circumvention efforts by wire cutting.

**[0015]** Accordingly, it is a primary object of the present invention to provide a self calibrating breath alcohol ignition interlock device.

**[0016]** Another important objective as seen from the above discussion is to provide a unit with enhanced ability to detect circumvention efforts such as imposter fraud, artificial air sample, deviation by destruction, etc.

**[0017]** The invention features of novelty which characterize it are pointed out with particularity in the claims which form a part of this disclosure. For a better understanding of the invention, its operating advantages and how its specific objects are achieved, reference is made to the accompanying drawings and the descriptive matter in which preferred embodiments of the invention are illustrated. It is to be understood that all of these features need not be used in the same unit, and that improvements in existing devices may be achieved by any one of the additional advantageous or improvements described herein for either the handheld unit or the relay box used alone or in combination.

**BRIEF SUMMARY OF THE INVENTION**

**[0018]** The invention relates to an improvement in a breath alcohol test devices that include within the handheld unit a fuel cell and a miniaturized self calibrating test device for the fuel cell thereby avoiding the need for 30, 60 and 90 day calibration testing. It also relates to various tamper proof or circumvention improvements that may be used alone or in combination with the self calibration improvement.

**[0019]** According to one embodiment the present invention is directed to a vehicle breathalyzer device that includes a breath alcohol testing device adapted to collect a breath

sample from a possible driver of a vehicle. The device also includes a first image recorder that records an image of the possible driver of the vehicle each time the driver provides a breath sample to the breath alcohol testing device and a second image recorder that records a verification image each time the breath sample is provided. The verification image may permit a determination of whether the possible driver is in a driver's seat of the vehicle when the breath sample is provided. The first and second image recorders may both be provided in the breath alcohol testing device, or the second image recorder may be mounted within the vehicle apart from the breath alcohol testing device in a location such as on the windshield. If the first and second image recorders are both provided as part of a handheld breath alcohol testing device the second image recorder may be aligned for pointing at the steering wheel as the breath sample is taken by a possible driver in the driver's seat. Additionally, the alcohol breath testing device may be associated with a separate relay box that is connected to the vehicle's electrical circuitry to impede operation of the vehicle if an acceptable breath sample is not provided.

**[0020]** According to another embodiment of the present invention a breath alcohol test device that has a breath tube, a fuel cell chamber in selective communication with the breath tube, and a pump for moving breath is improved by including a miniaturized Guth bath that periodically tests a headspace above a known-concentration alcohol sample to test the accuracy of allow self-calibration of the alcohol test device. The known-concentration alcohol sample may be provided within a sponge. The fuel cell chamber may include an outlet in communication with the pump and an inlet in communication with a control valve that can be adjusted to connect the inlet with the breath tube to test a breath sample and to connect the inlet with the headspace to perform a calibration test.

**[0021]** According to another embodiment, the present invention is a vehicle interlock breathalyzer system that includes a handheld part that has a breath sample collection and testing unit, and a relay box in connection with an electrical system of a vehicle to impede operation of the vehicle if an acceptable breath sample is not provided to the breath sample collection and testing unit. A first accelerometer is associated with either the handheld device part or the relay box part to detect attempts at destruction. The relay box part may include a computer memory for recording any detected attempts at destruction. A cell phone may be provided in the relay box part to report any recorded attempts at destruction. A second accelerometer may be provided in the relay box part or hand held part so that both parts include an accelerometer for detecting attempts at destruction. The first accelerometer may detect vehicle motion and record detected motion without an associated acceptable breath test as a possible violation event.

**[0022]** According to another embodiment of the invention, a vehicle interlock breathalyzer system that includes a handheld part with a breath sample collection and testing unit and a relay box part in connection with an electrical system of a vehicle to impede operation of the vehicle if an acceptable breath sample is not provided to the breath sample collection and testing unit, is improved by including: an electrical circuit within the relay box that detects the polarity of an ignition circuit of the vehicle, and a computer processor within the relay box that adjusts the relay box operation in accordance with the detected polarity.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**[0023]** FIG. 1 is a schematic showing the components of a breathalyzer ignition interlock system according to one embodiment of the present invention.

[0024] FIG. 2 is a perspective view of a top front side of a handheld device according to one embodiment of the present invention.

[0025] FIG. 3 is a perspective view of a bottom rear side of the handheld device of FIG. 2.

[0026] FIG. 4 is a perspective view of the bottom shell of the handheld device of FIG. 2.

[0027] FIG. 5 is a partial perspective view of the internal components of the handheld device of FIG. 2.

[0028] FIG. 6 is a perspective view of the components of the breath testing assembly from the handheld device of FIG. 2.

[0029] FIG. 7 is a partial cross-section view of the breath testing assembly of FIG. 6.

[0030] FIG. 8 is a perspective view of a relay box according to one embodiment of the present invention.

[0031] FIG. 9 is a perspective view of the internal components of the relay box of FIG. 8.

[0032] FIG. 10 is a simplified schematic of an electrical circuit used to interlock an ignition according to one embodiment of the present invention.

[0033] FIG. 11 is a simplified schematic of an electrical circuit that senses the polarity of a vehicle's lights according to one embodiment of the present invention.

[0034] FIG. 12 is a perspective view of an external camera unit for verifying that the person providing the breath sample is the driver according to one embodiment of the present invention.

[0035] FIG. 13 is a detailed circuit diagram of a starter enable relay according to the present invention.

[0036] FIG. 13 is a detailed circuit diagram of a lights relay according to one embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0037] FIG. 1 shows a breathalyzer ignition interlock device 10 according to one embodiment of the present invention. The interlock device 10 includes two primary components, a handheld unit 100 and a relay unit 200. The embodiment shown in FIG. 1 also includes a separate camera unit 300 that may be omitted in some embodiments. The handheld unit 100 contains the alcohol sensor and the user interface portions of the device 10. The relay box 200 provides a vehicle systems interface and is equipped to communicate with an outside service provider. The ignition interlock device 10, which may also be referred to herein as an interlock system, provides a mechanism for measuring breath alcohol content, for disabling a vehicle based on the measured alcohol content, for preventing or detecting attempts to cheat or tamper with the system, and for logging and reporting tested data and imaging.

[0038] The general arrangement of the interlock system 10 in use is illustrated in FIG. 1. A driver 30 that wishes to operate a motor vehicle 20 must first provide a breath sample to the interlock system 10 through the handheld unit 100. The handheld unit 100 analyzes the breath sample, and communicates the results of the test to the relay 200. If the results of the test are acceptable, the relay 200 will permit the driver 30 to engage the ignition and start the engine of the vehicle 20. If, however, the results of the test indicate that the blood alcohol content is above an acceptable level, the relay 200 will lock out the ignition of the automobile 20 to prevent operation of the vehicle 20 by an intoxicated driver. As discussed in greater detail below, the relay 200 may be provided with a cellular

phone and GPS device that communicate via satellite 50 and/or cell phone tower 60 with a remote computer 40 that may be controlled by a service provider. The service provider may be a third party commercial organization that facilitates the monitoring and maintenance of the system 10. Alternatively, the service provider could be a governmental agency or a private company that has a fleet of vehicles and drivers. Greater detail regarding each of the components and operation of the breathalyzer ignition interlock device 10 according to the present invention are provided below.

#### Handheld Device

[0039] FIG. 2 is an isometric view of a handheld unit 100 according to one embodiment of the present invention. The handheld unit 100 includes an outer case formed by a top shell 102 and a bottom shell 104. The outer case is preferably a relatively hard durable material that serves to protect the internal components of the handheld unit 100. The shells 102 and 104 may be formed by injection molding of hard plastic, or other similar material. Preferably, they are joined together in a fashion that permits access to the internal components of the device 100 without destruction of the outer case. For example, threaded fasteners may be used to join the top shell 102 to the bottom shell 104 (see FIG. 3).

[0040] A blow tube 106 is provided at one end of the case. In the embodiment shown, the blow tube 106 extends into an opening formed in the bottom shell 104. Preferably the blow tube 106 will be removably insertable into the handheld unit 100 by friction fit, or similar mechanism. This permits each driver to have their own blow tube 106 for sanitary reasons, and it also permits easy cleaning or replacement of the blow tube 106. An internal passage of the blow tube 106 will preferably include obstructions (not shown) to deflect and retain saliva or other contaminants that might be expelled while providing a breath sample. In this fashion, the external blow tube 106 acts as a spit trap.

[0041] The handheld unit 100 also includes a display screen 108 to provide a visual interface for a user. In a preferred embodiment, the display screen 108 is a color liquid crystal display with back lighting. An ambient light sensor 110 may be provided to automatically adjust the brightness of the display screen 108. Alternatively, a user may be able to adjust the brightness of the display screen 108 as desired. The display screen 108 may be used to show operating instructions, device status, and communications from a service provider.

[0042] The handheld unit 100 is provided with a keypad 112 to allow a user to operate and control the handheld unit 10. In the preferred embodiment shown, the keypad includes arrow keys and other function keys that may be dedicated to a specific purpose, or may have "soft" functionality as dictated by the current operating needs of the system. In alternative embodiments, the keypad 112 may be a small alpha numeric keyboard of the type found on cell phones or may even be a small "qwerty" keyboard as might be found on text messaging machines.

[0043] The handheld unit 100 may also be provided with a microphone 114 in order to receive audio input from a user. The audio input may be stored in the form of digital sound files, or may be used to communicate through a cell phone that may be provided in the handheld unit 100, or more preferably in the relay box 200. The handheld unit 100 may communicate with the relay box 200 by Bluetooth, radio frequency, or by a wire connection between the handheld unit 100 and the relay box 200.

[0044] A camera cover **116** is provided in the bottom shell **104** to protect the camera (not shown in FIG. 2, see FIG. 5) that is used to capture the image of a driver **30** as the driver **30** provides a breath sample into the blow tube **106**. The camera cover **116** should be transparent to permit the camera to capture an accurate image of the driver **30**.

[0045] FIG. 3 shows the handheld unit **100** of FIG. 2 flipped over to reveal the bottom side of the handheld unit **100**. The top shell **102** is fixed to the bottom shell **104** by small bolts **120**. Those skilled in the art will be aware of other suitable mechanisms for releasably connecting the top and bottom shells **102** and **104** together. The shells **102** and **104** are provided with a mechanism for sensing when the case of the handheld unit **100** has been opened. For example, the bottom shell **104** may be provided with a permanent magnet that is located in close proximity to a Hall effect sensor provided in the electronics for the handheld unit **100**. If the bottom shell **104** is removed in order to provide access to the electronics, the Hall effect sensor will detect the movement of the permanent magnet away from the sensor, and the handheld unit **100** will record the event, which may indicate that the unit **100** has been tampered with.

[0046] An exhaust tube **118** provides an outlet for breath samples that have been provided through the blow tube **106**. As discussed in more detail below in reference to FIG. 5, the exhaust tube **118** has provided within it a sensor for sensing the temperature of the breath sample to assure that it is at or near body temperature. The exhaust tube **118** has provided within it a small sample tube (these not shown in FIG. 3) from which the actual breath sample to be tested is withdrawn. The handheld unit **100** is also provided with sensors to sense whether air is being sucked through the exhaust tube, rather than blown into the blow tube **106** in an attempt to defeat the system.

[0047] Openings **122** are provided in the bottom shell **104** for alignment with a speaker (see FIG. 4).

[0048] An input jack **124** is provided at one end of the handheld unit **100**. The input jack **124** may be an RS 232 serial port or a USB host port. The input jack **124** can be used to transfer data back and forth with the relay box **200**, and may be used to provide power to the handheld unit **100** or to provide power to charge a battery provided within the handheld unit **100**. Threaded receivers **125** are provided adjacent to the input jack **124** for fixing an input plug to the input jack **124**.

[0049] A camera cover **126** is provided in the handheld unit **100** in an opposite end from the blow tube **106**. The camera cover **126** protects a camera (not shown in FIG. 3, see FIG. 5) that may be used to capture an image of the surroundings when a breath sample is corrected, in order to verify the location of the handheld unit **100** within the car **20** at the time the sample is provided.

[0050] FIG. 4 shows the interior of the bottom shell **104**. Speaker **128** is mounted within a speaker holder **129** integrally formed with the bottom shell **104**. A battery **130** that is used to provide power to the various components of the handheld unit **100** is provided within a battery holder **131**. Preferably the battery **130** is a lithium ion rechargeable battery. A permanent magnet **132** is mounted within a sleeve **133**. The permanent magnet **132** aligns with a Hall effect sensor (see FIG. 5) to form a mechanism for detecting when the case or the handheld unit **100** has been opened. The bottom shell **104** includes an opening **134** for receiving the blow tube **106**. An opening **136** is provided through the bottom plate of the

bottom shell **104** to provide an opening for the exhaust tube **118**. Each end of the bottom shell **104** is provided with an opening **138** for the digital cameras. Six receivers **140** are provided around the periphery of the bottom shell **104** for receiving small bolts **120** that connect the top shell **102** to the bottom shell **104**. A trench **142** is provided around the perimeter of the bottom shell **104** for receiving a tongue that protrudes from the top shell **102** and matingly engages the trench **142** in order to maintain the shells **102** and **104** in place, and to provide a water tight seal between the two shells **102** and **104**.

[0051] The internal components of the handheld unit **100** are shown in FIG. 5. The components are mounted on a printed circuit board (PCB) **144**. A first camera **146** is mounted on the same end of the PCB **144** at the breath tube inlet **148**. A second camera **150** is mounted at the opposite end of the PCB **144** from the first camera **146**. The second camera **150** is used for capturing images as a breath sample is taken to verify the location of a handheld unit **100** within the vehicle **20**. Preferably, the cameras **146** and **150**, which may also be referred to as imagers, image recorders, or image capturing devices, have the capability to operate in dark environments using infrared (IR) illumination. To accomplish this the cameras **146** and **150** are provided with IR light emitting diodes **147**. The cameras **146** and **150** include custom lenses that allow the passage of IR wavelengths. This permits the cameras **146** and **150** to be operated safely in the vehicle **20** after dark, when a driver **30** has dark adapted vision, and could be temporarily blinded by a bright light within the vehicle **20**. The use of IR illumination allows the system to have nearly the same image capturing capabilities regardless of ambient light. Generally speaking, images taken in daylight will record as color images, and those taken under IR illumination will record as monochrome images. The cameras **146** and **150** may be capable of capturing video images or still images, or both. The cameras **146** and **150** are connected to a central processing unit (CPU) (not shown) provided on the PCB **144**. The CPU includes both RAM and FLASH memory needed for operation and long term storage of data.

[0052] The breath tube inlet **148** and the exhaust tube **118** are provided as part of a breath directing block **152**. The breath directing block includes a side tube **154** that leads to a transducer **156** positioned immediately above stream from a constriction in the airway, such that the transducer **156** can be used to verify that the sample is being provided by blowing through the blow tube **106** and not by sucking air through the exhaust tube **118**.

[0053] Also connected with the CPU is a codec (not shown). The codec converts digital audio information to an analog signal and vice versa. In addition to being connected to the CPU, the codec is connected with a microphone **114** (see FIG. 2) and the speaker **128** (see FIG. 4). Audio outputs from the CPU are converted from a digital signal into an analog signal and then amplified and sent to the speaker. This allows the unit **100** to provide spoken messages and sounds to the user **30**. Similarly, the microphone converts sound into an electrical signal that is received by the codec and digitized into a form that can be read and stored by the CPU. The CPU can transmit the digital audio files to the relay box **200** by Bluetooth, radio frequency, or hardware connection. The relay box **200** can log and save the audio files, or may transmit them on to a service provider **40** (see FIG. 1) via a cellular phone provided in the relay box **200**.



[0054] Each handheld unit 100 contains an integrated circuit programmed by its manufacturer with a unique serial number. This serial number can be embedded in any communications from the handheld unit 100 to uniquely identify the unit.

#### Breath Test Assembly

[0055] A breath alcohol tester assembly 400 is provided on the PCB 144, and is shown in more detail in FIGS. 6 and 7. The breath alcohol tester assembly 400 contains all of the components needed to detect a breath sample airflow, measure temperature and pressures to prevent cheating on the test, convert any alcohol content to a measurable electrical signal, and to calibrate itself. With reference to FIGS. 6 and 7, it can be seen that the exhaust tube 118 includes a sample inlet 158. The sample inlet 158 is used to withdraw a portion of the breath sample to be tested for alcohol content. The breath directing block 152 is mounted to a fuel cell 402. The sample inlet 158 provides a passage into the fuel cell 402 via a valve 404. The fuel cell 402 is adapted to catalytically combine any alcohol in a sample introduced into the fuel cell 402 through the inlet 158 with oxygen to create an electrical signal that is amplified and measured to determine an alcohol concentration in the breath sample in a known fashion. A pump 406 is connected to the fuel cell 402 by tube 408. The pump 406 is used to supply a vacuum to the fuel cell 402 at the opposite end of the sample inlet 158. The pump 406 is used to extract the desired sample volume at the desired portion of the breath sample. The pump 406 is mounted within a pump bracket 410. Outlet wires 412 connect with electrodes inside the fuel cell 402 and provide the voltage output for amplification and analysis. A flex heater 414 surrounds the fuel cell 402 in order to heat the fuel cell 402 to a proper operating temperature. A flex heater 414 may also include a temperature sensing mechanism. Preferably the temperature of the fuel cell 402 is maintained at 34° C. to keep it above the sample temperature and to prevent condensation of water or vapors. The accuracy of the conversion process is also aided by maintaining a known temperature because the fuel cell catalytic process is temperature dependent. Also connected to the fuel cell 402 through the valve 404 is a calibrator housing 416. The calibration housing 416 includes internally a water alcohol mixture with a known alcohol concentration that can be used to calibrate the system. The valve 404 is a three-way three position solenoid valve. In a first position, it connects the sample inlet 158 with the insides of the fuel cell 402. In a second position, the valve 404 connects the interior space of the calibration housing 416 with the internal compartments of the fuel cell 402. In a third position, the valve 404 closes all of the inlets. A flexible heater 418 surrounds the calibration housing 416 to provide heat to the calibration housing 416 and maintain it at a desired temperature such that the alcohol vapor concentration within the calibration housing 416 is maintained at a proper level. A temperature sensor is also provided as part of the heater 418, or as a separate element in order to sense the temperature. Preferably, the calibration housing 416 will be made from aluminum, or other similar material that readily conducts heat. Second valve 420 is provided in association with the calibration housing 416 to control the flow of air at the upstream side of the calibration housing 416.

[0056] The details of the breath alcohol tester assembly 400 can be seen in FIG. 7, which shows a cross section of the assembly 400 from FIG. 6. When a breath sample is provided, the flow of air through the assembly 400 begins at the breath

tube inlet 148. The majority of the breath sample passes through the inlet tube 148 and out the exhaust tube 118. The approximate quantity of breath provided is monitored by sight tube 154 that extends into the breath inlet tube 148 and is used to measure the pressure and duration of the blow. The temperature of the sample is also monitored with a thermocouple (not shown) within the exhaust tube 118. After a sufficient volume of breath has been provided through the inlet tube 148, a small test sample of the breath is withdrawn through inlet 158 which leads from the exhaust tube 118 to the valve 404. The valve 404 is adjusted into a test position that pneumatically connects the inlet passageway 158 with the inside of the fuel cell 402 through a fuel cell inlet 422. From there the test sample winds back and forth through weir 424 to the fuel cell outlet 426 that leads to the tube 408.

[0057] The pump 406 is preferably a small bellows-type pump. The pump 406 is used to selectively withdraw a test sample through the fuel cell 402. The pump 406 is preferably able to selectively provide either a vacuum or a positive pressure through the tube 408. To withdraw a test sample through the fuel cell 402 as described above, a vacuum is applied through the tube 408. In order to assure no migration of the initial portion of a blow into the fuel cell 402, it is preferred to provide a slight positive pressure through the tube 408 prior to opening the valve 404 to permit the withdrawal of a test sample.

[0058] As the test sample flows through the fuel cell 402, the test sample comes in contact with electrode 428. The oxidation of any alcohol within the breath sample creates a current which is transformed to a difference between electrode 428 which is in contact with the sample and electrode 430. Outlet wires 412 that are connected to the electrodes 428 and 430 are used to convey the voltage difference to a computer which is able to convert the voltage to an estimated alcohol content within the breath sample, and hence an estimated of the test subject's test blood alcohol content.

[0059] The breath alcohol tester assembly 400 can be set to withdraw a calibration test sample from the calibration housing 416. To test a calibration sample, the valve 404 is adjusted to connect a head space 432 within the calibration housing 416 to the fuel cell inlet 422 through calibration housing outlet 434. Within the calibration housing 416 is a sponge 436 is provided that is saturated with a solution of water and alcohol that has a known concentration of alcohol. The sponge 436 is held in place within the calibration housing 416 between gaskets 438 that space the sponge 436 apart from breathable covers 440. The breathable covers 440 should be air permeable, water tight. A material sold under the brand name GoreTex which has openings or passageways small enough to prevent water from passing across the fabric, but large enough to permit air to pass through the fabric may be used to form the breathable covers 440.

[0060] If the calibration housing 416 and therefore the solution within the sponge 436 is maintained at a known temperature, the concentration of alcohol vapor within the air in head space 432 should be a known concentration that correlates with the concentration of alcohol within the solution. To withdraw a calibration sample, the pump 406 provides a vacuum through the tube 408, and the valve 404 is adjusted to connect the calibration housing outlet 434 with the fuel cell inlet 422. A calibration sample then flows from the head space 432 through the outlook 434, then through valve 404 and into the fuel cell 402 through the fuel cell opening 422. Once inside the fuel cell 402, the calibration test sample flows back

and forth through weirs 424 to come into contact with electrode 428 to cause oxidation and known voltage difference that can be measured. If the measured voltage corresponds with the known alcohol content of the sample solution within the sponge 436, then the blood alcohol tester assembly 400 is considered to be in proper calibration. If the measured voltage does not correspond with the known alcohol content of the sample solution, then the unit is not in calibration, and it may be necessary to obtain a new handheld unit 100, or to have the breath alcohol tester assembly 400 replaced. Valve 420 is used to control the flow of air into the calibration housing 416 through calibration housing inlet 442. The valve 420 is normally in a position to close inlet 442, but when a calibration sample is being withdrawn, the valve 420 is adjusted to permit the flow of air into the calibration housing 416 through inlet 442 in order to equalize the pressure within the housing 416.

#### Relay Box

[0061] FIGS. 8 and 9 show the relay box 200 at its internal components. The relay box 200 is electrically connected with the electrical system of the vehicle 20 and can lock out the vehicle's ignition system unless and until an acceptable breath test sample has been given by a driver. The relay box 200 may also be connected to provide control of the vehicle's horn and lights. The relay box 200 includes an embedded computer system (not shown) to manage the functioning of the ignition interlock system as well as communications between the handheld unit 100 and the service provider (see FIG. 1). The computer system implements a file storage system in a non-volatile/memory to log test results, tampering events, calibration information, and other pertinent system information. The relay box 200 has a power system with three potential sources of power and the means for switching between them as the circumstances dictate. The primary power source for the relay box 200 is the vehicle battery (not shown). Circuitry is provided to condition the vehicle power and prevent damage to the relay box 200 from unwanted transient events on the vehicle power system. The relay box circuits are designed to minimize the draw on the vehicle battery by actively managing the activity of the relay box 200. The other voltages required by the relay box are all generated from the primary power by power supply circuits. The computer system is able to measure the voltage provided by the vehicle battery to ensure that it is sufficient to operate the relay box 200.

[0062] As seen in FIG. 8, the relay box 200 includes a rugged outer case 202 that includes mounting tabs 204 that permit the relay box 200 to be fastened to the interior of a vehicle. A relay box insert 206 that includes all of the internal components of the relay box 200 is shown in FIG. 9. The relay box insert 206 slides into and is retained within the outer case 202. The insert 206 is held within the outer case 202 by resilient ears 208. Any attempt to open the relay box 200 by removing the insert 206 from the outer case 202 will activate a switch (not shown). Any activity on the switch is saved by a circuit and it signals to the relay box computer system as a tamper event. The tamper event is logged and communicated to the service provider.

[0063] The components for the relay box 200 are provided on a printed circuit board 210. The insert 206 is provided with a vehicle interface connector 212 that is used to connect the relay box 200 with the various electrical systems of the vehicle. The insert 206 is also provided with a handheld unit interface connector 214 for hard wire connection to the hand-

held unit 100. A battery insulator 216 provides thermal insulation for a lithium ion battery that provides power to continue operation of the relay box 200 for a short period of time in the event that a vehicle power is removed from the relay box 200. A heater may also be provided within the insulation to assure that the battery is operational at extreme cold temperatures. The lithium ion battery is maintained in a full state of charge using the vehicle power. A disconnection from the vehicle power system would be recorded as a tamper event and reported to the service provider. Circuitry is provided to monitor the actual battery temperature and regulate the heater to maintain the battery at a desired temperature. A large value capacitor (not shown) is also provided on the PCB 210. The capacitor provides a final energy storage backup that is utilized only after the unit has been disconnected from the vehicle power supply, and the lithium ion battery has been exhausted. The capacitor will provide the system with enough operating time to allow the computer to log the event, a critical data to the flash memory, and to shut down in an orderly manner.

[0064] A cellular phone and GPS unit are provided on the insert 206 beneath a mounting plate 218. The GPS unit is attached to a GPS antenna jack 220 by wire 222. The cellular phone is attached to cellular phone antenna jack 224 by wire 226. The cellular phone is used to communicate data to the service provider. The GPS unit is used to track the geographic location of the relay box 200 and hence the vehicle to which it is attached. This conservative backup means of determining vehicle motion, as well as providing the location of the vehicle at the time of any tamper event. This function can also verify legitimate events such as the vehicle being serviced, if the location is that of a dealer or garage. Physically, the GPS receiver is built into the cellular phone module. The cellular phone, in addition to communicating logs of the test results to the service provider can update software installed on the relay box computer. The cellular phone may permit messages to be relayed to the operator, via the handheld unit, from the service provider. The cellular phone could even be used to notify authorities in the event of a failed breath test while the vehicle is in operation.

[0065] The Bluetooth short range wireless data link provides two-way communication between the relay box and the handheld unit. Both digital audio and video can be transmitted. Data from breath tests will be transmitted to the relay box for storage, along with images captured by the handheld unit cameras as part of the breath test. Relay box and vehicle status information can be transmitted from the relay box to the handheld unit for display. Communications from the service provider received by the cellular phone can be relayed by the handheld via the Bluetooth data link, or through the handheld unit interface connector 214. Each relay box 200 contains an integrated circuit programmed by its manufacturer with a unique serial number. This serial number can be embedded in any communications from the relay box 200 to uniquely identify the unit.

[0066] The relay box insert 206 is provided with a three axis accelerometer. This device can be used for several purposes. An accelerometer can detect physical shocks to the relay box 200 such may be encountered when somebody attempts to defeat the system by striking it to render it inoperable. The accelerometer can also be used to detect vehicle motion, and thus provides a means of detecting if the vehicle is moving despite them not having been a successful breath test.

[0067] A number of relays are provided on the power circuit board 210 to allow the relay box 200 to disable the vehicle from starting, or to communicate that it is being operated after the driver has failed a re-test once it has been started. FIG. 10 illustrates a simplified circuit illustrating operation of one such relay. The relay 228 is placed in series with a vehicle control signal such as the starter solenoid power. The relay 228 is connected to the vehicle via two pins on the vehicle interface connector 212, one for each side of the brake made in the ignition control circuit. If an operator attempts to start the vehicle by closing the ignition switch, the relay box computer 230 senses the attempt. If a successful breath test has occurred, the CPU will close the relay 228 to complete the circuit and permit the vehicle to be started. In this fashion, any attempt to short circuit the relay 228 will also be detected, because it will be recorded as an attempt to start the vehicle without a successful breath test. A similar circuit to that shown in FIG. 10 may be provided for the fuel pump as opposed to, or in addition to, the starter circuit. A detailed example of a starter enable relay is shown in FIG. 13.

[0068] Additional relays may be provided to control other vehicle functions. These relay outputs are intended to be wired in parallel with an existing vehicle control wire, such as the power to the horn or the parking lights. A simplified circuit diagram illustrating this feature is shown in FIG. 11. Two relays may be provided to provide such control. A first relay 232 to select either a high (typically 12 V) or low voltage (typically ground) to activate the function, and a second relay 234 to either send or not send the selected voltage to a single pin on the vehicle interface connector 212. This configuration permits either the relay box or the intended vehicle switch to activate the function, and the relay box will not lock out the function. A detailed circuit diagram of the lights relay is shown in FIG. 14. The typical usage of these controls would be to honk the horn or flash the parking lights in order to draw attention to the vehicle in case it has been started without a successful breath test, or in case of failure of a rolling breath test. In jurisdictions which forbid either of these actions, a failure of a rolling re-test might result in an audible warning similar to that emitted by a smoke detector within the confines of the vehicle to discourage use of the vehicle in the event of a failed re-test.

[0069] The computer is able to assess the state of each relay 10 of the vehicle interface connector 212 at any time, regardless of the state of the relay. It is also able to stimulate each pin through a high resistance which does not allow activation of a vehicle function connected to the pin. These capabilities allow the computer to learn the expected responses of each pin that is connected to the vehicle at the time the unit is installed. The relay 232 is adjusted automatically by the CPU to be connected to the appropriate voltage (typically either ground or 12 V). Each time a test is performed, or an output changed, the computer can sense the state of the various pins and detect any anomalies. The system is able to detect if a different wire has been disconnected from the relay box, or if a pin has been shorted to another pin or external voltage source. Upon detection of an anomalous condition, the event is logged as a tamper event in the flash memory, and can be reported to the service provider via the cellular phone data link. This is also important because it permits simplified installation of the system. For example, in some vehicles the ignition switch may be provided between the high voltage in the starter, rather than between the starter and the ground.

[0070] Additionally, the vehicle interface connector 212 receives a signal that indicates the status of the engine tachometer. In conjunction with the ignition switch circuitry, the tachometer signal can be used to determine if the vehicle is being driven and whether rolling re-tests should be conducted.

#### External Camera

[0071] FIG. 12 shows camera unit 300 that may be attached to an internal surface of the vehicle, such as the windshield or dashboard. A mounting base 302 may include a flat surface or a suction cup with a ball joint 304 that attaches to an extension 306. An attachment base 308 is connected at the opposite end of the extension 306. The attachment base 308 is attached to a camera body 310, so that the camera body 310 is attached to the mounting base 302 to allow it to swivel for selectively aligning the camera body 310 within the vehicle to point in a desired direction. The camera body 310 has a cord 312 that may be connected to the relay or to a power source. A camera 314 is provided in the camera body 310 for recording images of possible drivers as they provide a breath sample. Preferably the camera 314 will record images in both the visible spectrum and the infrared (IR) spectrum. IR light emitting diodes (LEDs) 316 are provided in the camera base 308 to provide IR illumination of a possible driver as the camera 314 captures a digital image of the possible driver. IR illumination is preferable to standard flash or other bright visible lighting that would be distracting, or worse temporarily blinding, to a driver whose eyes are accustomed to low light. The camera unit 300 may include an internal memory for storing digital files of the images. It may also include structure for downloading the digital files of the images to the relay or to the service provider. The digital image files may be time stamped or otherwise indexed to associate them with a particular breath sample. The image files may be still images or may be short video clips of the breath sample being given.

#### Use of the System

[0072] The structures and features described above and shown in the figures may be used to test possible drivers of a vehicle before and during operation of the vehicle to assure that they are not operating the vehicle in a potentially dangerously intoxicated state. The system 10 includes numerous features that can detect and thwart attempts to bypass or defeat the breath test interlock.

[0073] With reference to FIGS. 1 and 2, a user (possible driver) 30 that desires to operate the vehicle 20, must first provide an acceptable breath sample to the breathalyzer ignition interlock device 10. The vehicle 20 includes a relay box 200 in connection with an electrical system of the vehicle 20 to impede operation of the vehicle 20 unless and until an acceptable breath sample is provided to the hand held testing unit 100. The driver 30 uses the keypad 112 to activate the handheld unit 100. A display on the screen 108 indicates when the device 100 is ready for use, and may display brief instructions on its use. The light sensor 110 will automatically adjust the brightness of the screen 108 to an appropriate level based on the ambient lighting conditions. It may take a few moments for the handheld unit 100 to determine whether the included fuel cell 402 (see FIGS. 6 and 7) is at the appropriate temperature of conducting a test. The internal heater 414 (FIG. 6) may be activated to warm the fuel cell to a needed

temperature. Once the handheld device indicates that it is ready, the user **30** may provide a breath sample.

[0074] To provide a breath sample, a user **30** grasps the handheld unit **100** and places the blow tube **106** in his or her mouth. The camera cover **116** that covers the breath tube camera **146** (FIG. 5) should be oriented directly above the blow tube **106** and pointed directly at the face of the user **30**. The user **30** should take a deep breath and blow into the blow tube **106** to provide a breath sample. The pressure sensors (see e.g. transducer **156** in FIG. 5) detect the airflow and make sure that the flow is caused by a blowing action rather than a sucking action on the exhaust tube **118** (FIG. 3). A temperature sensing element provided in the breath stream (see temperature sensor passage **160** in FIG. 6) provides a reading that permits the unit **100** to determine if the sample is at a temperature appropriate to having come from a human lung. The measured pressures allow the rate of flow, and ultimately the sample volume to be determined. The sample volume must be sufficient to have used air from the deep portion of the lung where the breath alcohol content is proportional to that of the user's blood.

[0075] As the user **30** provides the breath sample by blowing into the blow tube **106**, the blow tube camera (image recorder) **146** records a digital image of the user **30** and the second camera **150** records an image that verifies the location of the handheld unit **100**. For example, the steering wheel of the vehicle **20** may have a special target or sticker that can be recognized by the computer when captured as an image from the proper distance and alignment. Preferably the sticker would be tamper proof and would be printed with permanent ink that is reflective of IR wavelength. Alternatively, it may be possible to use recognition software that would permit recognition of the steering wheel, or some other internal component of the vehicle **20**. If the verification image is not recognized, the test would be considered not acceptable. In another embodiment the verification image is recorded and logged with the test results and the test subject image, but there is no pre-recognition required for an acceptable test that permits starting of the vehicle **20**. The handheld unit **100** may give an audio message or a message on the display indicating that a re-test is necessary. The handheld unit **100** may give an audio indication when the verification image is recognized so that the user **30** knows that it is acceptable to proceed with the test.

[0076] As best illustrated in FIGS. 6 and 7, during the initial phase as the user is blowing into the blow tube, the breath is simply allowed to flow into the inlet tube **148** and out the exhaust tube **118**. During this initial phase the valve **404** is set such that the inlet **422** to the fuel cell **402** is closed. Once a sample has met the criteria of pressure, temperature, flow rate and volume, the valve **404** is adjusted to connect the sample inlet **158** with the fuel cell inlet **422**, and the pump **406** provides a slight positive pressure to the fuel cell outlet **426**. The pump **406** then reverses and provides a vacuum at the fuel cell outlet **426** to induce a portion of the sample from the exhaust tube **118** through sample inlet **158** into an alcohol-specific fuel cell **402**. The pump **406** is precisely controlled to move a repeatable volume of sample into the cell **402** for each test. Preferably the pump **406** will be set to withdraw the sample smoothly so that the flow of sample through the fuel cell weirs **424** is smooth and even. The sample portion will interact with the electrode **428** to create a measurable current that corresponds with the alcohol content of the sample portion. The outlet wires **412** transmit the measured current to a

computer processor within the handheld unit **100** that translates the voltage into an estimated blood alcohol content for the user. The test results will be transmitted to the relay **200** where they will be recorded into a log and either immediately or at a later time re-transmitted to a service provider **40**. The test results may be displayed on the handheld unit display **108**.

[0077] If the estimated blood alcohol content is above an acceptable level, the relay **200** will not complete the ignition circuit (or in some instances the fuel pump circuit) (see FIG. 10) and the user **30** will not be able to start the vehicle **20**. The failed test will be recorded and logged in the memory of the relay computer, and the results will be communicated to the service provider **40** by the cellular phone. The identity of the person providing the unacceptable test may be determined by review of the associated digital image that was captured while the sample was being provided. The system **10** may lock out starting of the car for some time period after a failed test. The display **108** of the handheld unit **100** may indicate the time remaining before another test may be attempted, or may provide other information regarding the reason the test was not acceptable.

[0078] If the estimated blood alcohol content is at an acceptable level, the user **30** may start the vehicle **20**. The relay **200** will complete the ignition circuit for the starter (see FIG. 10) and the user **30** will be able to operate the vehicle **20**. After a short interval (sometimes a few minutes, sometimes a randomly selected time interval), a re-test may be required. This is sometimes referred to as a "rolling re-test" as it occurs after the car **20** has started; however, for safety reasons it is recommended that the user pull over to a safe location and conduct the test with the car in park. The re-test will transpire in much the same fashion as the initial test. It will be possible to compare the images of the persons that performed the tests to verify that the same person performed both tests.

[0079] If an unacceptable sample is given during a re-test, after the vehicle **20** is started, the violation will be recorded and logged and transmitted to the service provider **40** by cellular phone. Service provider **40** may be able to communicate with the driver **30** either by sending messages to the handheld via cell phone that are transmitted to the handheld by Bluetooth link, or possibly by live communication via cellular phone. The location of the vehicle may be determined from the GPS coordinates provided by the GPS unit within the relay **200**. The service provider **40** may contact authorities in the vicinity of the vehicle **20** so that the authorities can take action to stop the dangerous situation. The relay **200** may also activate vehicle functions to draw attention to the vehicle **20**, such as repeated or sustained honking of the horn and flashing of the parking lights. Alternatively, or in addition to the above, in case of failed re-test, an audio enunciator that is mounted externally to the relay box **200** and emits a smoke-alarm-like noise may be sounded to discourage the driver **30** from continuing to operate the vehicle **20**.

[0080] The GPS system within the relay **200** records the location of the vehicle **200**. If the GPS senses that the relay is changing locations, but an acceptable sample has not been provided, this event will be logged and recorded to be considered as a possible violation. Similarly, if the accelerometers in the relay **200** sense significant movement that is indicative of the vehicle **20** travelling, that is recorded and logged and considered to be a violation if it occurs without an acceptable sample having been provided.

**[0081]** Calibration of the unit **10** should be performed periodically to verify that the fuel cell is accurately reading the samples. To accomplish this, the computer in the handheld unit **100** may be programmed to periodically require the user **30** to initiate a calibration before a test can be performed. Alternatively, the computer in the handheld unit may be programmed to periodically self-initiate a calibration test. The calibration test procedure can best be understood with reference to FIGS. **6** and **7** and the accompanying discussion of those figures above. This calibration system eliminates the need to return the unit to the service provider, typically every 60 to 90 days, to be recalibrated. This results in substantial cost savings and eliminates the inconvenience to the customer of returning the vehicle to an installer location periodically. Additionally, the calibration results may be relied upon to verify for evidentiary purposes that a failed test result was accurate, so that failed test results may be relied upon to change terms of a violator's operating privileges.

**[0082]** A preferred embodiment of the present invention has been set forth above. It should be understood by one of ordinary skill in the art that modifications may be made in detail, especially in matters of shape, size, and arrangement of parts. Such modifications are deemed to be within the scope of the present invention, which is to be limited only by the broad general meaning of the terms in which the appended claims are expressed.

What is claimed is:

1. A vehicle interlock breathalyzer system comprising:  
a handheld part including a breath sample collection and testing unit;

- a relay box part for connection with an electrical system of a vehicle to impede operation of the vehicle if an acceptable breath sample is not provided to the breath sample collection and testing unit, and
  - a global positioning system to report the location of the vehicle interlock breathalyzer.
2. The vehicle interlock breathalyzer of claim **1** which includes the global positioning system in the handheld unit.
  3. The vehicle interlock breathalyzer of claim **1** which includes the global positioning system within the relay box.
  4. A vehicle interlock breathalyzer system comprising:  
a handheld part including a breath sample collection and testing unit;  
a relay box part for connection with an electrical system of a vehicle to impede operation of the vehicle if an acceptable breath sample is not provided to the breath sample collection and testing unit, and  
a Hall effect sensor in the handheld unit to detect tampering with the handheld unit.
  5. The vehicle interlock system of claim **4** which includes within the handheld part a transducer to detect air pressure within the handheld part.
  6. A vehicle interlock breathalyzer system comprising:  
a handheld part including a breath sample collection and testing unit;  
a relay box part for connection with an electrical system of a vehicle to impede operation of the vehicle if an acceptable breath sample is not provided to the breath sample collection and testing unit, and  
breath temperature sensor within the handheld unit.

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