(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 June 2014 (19.06.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/091293 A1

(51) International Patent Classification:
*A61F 9/06* (2006.01)

(21) International Application Number:
PCT/IB2013/002756

(22) International Filing Date:
13 December 2013 (13.12.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/736,767 13 December 2012 (13.12.2012) US
13/795,363 12 March 2013 (12.03.2013) US

(71) Applicant: **LINCOLN GLOBAL, INC.** [US/US]; 17721 Railroad Street, City of Industry, CA 91748 (US).

(72) Inventor: **KOOKEN, Todd, Eric**; 37775 Flanders Drive, Solon, OH 44319 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

**Published**:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(54) Title: POWERED AIR/PURIFYING RESPIRATOR HELMET WITH PHOTOVOLTAIC POWER SOURCE

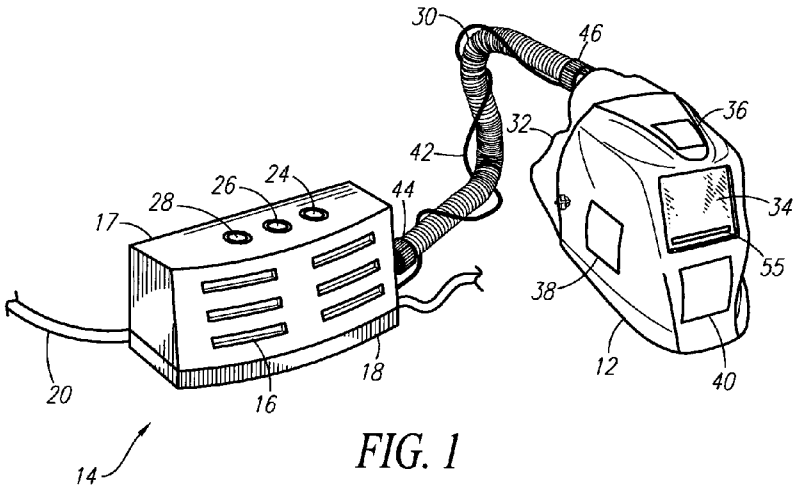


FIG. 1

(57) Abstract: A powered air-purifying respirator helmet system includes a helmet (12) having a lens (34, 39). A photovoltaic power source (36, 38, 40) is mounted on the helmet (12). A trunk-worn blower (14) is separate from the helmet (12). The trunk- worn blower (14) includes a fan (54) and a rechargeable battery (18) operably connected to power the fan (54). A flexible air-electrical conductor (42) interconnects the trunk-worn blower (14) and the helmet (12) to simultaneously supply both pressurizing air to the helmet (12) and electrical energy generated by the photovoltaic power source (36, 38,40) on the helmet (12) to the trunk-worn blower (14).

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# POWERED AIR-PURIFYING RESPIRATOR HELMET WITH PHOTOVOLTAIC POWER SOURCE

[0001] Benefit of U.S. Provisional Patent Application Serial Number 61/736,767 filed December 13, 2012, is hereby claimed and the disclosure incorporated herein by reference.

## FIELD OF THE INVENTION

[0002] The present invention relates to welding helmets, and in particular to powered air-purifying respirator (PAPR) welding helmets according to claims 1, 4 and 11.

## TECHNICAL BACKGROUND

[0003] PAPR welding helmets are supplied with a flow of air from a blower to create a positive air pressure within the helmet. The positive air pressure helps keep environmental contaminants, such as welding fumes, out of the helmet, so that they are not inhaled by the welding operator. The blower of the PAPR system is typically worn on the body of the welding operator, such as on a belt. An air hose connects the blower to the PAPR helmet. The blower can include one or more air filters for cleaning the air drawn from the welding environment. The blower can be battery-powered. However, batteries are heavy, and the use of a PAPR system during welding can fatigue the welding operator. Further, the battery can become discharged during use, temporarily rendering the PAPR system unusable while the battery is recharged or necessitating the replacement of the battery with a spare.

## DESCRIPTION

[0004] Against this background it is an object of the present invention to overcome the aforementioned limitations and disadvantages. More particular it is an object to optimite the handling of welding helmets. This problem is solved by a powered air-purifying respirator helmet system according to the claim 1, 4 and 11. Preferred embodiments of

the invention are subject of the subclaims. The following summary presents a simplified summary in order to provide a basic understanding of some aspects of the devices and systems discussed herein. This summary is not an extensive overview of the devices and systems discussed herein. It is not intended to identify critical elements or to delineate the scope of such devices and systems. Its sole purpose is to present some concepts in a simplified form as a prelude to the more detailed description that is presented later.

[0005] Example aspects and embodiments of the present invention are summarized below. It is to be appreciated that the example aspects and/or embodiments may be provided separately or in combination with one another.

[0006] In accordance with one aspect of the present invention, provided is a powered air-purifying respirator helmet system. The system includes a helmet having a lens. A photovoltaic power source is mounted on the helmet. A trunk-worn blower is separate from the helmet. The trunk-worn blower includes a fan and a rechargeable battery operably connected to power the fan. A flexible air-electrical conductor interconnects the trunk-worn blower and the helmet to simultaneously supply both pressurizing air to the helmet and electrical energy generated by the photovoltaic power source on the helmet to the trunk-worn blower.

[0007] In certain embodiments, the flexible air-electrical conductor comprises an air hose and a wire running along the air hose. In further embodiments, the wire is integral with the air hose. In still further embodiments, the air hose comprises a first coupling at a first end of the air hose and a second coupling at a second end of the air hose, and the wire interconnects the first coupling and the second coupling such that the electrical energy generated by the photovoltaic power source is conducted through the first coupling and the second coupling of the air hose. In certain embodiments, the fan is a radial fan configured to pressurize a blower enclosure, the flexible air-electrical conductor, and the helmet, and the photovoltaic power source is operably connected to supply electrical energy to one or both of the rechargeable battery and the radial fan. In certain embodiments, the photovoltaic power source is a first photovoltaic power source, the

lens comprises an auto-darkening LCD cartridge and includes an additional battery and second photovoltaic power source for powering the auto-darkening LCD cartridge, and the first photovoltaic power source supplies electrical energy to both of the trunk-worn blower and the auto-darkening LCD cartridge. In certain embodiments, the helmet includes an indicator for indicating a status of the trunk-worn blower. In further embodiments, the indicator indicates at least one of: blower running, blower fan speed, battery voltage, and battery charge level, and wherein the lens comprises an auto-darkening LCD cartridge that includes the indicator.

[0008] In accordance with another aspect of the present invention, provided is a powered air-purifying respirator helmet system. The system comprises a helmet including a lens. A photovoltaic power source is mounted on the helmet. A trunk-worn blower is separate from the helmet. The trunk-worn blower comprises a fan and a rechargeable battery operably connected to power the fan. An air hose interconnects the trunk-worn blower and the helmet to supply pressurizing air to the helmet. A cable runs along the air hose and interconnects the trunk-worn blower and the helmet to supply electrical energy generated by the photovoltaic power source to the trunk-worn blower.

[0009] In certain embodiments, the cable is integral with the air hose. In certain embodiments, the air hose comprises a first coupling at a first end of the air hose and a second coupling at a second end of the air hose, and the cable interconnects the first coupling and the second coupling such that the electrical energy generated by the photovoltaic power source is conducted through the first coupling and the second coupling of the air hose. In certain embodiments, the fan is a radial fan configured to pressurize a blower enclosure, the air hose, and the helmet; and the photovoltaic power source is operably connected to supply electrical energy to one or both of the rechargeable battery and the radial fan. In certain embodiments, the photovoltaic power source is a first photovoltaic power source, the lens comprises an auto-darkening LCD cartridge and includes an additional battery and second photovoltaic power source for powering the auto-darkening LCD cartridge, and the first photovoltaic power source supplies electrical energy to both of the trunk-worn blower and the auto-darkening LCD

cartridge. In certain embodiments, the helmet includes an indicator for indicating a status of the trunk-worn blower. In further embodiments, the indicator indicates at least one of: blower running, blower fan speed, battery voltage, and battery charge level, and wherein the lens comprises an auto-darkening LCD cartridge that includes the indicator.

[0010] In accordance with another aspect of the present invention, provided is a powered air-purifying respirator helmet system. The system comprises a helmet including a lens comprising an auto-darkening LCD cartridge. A photovoltaic power source is mounted on the helmet. A trunk-worn blower is separate from the helmet, the trunk-worn blower comprising a radial fan and a rechargeable battery operably connected to power the radial fan. An air hose interconnects the trunk-worn blower and the helmet to supply pressurizing air to the helmet. The photovoltaic power source supplies electrical energy to both of the trunk-worn blower and the auto-darkening LCD cartridge.

[0011] In certain embodiments, a cable runs along the air hose and interconnects the trunk-worn blower and the helmet to supply electrical energy generated by the photovoltaic power source to the trunk-worn blower. In further embodiments, the cable is integral with the air hose, and the air hose comprises a first coupling at a first end of the air hose and a second coupling at a second end of the air hose, and the cable interconnects the first coupling and the second coupling such that electrical energy generated by the photovoltaic power source is conducted through the first coupling and the second coupling in the air hose. In still further embodiments, the helmet includes an indicator for indicating a status of the trunk-worn blower, the indicator indicating at least one of: blower running, blower fan speed, battery voltage, and battery charge level.

## DESCRIPTION OF THE DRAWINGS

[0012] FIG. 1 is a perspective view of a PAPR welding helmet system;

[0013] FIG. 2 is a perspective view of the PAPR welding helmet system in use;

[0014] FIG. 3 shows an example auto-darkening LCD cartridge for a welding helmet;

[0015] FIG. 4 is a perspective view of an air hose;

[0016] FIG. 5 is a perspective view of an air hose; and

[0017] FIG. 6 is a schematic electrical diagram of an example PAPR welding helmet system.

## DETAILED DESCRIPTION OF THE INVENTION

[0018] The present invention relates to powered air-purifying respirator (PAPR) welding helmets. The present invention will now be described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. It is to be appreciated that the various drawings are not necessarily drawn to scale from one figure to another nor inside a given figure, and in particular that the size of the components are arbitrarily drawn for facilitating the understanding of the drawings. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It may be evident, however, that the present invention can be practiced without these specific details. Additionally, other embodiments of the invention are possible and the invention is capable of being practiced and carried out in ways other than as described. The terminology and phraseology used in describing the invention is employed for the purpose of promoting an understanding of the invention and should not be taken as limiting.

[0019] Figure 1 provides a perspective view of an example PAPR welding helmet system. The system includes a helmet, such as a welding helmet **12**, and a trunk-worn blower **14** (hereinafter "blower"). The welding helmet **12** and blower **14** are separate but interconnected devices that form parts of the PAPR system.

[0020] The blower **14** has a fan (not shown) for drawing air into the blower from the environment through a plurality of air intake ports **16**. Example fans for use in the blower **14** in include radial and axial fans. A radial fan draws in air along its axis and discharges it radially due to a rotating impeller. An axial fan moves air along its axis of

rotation due to rotating fan blades. The specific shape given to the blower housing or enclosure **17** can be based on the type of fan used in the blower **14**. For example, an axial fan can allow the blower enclosure **17** to assume a narrow, rectangular shape (as shown in Fig. 1), since air is discharged radially from the fan. If an axial fan is used, the blower enclosure **17** can have a more elongated and possibly less narrow shape (e.g., cylindrical) to accommodate an axial air flow within the enclosure.

[0021] The blower **14** further includes one or more filters for filtering airborne matter from the environment. For example, the blower **14** can include a pre-filter (e.g., a foam filter) followed by a HEPA filter (high-efficiency particulate air filter).

[0022] The blower **14** and its fan are powered by a rechargeable battery **18**. In certain embodiments, the battery **18** is readily removable for replacement with another battery and/or for recharging the battery remotely from the blower. An example battery is a sealed 12V lithium-ion battery.

[0023] The blower **14** is worn by a welding operator, as shown in Fig. 2. The blower **14** can be attached to a belt **20** and/or a shoulder harness **22** that is worn by the operator at least partially around the trunk of his body. Thus, the blower **14** is "trunk-worn". The blower **14** can be worn at the back of the operator, to minimize the welding fumes drawn in by the blower **14**.

[0024] The blower **14** can include operator controls **24**, **26**, **28** in the form of buttons, knobs, etc., to turn the blower on and off and to control the speed of the blower. For example, the blower **14** can be operated at either a low speed or a high speed, to thereby deliver different volumes of air to the helmet **12** per unit time (different CFM). The blower **14** can also include indicators, such as an ON/OFF indicator, a battery charge level indicator, and the like.

[0025] A flexible air hose **30** connects the blower **14** to the welding helmet **12** and supplies pressurizing air from the blower to pressurize the helmet. The helmet **12** can include a sealing hood **32** for establishing a pressurized environment around the face of the welding operator. The fan in the blower **14** pressurizes the blower enclosure **17**, the

air hose **30** interconnecting the blower enclosure and the welding helmet **12**, the helmet, and sealing hood **32** with air drawn from the environment.

[0026] The welding helmet **12** includes lens **34** to protect the eyes of the welding operator during welding. The lens **34** can be a glass lens with a fixed shade, or the lens can be an electronic, auto-darkening LCD cartridge. Auto-darkening LCD cartridges have arc sensors that respond to the light given off by an electric arc during arc welding. The arc sensors control the operation of a liquid crystal display (LCD) lens in the cartridge. The LCD lens can quickly change from a light state in which a workpiece is readily visible to a dark state, based on the presence of an arc. When the LCD lens is in the dark state, the operator is protected from the light of the arc.

[0027] An example auto-darkening LCD cartridge **31** is shown in Fig. 3. The auto-darkening LCD cartridge **31** can include operator controls **33**, **35**, **37** to adjust parameters such as shade level, sensitivity, and delay. An operator might require a higher shade level when the electric arc used for welding is particularly bright, such as when welding thick materials at high amperages. A lower shade level might be desired when using a less intense arc, such as when welding thinner materials at lower amperages. The sensitivity setting determines the light level at which the LCD lens **39** switches from the light to the dark state. An operator can reduce the sensitivity setting to avoid nuisance switching of the lens state, such as while working in the presence of other welding operators. Delay controls can be used to lengthen or shorten the amount of time it takes for the lens to return to the light state following the completion of a weld. The auto-darkening LCD cartridge **31** can include one or more batteries **41** for powering the cartridge. The auto-darkening LCD cartridge **31** can include additional interface devices for communicating information about the status of the blower, such as a speaker **58** and/or visual indicator **60**, as discussed further below.

[0028] Returning to Figs. 1 and 2, the welding helmet **12** includes one or more photovoltaic (PV) power sources **36**, **38**, **40**, such as PV cells (or arrays of PV cells), mounted on the helmet. The PV power sources **36**, **38**, **40** supply electrical power to the blower **14** to at least partially power the fan in the blower and/or charge the battery

**18**. The PV power sources **36**, **38**, **40** can help minimize the size of the battery **18** in the blower **14** and/or maximize the length of time that the battery can be used before recharging is required. Electrical energy generated by the PV power sources **36**, **38**, **40** is supplied to the blower **14** via an electrical conductor **42** (e.g., wires or a cable) running along the air hose **30**.

[0029] During a welding operation, in particular an arc welding operation, the light generated during welding irradiates the PV power sources **36**, **38**, **40** on the welding helmet **12**. The PV power sources **36**, **38**, **40** in turn generate electricity, which is used to power the blower **14** and/or charge the battery **18** in the blower. In Fig. 2, an electric arc **48** is generated from a welding torch **50**, and the PV power sources on the welding helmet **12** convert light from the arc into electricity for powering the blower **14** and/or charging the battery **18**.

[0030] The electrical conductor **42** runs along the air hose **30**. Together, the air hose **30** and electrical conductor **42** form a flexible conductor for both air and electricity (i.e., a flexible air-electrical conductor) that interconnects the blower **14** and welding helmet **12**. The flexible air-electrical conductor simultaneously supplies both pressurizing air to the helmet **12** and electrical energy generated by the PV power sources **36**, **38**, **40** to the blower **14**.

[0031] In certain embodiments, the conductor **42** is integral with the air hose **30**. Figure 4 shows an example embodiment in which a cable **42a** for supplying power to the blower has been embedded within the housing or wall of the air hose **30**. The couplings **44**, **46** at either end of the air hose **30** can provide electrical connections from the helmet **12** (Fig. 1 and 2) and its PV power sources **36**, **38**, **40** to the blower **14**. The cable **42a** interconnects the couplings **44**, **46** so that the electrical energy generated by the PV power sources on the welding helmet is conducted through the couplings to the blower. The couplings **44**, **46** and the associated ports (outlets or inlets) on the blower and welding helmet can have terminals for transmitting the electrical energy generated by the PV power sources to the conductor **42a** and blower through the couplings **44**, **46**. Thus, the couplings **44**, **46** can be part of the power supply circuitry from the helmet **12**

to the blower **14**, and can conduct electrical energy from the PV power sources **36**, **38**, **40** to the blower via said terminals.

[0032] Figure 5 shows another example embodiment in which the conductor **42** is integral with the air hose **30**. The conductor **42** is wrapped around a wall or carcass of the hose **30**, and the conductor **42** and wall or carcass are covered with a fabric sleeve **43**. Again, the couplings **44**, **46** at either end of the air hose can provide electrical connections from the helmet **12** (Fig. 1 and 2) and its PV power sources **36**, **38**, **40** to the blower **14**, with the conductor **42** interconnecting the couplings **44**, **46**.

[0033] Returning to Figs. 1 and 2, the PV power sources can be located on the welding helmet **12** so as to maximize their exposure to the light from the arc **48**. It is to be appreciated that any number of PV power sources can be placed on the welding helmet **12** as desired. For example, the surface of the welding helmet could be substantially covered by PV power sources. Additional PV power sources for powering the blower can be incorporated into the belt **20** and/or shoulder harness **22**, or into protective clothing worn by the welding operator (e.g., into a welding jacket).

[0034] A schematic electrical diagram of a PAPR welding helmet system is shown in Fig. 6. One or more PV power sources (shown schematically as PV power source **36**) at the welding helmet **12** supplies electrical energy to the battery **18** and/or radial fan **54** at the blower **14**. The conductor **42** electrically connects the welding helmet **12** to the blower **14** as described above. The welding helmet **12** can include regulating circuitry **52** for regulating the voltage/current/power supplied to the blower **14** from the PV power source **36**. Alternatively, the regulating circuitry can be incorporated into blower control circuitry **56** at the blower **14**.

[0035] In certain embodiments, the PV power sources can supply power to the auto-darkening LCD cartridge **31** in addition to the blower **14**, as shown schematically in Fig. 6. Auto-darkening LCD cartridges require a source of power to operate, and the power supply for the cartridge can be integrated with the power supply for the blower. The PV power source **36** on the welding helmet can provide power to the auto-darkening LCD

cartridge **31** and/or to the battery **41** for the cartridge and simultaneously provide power to the blower **14**. As shown in Fig. 1, the cartridge itself can include a PV power source **55** for supplying electrical energy to the cartridge and/or the blower **14**.

[0036] In certain embodiments, information is transmitted from the blower **14** to the welding helmet **12** and conveyed to the welding operator by the welding helmet. For example, information can be transmitted from the blower **14** to the welding helmet **12** via the conductor **42** (Figs. 1, 2). The information could also be transmitted wirelessly via short-range wireless communications (e.g., Bluetooth). Transmitted information can include blower status, such as blower running (e.g., ON/OFF), blower fan speed, battery voltage, battery charge level, estimated remaining run time, filter status (e.g., blocked or clogged condition), average power from PV power sources, etc. The information can be conveyed to the welding operator audibly and/or visually by the welding helmet **12**. For example, the welding helmet can emit audible beeps to convey information to the welding operator. In Fig. 3, the auto-darkening LCD cartridge **31** includes a speaker **58** for providing an audible indication or alarm (e.g., for low blower battery charge) and a visual indicator **60** (e.g., for blower battery charge).

[0037] In an embodiment, the PAPR welding helmet system with PV power sources is capable of operating the blower **14** for at least eight hours.

[0038] It should be evident that this disclosure is by way of example and that various changes may be made by adding, modifying or eliminating details without departing from the fair scope of the teaching contained in this disclosure. The invention is therefore not limited to particular details of this disclosure except to the extent that the following claims are necessarily so limited.

REFERENCE NUMBERS

| | |
|---|---|
| 12 | welding helmet |
| 14 | trunk-worn blower |
| 16 | air intake port |
| 17 | housing/ enclosure |
| 18 | battery |
| 20 | belt |
| 22 | shoulder harness |
| 24 | operator control |
| 26 | operator control |
| 28 | operator control |
| 30 | air hose |
| 31 | LCD cartridge |
| 32 | sealing hood |
| 33 | operator control |
| 34 | lens |
| 35 | operator control |
| 36 | power source |
| 37 | operator control |
| 38 | power source |
| 39 | lens |
| 40 | power source |
| 41 | battery |
| 42 | electrical conducter |
| 42a | cable |
| 43 | fabric sleeve |
| 44 | coupling |
| 46 | coupling |
| 48 | arc |
| 50 | welding torch |
| 54 | radial fan |
| 56 | blower control circuity |
| 58 | speaker |
| 60 | visual indicator |

## CLAIMS

What is claimed is:

1. A powered air-purifying respirator helmet system, comprising:

a helmet (12) including a lens (34, 39);

a photovoltaic power source (36, 38, 40) mounted on the helmet (12);

a trunk-worn blower (14) separate from the helmet (12), the trunk-worn blower (14) comprising a fan (54) and a rechargeable battery (18) operably connected to power the fan (54);

a flexible air-electrical conductor (42) interconnecting the trunk-worn blower (14) and the helmet (12) to simultaneously supply both pressurizing air to the helmet (12) and electrical energy generated by the photovoltaic power source (36, 38, 40) on the helmet (12) to the trunk-worn blower (14).

2. The powered air-purifying respirator helmet system of claim 1, wherein the flexible air-electrical conductor (42) comprises an air hose (30) and a wire running along the air hose (30).

3. The powered air-purifying respirator helmet system of claim 1, wherein the fan is a radial fan configured to pressurize a blower enclosure, the flexible air-electrical conductor, and the helmet, and

wherein the photovoltaic power source is operably connected to supply electrical energy to one or both of the rechargeable battery and the radial fan.

4. A powered air-purifying respirator helmet system, comprising:

a helmet (12) including a lens (34, 39);

a photovoltaic power source (36, 38, 40) mounted on the helmet (12);

a trunk-worn blower (14) separate from the helmet (12), the trunk-worn blower (14) comprising a fan (54) and a rechargeable battery (18) operably connected to power the fan (54);

an air hose (30) interconnecting the trunk-worn blower (14) and the helmet (12) to supply pressurizing air to the helmet (12);

and a cable (42a) running along the air hose (30) and interconnecting the trunk-worn blower (14) and the helmet (12) to supply electrical energy generated by the photovoltaic power source (36, 38,40) to the trunk-worn blower (14).

5. The powered air-purifying respirator helmet system of any of the claims 1 to 4, wherein the wire and/or the cable (42a) is integral with the air hose (30).

6. The powered air-purifying respirator helmet system of any of the claims 1 to 6, wherein air hose (30) comprises a first coupling (44) at a first end of the air hose (30) and a second coupling (46) at a second end of the air hose (30), and wherein the wire and/or the cable interconnects the first coupling (44) and the second coupling (46) such that the electrical energy generated by the photovoltaic power source (36, 38, 40) is conducted through the first coupling (44) and the second coupling (46).

7. The powered air-purifying respirator helmet system of any of the claims 1 to 6, wherein the fan (54) is a radial fan configured to pressurize a blower enclosure (17), the air hose (30), and the helmet (12), and

wherein the photovoltaic power source (36, 38, 40) is operably connected to supply electrical energy to one or both of the rechargeable battery (18) and the radial fan (54).

8. The powered air-purifying respirator helmet system of any of the claims 1 to 7, wherein the photovoltaic power source (36, 38, 40) is a first photovoltaic power source;

wherein the lens (34, 39) comprises an auto-darkening LCD cartridge (31) and includes an additional battery and second photovoltaic power source for powering the auto-darkening LCD cartridge (31), and

wherein the first photovoltaic power source supplies electrical energy to both of the trunk-worn blower (14) and the auto-darkening LCD cartridge (31).

9. The powered air-purifying respirator helmet system of any of the claims 1 to 8, wherein the helmet (12) includes an indicator (60) for indicating a status of the trunk-worn blower (14).

10. The powered air-purifying respirator helmet system of any of the claims 1 to 9, wherein the indicator (60) indicates at least one of: blower ON/OFF, blower fan speed, battery voltage, and battery charge level, and wherein the lens (34, 39) comprises an auto-darkening LCD cartridge (31) that includes the indicator (60).

11. A powered air-purifying respirator helmet system, comprising:

a helmet (12) including a lens (34, 39) comprising an auto-darkening LCD cartridge (31);

a photovoltaic power source (36, 38,40) mounted on the helmet (12);

a trunk-worn blower (14) separate from the helmet (12), the trunk-worn blower (14) comprising a radial fan (54) and a rechargeable battery (18) operably connected to power the radial fan (54);

an air hose (30) interconnecting the trunk-worn blower (14) and the helmet (12) to supply pressurizing air to the helmet (12),

wherein the photovoltaic power source (36, 38,40) supplies electrical energy to both of the trunk-worn blower (14) and the auto-darkening LCD cartridge (31).

12. The powered air-purifying respirator helmet system of claim 11, further comprising a cable (42a) running along the air hose (30) and interconnecting the trunk-worn blower (14) and the helmet (12) to supply electrical energy generated by the photovoltaic power source (36, 38,40) to the trunk-worn blower (14).

13. The powered air-purifying respirator helmet system of claim 11 or 12, wherein the cable (42a) is integral with the air hose (30),

wherein air hose (30) comprises a first coupling (44) at a first end of the air hose (30) and a second coupling (46) at a second end of the air hose(30), and

wherein the cable (42a) interconnects the first coupling (44) and the second coupling (46) such that electrical energy generated by the photovoltaic power source (36, 38,40) is conducted through the first coupling (44) and the second coupling (46).

14. The powered air-purifying respirator helmet system of any of the claims 1 to 13, wherein the helmet (12) includes an indicator (60) for indicating a status of the trunk-worn blower (14), the indicator (60) indicating at least one of: blower ON/OFF, blower fan speed, battery voltage, and battery charge level.

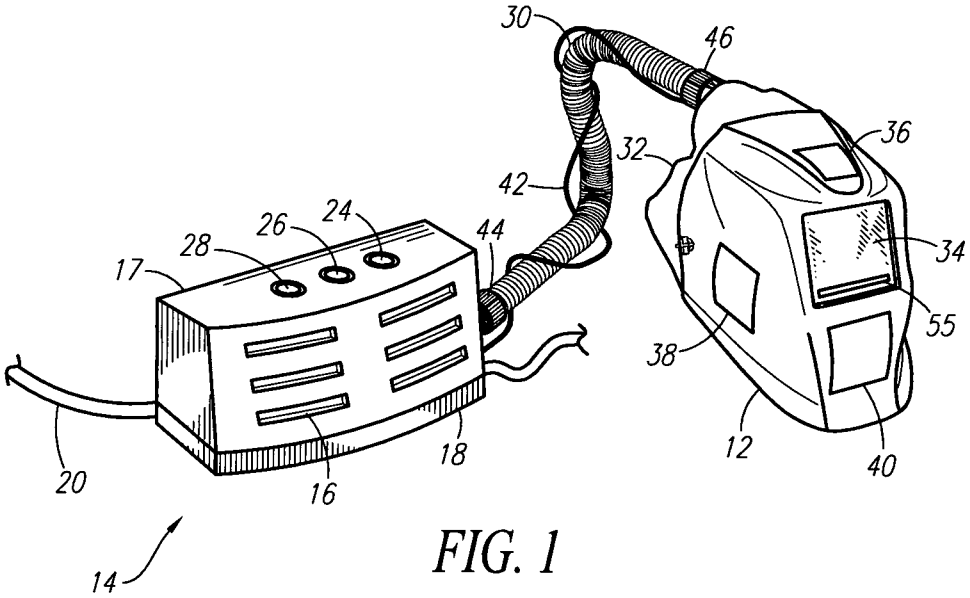
30
46
36
32
42
24
26
28
44
17
34
55
38
12
40
18
16
20
14

FIG. 1

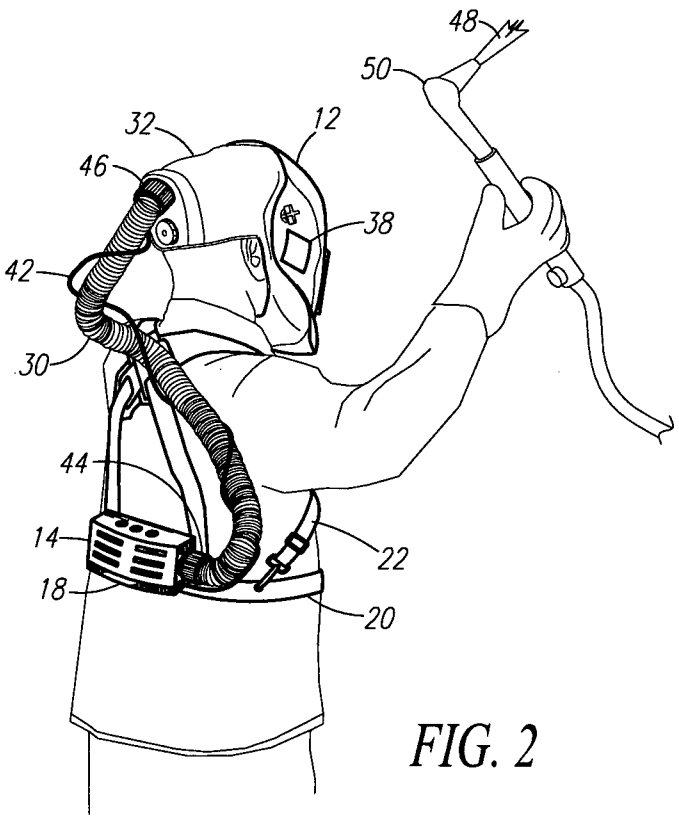
48
50
32
12
46
38
42
30
44
14
22
18
20

FIG. 2

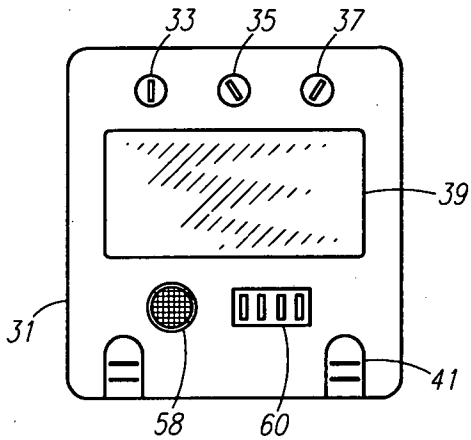


FIG. 3


FIG. 4

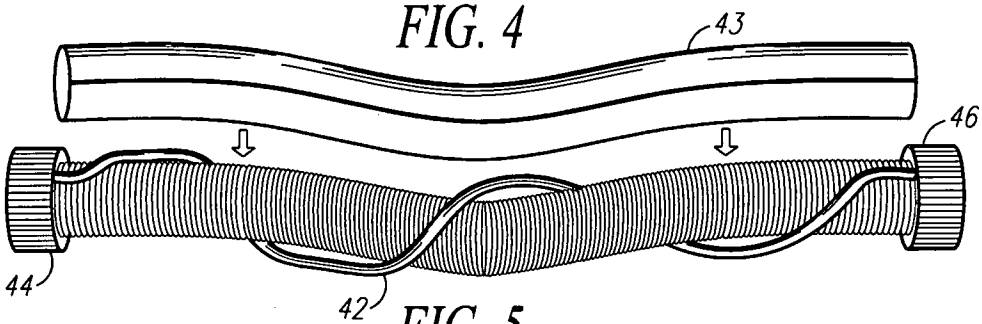


FIG. 5

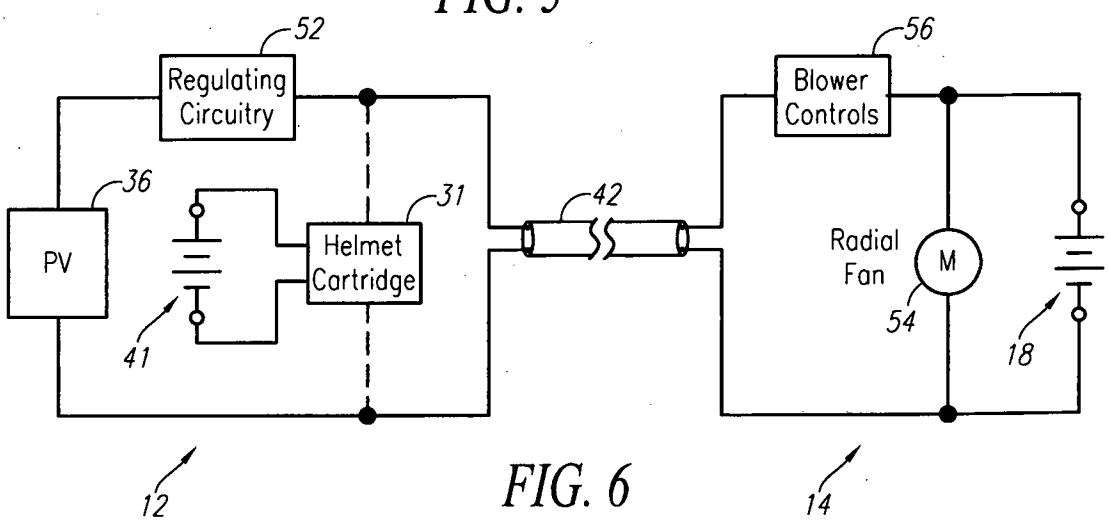


FIG. 6

# INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2013/002756

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61F9/06
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61F

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>Y | US 5 555 879 A (HELIN ARTO A [FI] ET AL)<br>17 September 1996 (1996-09-17)<br>the whole document<br>----- | 1-8,<br>11-13<br>9,10,14 |
| Y | US 2009/231423 A1 (BECKER WILLIAM JOSHUA [US] ET AL) 17 September 2009 (2009-09-17)<br>paragraph [0025]<br>----- | 9,10,14 |
| A | US 5 561 855 A (MCFALL MIKE G [US])<br>8 October 1996 (1996-10-08)<br>column 2, line 48 - column 5, line 44;<br>figures 1-4<br>----- | 1-4,7,11 |

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 8 April 2014 | 15/04/2014 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Porta, Marcello |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2013/002756

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| | | WO 9318726 A1 | 30-09-1993 |
| US 2009231423 A1 | 17-09-2009 | US 2009231423 A1 | 17-09-2009 |
| | | WO 2009114753 A2 | 17-09-2009 |
| US 5561855 A | 08-10-1996 | NONE | |