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(54) **Self-contained breathing apparatus and control system therefor**

(57) The present invention provides a self contained breathing apparatus comprising: a breathing circuit including a carbon dioxide scrubber and a gas supply valve for the addition of oxygen or a mixture of oxygen and other gas(es) to the breathing circuit from a gas supply; a mouthpiece valve (12) for the inhalation and exhalation of breathable gas from and to the said breathing circuit; an electronic controller operably connected to at least one oxygen sensor for sensing oxygen partial pressure in the breathing circuit and operably connected to the said gas supply valve for the addition of oxygen, or a mixture of oxygen and other gas(es), to the breathing circuit from said gas supply, the said controller operably

controlling the said gas supply valve to maintain at least a minimum pre-determined oxygen partial pressure in the breathing circuit; the said controller having switch means (46, 68, 70, 74) operably connected to and/or associated with a breathing circuit valve such that the action of switching on the said breathing circuit valve (12) for the delivery of breathable gas to the said mouthpiece (35) switches on the electronic controller for operational control such that the electronic controller is switched on at all times when the breathing circuit valve is switched on and capable of delivering breathable gas to the user.

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Description

[0001] The present invention relates generally to self-contained breathing apparatus of the closed or semi-closed type, commonly referred to as rebreathers, and in particular to an electronic controller suitable for use with such apparatus.

[0002] Self-contained breathing apparatus may be used for under water diving or in other hostile environments in which a user may need a supply of breathable gas. Such uses include fire fighting, where the atmosphere may be heavily polluted with combustion products and noxious gases, or other industrial environments where the atmosphere may be polluted or otherwise unbreathable. Breathing apparatus may also be used at high altitude where the atmosphere itself is insufficient to support life. Although applicable to a wide range of uses the present invention will be particularly described hereinafter with reference to its application to underwater breathing apparatus for diving applications. It is to be understood, however, that reference to this particular application is provided without prejudice to the generality of the invention or its range of applications.

[0003] An improved-closed circuit self-contained breathing apparatus is described in the UK patent application number 9719824.6. This earlier application describes the difference between so-called open-circuit breathing apparatus, widely used for sport diving, and the closed-circuit or "rebreather" type of apparatus in which the carbon dioxide content of exhaled air is removed, after exhalation, within the apparatus and fresh oxygen introduced to replace that consumed. This earlier application also describes the advantages of extended capacity which can be obtained using rebreathers therefore allowing sport (and other) divers to remain reliant on the breathing apparatus for much longer periods than were available using the stored gas open circuit systems.

[0004] Electronic rebreathers tend to have two modes of operation. When the apparatus is initially switched on the electronic controller will typically enter a self-test mode, to test, inter alia, batteries, oxygen sensors and connections to key components. In an interactive session the user is asked certain questions such as do they want to calibrate the equipment before use and/or reset the timer. The calibration sequence involves surrounding the oxygen sensors with oxygen at a known pressure (normally atmospheric pressure). It is normal to calibrate each time the equipment is used. The timer on the other hand may be reset to record a lapsed time, to time any one of number of events, such as time since last battery change, or time since last scrubber change. The user is also prompted to carry out certain safety checks and complete pre-dive drills such as open oxygen valve, check diluent, open mouthpiece, prior to calibration. On answering these questions, and after calibration if requested, the controller enters into dive mode where the oxygen control is implemented. In known equipment the oxygen controller typically has a target oxygen partial pressure

(P02) of 0.7 bar. A solenoid valve which controls the amount of oxygen in the breathing circuit is activated and oxygen added until the set point of 0.7 bar is reached when in dive mode.

[0005] Several proposals have been made for automatic switch-on of the controller including the use of a pressure activated switch so that once the diver submerges the equipment switches on automatically at a pre-defined depth. A problem with this approach is that it does not take into account situations where the diver may be swimming on or close to the surface where the pressure activated switch would not be activated. Another proposed solution has been to use 'wet switches' which automatically activate the breathing apparatus when the diver enters the water. A drawback with this approach is that the electrical current across the contacts of a wet switch depends on the mineral content of the water in which the breathing apparatus is immersed. In some situations, for example, with fresh water diving, there is insufficient electrical current generated to activate the switch. Another problem associated with this approach is that it is far more difficult to control the breathing apparatus as it may switch on at times when it is not required or will not switch off simply because it is wet. Moreover, there is generally a requirement for the system to run through pre-dive tests before the diver enters the water as discussed above and entering the water before these tests and checks are completed is not desirable.

[0006] Another proposed solution to the above mentioned problem is to provide the breathing apparatus with a sensor which is adapted to detect low oxygen pressure in the breathing circuit so that the electronic controller is activated before a potentially dangerous situation occurs. The problem with this proposal is that the controller would be activated inadvertently whenever there was a fall in pressure, for example when the equipment is transported on an aircraft or in a vehicle at high altitude.

[0007] There is a requirement therefore for a self-contained breathing apparatus having a control system which switches on automatically to prevent inadvertent use of the breathing apparatus at times when the electronic controller is switched off, but also to avoid inadvertent activation of the controller when the breathing apparatus is not being used.

[0008] According to a first aspect of the present invention there is provided a self contained breathing apparatus comprising: a breathing circuit including a carbon dioxide scrubber and a gas supply valve for the addition of oxygen or a mixture of oxygen and other gas(es) to the breathing circuit from a gas supply; a mouthpiece valve for the inhalation and exhalation of breathable gas from and to the said breathing circuit; an electronic controller operably connected to at least one oxygen sensor for sensing oxygen partial pressure in the breathing circuit and operably connected to the said gas supply valve for the addition of oxygen, or a mixture of oxygen and other gas(es), to the breathing circuit from said gas supply, the said controller operably controlling the said gas

supply valve to maintain at least a minimum pre-determined oxygen partial pressure in the breathing circuit; the said controller having switch means operably connected to and/or associated with a breathing circuit valve such that the action of switching on the said breathing circuit valve for the delivery of breathable gas to the said mouthpiece switches on the electronic controller for operational control such that the electronic controller is switched on at all times when the breathing circuit valve is switched on and capable of delivering breathable gas to the user.

[0009] In this way the electronic controller is switched on once the breathing circuit valve has been activated, that is to say moved to a position where it is capable of delivering breathable gas to the user. Thus, in the present invention the action of opening the breathing circuit valve is the only action the user has to implement before breathing from the apparatus. As the breathing circuit valve is the only element that would otherwise prevent the user from breathing from the unit the present invention ensures that the electronic controller is switched on at all times when the breathing apparatus is capable of delivering breathable gas to the user.

[0010] In preferred embodiments the gas supply valve is an electrically operated valve, preferably a solenoid valve.

[0011] In preferred embodiments the electronic controller is arranged so that the action of switching off the breathing circuit valve does not switch off the controller. Thus in preferred embodiments where the breathing circuit valve comprises the mouth piece valve or a part thereof, the apparatus continues to function even if the mouthpiece valve is closed subsequent to the unit being switched on, for example if a diver closes the mouthpiece under water as a diver may do from time to time, for example when temporarily changing mouthpieces for some reason such as in a practice drill. As the mouthpiece valve must be opened before the diver can breathe from the unit embodiments of the present invention substantially prevent the breathing apparatus being used without the electronic controller being switched on. In this way the oxygen content in the breathing circuit is monitored at all times the user is capable of breathing from the apparatus.

[0012] In preferred embodiments the mouthpiece valve comprises a pair of relatively moveable, preferably rotatable, valve members which move/rotate with respect to each other to cause the mouthpiece valve to open and close. The remotely operated controller switch is preferably integrated into the mouthpiece valve in such a way that the relative rotation of the valve members operates the switch. Mouthpiece valves having relatively rotatable valve members for the delivery of breathable gas are known. It is possible therefore to integrate the remotely operated switch into the mouthpiece valve so that it is activated by the established action of rotating one of the valve members relative to the other to switch on the supply of breathable gas. In this way the diver is not presented with any additional checks to ensure that the electronic

controller is correctly switched on since the familiar action of rotating one of the valve members relative to the other automatically operates the remote switch turning on the electronic controller. In this way the remotely operated switch may be considered to be manually operated since it relies on the manual action of turning on the mouthpiece valve.

[0013] The switch means may comprise optical switch means, preferably in the form of an optical circuit, most preferably in the form of an optical circuit which is arranged such that a break in the optical circuit switches the state of the controller from on to off or vice versa. In preferred embodiments the electronic controller is switched on for operational control of the breathing apparatus when a break in the optical circuit is detected.

[0014] The optical circuit may comprise optical fibre light transmittent means for transmitting light from a light emitter, for example an LED, sealed with the controller and associated electronics of the apparatus remote from the switch located and associated with the mouth piece valve, with a detector for detecting the emitted light also positioned in the region of the emitter. In such an arrangement, relative movement of the valve members may cause a break in the optical circuit between the emitter and detector such that relative movement of the valve members to open or close the breathing circuit valve can be detected by the controller depending on whether the emitted light is detected at the detector or not. The use of an optical circuit in this way is particularly advantageous in embodiments of the present invention adapted for diving as there is no need to provide sealing for the switch remotely positioned in the breathing circuit, for example at the mouth piece valve. The electronic components including light emitter and light detector can be readily sealed with the other electronic components including the controller and therefore no additional sealing is required in other regions of the breathing apparatus as would be necessary in embodiments implementing an electrical or electronic switch remotely positioned at a breathing circuit valve. The advantages of using optical circuits in this way are described further in the applicant's UK patent GB 2, 412, 324 where a cluster of light transmitting fibre optic polyethylene rods are used for transmitting visible light signals from light emitters sealed with the controller on the backpack part of the breathing apparatus to a head up display unit mounted on the mouth piece valve. The present invention contemplates embodiments where the additional rods or strands of optical fibre for implementation of embodiments of the present invention are routed in the same cable, or sheathing as the optical fibre strand/rods for the head up display unit.

[0015] In preferred embodiments operation of the switch means is arranged to configure the optical circuit in an open configuration or a closed configuration. Thus, embodiments of the present invention contemplate arrangements where a single light transmission path between the emitter and detector is provided by discrete sections of light transmitting elements, for example a sin-

gle length of optical fibre between the light emitter and the mouth piece valve and a similar return length between the mouth piece valve and the detector, with the respective ends of the light transmittent fibre being positioned such that they are optically coupled by a light transmitting element mounted on a moveable part of the mouth piece valve member so that the coupling element completes the optical circuit when in registration with the respective ends of the light transmittent fibres or rods and breaks the circuit to create an open optical circuit when moved out of registration with the respective ends. As previously mentioned, preferably the electronic controller is switched on for operational control of the breathing apparatus when a break in the circuit is detected. In this way the apparatus is designed to be "fail safe" in the sense that the controller is switched to an operational mode for controlling the oxygen content of the breathing circuit whenever the detector fails to detect emitted light.

[0016] In other preferred embodiments the remotely operated switch comprises an electromagnetic switch. For example, in embodiments where the mouthpiece valve comprises a pair of relatively rotatable valve members as described above one of the valve members may be provided with a magnet and the other valve member with a Reed switch, or Hall effect switch or other magnetic switch. In this way the remotely operated switch may be readily integrated into the rotatable valve members without significant detriment to the simplicity and functionality of the mouthpiece valve.

[0017] In preferred embodiments the controller includes a power supply and the remotely operated switch is arranged to switch on the power supply to the controller.

[0018] According to another aspect of the present invention there is provided a control system for a closed circuit self contained breathing apparatus, the breathing circuit of which includes a mouthpiece valve for the inhalation and exhalation of breathable gas from and to the said breathing circuit, a carbon dioxide scrubber and a valve, preferably an electrically operated valve, for the addition of oxygen to the breathing circuit from an oxygen supply; the said control system comprising: an electronic controller operably connected to at least one oxygen sensor for sensing oxygen partial pressure in the breathing circuit and operably connected to the said electrically operated valve for the addition of oxygen, or a mixture of oxygen and other gas(es), to the breathing circuit from a gas supply, the said controller operably controlling the said electrically operated valve to maintain at least a minimum pre-determined oxygen partial pressure in the breathing circuit; the said controller having switch means, preferably remotely operated switch means, operably connected to a breathing circuit valve in such a way that the action of switching on the said breathing circuit valve for the delivery of breathable gas to the said mouthpiece also switches on the electronic controller so that the electronic controller is switched on at all times when the breathing circuit valve is switched on and capable of de-

livering breathable gas to the user.

[0019] Various embodiments of the present invention will now be more particularly described, but by way of example only, with reference to the accompanied drawings, in which:

Figure 1 is a perspective view of a mouthpiece valve suitable for use with the present invention;

Figure 2 is a mouthpiece valve similar to that shown in Figure 1 having a more simplified construction;

Figure 3 is a perspective view of the mouthpiece valve of Figure 2 indicating the operation of the valve in use;

Figures 4a and 4b are different perspective schematic views of a mouthpiece valve constructed in accordance with an embodiment of the present invention with the valve in its closed position.

[0020] Figures 5a and 5b show the same valve as Figures 4a and 4b with valve in its open position for the delivery of breathable gas to the mouthpiece.

[0021] In Figures 1 to 5b the same reference numerals are used to indicate same or similar elements.

[0022] Referring to Figure 1 there is shown, by way of background, an exploded view of a known type of mouthpiece valve of a closed circuit self-contained breathing apparatus. The mouthpiece valve of Figure 1 is disclosed in GB-A-2, 340,760, and is typical of a state of the art mouthpiece valve for breathing apparatus of the type to which the present invention pertains and which may be utilised in the implementation of the present invention.

[0023] As can be seen in Figure 1 the mouthpiece valve 12 comprises a main cylindrical body 28 open at opposite ends to provide an inhalation port 29 and exhalation port 30, and having an opening in its cylindrical wall surrounded by an oval-section spigot 31 to define the mouthpiece port. The interior of the mouthpiece port constituted by the spigot 31 communicates with the interior chamber within the cylindrical body 28. The spigot 31 has a surrounding rim 34 to allow a resilient elastomeric mouthpiece generally indicated 35, and of conventional shape, to be fitted thereto. The spigot 31 may be coupled to a full-face mask or half-mask.

[0024] Within the interior chamber 33 of the cylindrical body 28 is a cylindrical baffle 37 having open opposite ends 38, 39 and an intermediate opening 40 which in the orientation of the baffle 37 shown in Figure 1 is in alignment with the mouthpiece port 31 and has a surrounding resilient grommet 41 which seals against the cylindrical interior surface of the chamber 33 such that when the baffle 37 is rotated about its longitudinal axis in a direction, as indicated by the double arrow A of Figure 1, the interior chamber 33 of the baffle 37 is sealed from the mouthpiece port 31.

[0025] At each end of the body 28 are located respec-

tive unidirectional valves 27, 15. These valves are held in place by gland fittings 42, 43 over which are engaged internally threaded annular coupling members 46, 47 having external surface formations such as grooves or splines to facilitate gripping by a user's fingers.

[0026] The rings 46, 47 in turn couple via the gland fittings 42, 43 with the end portions of the cylindrical baffle 37 to enable this to be turned in the directions shown by the double arrow A with respect to the body 28 whilst the user holds the mouthpiece 35 in his or her mouth.

[0027] If the rings 46 and 47 are gripped whilst the mouthpiece is still in the user's mouth, the internal sleeve 37 can be turned through an angle of approximately 30 degrees, which displaces the port 40 from the mouthpiece opening 31 thereby isolating the rebreather circuit from the external environment. If the user should now take that mouthpiece 35 out of his or her mouth the maximum volume within the mouthpiece valve which can be subject to flooding is the part-circumferential chamber defined by the groove 48 in the sleeve 47. This can be purged simply by exhaling.

[0028] The gland fitting 43, also has a radial flange 53 engaged by a radially inwardly directed flange 55 of ribbed annular coupling member 47 by which the gland fitting 43 is secured to the body of the mouthpiece, for which purpose the ring 47 is internally threaded for engagement on a threaded end porting 56 of the mouthpiece body, with the gland fitting 43 trapped between the flange 55 and the unidirectional valve 15 located between the radially outwardly projecting flange 53 and the end face of the mouthpiece body. In order to make a watertight seal the end face of the flange 53 of the gland fitting 43 is provided with a circular groove housing an O-ring seal which projects partly from the face to be engaged on the face of the unidirectional valve 15 and compressed to form a watertight seal when the ring 47 is threaded onto the threaded end part 56 of the valve body. By unscrewing the rings 47 and 46 the fitting can be readily released to allow cleaning and disinfecting of the hoses and the mouthpiece whilst, when screwed up firmly, the hose coupling thus formed is secure and watertight, being capable of withstanding considerable loads without applying undue stress on the hose itself.

[0029] A more simplified version of the rotary mouthpiece valve of Figure 1 is shown in Figures 2 and 3 where the additional housing 36, 50 containing the pressure sensitive valve is absent. In other respects the valve shown in Figures 2 and 3 is more or less the same and operates on the same principal shown in Figure 1. The central body section including in the housing 28 rotates and moves independently of the two outer sections provided by the rings 46 and 47 which move together with the inner tube or baffle 37. In use it is obviously easier for the diver to hold the mouthpiece and rotate the outer rings as the mouthpiece will be held in the diver's mouth.

[0030] In accordance with an embodiment of the present invention a mouthpiece valve of the aforementioned type, as described in reference to Figures 1-3, is

provided with a switch for switching on the electronic controller of the self-contained breathing apparatus when the mouthpiece valve is switched on to deliver breathable gases to the mouthpiece port 31, that is to say when the inner cylindrical element 37 is rotatably positioned within the housing 12 so that the port 31 is in fluid communication with the interior of the cylindrical member 37 via the opening 40. The switch (not shown) may be of any particular type including but not limited to electrical, electromagnetic, electronic, optical or opto-electronic. For example a Reed switch or Hall effect switch may be used as this readily enables the switch to be integrated into the mouthpiece valve between the two relatively rotatable parts of the valve. For example, a magnet (not shown) may be carried on the rotatable cylindrical element 37 with a Reed switch or Hall effect switch provided on the housing 28 so that the switch is activated upon rotation of the inner cylindrical member 37 within the housing 12 to the open position, where the inhalation mouthpiece port 34 is in fluid communication with the interior of the cylindrical valve member 37 via the opening 40. The present invention also contemplates embodiments where opto-electronic switches are envisaged. An optical system is particularly advantageous in the context of an underwater breathing apparatus since there is no requirement to electrically insulate the optical communication means, i.e. optical rod or fibre, from the salt-water environment when the apparatus is used.

[0031] An embodiment of an optical system is schematically shown in Figures 4a, 4b, 5a and 5b where the mouth piece valve 12 is shown in combination with inhalation and exhalation breathing hoses 60, 62. In the illustrated embodiment an optical circuit is provided by means of a pair of fibre optic polyethylene rods 64 and 66 within a cable sheath 68, a terminal end of which is provided with a cylindrical terminal 70 which is received in a ring like holder 72 extending from the surface of the annular coupling ring 46. One of the optical fibre strands 64 is optically coupled at its other end (not shown) to a light emitter, preferably an LED, with the other end (not shown) of the optical fibre strand 66 optically coupled to a light detector. In preferred embodiments the LED, detector associated electronics and power source are housed in the lid of the breathing apparatus adjacent the CO₂ scrubber, with or adjacent to the rebreather electronics and power source, where the electrical and electronic components are sealed against water ingress and other environmental considerations. It is to be understood that a major advantage of using such polyethylene rods in embodiments of the present invention is that they are small and very robust and importantly do not have to be pressure proof or water proof, and are therefore able to operate at any depth, more importantly if they break, crack or split, they do not short out as would be the case with electrical connections and affect the electronics of the breathing apparatus.

[0032] As previously mentioned the optical fibre strands or rods 64 and 66 may be provided in a single

cable carrying multiple strands within a single sheath 68 to provide light transmission for visible signals in embodiments having a head up display as described in GB 2, 412, 324.

[0033] When the mouth piece valve is closed as shown in Figures 4a and 4b the light circuit provided by the light emitter, optical fibre rods 64, 66 and light detector is completed by means of a coupling element 74 mounted on the cylindrical body 28. The coupling element 74 may comprise any type of optical coupling element to provide an optical transmission circuit between the respective terminal ends of fibre optic rods 64 and 66 to complete the circuit between the emitter and detector. The element 74 may comprise a 180 degree bend of fibre optic cable, a reflector, prism or other optical component or components capable of completing the circuit when the ring 46 is rotatably positioned such that the ends of the optical fibre strands 64, 66 are in registration with the coupling element 74.

[0034] As can be seen in the schematic drawings of Figures 5a and 5b when the annular coupling rings of 46 and 47 are rotated relative to the cylindrical body 28 to turn on the mouth piece valve and enable breathable gas to flow to the mouth piece 35, as shown by the relative positions of the cylindrical body and annular coupling ring 46 in Figures 5a and 5b, the optical circuit is broken since the respective ends of the fibres 64 and 66 are no longer in registration with the coupling element 74, and therefore the optical circuit may be considered to be an "open circuit" in the sense that light emitted from the light emitter

will not be returned to the detector as previously in the closed position of the valve shown in Figures 4a and 4b. **[0035]** In a preferred embodiment the electronic controller is programmed to wake up every thirty seconds or so and fire the LED. If the mouthpiece is closed, as in Figures 4a and 4b, the light signal is reflected back down the other optical fibre rod 66 and is received by the detector and the electronics of the controller shut down for another thirty seconds or so. Other intervals are contemplated including for example a one minute interval, or duty cycle, to conserve power. In this mode the controller is not switched on operationally to monitor and control oxygen partial pressure in the breathing circuit. If, on the other hand, the mouth piece valve is open as shown in Figures 5a and 5b, for example when the diver is breathing from the apparatus, the breathing apparatus electronics are immediately switched on ready to warn the diver of low or high oxygen levels and also to operate a gas supply valve, typically a solenoid valve, to add oxygen to the gas in the breathing circuit, if appropriate.

[0036] The optoelectronic embodiment described with reference to Figures 4a, 4b and 5a and 5b has the advantage that if the light transmitter or the cable is disconnected, or for that matter any malfunction of the optical circuit occurs, the breathing apparatus fails safe and the controller switches on.

[0037] It is envisaged that the electronic controller will provide an audible and/or visible alarm when the control-

ler is switched on so that the diver becomes accustomed to hearing/seeing the alarm when he or she opens the mouthpiece valve. It is also envisaged that in the pre-dive mode, or test mode, previously described, oxygen partial pressure (P02) will be controlled at 0.21 bar, with an alarm signal generated by the electronic controller if the oxygen partial pressure drops below 0.16 bar, in addition to an alarm signal if the diver descends below 1.2 metres whilst still in the pre-dive or test mode. It is also envisaged that if the diver descends below 1.2 metres in addition to an alarm signal, both audible and visible, the controller switches into the dive mode with an oxygen partial pressure set point of 0.7 bar. Visible signals are also contemplated in embodiments having a head up display of the type described in GB 2, 412, 324 and previously referred to.

[0038] Although the invention has been described with reference to implementation in a mouthpiece valve having a rotary valve system, embodiments of the present invention are also contemplated where the remote switch is implemented in other types of mouthpiece valves, and in other parts of the breathing circuit, although integration into the mouthpiece valve is particularly convenient for the reasons set out above.

Claims

1. A self contained breathing apparatus comprising:

a breathing circuit including a carbon dioxide scrubber and a gas supply valve for the addition of oxygen or a mixture of oxygen and other gas(es) to the breathing circuit from a gas supply; a mouthpiece valve for the inhalation and exhalation of breathable gas from and to the said breathing circuit; an electronic controller operably connected to at least one oxygen sensor for sensing oxygen partial pressure in the breathing circuit and operably connected to the said gas supply valve for the addition of oxygen, or a mixture of oxygen and other gas(es), to the breathing circuit from said gas supply, the said controller operably controlling the said gas supply valve to maintain at least a minimum pre-determined oxygen partial pressure in the breathing circuit; the said controller having switch means operably connected to and/or associated with a breathing circuit valve such that the action of switching on the said breathing circuit valve for the delivery of breathable gas to the said mouthpiece switches on the electronic controller for operational control such that the electronic controller is switched on at all times when the breathing circuit valve is switched on and capable of delivering breathable gas to the user.

2. Breathing apparatus as claimed in Claim 1 wherein said breathing circuit valve comprises part of said mouthpiece valve.
3. Breathing apparatus as claimed in Claim 2 wherein the said mouthpiece valve comprises a pair of relatively movable valve members which move with respect to each other to cause the mouthpiece valve to open and close and the said switch means is at least partly integrated into the said mouthpiece valve such that relative movement of the valve members operates the said switch.
4. Breathing apparatus as claimed in Claim 3 wherein the said movable valve members comprise a pair of relatively rotatable valve members which rotate with respect to each other to cause the mouthpiece valve to open and close and relative rotation of the valve members operates the said switch.
5. Breathing apparatus as claimed in Claim 3 or Claim 4 wherein the said switch means is integrated into said moveable/rotatable valve members.
6. Breathing apparatus as claimed in any preceding claim wherein the said switch means is manually operated.
7. Breathing apparatus as claimed in any preceding claim wherein the said switch means comprises optical switch means.
8. Breathing apparatus as claimed in Claim 7 wherein said optical switch means comprises an optical circuit.
9. Breathing apparatus as claimed on Claim 8 wherein said optical circuit is arranged such that a break in the said circuit switches the state of the said controller, on or off, preferably the electronic controller is switched on for operational control of the apparatus when a break in the said circuit is detected.
10. Breathing apparatus as claimed in Claim 9 wherein operation of said switch means is arranged to configure the said optical circuit in an open circuit configuration or a closed circuit configuration.
11. Breathing apparatus as claimed in any one of Claims 1 to 6 wherein the said switch means comprises an electro-magnetic switch.
12. Breathing apparatus as claimed in Claim 11 wherein the said switch means comprises a reed switch or Hall effect switch.
13. Breathing apparatus as claimed in Claim 12 when directly or indirectly dependent on Claim 4 wherein the said reed switch or Hall effect switch is integrated into said rotatable valve members.
14. Breathing apparatus as claimed in any preceding claim wherein the said controller includes a main power supply which is switched on by operation of the said switch means.
15. A control system as claimed in any preceding claim wherein the electronic controller is arranged so that the action of switching off the said breathing circuit valve does not switch off the said controller.
16. A control system for a closed circuit self contained breathing apparatus, the breathing circuit of which includes a mouthpiece valve for the inhalation and exhalation of breathable gas from and to the said breathing circuit, a carbon dioxide scrubber and an electrically operated valve for the addition of oxygen to the breathing circuit from an oxygen supply; the said control system comprising: an electronic controller operably connected to at least one oxygen sensor for sensing oxygen partial pressure in the breathing circuit and operably connected to the said electrically operated valve for the addition of oxygen, or a mixture of oxygen and other gas(es), to the breathing circuit from a gas supply, the said controller operably controlling the said electrically operated valve to maintain at least a minimum pre-determined oxygen partial pressure in the breathing circuit; the said controller having a remotely operated switch operably connected to a breathing circuit valve in such a way that the action of switching on the said breathing circuit valve for the delivery of breathable gas to the said mouthpiece also switches on the electronic controller so that the electronic controller is switched on at all times when the breathing circuit valve is switched on and capable of delivering breathable gas to the user.

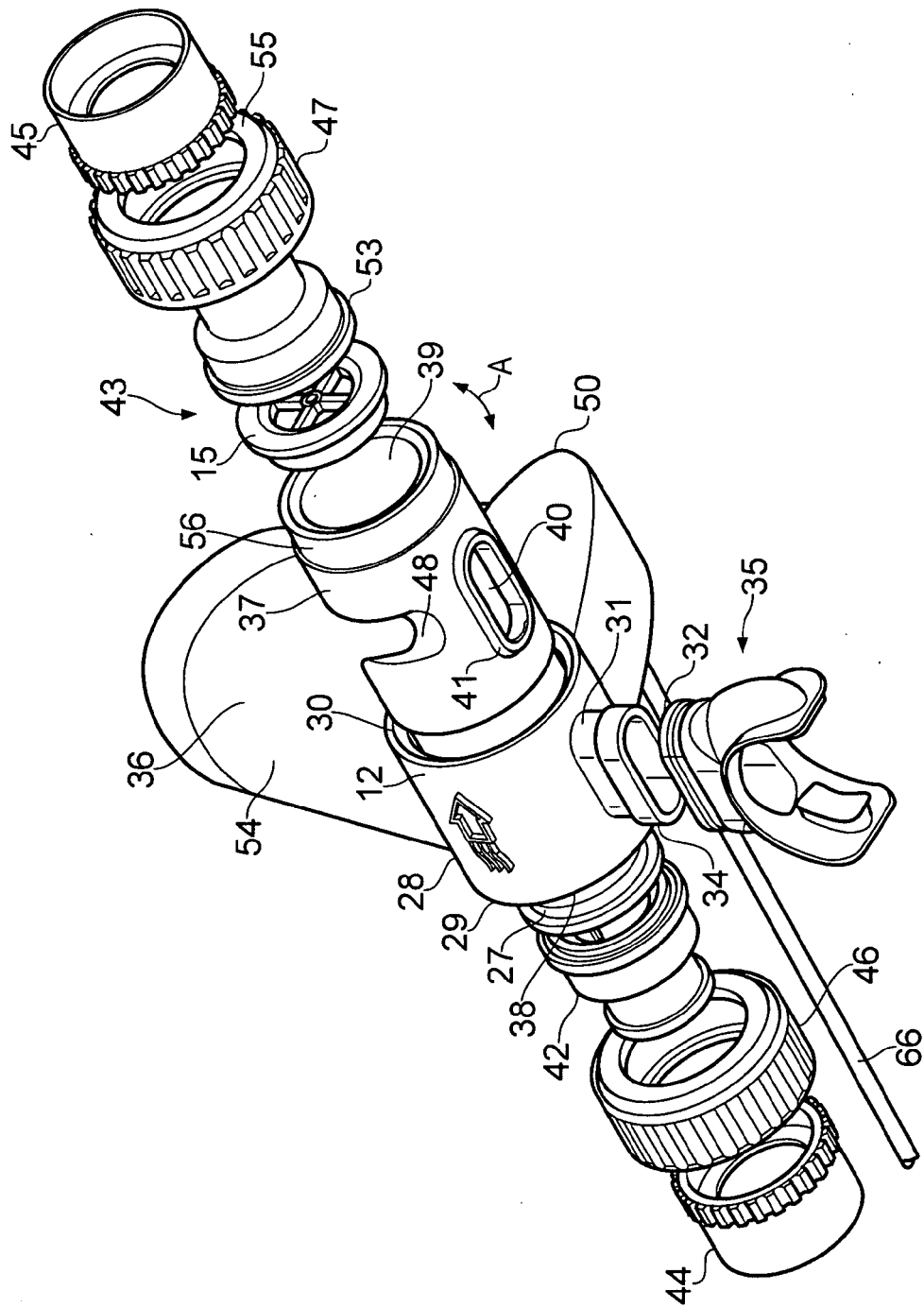


FIG. 1

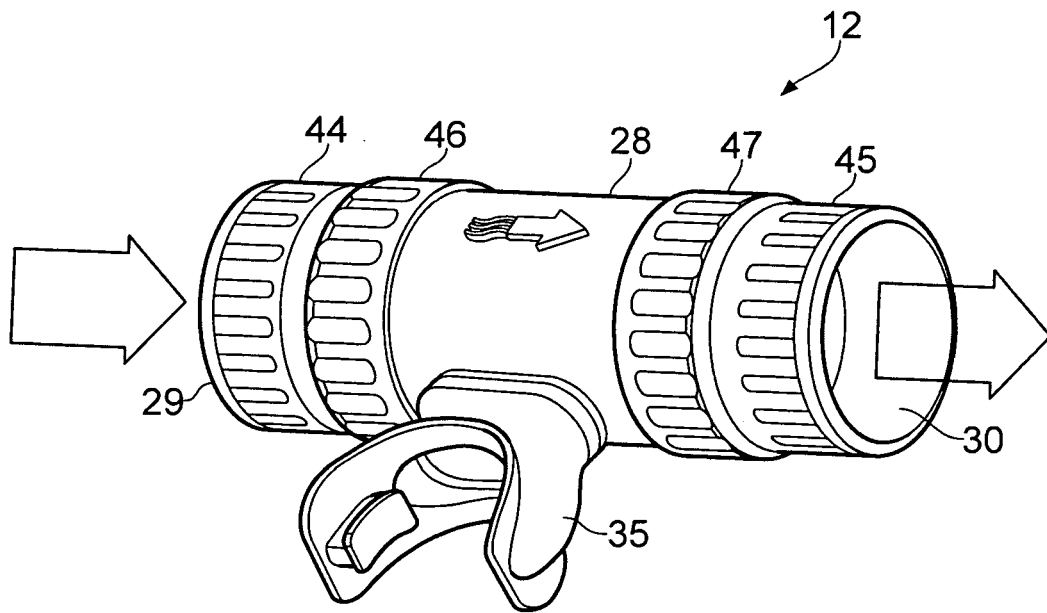


FIG. 2

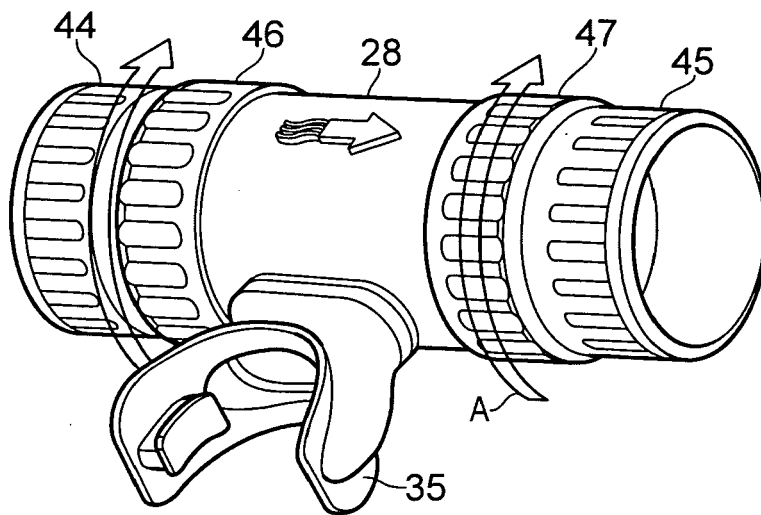


FIG. 3

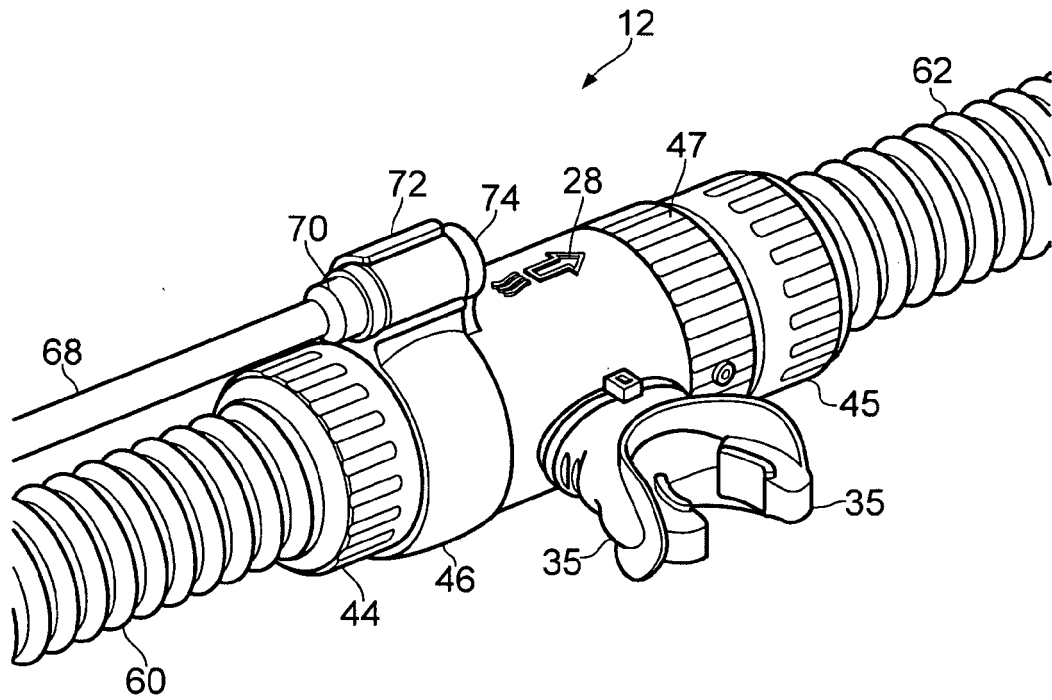


FIG. 4a

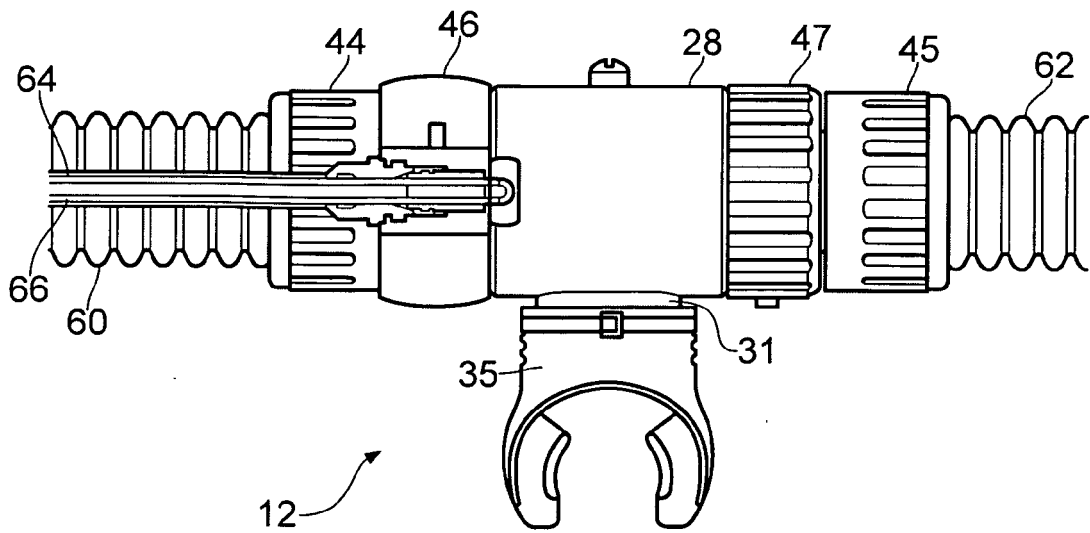


FIG. 4b

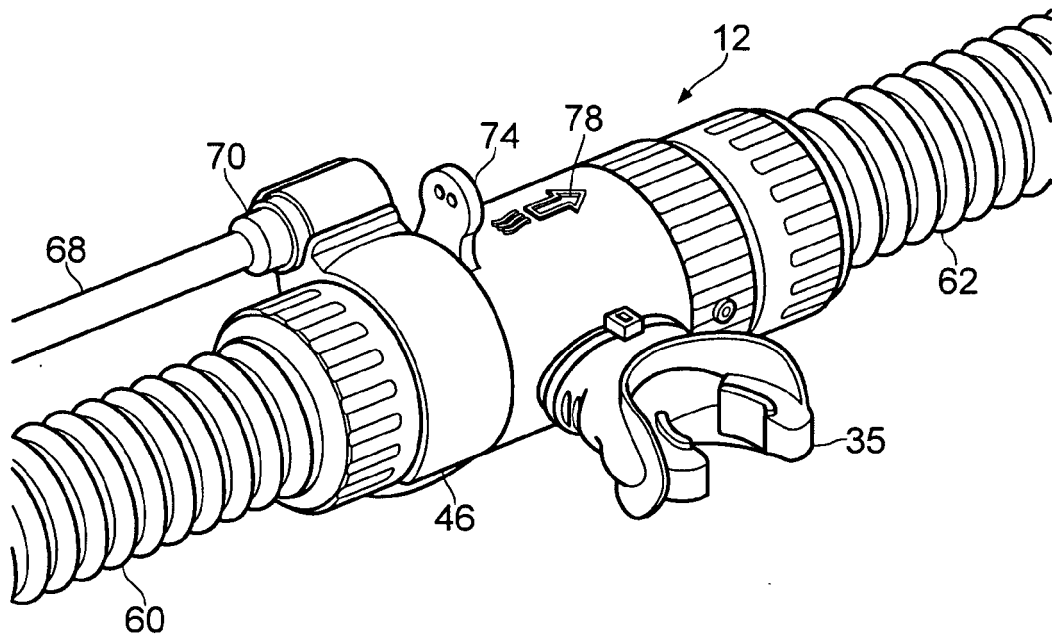


FIG. 5a

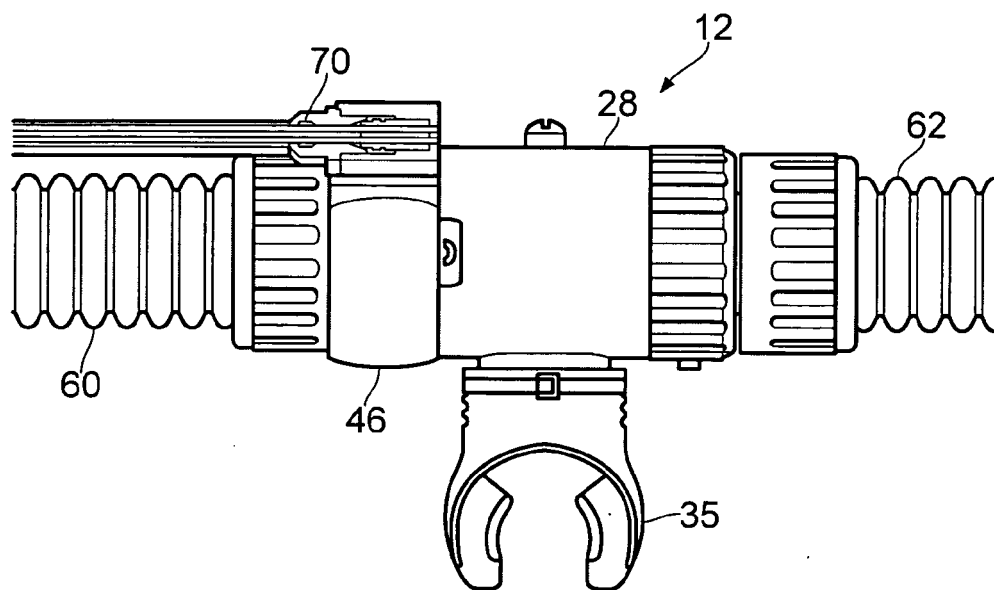


FIG. 5b



EUROPEAN SEARCH REPORT

Application Number
EP 10 25 0530

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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