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PALMER et al.

(54) **IN-LINE ACCESSORY FOR A SELF-CONTAINED BREATHING APPARATUS**

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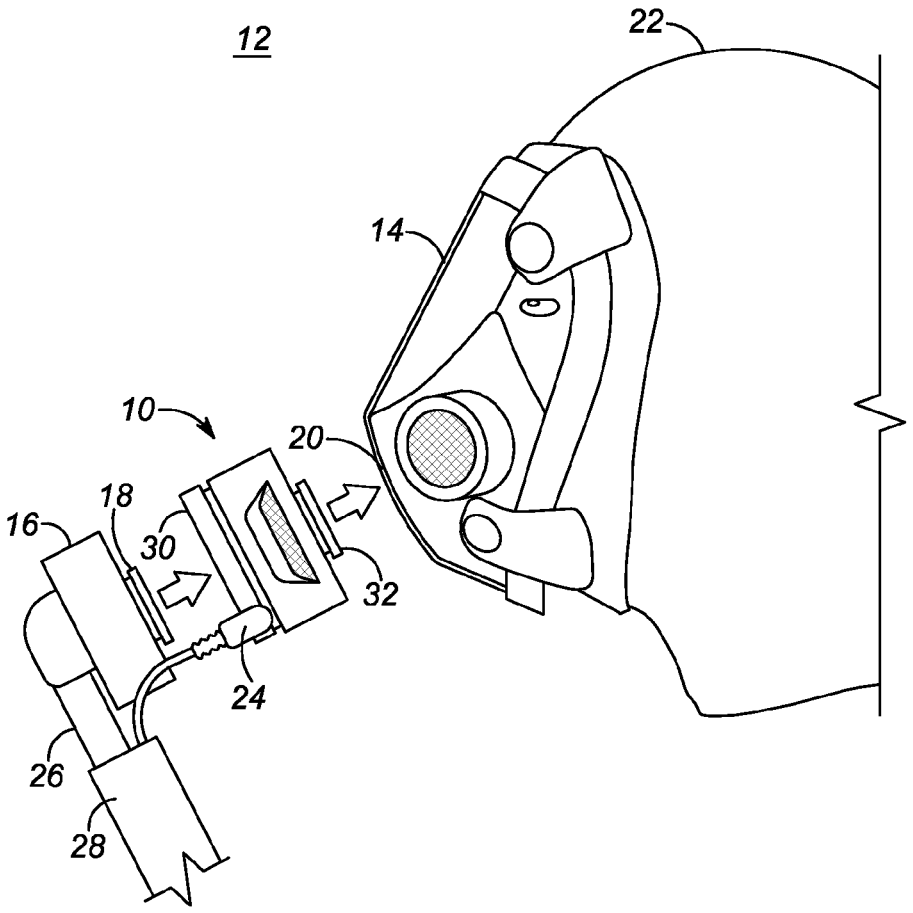
(57) **ABSTRACT**

An in-line accessory (**10**) for use with a self-contained breathing apparatus (SCBA) system (**12**) and associated method include a hardware form factor comprising an opening (**42**); a first connection interface (**30**) on the hardware form factor configured to selectively connect with a connection interface on a regulator (**16**) of the SCBA system (**12**); a second connection interface (**32**) on the hardware form factor configured to selectively connect with a connection interface on a mask (**14**) of the SCBA system (**12**); and circuitry disposed on and/or within the hardware form factor to perform and add one or more functions to the SCBA system (**12**); wherein the hardware form factor is disposed between the regulator (**16**) and the mask (**14**) in a non-obtrusive manner in the SCBA system (**12**) and the opening (**42**) supports air flow from the regulator (**16**) to the mask (**14**).



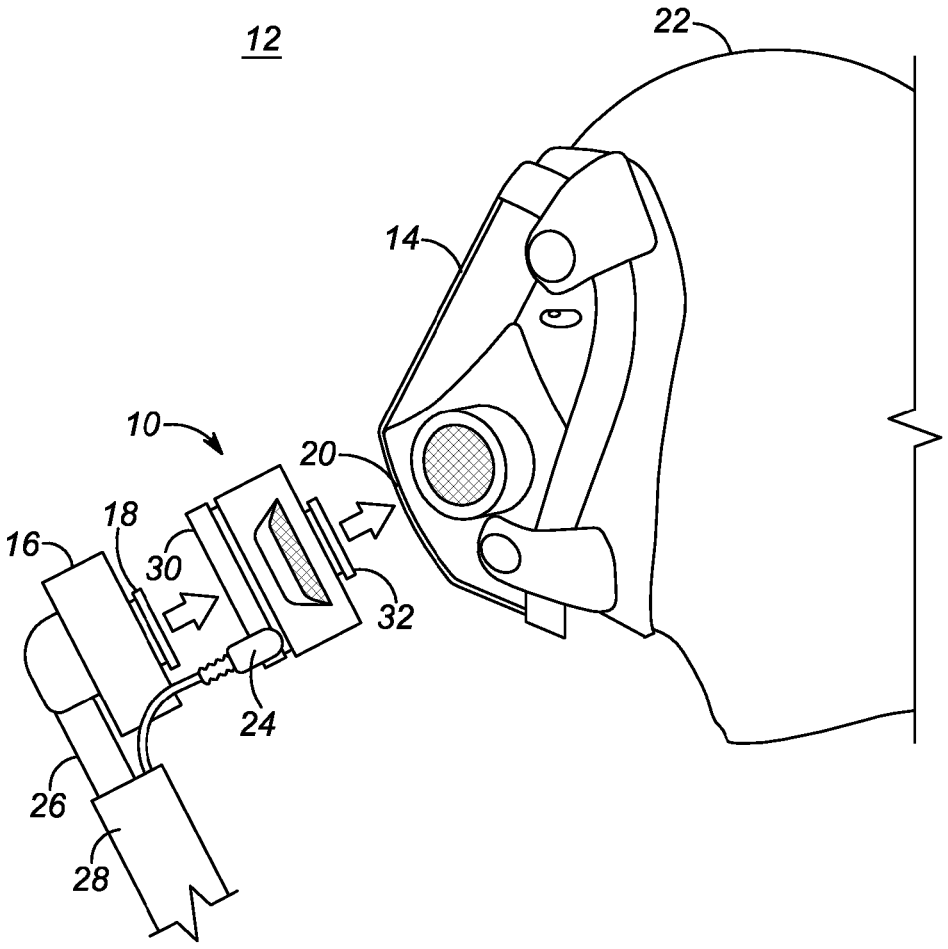


FIG. 1

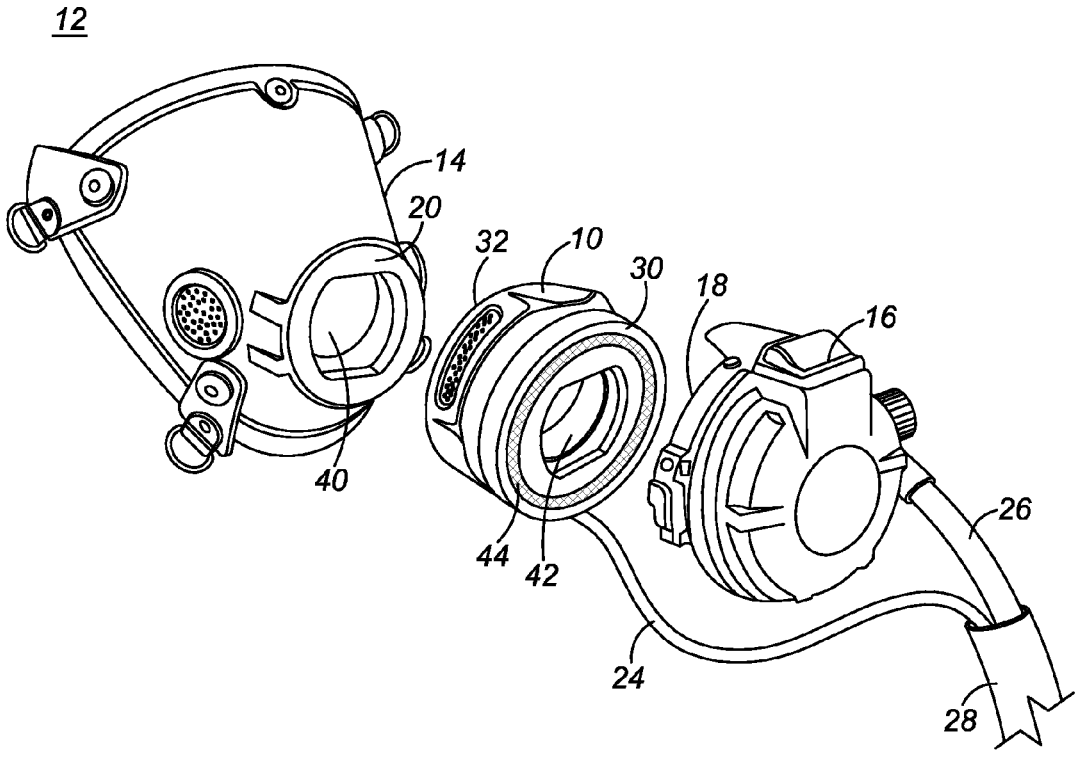


FIG. 2

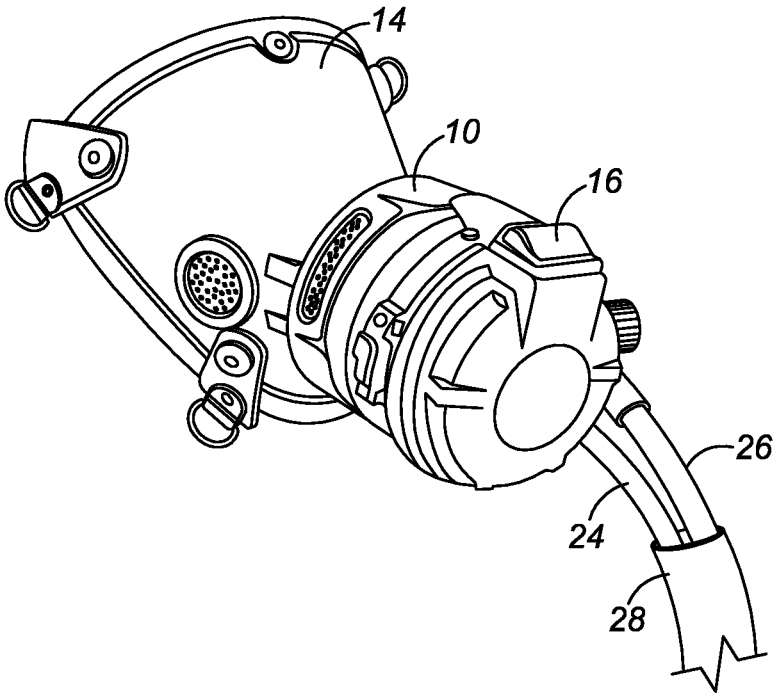


FIG. 3

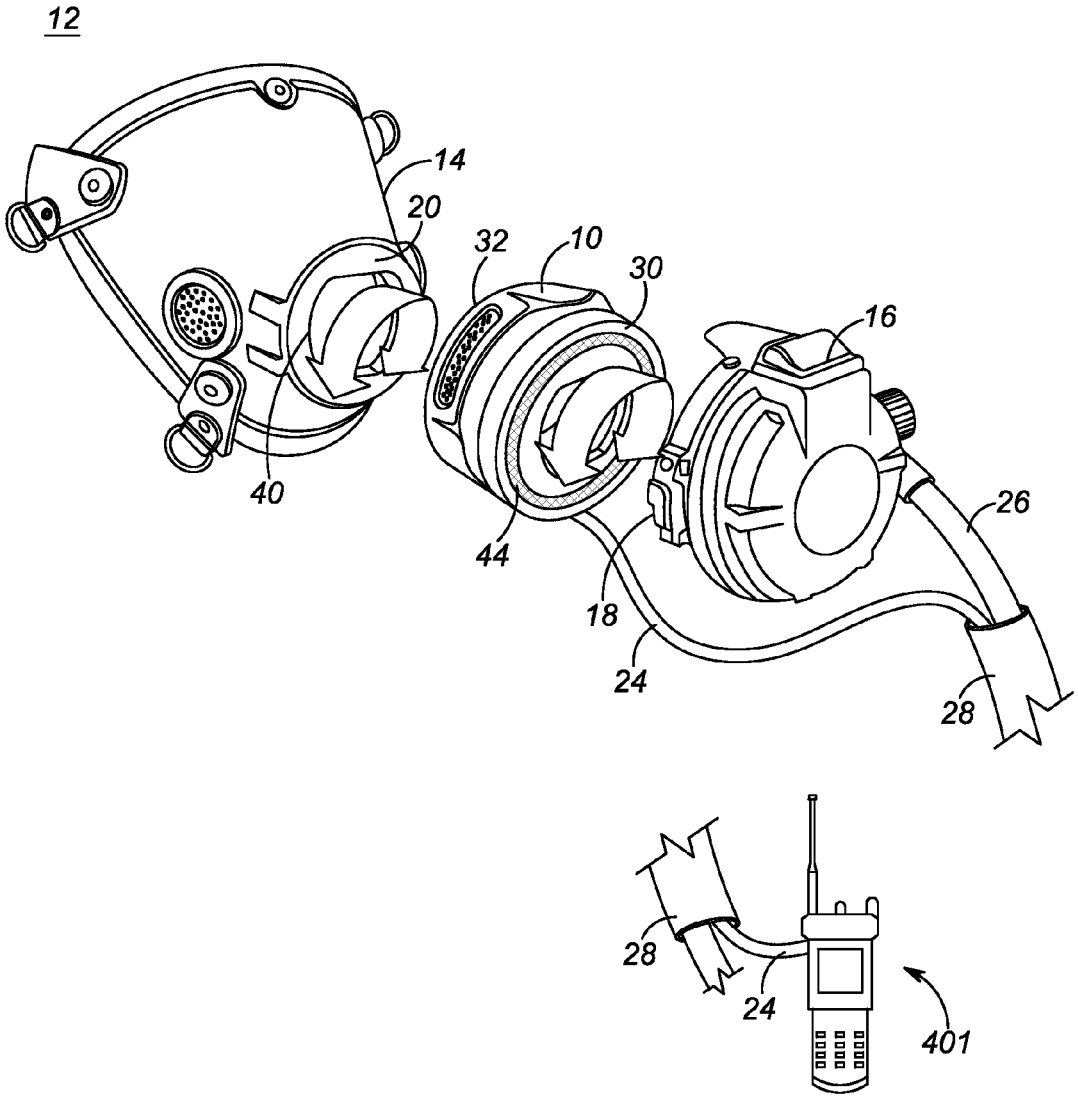


FIG. 4

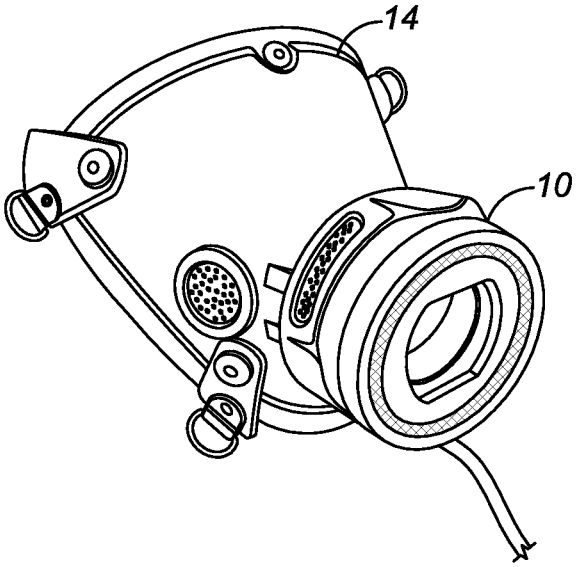


FIG. 5

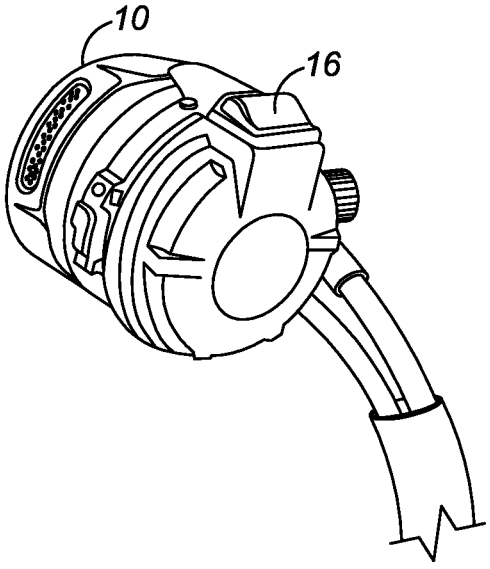


FIG. 6

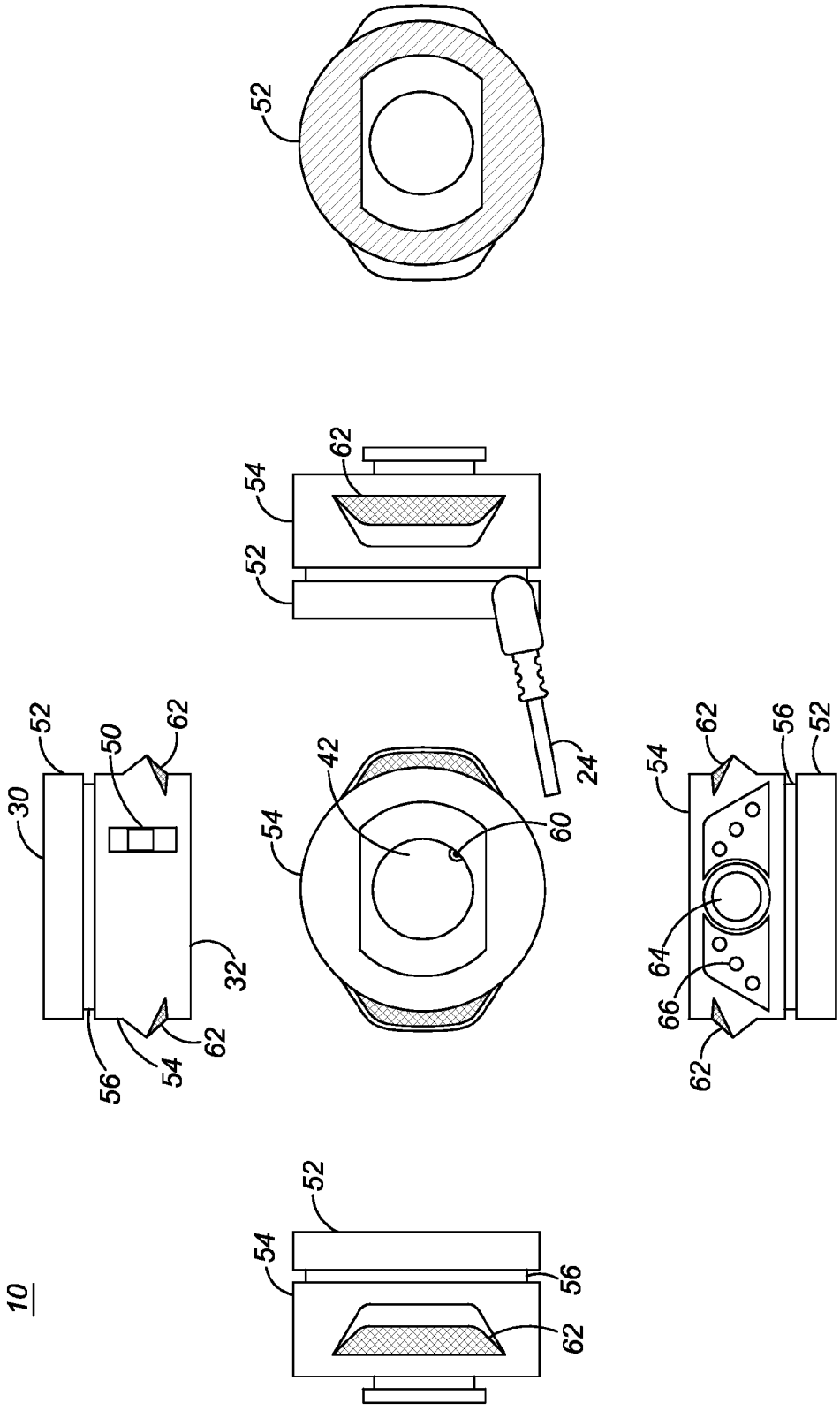

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FIG. 7

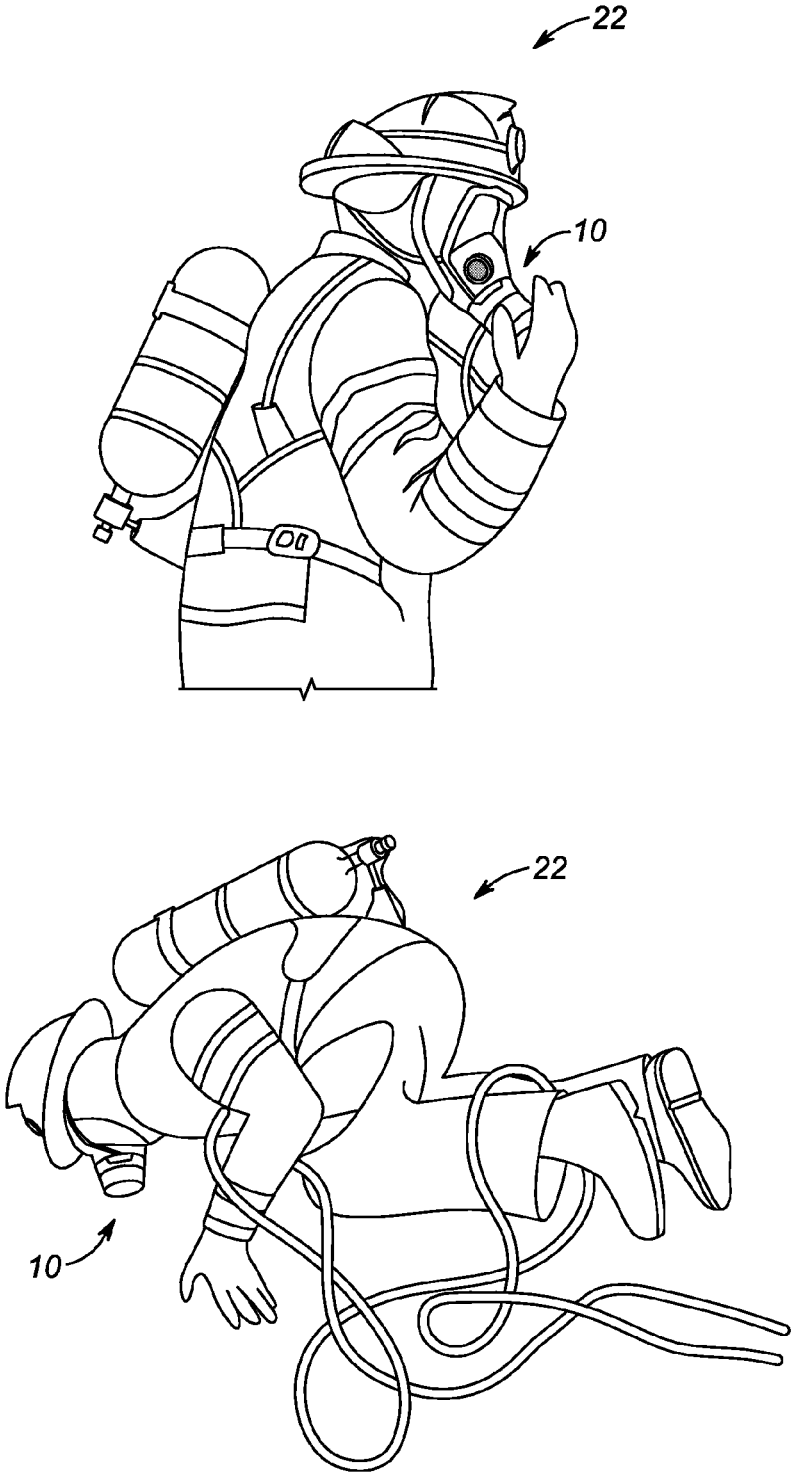


FIG. 8

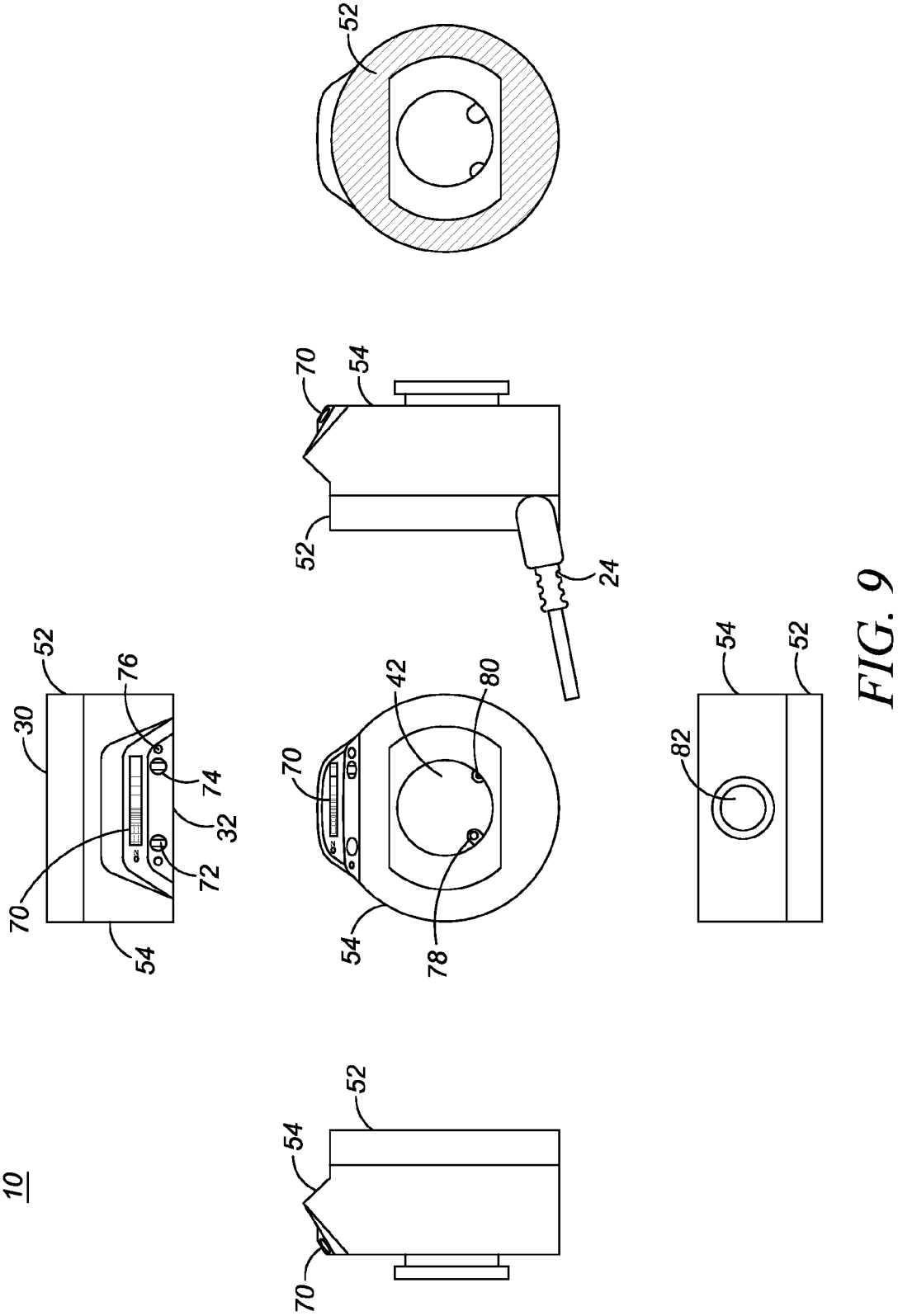
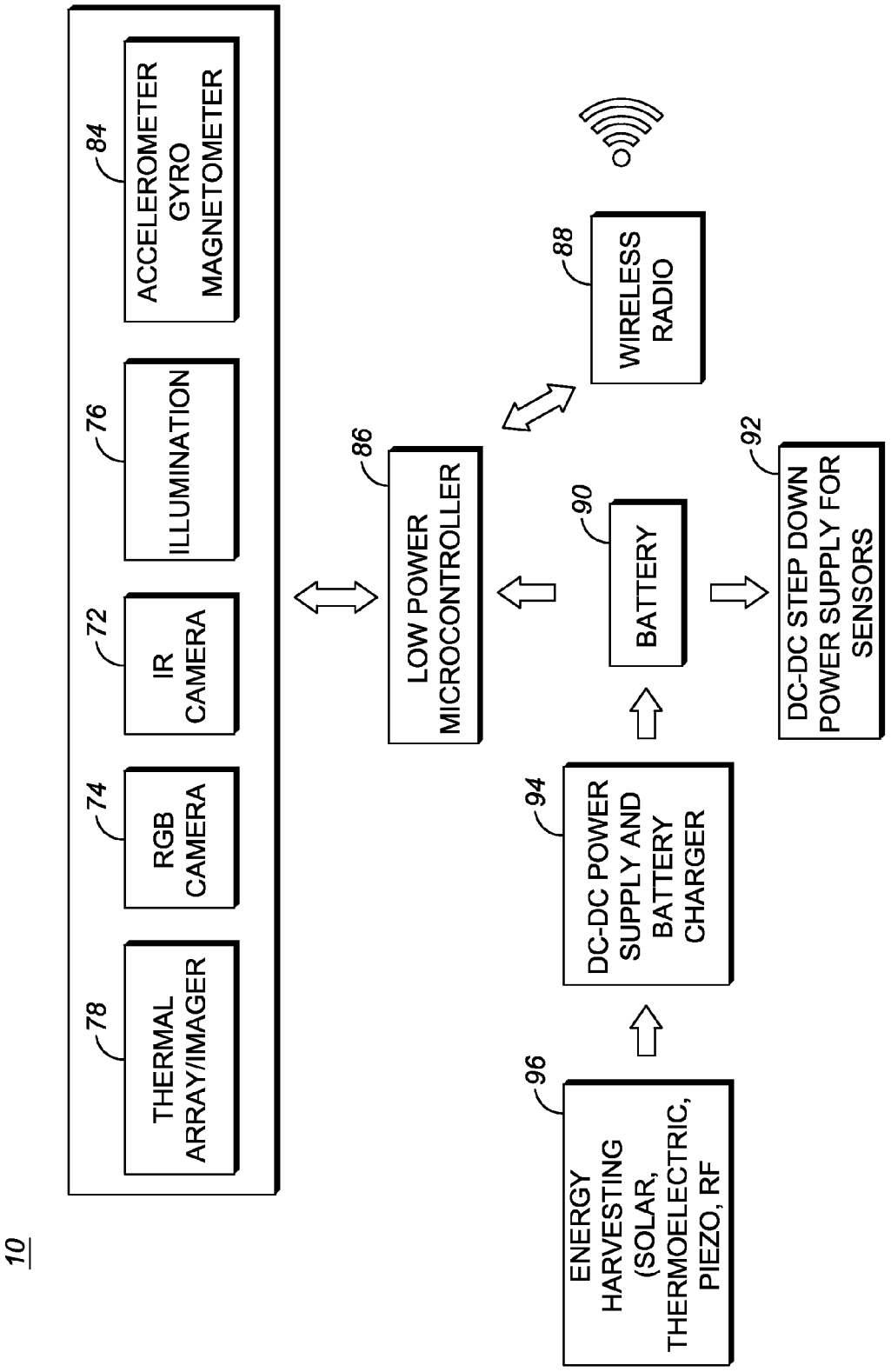


FIG. 9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78
THERMAL ARRAY/IMAGER
74
RGB CAMERA
72
IR CAMERA
76
ILLUMINATION
84
ACCELEROMETER GYRO MAGNETOMETER
86
LOW POWER MICROCONTROLLER
88
WIRELESS RADIO
90
BATTERY
92
DC-DC STEP DOWN POWER SUPPLY FOR SENSORS
94
DC-DC POWER SUPPLY AND BATTERY CHARGER
96
ENERGY HARVESTING (SOLAR, THERMOELECTRIC, PIEZO, RF

FIG. 10

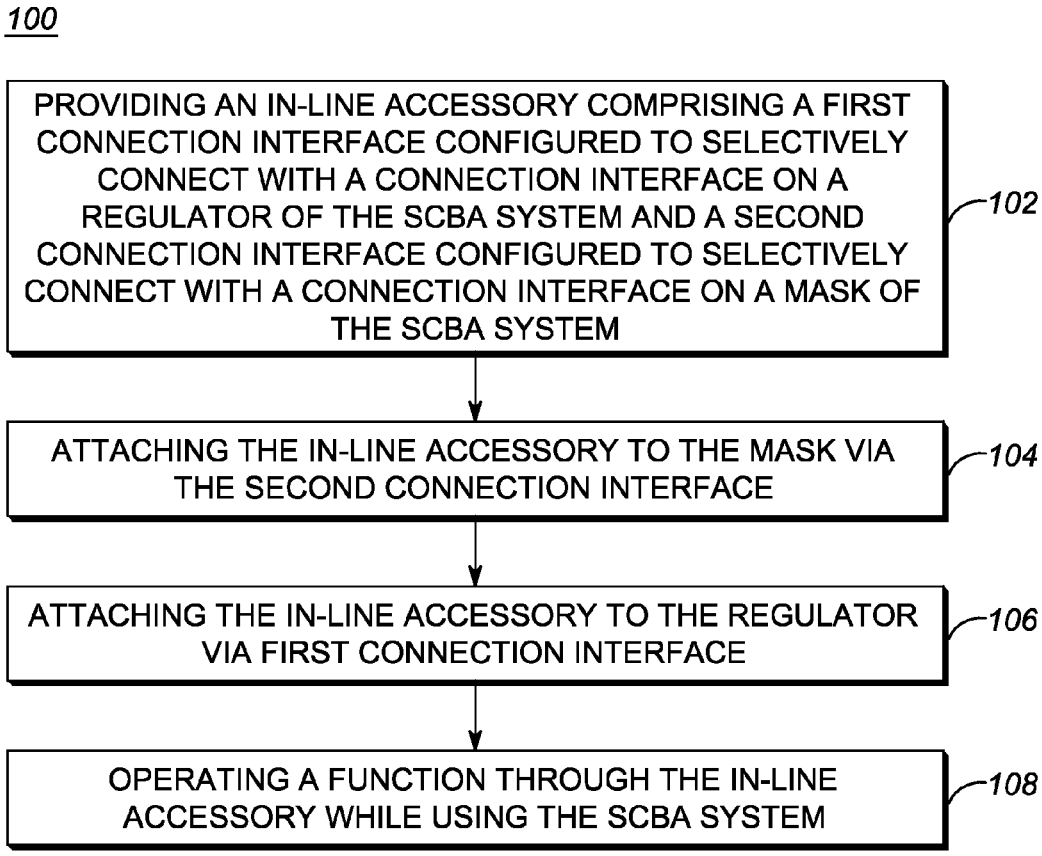
100
PROVIDING AN IN-LINE ACCESSORY COMPRISING A FIRST CONNECTION INTERFACE CONFIGURED TO SELECTIVELY CONNECT WITH A CONNECTION INTERFACE ON A REGULATOR OF THE SCBA SYSTEM AND A SECOND CONNECTION INTERFACE CONFIGURED TO SELECTIVELY CONNECT WITH A CONNECTION INTERFACE ON A MASK OF THE SCBA SYSTEM
102
ATTACHING THE IN-LINE ACCESSORY TO THE MASK VIA THE SECOND CONNECTION INTERFACE
104
ATTACHING THE IN-LINE ACCESSORY TO THE REGULATOR VIA FIRST CONNECTION INTERFACE
106
OPERATING A FUNCTION THROUGH THE IN-LINE ACCESSORY WHILE USING THE SCBA SYSTEM
108

FIG. 11

IN-LINE ACCESSORY FOR A SELF-CONTAINED BREATHING APPARATUS

BACKGROUND OF THE INVENTION

[0001] A self-contained breathing apparatus (SCBA), sometimes referred to as a compressed air breathing apparatus (CABA), air-pack, or simply breathing apparatus (BA), is a device worn by rescue workers, firefighters, and others to provide breathable air in an IDLH (immediate danger to life and health) atmosphere. When not used underwater, they are sometimes called industrial breathing sets. The term "self-contained" means that the breathing set is not dependent on a remote supply (e.g., through a long hose). If designed for use under water, the apparatus is called SCUBA (self-contained underwater breathing apparatus). A SCBA typically has three main components: a high-pressure tank, a pressure regulator, and an inhalation connection (mouthpiece, mouth mask or face mask), connected together and mounted to a carrying frame.

[0002] With conventional SCBA, such as with firefighters, one of the most noticeable problems is attempting to locate equipment features (i.e., air tank regulators, radios, remote speaker microphones (RSMs), etc.) while in high stress, low visibility, and low dexterity situations. There is also a general lack of integration of these equipment which only adds to the difficulty. With respect to conventional RSM use with SCBA, there are interaction, ergonomic, wearability, and device management challenges that users experience with current RSMs and other audio devices. Furthermore, for rescue workers, firefighters, or other working in hazardous environments, when a person is injured or incapacitated, it can be difficult for them to communicate their situation to others. Complex and restrictive respiration gear can further compound the problem. Further, there are almost no unobtrusive methods currently available to detect an injury or incapacitation and automatically communicate this information to others. The specialized gear that workers in hazardous environments must wear limits solutions. Additionally for these persons there are no unobtrusive methods currently available to predict potential health hazards such as, dehydration, dangerously high blood pressure, disorientation, etc.

[0003] Systems and products that currently exist are not adequately located on the body. Life-monitoring systems should ideally be placed at the users head/face so that sensor information is closely coupled to the bodily features that communicate their vital status (breath, eyes, head position, head temp)

[0004] Accordingly, there is a need for an in-line accessory for a self-contained breathing apparatus (SCBA) addressing the aforementioned limitations.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0005] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, together with the detailed description below, are incorporated in and form part of the specification, and serve to further illustrate embodiments of concepts that include the claimed invention, and explain various principles and advantages of those embodiments.

[0006] FIG. **1** is a perspective diagram of an in-line accessory that is coupled to a SCBA system in accordance with some embodiments.

[0007] FIG. **2** is a perspective diagram of the SCBA system of FIG. **1** with the in-line accessory disconnected in accordance with some embodiments.

[0008] FIG. **3** is a perspective diagram of the SCBA system of FIGS. **1-2** with the in-line accessory connected in accordance with some embodiments.

[0009] FIG. **4** is a perspective diagram of the SCBA system of FIGS. **1-3** illustrating connecting the in-line accessory to the mask and the regulator in accordance with some embodiments.

[0010] FIG. **5** is a perspective diagram of manual locking the in-line accessory to the mask in accordance with some embodiments.

[0011] FIG. **6** is a perspective diagram of manual locking the in-line accessory to the regulator in accordance with some embodiments.

[0012] FIG. **7** is a schematic diagram of the in-line accessory as a remote speaker microphone (RSM) in accordance with some embodiments.

[0013] FIG. **8** is a diagram of a user operating the in-line accessory as an RSM with PTT activation in accordance with some embodiments.

[0014] FIG. **9** is a schematic diagram of the in-line accessory as a biometric sensor and the like in accordance with some embodiments.

[0015] FIG. **10** is a block diagram of an electrical architecture of the in-line accessory as a sensor in accordance with some embodiments.

[0016] FIG. **11** is a flowchart of an in-line accessory method for integration with a self-contained breathing apparatus (SCBA) system in accordance with some embodiments.

[0017] Skilled artisans will appreciate that elements in the figures are illustrated for simplicity and clarity and have not necessarily been drawn to scale. For example, the dimensions of some of the elements in the figures may be exaggerated relative to other elements to help to improve understanding of embodiments of the present invention.

[0018] The apparatus and method components have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the embodiments of the present invention so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

DETAILED DESCRIPTION OF THE INVENTION

[0019] In an exemplary embodiment, an in-line accessory (**10**) for use with a self-contained breathing apparatus (SCBA) system (**12**) includes a hardware form factor comprising an opening (**42**); a first connection interface (**30**) on the hardware form factor configured to selectively connect with a connection interface on a regulator (**16**) of the SCBA system (**12**); a second connection interface (**32**) on the hardware form factor configured to selectively connect with a connection interface on a mask (**14**) of the SCBA system (**12**); and circuitry disposed on and/or within the hardware form factor to perform and add one or more functions to the SCBA system (**12**); wherein the hardware form factor is disposed between the regulator (**16**) and the mask (**14**) in a non-obtrusive manner in the SCBA system (**12**) and the opening (**42**) supports air flow from the regulator (**16**) to the mask (**14**).

[0020] In another exemplary embodiment, a self-contained breathing apparatus (SCBA) system (**12**) includes a mask (**14**) comprising a first connection interface (**20**); a regulator

(16) comprising a second connection interface (18), wherein the first connection interface (20) is configured to connect with the second connection interface (18); and an in-line accessory (10) comprising a third connection interface (32) configured to selectively connect with the first connection interface (20) and a fourth connection interface (30) configured to selectively connect with the second connection interface (18), wherein the in-line accessory (10) is selectively disposed between the mask (14) and the regulator (16) to add one or more functions to the SCBA system (12), wherein air flows between the regulator (16) and the mask (14) via an opening (42) in the in-line accessory; wherein the in-line accessory (10) is disposed between the regulator (16) and the mask (14) in a non-obtrusive manner in the SCBA system (12).

[0021] In yet another exemplary embodiment, an in-line accessory (10) method for integration with a self-contained breathing apparatus (SCBA) system (12) includes providing an in-line accessory (10) comprising a first connection interface (30) configured to selectively connect with a connection interface on a regulator (16) of the SCBA system (12) and a second connection interface (32) configured to selectively connect with a connection interface on a mask (14) of the SCBA system (12); attaching the in-line accessory (10) to the mask (14) via the second connection interface (32); attaching the in-line accessory (10) to the regulator (16) via first connection interface (30); and operating a function through the in-line accessory (10) while using the SCBA system (12); wherein the in-line accessory (10) is disposed between the regulator (16) and the mask (14) in a non-obtrusive manner in the SCBA system (12).

[0022] In various exemplary embodiments, an in-line accessory for a self-contained breathing apparatus (SCBA) and associated method are described. The in-line accessory is configured to leverage existing equipment via an in-line configuration between the pressure regulator and the inhalation connection of a SCBA. In an exemplary embodiment, the in-line accessory includes a hardware platform/interface form factor that exploits the twist-mount interface between a Scott Air-Pak regulator and face mask being connected therebetween in-line (in-line meaning that openings on the regulator, facemask, and in-line accessory align such that a straight line can pass through all of the openings, and preferably the straight line can pass through a user's open mouth through the openings). In alternate embodiments of the present invention, the openings may not be in-line. In various exemplary embodiments, the in-line accessory can include, without limitations, biometric sensors, thermal sensors, remote speaker microphones (RSMs), push-to-talk RSMs, heads up display, and the like. Advantageously, the in-line location is a prime location on a user being in position where the user can easily hear, see, speak, or otherwise interact with the in-line accessory, and also an ideal location to capture biometric and environmental data about the worker. Co-locating an environmental or biometric sensor on the firefighters head is ideal

[0023] FIG. **1** is a perspective diagram of an in-line accessory **10** that is coupled to a SCBA system **12** in accordance with some embodiments. The SCBA system **12** includes a mask **14** and a regulator **16**. The mask **14** and the regulator **16** can be Scott compliant devices. The in-line accessory **10** also contemplates extension/use with other types of SCBA gear from other manufacturers besides Scott. Conventionally, the mask **14** connects to the regulator **16** via a male twist-lock interface **18** on the regulator **16** and a female twist-lock interface **20** on the mask **14**. The mask **14** is worn by a user **22** over the user's mouth and nose and the regulator **16** connects to an air supply (not shown) such that air is supplied to the user **22** via the regulator **16** through the mask **14**. For example, the female twist-lock interface **20** and the male twist-lock interface **18** include an opening for air-flow therethrough.

[0024] In various exemplary embodiments, the in-line accessory **10** includes a puck-like (i.e., hockey puck) form factor that attaches to the standard mating interface of the mask **14** and the regulator **16**. The in-line accessory **10** is configured to connect between the mask **14** and the regulator **16** leveraging the female twist-lock interface **20** and the male twist-lock interface **18** for connectivity, including an opening for air-flow between the regulator **16** and the mask, and providing hardware platform/interface form factor for various functions as described herein. Specifically, the in-line accessory **10** leverages the existing twist-mount interface between a Scott-Air-Pak regulator and face mask.

[0025] The in-line accessory **10** can include a cable connection **24** for data and/or power that is routed together with an air cable **26** attached to the regulator **16** in a same sheath **28**. The cable connection **24** can connect the in-line accessory **10** to an air pack (not shown) or other components. The cable connection **24** is an accessory cord providing connectivity to the in-line accessory **10**. The sheath **28** allows the cable connection **24** to be routed with the air cable **26**. Alternatively, the cable connection **24** could be routed in a jacket on the user **22**. Also, the in-line accessory **10** can include wireless connectivity and on-board power via a battery or the like. Here, the in-line accessory may not need the cable connection **24**. The in-lines accessory **10** can also include wireless with the cable connection **24** included as well.

[0026] The in-line accessory **10** can provide one or more functions while being mounted and sandwiched between the mask **14** and regulator **16**. Thus the in-line accessory **10** is located in front of the user's mouth and in-line with the user's air-flow. In other words, a straight line can be drawn from through the opening of the user's mouth, through the openings of the in-line accessory. This is a prime location for technology on the user **22** due to being in a position where the user **22** can easily hear, see, speak, or otherwise interact with a piece of technology, and also an ideal location to capture biometric and environmental data about the user **22**.

[0027] In an exemplary embodiment, the user **22** can be a firefighter or the like and the in-line accessory **10** can include an environmental sensor or biometric sensor. Co-locating an environmental sensor or biometric sensor on the firefighter's head is ideal. Here, the location is in-line with the user's air-flow, breathing, etc. and it does not add considerable bulk to the SCBA system **12**. Additionally, the user **22** can be a HAZMAT worker, a construction worker, a SCUBA diver, etc. Various functions of the in-line accessory **10** could include, without limitation, a Remote Speaker Microphone (RSM), Biometric Monitoring, Environmental/Temperature Monitoring, Rollover Detection System, Heads Up Display (HUD), Indoor Locationing System, etc.

[0028] Advantageously, the in-line accessory **10** leverages existing user equipment rather than adding a new freestanding piece, is positioned/located in a lower field of view of the user **22** where it can be easily viewed/seen, is positioned/located up on the face of the user **22** where it can be reached and interacted with easily, is positioned/located up on the head and in-line with air-flow/breathing of the user **22** where

collecting data about the user **22**, etc. That is, due to the position/location of the in-line accessory, environmental or biometric data captured at this location would be most relevant to the user's true situation.

[0029] The in-line accessory **10** is configured to interface to the mask **14** and the regulator **16**. On a side of the in-line accessory **10** facing the regulator **16**, the in-line accessory **10** includes an interface that is the same as the interface on the mask **14**, and on a side of the in-line accessory **10** facing the mask **14**, the in-line accessory **10** includes an interface that is the same as the interface on the regulator **16**. Stated differently, the in-line accessory **10** includes a dual-sided interface that is compatible with the associated interfaces on the mask **14** and the regulator **16** to form a compact and integrated device in the SCBA system **12**. The in-line accessory **10** also includes a mating surface air seal that seals against the mask **14** and the regulator **16**. In this manner, the in-line accessory **10** is fully compatible with the existing interfaces in the SCBA system **12** and requires no special hardware for attachment thereto.

[0030] In an exemplary embodiment for a Scott SCBA system, the in-line accessory **10** includes a female twist-lock interface **30** and a male twist-lock interface **32**. The female twist-lock interface **30** is configured to interface the male twist-lock interface **18** on the regulator **16**, and the male twist-lock interface **32** is configured to interface the female twist-lock interface **20** on the mask **14**. In other SCBA systems besides Scott, those of ordinary skill in the art will recognize that other types of interfaces are also contemplated besides the twist-lock interfaces **18**, **20**, **30**, **32**. The male twist-lock interface **32**, as a connection interface, is substantially the same as the male twist-lock interface **18**, as a connection interface, on the regulator **16** and the female twist-lock interface **30**, as a connection interface, is substantially the same as the female twist-lock interface **20** on the mask **14** thereby enabling the in-line accessory **10** to connect with the SCBA system **12** without changes to the SCBA system **12**.

[0031] FIGS. **2** and **3** are perspective diagrams of the SCBA system **12** with the in-line accessory **10** disconnected (FIG. **2**) and connected (FIG. **3**) in accordance with some embodiments. Specifically, FIGS. **2** and **3** illustrate the SCBA system **12** without the user **22**. In FIG. **2**, the in-line accessory **10** is illustrated separate and disconnected from the mask **14** and the regulator **16**, and in FIG. **3**, the in-line accessory **10** is illustrated connected to the mask **14** and the regulator **16**. The mask **14** includes the female twist-lock interface **20** and an opening **40**. Again, conventionally, the regulator **16** connects to the mask **14** through its male twist-lock interface **18** connecting to the female twist-lock interface **20**, and the regulator **16** provides air flow from the air cable **26** to the user **22** through the opening **40**.

[0032] The in-line accessory **10** includes an opening **42** which can be similarly shaped as the opening **40** allowing air flow from the regulator **16** via the air cable **26** to the user **22** through both the openings **40**, **42**. The in-line accessory **10** can include a substantially cylindrical shape with the opening **42** in a center portion. Again, this gives the in-line accessory **10** a "puck-like" shape. The in-line accessory **10** can include a seal **44** which forms an air-tight barrier between the in-line accessory **10** and the regulator **16** (also, another seal (not shown) can be between the in-line accessory **10** and the mask **14** on the other side). The seal **44** on the in-line accessory **10** forms an air-tight barrier between the in-line accessory **10** and the regulator **16**, and another seal (not shown) forms an air-tight barrier between the in-line accessory **10** and the mask **14**.

[0033] In FIG. **3**, in the connected state, the in-line accessory **10** slightly protrudes from the mask **14** adding a small amount of length to the regulator **16**. In an exemplary embodiment, the in-line accessory **10** can include a length extending outwards from the mask **14** when connected that is equal to or less than a length of the regulator **16**. In this manner, the in-line accessory **10**, while being added on, interconnects in an existing manner in an integrated fashion in the SCBA system **12**.

[0034] The location of the in-line accessory **10** between the mask **14** and the regulator **16** in an integrated fashion has dual purposes, namely it provides an ideal location to add functionality to the SCBA system **12** and it avoids bulky additions being added to the SCBA system **12** which can be detrimental in the field. The location of the in-line accessory **10**, i.e. near the user's mouth, face, etc., in a prime location to locate equipment features while in high stress, low visibility, and low dexterity situations. There is also a general lack of integration of conventional equipment which only adds to the difficulty, but is solved by the integration of the in-line accessory **10** with existing connection techniques. For example, most firefighters currently utilize some version of the Scott Air-Pak SCBA breathing system which features a twist-lock interface between the regulator **16** and the mask **14**. The in-line accessory **10** offers an insight to leverage this twist lock interface would be an ideal solution to streamline the gear, put critical feedback devices in their field of view, and place important communication devices within easy reach. Also, the in-line accessory **10** is relevant to other user types beyond firefighters, including HAZMAT, or any use case that requires the use of the regulator **16** and the mask **14** as part of the SCBA system **12** (or a SCUBA system).

[0035] FIG. **4** is a perspective diagram of the SCBA system **12** illustrating connecting the in-line accessory **10** to the mask **14** and the regulator **16** in accordance with some embodiments. Here, in FIG. **4**, the SCBA system **12** includes a twist-lock configuration. Other locking configurations are also contemplated. To connect the in-line accessory **10**, the in-line accessory **10** can be connected to either the mask **14** or the regulator **16** first via a twist and lock motion. For example, connecting the in-line accessory **10** to the mask **14**, the male twist-lock interface **32** is twisted in the female twist-lock interface **20** on the mask **14**, and connecting the in-line accessory **10** to the regulator **16**, the male twist-lock interface **18** on the regulator **16** is twisted in the female twist-lock interface **30**. The twist-lock interfaces **18**, **20**, **30**, **32** operate by twisting in one direction until locked and twisting in an opposite direction until unlocked.

[0036] FIGS. **5** and **6** illustrate perspective diagrams of manual locking options for the in-line accessory **10** to the mask **14** (FIG. **5**) or to the regulator **16** (FIG. **6**) in accordance with some embodiments. Additionally, the in-line accessory **10** could also contain a manual locking mechanism that allows it to be locked to either the mask **14** (FIG. **5**) (so the regulator **16** can be twisted off the mask **14** and the in-line accessory **10** and removed for breathing when not using the air tank), or for the in-line accessory **10** to be locked to the regulator **16** so that it can easily be removed along with the regulator **16**. Having this option would allow for some flexibility in how it is used. This locking option allows the in-line accessory **10** to be semi-permanently stay attached to either

side of the SCBA system **12**. For example, the in-line accessory **10** can include a notch lock which can be positioned to semi-permanently lock the in-line accessory **10** to the mask **14** or the regulator **16**.

[0037] FIG. **7** is a schematic diagram of the in-line accessory **10** as a remote speaker microphone (RSM) in accordance with some embodiments. Specifically, FIG. **7** illustrates various views of the in-line accessory **10** and associated components for operation as an RSM. The in-line accessory **10** can include a lock switch **50**, such as, for example, on a top side. The lock switch **50** can be used to implement the manual locking mechanism described above. The lock switch **50** can have three settings—semi-permanent lock of the in-line accessory **10** to the regulator **16**, semi-permanent lock of the in-line accessory **10** to the mask **14**, and no lock. For example, placed in the middle, as shown in FIG. **7**, the lock switch **50** can be in the no lock setting. If the lock switch **50** is moved towards the female twist-lock interface **30**, this can lock the in-line accessory **10** to the regulator **16**, and if the lock switch **50** is moved towards the male twist-lock interface **32**, this can lock the in-line accessory **10** to the mask **14**. That is, the lock switch **50** can selectively implement the manual locking mechanism to provide one of a semi-permanent lock of the in-line accessory **10** to the regulator **16**, a semi-permanent lock of the in-line accessory **10** to the mask **14**, and no lock. The semi-permanent lock enables the in-line accessory **10** to remain attached to one of the mask **14** or the regulator **16** when disconnected in the SCBA system **12**.

[0038] As an RSM, the in-line accessory **10** leverages the twist-lock interface between the mask **14** and the regulator **16** to add a donut-like form-factor RSM between the mask **14** and the regulator **16**. The opening **42** allows air to pass freely though the in-line accessory **10**, i.e. between the regulator **16** and the mask **14**. Again, the in-line accessory **10** is optimally placed directly in front of the user's mouth—perfectly placed for speech pickup. The in-line accessory **10**, as an RSM or the like, can include a two piece design including pieces **52**, **54** and an intermediate section **56** therebetween. In an exemplary embodiment, the pieces **52**, **54** can be compressed relative to one another with the intermediate section **56**. For example, the piece **52** that connects to the regulator **16** and the piece **54** that connects to the mask can compress slightly and click relative to one another, and this can be used as a push-to-talk (PTT) button. That is, the form factor of the in-line accessory **10** can include the pieces **52**, **54** and the intermediate section **56** therebetween such that the pieces **52**, **54** are compressible relative to one another and compression is utilized for push-to-talk (PTT) activation.

[0039] Advantageously, this enables all of the regulator **16** to effectively become the PTT button. This creates a very easy to use PTT interface and, if the user becomes trapped and the user's arms are inoperable, the user could press the mask **14** and/or the regulator **16** to a surface to actuate the PTT to call Mayday.

[0040] Again, the in-line accessory **10** includes the female twist-lock interface **30** on one side on the piece **52** and the male twist-lock interface **32** on the other side on the piece **54**. The in-line accessory **10** includes at least one microphone **60** which can be located in the opening **42** and at least one speaker **62**. Here, the in-line accessory **10** is shown with two speakers **62** located on the sides and angled and directed backward towards the user's ears. The in-line accessory **10** can include the cable connection **24** connected to the piece **52** to provide power/data connectivity. Alternatively, the in-line accessory can be cordless with wireless connectivity and on-board power (battery).

[0041] The in-line accessory **10** can include an emergency button **64** which can be pressed to signify an emergency and one or more light emitting diode (LED) lights **66** on the bottom side of the in-line accessory **10**. The LED lights **66** are situated to shine light on the user's frontal area to help them see and interact with their gear in darkened environments, free themselves if they become stuck, and also enable others to see them better. Additionally, the in-line accessory **10** could incorporate other features such as biometric monitoring (breathing rate, heart rate, user temperature, etc.) and communicate a user's vitals via their radio/device. The cable connection **24** could be routed along with the air cable **26** via the use of the sheath **28** that would co-locate the cord and hose. Optionally, the user **22** could route the cable connection **24** in a normal fashion through the user's **22** clothing, e.g. down into or through a jacket where a radio is placed. Either solution results in a very short exposed cord length, thereby greatly reducing the chances of the cable connection **24** becoming tangled, snagged, or cut/melted. The cable connection **24** terminates in a radio **401** which can be located on or held by the user. This is shown in FIG. **4**. The cable connection **24** serves as a communications link between the in-line device and the radio **401**.

[0042] FIG. **8** is a diagram of a user **22** operating the in-line accessory **10** as an RSM with PTT activation in accordance with some embodiments. Again, handheld RSM form factors are not optimized for firefighters and other extreme environment users and do not integrate with well with the SCBA system **12**. There are problems with the usability of conventional hand-gripped speaker microphones due to the placement on the chest in a non-visible location while wearing gear. A hanging cord is also a liability and can easily get snagged or tangled in the user's gear when maneuvering in tight areas. The microphone and speaker of a conventional RSM are also not in an ideal location to pick up the user's voice and be heard—especially for this application—hostile environments. This is largely due to the fact that they are wearing the SCBA system **12** with mouths covered by the mask **14**, making it difficult to speak into the conventional RSM. Thus, with the SCBA system **12**, users struggle to hold the grasp the conventional RSM and hold it close to the exhalation port on the mask **14** where their voice can be heard. The securing clip that holds the conventional RSM to a user's gear is also inadequate for extreme applications due to the friction/drag across a user's gear as he maneuvers through tight quarters. With the aforementioned in mind, the in-line accessory **10** offers the RSM with integration in the SCBA system **12** without obscuring the user's field of view, i.e. the in-line accessory **10** mounts to the existing interface between the mask **14** and the regulator **16** and does not hang off the mask **14** at another location.

[0043] In FIG. **8**, the user **22**, e.g. a firefighter, is shown in two views with the in-line accessory **10** with PTT activation. First, the user **22** can compress and hold the regulator **16** and/or the in-line accessory **10** to activate PTT. Second, if the user **22** is down or hands are unavailable, the user **22** can press the regulator **16** and/or the mask **14** against something to activate PTT. Advantageously, the in-line accessory **10** is able to be activated hands-free in a situation where the user's

hands are disabled. Note, in addition to PTT, the in-line accessory **10** can operate as an open microphone, etc. Also, these modes could be configurable.

[0044] FIG. **9** is a schematic diagram of the in-line accessory **10** as a biometric sensor and the like in accordance with some embodiments. Similar to FIG. **7**, FIG. **9** illustrates various views of the in-line accessory **10** and associated components for operation as a sensor. Those of ordinary skill in the art will recognize that the in-line accessory **10** can provide additional functionality besides an RSM or sensor, and these exemplary embodiments are presented herein for illustration purposes. As a sensor, the in-line accessory **10** can include the two pieces **52**, **54**, but they do not need to compress for PTT (thus, the intermediate section **56** is not necessary). Again, the in-line accessory **10**, as a sensor, is a hardware platform/interface that leverages the twist-mount interface between the regulator **16** and the mask **14**.

[0045] As a sensor, the in-line accessory **10** can be a biometric monitoring system which fastens in between the regulator **16** and the mask **14** in the SCBA system **12** that is commonly worn by personnel working in hazardous environments. The in-line accessory **10** can include the capability to detect real time heart rate, body core/skin temperature, eye blink rate and head tracking for consciousness and respiration rate in real time, and the like. The in-line accessory **10** could also have the capability to display relevant information or warnings to the user **22** and transmit information to command staff or other users, if appropriate. The in-line accessory **10** can also query the user **22** through the display or audio to respond to stimuli, such as "blink your eyes twice" or "take a deep breath," etc.

[0046] The in-line accessory **10** can include a heads-up display **70**, a near infrared (IR) camera **72**, a red/green/blue (RGB) camera **74**, and an illumination LED **76**. The in-line accessory **10** can also include a thermal camera **78**, a microphone **80**, and an emergency button **82**. Collectively, the IR camera **72**, the RGB camera **74**, the illumination LED **76**, and the thermal camera **78** can be referred to as a plurality of imaging devices **72**, **74**, **76**, **78** for monitoring biometric information of the user **22**. For heart rate, with the RGB camera **74** and the IR camera **72**, it is possible to measure slight variations in light absorption which can be mapped to a heart rate. Core/Skin temperature can be measured using a far infrared thermal IR array or a single thermal IR sensor pointing at the face. A few pixels in the thermal array can be used to measure the eye temperature for core temperature measurement. This can be used to measure hyperthermia. The thermal camera can also be positioned to measure the temperature of an object in the firefighter's field of view. The in-line accessory **10** can also include other environmental sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, air quality, etc.

[0047] Eye tracking can be determined using the RGB camera **74** and illumination, such as from the illumination LED **76** which is near IR to prevent blinding the user **22**. The RGB camera **74** field-of view could include at least one eye to detect blink rate and eyelid state. This could be used to gauge the firefighter's state of consciousness. An accelerometer can also be used to perform head tracking to further aid in consciousness detection. Respiration rate could be detected using the microphone **80** to detect the positive pump triggering noise in the SCBA system **12**, it might be possible to detect the approximate breathing rate. Feedback mechanism can be provided through visual or audio messages to optimize breathing rate. Head position and impact can be measured using an accelerometer/gyroscope combination. Since the mask **14** is fixed with respect to the eye, the above measurements becomes less challenging than a standalone device that is not hands free.

[0048] When a fireman (or other working in hazardous environments) is injured or incapacitated, it can be difficult for them to communicate their situation to others. Complex and restrictive respiration gear can further compound the problem. Further, there are almost no unobtrusive methods currently available to detect an injury or incapacitation and automatically communicate this information to others. The specialized gear that workers in hazardous environments must wear limits solutions. Thus, the in-line accessory **10** offers a unobtrusive system and method for health monitoring, e.g. dehydration, dangerously high blood pressure, disorientation, etc. Advantageously, the location of the in-line accessory **10** is optimal for such life-monitoring systems—placed at the user's head/face so that sensor information is closely coupled to the bodily features that communicate their vital status (breath, eyes, head position, head temp).

[0049] FIG. **10** is a block diagram of an electrical architecture of the in-line accessory **10** as a sensor in accordance with some embodiments. Again, the in-line accessory **10** can include the IR camera **72**, the RGB camera **74**, the illumination LED **76**, the thermal camera **78** which can be a thermal array or imager, and an accelerometer/gyro/magnetometer **84**. Each of the aforementioned components **72**, **74**, **76**, **78**, **84** can be communicatively coupled to a microcontroller **86** which can be communicatively coupled to a wireless radio **88**.

[0050] The microcontroller **86** is a hardware device for executing software instructions. The microcontroller **86** can be any custom made or commercially available processor, a central processing unit (CPU), an auxiliary processor among several processors associated with the in-line accessory **10**, a semiconductor-based microprocessor (in the form of a microchip or chip set), or generally any device for executing software instructions. When the in-line accessory **10** is in operation, the microcontroller **86** is configured to execute software stored within memory, to communicate data to and from the memory, and to generally control operations of the in-line accessory **10** pursuant to the software instructions. In an exemplary embodiment, the microcontroller **86** may include a mobile optimized processor such as optimized for power consumption and mobile applications.

[0051] The wireless radio **88** enables wireless communication to an external access device or network. Any number of suitable wireless data communication protocols, techniques, or methodologies can be supported by the wireless radio **88**, including, without limitation: RF; IrDA (infrared); Bluetooth; ZigBee (and other variants of the IEEE 802.15 protocol); IEEE 802.11 (any variation); IEEE 802.16 (WiMAX or any other variation); Direct Sequence Spread Spectrum; Frequency Hopping Spread Spectrum; Long Term Evolution (LTE); cellular/wireless/cordless telecommunication protocols (e.g. **3**G/**4**G, etc.); wireless home network communication protocols; paging network protocols; magnetic induction; satellite data communication protocols; wireless hospital or health care facility network protocols such as those operating in the WMTS bands; GPRS; proprietary wireless data communication protocols such as variants of Wireless USB; and any other protocols for wireless communication.

[0052] The in-line accessory **10** can also include a battery **90**, a DC-DC step down power supply **92** for the sensors, a DC-DC power supply and/or battery charger **94**, and optionally an energy harvester **96**. The battery **90** can power the microcontroller **86** and the wireless radio **88** and the various components **72**, **74**, **76**, **78**, **84** via the DC-DC step down power supply **92**. The DC-DC power supply and/or battery charger **94** can charge the battery **90** from an external power source as well as from the energy harvester **96** which can be solar, thermoelectric, piezoelectric, RF, etc.

[0053] FIG. **11** is a flowchart of an in-line accessory method **100** for integration with a self-contained breathing apparatus (SCBA) system in accordance with some embodiments. The in-line accessory method **100** includes providing an in-line accessory comprising a first connection interface configured to selectively connect with a connection interface on a regulator of the SCBA system and a second connection interface configured to selectively connect with a connection interface on a mask of the SCBA system (step **102**); attaching the in-line accessory to the mask via the second connection interface (step **104**); attaching the in-line accessory to the regulator via first connection interface (step **106**); and operating a function through the in-line accessory while using the SCBA system (step **108**); wherein the in-line accessory is disposed between the regulator and the mask in a non-obtrusive manner in the SCBA system.

[0054] In the foregoing specification, specific embodiments have been described. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present teachings.

[0055] The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

[0056] Moreover in this document, relational terms such as first and second, top and bottom, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," "has", "having," "includes", "including," "contains", "containing" or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises, has, includes, contains a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element proceeded by "comprises . . . a", "has . . . a", "includes . . . a", "contains . . . a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises, has, includes, contains the element. The terms "a" and "an" are defined as one or more unless explicitly stated otherwise herein. The terms "substantially", "essentially", "approximately", "about" or any other version thereof, are defined as being close to as understood by one of ordinary skill in the art, and in one non-limiting embodiment the term is defined to be within 10%, in another embodiment within 5%, in another embodiment within 1% and in another embodiment within 0.5%. The term "coupled" as used herein is defined as connected, although not necessarily directly and not necessarily mechanically. A device or structure that is "configured" in a certain way is configured in at least that way, but may also be configured in ways that are not listed.

[0057] It will be appreciated that some embodiments may be comprised of one or more generic or specialized processors (or "processing devices") such as microprocessors, digital signal processors, customized processors and field programmable gate arrays (FPGAs) and unique stored program instructions (including both software and firmware) that control the one or more processors to implement, in conjunction with certain non-processor circuits, some, most, or all of the functions of the method and/or apparatus described herein. Alternatively, some or all functions could be implemented by a state machine that has no stored program instructions, or in one or more application specific integrated circuits (ASICs), in which each function or some combinations of certain of the functions are implemented as custom logic. Of course, a combination of the two approaches could be used.

[0058] Moreover, an embodiment can be implemented as a computer-readable storage medium having computer readable code stored thereon for programming a computer (e.g., comprising a processor) to perform a method as described and claimed herein. Examples of such computer-readable storage mediums include, but are not limited to, a hard disk, a CD-ROM, an optical storage device, a magnetic storage device, a ROM (Read Only Memory), a PROM (Programmable Read Only Memory), an EPROM (Erasable Programmable Read Only Memory), an EEPROM (Electrically Erasable Programmable Read Only Memory) and a Flash memory. Further, it is expected that one of ordinary skill, notwithstanding possibly significant effort and many design choices motivated by, for example, available time, current technology, and economic considerations, when guided by the concepts and principles disclosed herein will be readily capable of generating such software instructions and programs and ICs with minimal experimentation.

[0059] The Abstract of the Disclosure is provided to allow the reader to quickly ascertain the nature of the technical disclosure. It is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims. In addition, in the foregoing Detailed Description, it can be seen that various features are grouped together in various embodiments for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed embodiments require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed embodiment. Thus the following claims are hereby incorporated into the Detailed Description, with each claim standing on its own as a separately claimed subject matter.

We claim:

1. An in-line accessory (**10**) for use with a self-contained breathing apparatus (SCBA) system (**12**), comprising:

a hardware form factor comprising an opening (**42**);

a first connection interface (**30**) on the hardware form factor configured to selectively connect with a connection interface on a regulator (**16**) of the SCBA system (**12**);

a second connection interface (**32**) on the hardware form factor configured to selectively connect with a connection interface on a mask (**14**) of the SCBA system (**12**); and

circuitry disposed on and/or within the hardware form factor to perform and add one or more functions to the SCBA system (**12**);

wherein the hardware form factor is disposed between the regulator (**16**) and the mask (**14**) in a non-obtrusive manner in the SCBA system (**12**) and the opening (**42**) supports air flow from the regulator (**16**) to the mask (**14**).

2. The in-line accessory (**10**) of claim **1**, wherein the first connection interface (**30**) and the second connection interface (**32**) comprise twist-lock interfaces.

3. The in-line accessory (**10**) of claim **1**, wherein the first connection interface (**30**) is substantially the same as the connection interface on the mask (**14**) and the second connection interface (**32**) is substantially the same as the connection interface on the regulator (**16**) thereby enabling the in-line accessory (**10**) to connect with the SCBA system (**12**).

4. The in-line accessory (**10**) of claim **3**, further comprising:

a seal (**44**) on the first connection interface (**30**) forming an air-tight barrier between the in-line accessory (**10**) and the regulator (**16**); and

a seal on the second connection interface (**32**) forming an air-tight barrier between the in-line accessory (**10**) and the mask (**14**).

5. The in-line accessory (**10**) of claim **1**, further comprising:

a cable connection (**24**) connected to the in-line accessory (**10**) for data and/or power, wherein the cable connection (**24**) is one of routed in a sheath (**28**) with an air cable (**26**) to the regulator (**16**) or routed in clothing of a user (**22**).

6. The in-line accessory (**10**) of claim **1**, further comprising:

a lock switch (**50**) for selectively implementing a manual locking mechanism to provide one of a semi-permanent lock of the in-line accessory (**10**) to the regulator (**16**), a semi-permanent lock of the in-line accessory (**10**) to the mask (**14**), and no lock, wherein the semi-permanent lock enables the in-line accessory (**10**) to remain attached to one of the mask (**14**) or the regulator (**16**) when disconnected in the SCBA system (**12**).

7. The in-line accessory (**10**) of claim **1**, wherein the circuitry performs the one or more functions comprising any of a remote speaker microphone, a biometric sensor, an environmental sensor, a rollover detection system, a heads up display, and an indoor locationing system.

8. The in-line accessory (**10**) of claim **1**, wherein the circuitry performs the one or more functions comprising a remote speaker microphone, wherein the hardware form factor comprises pieces (**52**, **54**) and an intermediate section (**56**) therebetween such that the pieces (**52**, **54**) are compressible relative to one another and compression is utilized for push-to-talk (PTT) activation.

9. The in-line accessory (**10**) of claim **1**, wherein the circuitry comprises a plurality of imaging devices (**72**, **74**, **76**, **78**) for monitoring biometric information of the user (**22**).

10. A self-contained breathing apparatus (SCBA) system (**12**), comprising:

a mask (**14**) comprising a first connection interface (**20**);

a regulator (**16**) comprising a second connection interface (**18**), wherein the first connection interface (**20**) is configured to connect with the second connection interface (**18**); and

an in-line accessory (**10**) comprising a third connection interface (**32**) configured to selectively connect with the first connection interface (**20**) and a fourth connection interface (**30**) configured to selectively connect with the second connection interface (**18**), wherein the in-line accessory (**10**) is selectively disposed between the mask (**14**) and the regulator (**16**) to add one or more functions to the SCBA system (**12**), wherein air flows between the regulator (**16**) and the mask (**14**) via an opening (**42**) in the in-line accessory;

wherein the in-line accessory (**10**) is disposed between the regulator (**16**) and the mask (**14**) in a non-obtrusive manner in the SCBA system (**12**).

11. The SCBA system (**12**) of claim **10**, wherein the first connection interface (**20**), the second connection interface (**18**), the third connection interface (**32**), and the fourth connection interface (**30**) comprise twist-lock interfaces.

12. The SCBA system (**12**) of claim **10**, wherein the fourth connection interface (**30**) is substantially the same as the first connection interface (**20**) and the third connection interface (**32**) is substantially the same as the second connection interface (**18**).

13. The SCBA system (**12**) of claim **10**, further comprising:

a cable connection (**24**) connected to the in-line accessory (**10**) for data and/or power, wherein the cable connection (**24**) is one of routed in a sheath (**28**) with an air cable (**26**) to the regulator (**16**) or routed in clothing of a user (**22**).

14. The SCBA system (**12**) of claim **10**, further comprising:

a lock switch (**50**) for selectively implementing a manual locking mechanism to provide one of a semi-permanent lock of the in-line accessory (**10**) to the regulator (**16**), a semi-permanent lock of the in-line accessory (**10**) to the mask (**14**), and no lock, wherein the semi-permanent lock enables the in-line accessory (**10**) to remain attached to one of the mask (**14**) or the regulator (**16**) when disconnected in the SCBA system (**12**).

15. The SCBA system (**12**) of claim **10**, wherein the circuitry performs the one or more functions comprising any of a remote speaker microphone, a biometric sensor, an environmental sensor, a rollover detection system, a heads up display, and an indoor locationing system.

16. The SCBA system (**12**) of claim **10**, wherein the circuitry performs the one or more functions comprising a remote speaker microphone, wherein the hardware form factor comprises pieces (**52**, **54**) and an intermediate section (**56**) therebetween such that the pieces (**52**, **54**) are compressible relative to one another and compression is utilized for push-to-talk (PTT) activation.

17. The SCBA system (**12**) of claim **10**, wherein the circuitry comprises a plurality of imaging devices (**72**, **74**, **76**, **78**) for monitoring biometric information of the user (**22**).

18. An in-line accessory (**10**) method for integration with a self-contained breathing apparatus (SCBA) system (**12**), comprising:

providing an in-line accessory (**10**) comprising a first connection interface (**30**) configured to selectively connect with a connection interface on a regulator (**16**) of the SCBA system (**12**) and a second connection interface

(**32**) configured to selectively connect with a connection interface on a mask (**14**) of the SCBA system (**12**);

attaching the in-line accessory (**10**) to the mask (**14**) via the second connection interface (**32**);

attaching the in-line accessory (**10**) to the regulator (**16**) via first connection interface (**30**); and

operating a function through the in-line accessory (**10**) while using the SCBA system (**12**);

wherein the in-line accessory (**10**) is disposed between the regulator (**16**) and the mask (**14**) in a non-obtrusive manner in the SCBA system (**12**).

* * * * *