

MODULAR POWERED AIR PURIFYING RESPIRATOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/989,223, filed on November 20, 2007, which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] The invention relates to powered air purifying respirators. In one of its aspects, the invention relates to a modular powered air purifying respirator that is adapted to be removably mounted to a respirator mask and to a filter canister. In another of its aspects, the invention relates to a modular powered air purifying respirator that is adapted to be removably mounted to a hose that is connected to a respirator mask. In yet another of its aspects, the invention relates to a modular powered air purifying respirator that has a portable, rechargeable power source. In yet another of its aspects, the invention relates to a sealed modular powered air purifying respirator that has a replaceable, portable power source. In yet another of its aspects, the invention relates to a modular powered air purifying respirator which delivers a constant flow of purified air to a respirator in the event of partial filter clogging.

Description of the Related Art

[0003] Powered air-purifying respirators (PAPRs) continually supply positive air pressure to a respirator to maintain positive pressure in the respirator. PAPRs are generally used in military, industrial or hazardous environments to provide personal respiratory protection by preventing ambient air from entering the user's mask, helmet, or hood. Respiratory hazards might include particulate matter, harmful gases, or vapors, which are removed by passing the ambient air through the filter. Typically, a powered air-purifying respirator includes a powered fan that forces ambient air through one or more filters for delivery to an inlet opening in the respirator. The fan and filter may be mounted on a facemask, or in some cases, may be mounted on a belt or backpack and connected to the

facemask through a hose and a fan. Power for the fans are typically mounted remote from the facemask but can also be mounted on the mask itself.

[0004] United States Patent No. 4,886,056 to Simpson discloses a positive pressure filter respirator that is mounted on a full face mask comprising an outer mask and an inner orinasal mask. The outer mask includes an air inlet to which a filter canister is screw-mounted. Immediately within the filter canister is located a centrifugal fan which is arranged to be driven by a battery operated motor so as to draw ambient air through the filter canister and into the interior of the outer mask.

[0005] U.S. Patent No. 6,435,184 to Ho discloses a PAPR gas mask having a second filter body disposed in front of the filter body. The gas mask structure includes a rear cup body, two battery seats and a front cup body. The battery seats are respectively disposed on two sides of the bottom of the rear cup body for receiving batteries therein to provide power for a motor to drive a fan. A filter body is positioned in a fixing seat of the front cup body. A cover body is screwed on the fixing seat to fix the filter body therein and tightly hold a second filter body in front of the filter body. The fan serves to generate air flow which is filtered through the second filter body and the filter body and then conducted into the guide way of the rear cup body. The batteries are rechargeable by plugging in a charger.

[0006] U.S. Patent Application Publication No 2007/0163588 to Hebrank et al discloses a personal respirator and clean air system comprising an air mover, a particle filter, and a supply means mounted to a belt. The respirator is operably connected to a face mask by a supply hose, the opposite end of the supply hose being attached to the PAPR housing. The system typically includes a power supply, which can take the form of at least one battery or multiple batteries mounted in a cartridge, or a re-chargeable battery pack receivable in a compartment in the housing. For certain end uses, the system can instead, or in addition, include an AC adapter to allow the system to be powered off an AC outlet or to facilitate charging of the batteries. The AC adaptor can be mounted inside the housing.

SUMMARY OF THE INVENTION

[0007] According to the invention, a modular powered air purifying respirator (PAPR) comprises a housing, a fan, a motor, and a portable power source mounted within a housing, an inlet opening in the housing for selectively mounting a filter canister for filtering air that is drawn into the inlet opening, an outlet opening formed in the housing; and a releasable mounting connector that is adapted to mount the housing to a facepiece of a respirator mask or to a conduit that is fluidly connected a facepiece inlet opening of a respirator mask. The modular PAPR can thus be positioned between a filter canister and a respirator mask, or between a filter and a conduit connected to a respirator mask, to draw air in axial flow through the filter and deliver filtered air to a mask.

[0008] In one embodiment, the housing is formed by an upper cylindrical portion and a lower cylindrical portion. In another embodiment, the power source is mounted within the upper cylindrical portion of the housing and the power source comprises at least one battery. Preferably, the at least one battery is rechargeable. Typically, there are multiple batteries that are spaced annularly about a central axis of the housing.

[0009] In another embodiment, the housing further has a receptacle electrically connected to the motor for powering the motor. In addition, the receptacle electrically can be connected to the power source for recharging the power source. Further, the (PAPR) module can have a control circuit electrically connected to the motor and the power source for controlling the power to the motor.

[00010] In a preferred embodiment, a scroll is mounted between the fan and the outlet opening to optimize the air flow to the respirator.

[00011] In another embodiment, the inlet opening is formed by an internally threaded sleeve. In addition, the outlet opening can be formed by an externally threaded sleeve.

[00012] In yet another embodiment, the inlet opening is formed by a bayonet connector. In addition, the outlet opening can be formed by a bayonet connector.

[00013] In use, ambient air is drawn into the inlet opening through the attached filter by the centrifugal fan, which is driven by direct connection to the shaft of the motor. The air is then accelerated by an optimized scroll to pass pressurized air through the outlet opening to a respirator mask.

[00014] The PAPR module can be employed in multiple use configurations. For example, it could also be configured for use with an air hose and belt, and worn on the waist, back, or any remote location.

BRIEF DESCRIPTION OF THE DRAWINGS

[00015] In the drawings:

[00016] FIG. 1 is a perspective view of a PAPR module according to a first embodiment of the invention.

[00017] FIG. 2 is a cross-sectional view of the PAPR module taken along line 2-2 of FIG. 1.

[00018] FIG. 3 is a sectional view of the PAPR module taken along line 3-3 of FIG. 2.

[00019] FIG. 4A is an exploded view of the PAPR module of FIG. 1 and a filter.

[00020] FIG. 4B is a perspective view of the PAPR module of FIG. 1 coupled to a filter.

[00021] FIG. 5 is a cross-sectional view of a PAPR module of FIG. 1 illustrating an air flow path.

[00022] FIG. 6 is a perspective view of a PAPR module according to a second embodiment of the invention.

[00023] FIG. 7 is a perspective view of a PAPR module according to a third embodiment of the invention.

[00024] FIG. 8 is a detail view of a PAPR module of FIG. 1 according to a fourth embodiment of the invention and showing an optional remote switch.

[00025] FIG. 9 is a perspective view of a PAPR module of FIG. 1 illustrating a mask mounted use configuration.

[00026] FIG. 10 is a perspective view of the PAPR module of FIG. 1 illustrating a remote use configuration.

[00027] FIG. 11 is a perspective view of the PAPR module of FIG. 1 illustrating a remote use configuration utilizing a plenum belt.

[00028] FIG. 12 is a detail view of a PAPR module of FIG. 1 illustrating a wireless heads up display feature utilizing a transmitter and mask.

[00029] FIG. 13 is a perspective exploded view of the PAPR module of FIGS. 1-3 or 6-8 in combination with a particulate filter module and a low profile hose assembly.

[00030] FIG. 14 is side view of the assembled PAPR module, particulate filter module and low profile hose assembly of FIG. 13.

[00031] FIG. 15 is a graphical representation of the PAPR assembly of FIGS. 13 and 14 mounted on a belt and carried by a user.

[00032] FIG. 16 is a perspective exploded view of the PAPR module of FIGS. 1-3 or 6-8 in combination with a CBRN filter module and a low profile hose assembly.

[00033] FIG. 17 is side view of the assembled PAPR module, CBRN filter module and low profile hose assembly of FIG. 16.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

[00034] Referring to FIGS. 1 and 2, a first embodiment of a powered air purifying respirator (PAPR) module 10 according to the present invention is illustrated. The PAPR module 10 is a self-contained, compact unit, and generally comprises a motor 24, a fan 26, a scroll 28, and a power source 22 all within a single housing 12. The PAPR module 10 has an inlet 18 that can be attached to an air filtering means, and an outlet 20 that can be attached to a user-wearable respiration protection device. The PAPR module 10 can be considered an “in-line” PAPR, wherein the inlet 18 and outlet 20 are co-axially aligned, such that the direction of inlet and outlet airflow is generally parallel to the center axis of the PAPR.

[00035] The PAPR module 10 housing 12 is comprised of two cylindrical portions, an upper body 14 and a lower body 16. The lower body 16 is circular in cross-sectional configuration, although other cross-sectional configurations are possible, and comprises two contiguous segments, a main lower body 62 and an externally threaded mask sleeve 60. The outlet 20 is defined by the threaded mask sleeve 60, which is advantageously used to couple the PAPR module 10 to a user-wearable respiration protection device, as described below.

[00036] Positioned over the open end of the lower body 16 is a lower body cover 32. The lower body cover 32 is sealed in air-tight fashion to the lower body 16 by welding, or any other suitable means. Together, the lower body 16 and lower body cover 32 form an enclosed space to create a sealed breathing zone 36 that is in fluid communication with the inlet 18 and the outlet 20. Thus, only air which has passed through an air filter canister attached to the inlet 18 can pass to a respirator through the outlet 20.

[00037] An internally threaded filter sleeve 64 extends upwardly from a face 68 of the lower body cover 32 opposite the sealed breathing zone 36. The threaded filter sleeve 64 defines the inlet 18 of the PAPR module 10 and can be used to couple an air filtering canister to the PAPR module 10.

[00038] The upper body 14 is fixed to the lower body 16 at the lower body cover 32. The upper body 14 typically has the same cross-sectional configuration as the lower body 16 to create the aesthetic appearance of a compact, self-contained unit. A circular opening 52

formed by a depending flange 50 in the top surface of the upper body 14 receives the threaded filter sleeve 64. An O ring seal 34 between the depending flange 50 and the sleeve 64 hermetically seals the sleeve 64 to the depending flange. The upper body 14 also includes an integral power switch 66, which is located on the exterior of the upper body 14. The upper body 14 can be either removably or fixedly attached to the lower body cover 32.

[00039] An O ring seal 34 is positioned on a rib 48 on the face 68 of the lower body cover 32 between at the interface between the upper body 14 and the lower body cover 32 to seal the two parts together. The O ring seals 34 are circular and can be made of any suitable elastomeric material.

[00040] A split ring, lid retaining clip 38 is positioned in a groove in the upper body 14 and is snap fit into a groove 54 on the exterior of the threaded filter sleeve 64 to retain the upper body 14 on the sleeve 64.

[00041] The centrifugal fan 26, scroll 28 and motor 24 are positioned within the sealed breathing zone 36. The centrifugal fan 26 and motor 24 are co-axial and the centrifugal fan 26 is driven by direct connection to a shaft 30 of the motor 24. The scroll 28 encircles the centrifugal fan 26 and is located between the fan and the lower body 16. The centrifugal fan 26 draws air through the inlet 18 and propels it radially. The scroll 28 then spirally directs the pressurized air toward the outlet 20. The motor 24 is preferably oriented in axial alignment with the central axis of the housing.

[00042] Referring to FIG. 3, a controller 42 is located on the face 68 of the lower body cover 32. The controller 42 monitors the speed of the centrifugal fan 26 and controls the motor 24 speed in response to the monitored fan speed to ensure a substantially constant flow rate through the PAPR module 10. Control of the motor 24 by this method provides the ability to maintain a minimum flow rate between the inlet 18 and outlet 20 openings, even when an air filter in line with the inlet 18 is partially clogged. The controller is connected to a speed sensor (not shown) that senses that rotational speed of the motor shaft, compares the sensed speed to a predetermined speed set in the controller and adjusts the power to the motor so that the sensed speed matches the predetermined. To this end, the controller has a power supply circuit that is connected to the batteries and is also connected to the motor to control the current supplied to the motor. The power switch 66 is slidable between open and closed position to controls the power supplied by the batteries to the controller 42. .

[00043] The controller 42 can further be configured to store a simplistic and limited amount of data, with possible received inputs from the motor 24 and the power source 22. Operational data, such as the voltage of the power source 22 can be measured and monitored.

[00044] Referring to FIGS. 2 and 3, the upper body 14 and lower body cover 32 together form an enclosed space 90 in which the power source 22 can be located. The power source provides power at least to the motor 24 and the controller 42.

[00045] The power source 22 is typically one or more rechargeable batteries 22. The batteries 22 are received within cradles 92 formed on the face 68 of the lower body cover 32 and spaced annularly about the threaded filter connector 64. The upper body 14 serves as a lid to enclose the batteries 22 located within the cradles and can optionally be removable to gain access the batteries 22. The batteries 22 can be configured to provide power to the motor 24 for up to eight hours of continuous run time.

[00046] As shown in FIGS. 4A and 4B, the PAPR module 10 can be coupled to an air filtering means, such as a canister filter 58. The attachment is made by threading the externally threaded canister filter 58 to the internally threaded filter sleeve 64 at the inlet 18 of the PAPR module 10. The canister filter 58 typically will include filtration beds for filtering particulate material and/or gaseous material and can be selected comprising various filtering materials according to the user's intended environment. Suitable filter beds are disclosed in the U.S. Patent No. 7,213,595, which is incorporated herein by reference. The PAPR module 10 can be selectively configured to couple with both traditional and conformal canister filters, one type of which is disclosed in U.S. Patent Application Publication No. US 2005/0161911, filed April 26, 2002. The PAPR module 10 can be configured to couple with a filter canister having a standard 40 mm thread, or other standard threads

[00047] Referring to FIG 5, an air flow path of the PAPR module 10 is illustrated. As described above, power to the PAPR module 10 can be turned on and off by means of the power switch 66. When powered on, unfiltered ambient air is drawn through an air filter 58 and into the inlet 18 of the PAPR module 10 by the centrifugal fan 26. The centrifugal fan 26 propels the air radially and the scroll 28 then spirally directs the pressurized air toward the outlet 20 of the PAPR module 10 and to the user wearable respiration protection device.

[00048] Referring to FIG. 6, a second embodiment of the PAPR module 10 according to the present invention is illustrated, where similar elements from the first embodiment are labeled with the same reference numerals. In this embodiment, the PAPR module 10 includes an integral power switch 66, which is located on the exterior of the upper body 14. The power

switch 66 can be optionally oriented for either right or left handed users by rotating the upper body 14 on the lower body cover 32. The seals 34 maintain contact during the rotation of the upper body 14 while the lid retaining clip 38 keeps the upper body 14 retained to the PAPR module 10. Electrical contact is maintained throughout rotation by a switch contact track 40 that is made of conductive material and is located along the circumference of the lower body cover 32. The switch contact track 40 is continuous about the entire circumference, allowing the power switch 66 to maintain electrical contact at any degree of rotation. Alternatively, limited rotation of the power switch 66 and upper body 14 could be achieved through other suitable methods, such as maintaining electrical contact by means of a wire connection.

[00049] Referring to FIG. 7, a third embodiment of the PAPR module 10 according to the present invention is illustrated, where elements similar to those from the first embodiment are labeled with the same reference numerals. In this embodiment, the PAPR module 10 includes a user warning system comprised of a light 70 and/or an audible alarm 72 used to indicate to the user the operational status of the PAPR module 10. The controller (not shown) can use the stored data to switch on the light 70 and/or actuate the audible alarm 72 to indicate, for example, a condition of low air flow and/or low battery power. The optional light 70 can be positioned anywhere on the PAPR module such that the light 70 is visible to the user. One contemplated location for the light 70, shown in FIG. 7, is on the outer surface of the upper body 14. Another contemplated location for the light 70, also shown in FIG. 7, is extending around the circumference of the PAPR module 10. For the latter contemplated location, the portion of the lower body cover 32 exposed between the upper and lower bodies 14, 16 can comprise an integrated light pipe serving as the light 70. This location may be preferable, since the light 70 is visible from more directions.

[00050] Referring to FIG. 8, a fourth embodiment of the PAPR module 10 according to the present invention is illustrated, where similar elements from the first embodiment are labeled with the same reference numerals. In this embodiment, the PAPR module 10 includes a cable management feature and an interface port 74 by which the enclosed rechargeable batteries 22 may be charged. Charging of the batteries 22 is accomplished by affixing to a socket on the interface port 74 a complementary plug 78 of an AC charger 76. Further, the AC charger 76 can be attached to the socket of the interface port 74 and to an AC outlet to provide a power source for the PAPR module 10. Optionally, an external battery pack 80 can be connected to the PAPR module 10 through the interface port 74. The external battery pack 80 can provide power to the PAPR module 10 for extended use, up to, for example, twelve hours or more of

run time. When the external battery pack 80 is plugged into the interface port 74, the PAPR module 10 is powered first by the battery pack 80; upon depletion of the battery pack 80, the system “hot-swaps” to run for additional time, now powered by the internal batteries 22. A warning light 70 signals to the user that the battery pack 80 is close to depletion, and the PAPR module 10 is automatically switched to the internal batteries 22 when depletion of the battery pack 80 does occur. An alarm can also sound to additionally signal to the user that the battery pack 80 is close to depletion, and that a “hot-swap” is about to occur. The AC charger 76 and external battery pack 80 can be two separate components, or can be combined into one multi-purpose component.

[00051] Furthermore, the interface port 74 can function as a multipurpose communication port to the PAPR module 10. The interface port 74 can be configured to provide inputs, for example to disable the audible alarm in desirable situations. Data stored by the controller 42 can also be uploaded to a remote computer through the interface port 74 to provide information, for example, of run time or activation of the warning system.

[00052] The cable management function is provided by a plug cavity 44 and a crescent groove 46. The interface port 74 is located at approximately the center of the plug cavity 44 the plug 78 can be inserted into the interface port 74 along the plug cavity 44 in either of two directions. The plug cavity 44 can thus be used for either right or left handed orientation. The crescent groove 46 is formed on the surface of the lower body 16 periphery and is spaced from the plug cavity 44. The crescent groove 46 is formed to receive and retain a cable 88 extending from the plug 78. The cable 88 is inserted into the crescent groove 46 to keep the plug 78 from being dislodged from the interface port 74. There are multiple crescent grooves 46 on the lower body 16 surface to further aid in selectively orienting the plug 78 for either right or left handed users.

[00053] The PAPR module 10 can be designed for extended use or for one-time use, after which the PAPR module 10 may be discarded, depending on the economics of the prospective use. For an extended use model, the PAPR 10 can utilize components with longer use lives, and may be higher cost components, such as a precious metal brushed motor 24 and rechargeable lithium-ion batteries for the power source 22. For a one-time use model, the PAPR module 10 can utilize components that do not have to be used more than one, and may be lower cost components, such as a less expensive motor 24 with a lower life expectancy or durability and alkaline batteries for the power source 22. The one-time use

model can also be made available to the consumer with a filter 58 bonded to the PAPR module 10, and packaged in a sealed package to be opened by the user at the time of need.

[00054] The PAPR module 10 can be employed in multiple different use configurations. Referring to FIGS. 9-D, four exemplary use configurations are illustrated. FIG. 9 shows the PAPR module 10 mounted to a mask facepiece 56. A filter canister 58 can be attached to the PAPR module 10, as described above, and the PAPR module 10 can be attached to the mask facepiece 56 at an inlet valve 96 as disclosed, for example, in U.S. Patent No. 7,213,595. Attachment to the mask facepiece 56 is made by threading the externally threaded mask sleeve 60 at the outlet 20 of the PAPR module 10 to an internally threaded inlet (not shown) of the mask facepiece 56. Alternatively, the PAPR module can have a bayonet attachment as disclosed in U.S. Patent No. 7,213,595 and the mask facepiece can have a complementary bayonet attachment 94 for a quick attachment. In similar manner both the inlet opening 18 of the PAPR module and the outlet opening of the filter canister 58 can have complementary bayonet fixtures for quick attachment and detachment of the filter canister 58 from the PAPR module 10.

[00055] In another configuration, as shown in FIG. 10, the PAPR module 10 is shown mounted to a belt 86 worn on the waist, back, or other body location of a user for use with an air hose 82 between the modular PAPR 10 and a mask facepiece 56. One end of the hose 82 is fixedly attached to the PAPR module 10 utilizing the above mentioned interconnecting threads and the other end extends to the user's mask facepiece 56 or a hood. A filter 58 is attached to the PAPR module 10 inlet 18, as described above.

[00056] In yet another configuration, as shown in FIG. 11, the PAPR module 10 is shown mounted to a plenum belt 98 to be worn on the waist, back, or other body location of a user for use with an air hose 82 between the modular PAPR 10 and a mask facepiece 56. The plenum belt 98 comprises a flexible hollow plenum 102 and two belt straps 100, and includes a plurality of threaded openings 108, for example, two threaded openings and a third opening formed by a threaded sleeve 110. The inlet 18 of the PAPR module 10 can be attached to the plenum belt 98 through the threaded sleeve 110 and the outlet 20 can be attached to a hose 82 through the threaded sleeve 60 in fluid communication with the user's mask facepiece 56. Attachment of the PAPR module 10 to the plenum belt 98 can be made by threading the internally threaded filter sleeve 64 at the inlet 18 of the PAPR module 10 to the externally threaded sleeve 110 on the plenum belt 98. The hose 82 is attached to the PAPR module 10 and a user's mask facepiece 56 or hood as described above. At least one filter canister 58

having an inlet opening 59 can be attached to the plenum belt 98 by threading the externally threaded filter canister 58 to an internally threaded opening 108 on the plenum belt 98. The above mentioned attachments can alternatively have a bayonet attachment as disclosed in U.S. Patent No. 7,213,595.

[00057] In the above configuration, as shown in FIG. 11, air is drawn by the PAPR module 10 through the openings 59 in the canister filters 58 and into the plenum belt 98. Filtered air then enters the PAPR module 10 from the plenum belt 98 and is passed through the PAPR module 10 to the hose 82. The filters that are attached to the belt to meet certain conditions, such as heavy industrial/infection control and CBRN, The belt can be strapped to a SCBA tank or worn as a bandolier. Convention and conformal filters can be mounted to the belt. Thus the belt provides a user with flexibility for many different conditions to protect against CBRN (chemical, biological, radiological, and nuclear) hazards by utilizing CBRN filters. The plenum belt 98 can be made of a thermoplastic elastomer, such as a butyl material for agent resistance, ethylene propylene diene monomer rubber, or any other suitable material.

[00058] In both the remote, or belt-worn, configurations shown in FIGS. 10 and 11, a remote switch 112 can be advantageously used to remotely power on/off the PAPR module 10 when it is worn on the back, or other location, as shown in FIG. 8A. The remote switch 112 plugs into the interface port 74, in similar fashion as described above, and can also be configured to provide the user with information, such as run time or battery life indication, for example. The remote switch 112 can be clipped to the user's belt or other object, could be carried in the user's pocket, or any other suitable means or method. The remote switch 112 beneficially allows the user easy access, without having to remove the belt, to power the PAPR module 10 on or off when it is located in a hard to reach location, such as the user's back.

[00059] Referring to FIG. 12, a fourth user configuration is shown where the PAPR module 10 can be used with a wireless transmitter 114 that can be affixed to the interface port 74 for wireless communication to a heads up display module 116 located in the user's facepiece 56 or hood. The heads up display can be mounted in the facepiece 56, and can display operational information, such as run time or battery power level, for example, to be viewed by the user on the inside of the facepiece 56. The heads up wireless transmitter 114 and display module 116 can be used with both a mask mounted PAPR module 10 and a belt or remote mounted PAPR module 10.

[00060] One of the most significant benefits the PAPR module 10 provides is the ability to modularize the respirator system. Depending on several variables, such as the hazard to protect against or the economics of the prospective user, the PAPR module 10 can be used in several different configurations and against a variety of hazards. The same PAPR module 10 can be mounted on the user's facemask or mounted on a plenum belt 98 to advantageously protect against CBRN hazards. This modularity is unique to the disclosed invention.

[00061] To this end, the PAPR module 10 can be made available to the consumer in various kits. These kits can consist of the PAPR module 10 and multiple combinations of the accessory components, such as a hose 82, mask 56, hood, external battery pack 80, belt or harness, wireless heads up display 114, 116, battery charger 76, or filters 58. The various combinations of components within the kits can be offered to the consumer based on typical use configurations and perceived user needs.

[00062] Referring now to Figures 13 and 14, where like numerals have been used to identify like parts, the in-line PAPR 10 is shown in exploded view with a particulate filter 126 and a low profile hose assembly. The low profile hose assembly comprises a relatively flat plenum 120 having a threaded inlet opening 122 which threadably receives the threaded sleeve 60 of the PAPR module 10. A low profile hose 124 is connected to the plenum 120 and is in fluid communication with the threaded inlet opening 122. The annular particulate filter module 126 has an annular housing with particulate filter material therein and has a slot opening 130 which indexes with the power switch 66 of the PAPR 10. The particulate filter material can be any suitable particle filter which includes a pleated filter material commonly used in particle filters. An inlet opening 132 is in fluid communication with the particle filter within the annular housing 128. The filter module 126 further has a threaded outlet sleeve (not shown), similar to the threaded sleeve 60 of the PAPR module 10, which is threadably received in the threaded inlet of the PAPR module 10. As illustrated in Figure 14, the annular particulate filter module 126 surrounds the PAPR 10 and has a very low profile.

[00063] The assembled low-profile particulate filter module 126, PAPR module 10 and the low-profile hose assembly can be used in a number of different applications, including a medical/infection controlled environment for high flow industrial uses such as dust markets and for infection controlled environments. Referring to Figure 15, the particulate filter module 126 with in-line PAPR 10 and low-profile module is shown with a medical/infection control worker 134 bearing a hood 136 which is connected to the PAPR 10/particulate filter module 126 through the low-profile hose 124.

[00064] Referring now to Figures 16 and 17, a CBRN embodiment is illustrated with a CBRN filter module 138, a PAPR 10, and a hose module that includes a plenum fixture 42, a low-profile hose 146 and a threaded inlet opening 144. The threaded sleeve 60 of the PAPR 10 is threadably received in the threaded opening 144 which is in open communication with the low-profile hose 146. The CBRN filter module has the usual CBRN filter materials, which can include a particle filter as well as a particulate carbon filter. The CBRN module 138 has an inlet opening 140 as is conventional with the filter canisters of this nature. An example of a suitable filter module 138 is disclosed in U.S. Patent Publication No. U.S. 2005/016091181, which is incorporated herein by reference in its entirety. Typically, the plenum fixture 142 as well as the plenum fixture 120, can be fitted with a belt clip or belt mounting for mounting the plenum fixture to a belt which is worn by a user.

[00065] The invention is applicable to a number of different applications and the PAPR module 10 can be manufactured in many different forms to suit the particular application. The PAPR can be used as an external mount of a filter on a mask area or away from the mask area, as may be required, for example in an Air Force mask. The PAPR can further be integrated into a suit for cleanup/light industrial use. Further, the PAPR can be manufactured with a breathing control unit which can maintain a predetermined airflow through the PAPR, or, alternatively, provide an adjustable control for control of the flow rate through the PAPR. Further, the PAPR can be manufactured with a switch which turns the PAPR module power on and off, depending on the needs of the user.

[00066] The invention also contemplates packaging the PAPR module with a variety of accessories which can be used for a variety of different situations. For example, one or more PAPR modules can be mounted with a belt, for example, as illustrated in Figure 11, along with a variety of filter modules which can be used for different environmental conditions, such filter modules including a particle filter, as illustrated in Figures 13 and 14, a CBRN filter module, which is used for filtering toxic gases as well as toxic particles, and an auxiliary TIM filter for boosting the filter capacity of a CBRN module, for use in TIM gases. An auxiliary TIM filter module used in conjunction with a CBRN filter module is disclosed in the PCT Patent Publication WO 2001/78839 A1, which disclosure is incorporated herein by reference.

[00067] The module kit can and further include a module control unit or data collection unit which can be plugged into the PAPR module through the interface port 474, a recharging

module, as illustrated in Figure 8, which can also be plugged into the interface port 74, and an auxillary battery unit, also illustrated in Figure 8.

[00068] The invention provides for a very low-profile, yet highly productive and lightweight and highly adaptable module for providing filtered air to a mask, a hood or similar breathing apparatus. It can be packaged with a number of different variance for a variety of different environments which can be selected by the user for use with conventional breathing masks. It provides a very effective and lightweight module which can be operated with internal batteries, solely on an external battery, or a combination of the two with a hot swap circuit over extended periods of time.

[00069] While the invention has been specifically described in connection with certain specific embodiments thereof, it is to be understood that this is by way of illustration and not of limitation. Reason variation and modification are possible within the scope of the forgoing disclosure and drawings without departing from the spirit of the invention which is defined in the appended claims.

CLAIMS

What is claimed is:

1. A powered air purifying respirator (PAPR) module comprising:
a housing;
a fan having a fan inlet and a fan outlet, a motor operably connected to the fan for driving the fan, and a power source mounted within a housing and operably connected to the motor for powering the motor;
an inlet opening in the housing in fluid communication with the fan inlet for selectively mounting a filter canister for filtering air that is drawn into the inlet opening;
an outlet opening formed in the housing and in fluid communication with the fan outlet; and
a releasable mounting connector that is adapted to mount the housing to a facepiece of a respirator mask or to a conduit that is fluidly connected a facepiece inlet opening in a respirator mask;
whereby the modular PAPR can be positioned between a filter canister and a respirator mask or between a filter canister and a conduit that is connected to a respirator mask.
2. The powered air purifying respirator (PAPR) module according to claim 1 wherein the housing is formed by an upper cylindrical portion and a lower cylindrical portion.
3. The powered air purifying respirator (PAPR) module according to claim 2 wherein the power source is mounted within the upper cylindrical portion of the housing.
4. The powered air purifying respirator (PAPR) module according to any of claims 1- 3 wherein the power source comprises at least one battery.
5. The powered air purifying respirator (PAPR) module according to claim 4 wherein the at least one battery is rechargeable

6. The powered air purifying respirator (PAPR) module according to claim 4 or 5 wherein there are multiple batteries that are spaced annularly about a central axis of the housing.

7. The powered air purifying respirator (PAPR) module according to claim any of claims 1-6 wherein the housing further has a receptacle electrically connected to the motor for powering the motor.

8. The powered air purifying respirator (PAPR) module according to any of claims 1-6 wherein the power source is rechargeable and the housing further has a receptacle electrically connected to the power source for recharging the power source.

9. The powered air purifying respirator (PAPR) module according to any of claims 1-8 and further comprising a controller electrically connected to the motor and the power source for controlling the power to the motor.

10. The powered air purifying respirator (PAPR) module according to any of claims 1-9 and further comprising a scroll mounted between the fan outlet and the housing outlet opening to optimize the air flow to the respirator.

11. The powered air purifying respirator (PAPR) module according to any of claims 1-10 wherein the inlet opening is formed by an internally threaded sleeve.

12. The powered air purifying respirator (PAPR) module according to any of claims 1-11 wherein the outlet opening is formed by an externally threaded sleeve.

13. The powered air purifying respirator (PAPR) module according to any of claims 1-10 wherein the inlet opening is formed by a bayonet connector.

14. The powered air purifying respirator (PAPR) module according to any of claims 1-10 and 13 wherein the outlet opening is formed by a bayonet connector.

15. The powered air purifying respirator (PAPR) module according to any of claims 1-10, 13 and 14 and further including an indicator for informing a user of a condition of the PAPR.

16. The powered air purifying respirator (PAPR) module claim 15 wherein the condition is the life of any battery in the PAPR module.

17. The powered air purifying respirator (PAPR) module claim 15 wherein the condition is low air flow through the PAPR module.

18. The powered air purifying respirator (PAPR) module according to any of claims 15 - 17 wherein the indicator is an audible signal.

19. The powered air purifying respirator (PAPR) module according to any of claims 15 - 17 wherein the indicator is a visual signal.

20. The powered air purifying respirator (PAPR) module claim 19 wherein the visual signal extends around the circumference of the PAPR module for viewing from any angle.

21. The powered air purifying respirator (PAPR) module according to any of claims 1-20 and further comprising a switch having an actuator mounted to an external portion of the housing for controlling the power to the motor, wherein the external portion of the housing on which the switch is mounted is rotatable with respect to other parts of the housing so that the switch actuator can be oriented for operation by a right hand or left hand of the user.

22. The powered air purifying respirator (PAPR) module according to claim 7 wherein the housing further has wire management channels adjacent the receptacle for receiving a wire that leads to the receptacle from either side of the receptacle.

23. The powered air purifying respirator (PAPR) module according to claim 9 wherein the controller is adapted to store data that can also be uploaded to a remote computer through an interface port provide information related to conditions of the PAPR or its operation.

24. The powered air purifying respirator (PAPR) module according to claim 23 wherein the controller is adapted receive inputs from a remote source for control of the PAPR module.

25. The powered air purifying respirator (PAPR) module according to claim 24 wherein the interface port is wireless.

26. The powered air purifying respirator (PAPR) module according to claim 24 wherein the interface port includes a receptacle in the housing that is hard wired t the controller.

27. The powered air purifying respirator (PAPR) module according to any of claim 9 -26 the controller is adapted to monitor the speed of the fan and control the motor speed in response to the monitored fan speed to adjust the fan speed for a substantially constant flow rate through the PAPR module.

28. The powered air purifying respirator (PAPR) module according to any of claim 9 -26 the controller is adapted to monitor the internal battery life and to connect the motor to an external power source when the internal battery life falls below a predetermined level.

29. The powered air purifying respirator (PAPR) module according to any of claims 1-28 and further comprising a remote switch spaced from the PAPR module and connected to the power source for enabling or disabling the power source.

30. The powered air purifying respirator (PAPR) module according to any of claims 1-29 and further comprising a remote heads up display adapted to be mounted to a mask or other structure that is visible to a user and connected to the PAPR module to indicate a condition of the PAPR.

31. A air purifying kit for use with a mask or hood and comprising:
one or more powered air purifying respirator (PAPR) module according to any of claims 1-30;

one or more filtration modules that are adapted to mount to the PAPR module and to filter CBN, NBC CBRN, TIM and particulate materials in the atmosphere;

optionally, an auxiliary power source with a wire that is adapted to connect to the PAPR and supply power to the motor therein, and

optionally, a battery charger,

a belt for remote mounting one or more of the PAPR modules to the body of a user

a hose kit for connecting the one or more of the remotely mounted PAPR modules to a mask or hood ; and

optionally, a heads up display for mounting to a mask or hood of a user.

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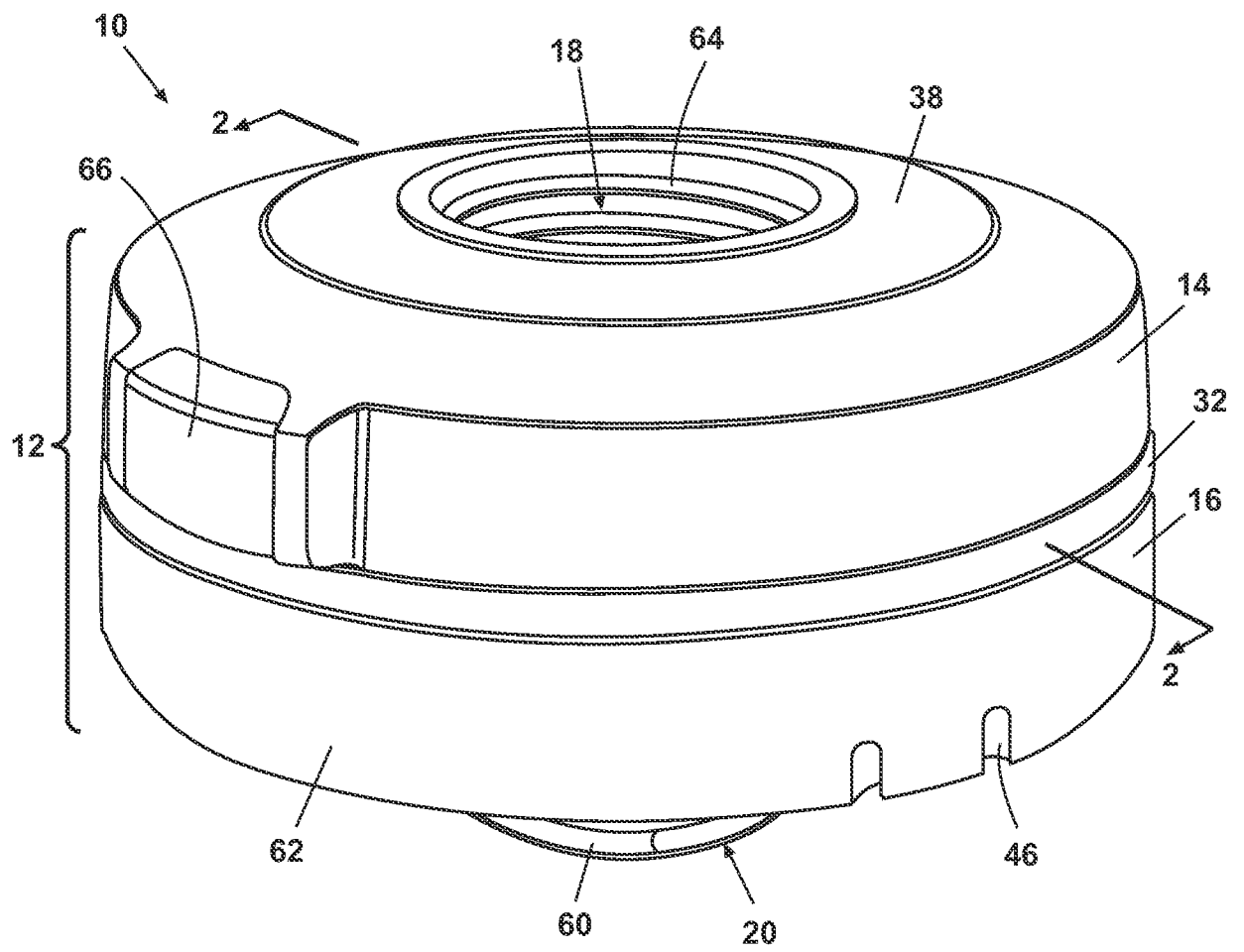


Fig. 1

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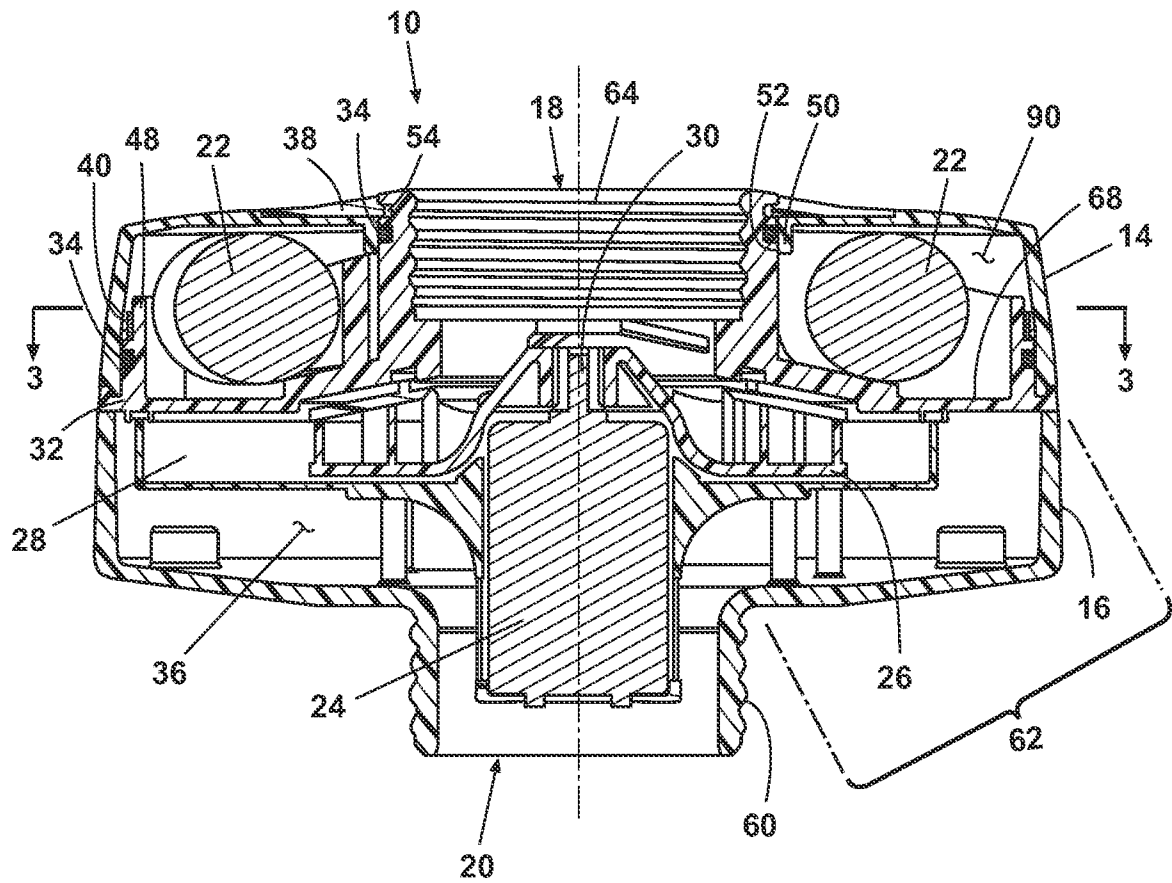


Fig. 2

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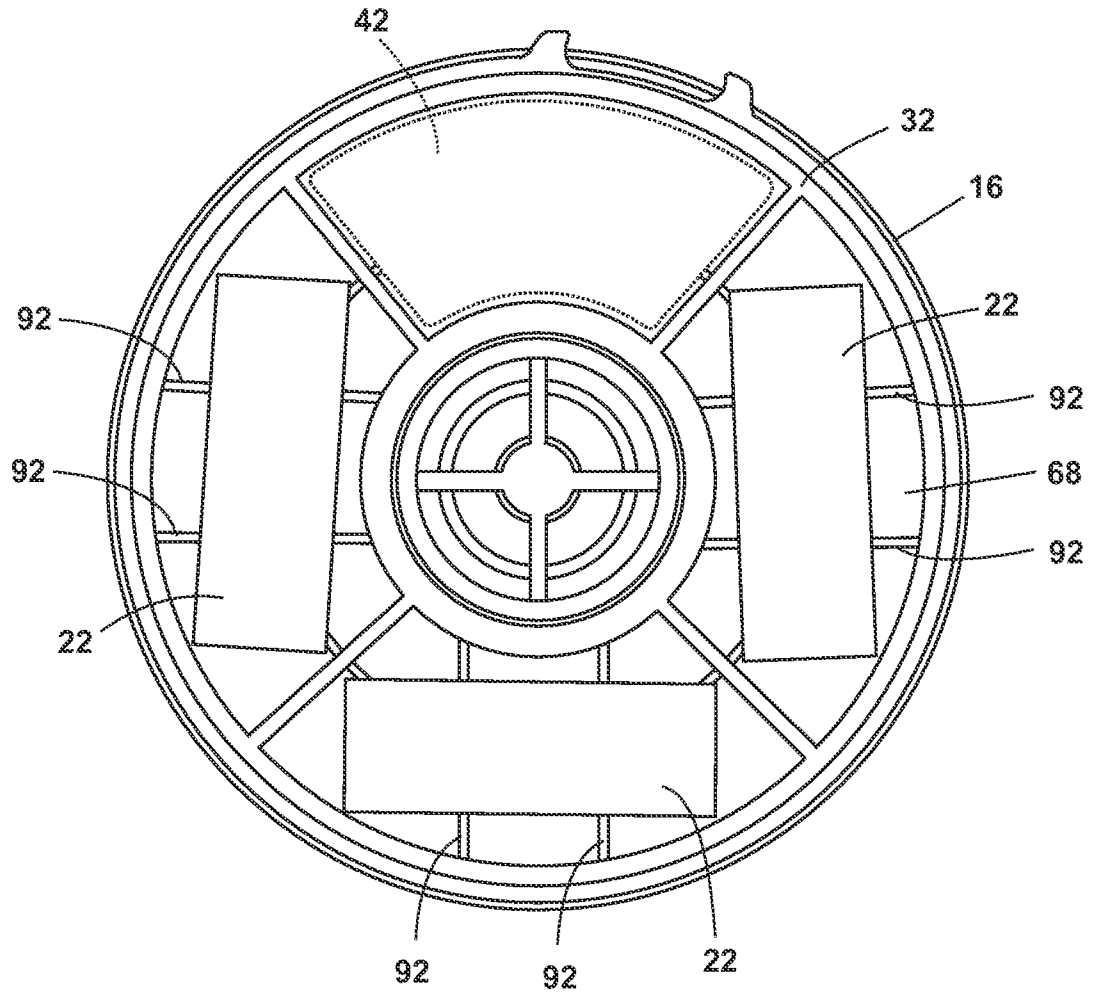


Fig. 3

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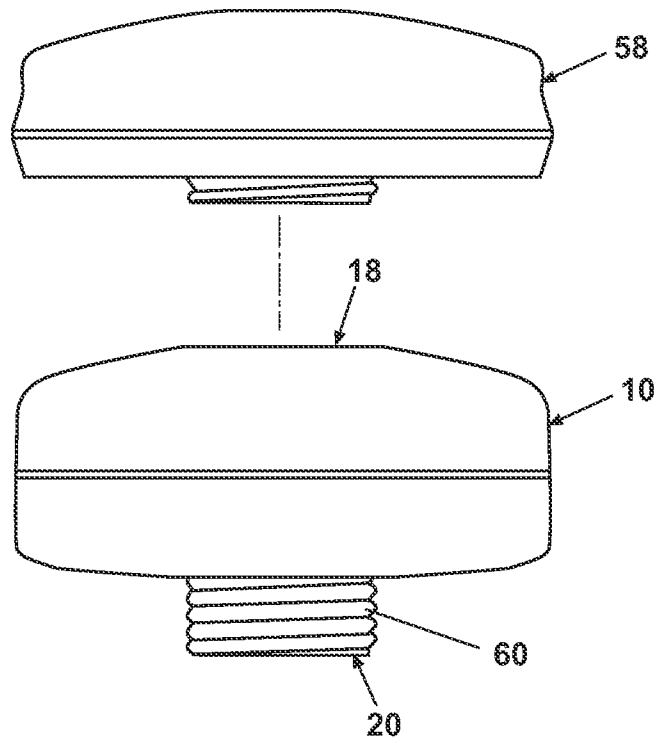


Fig. 4A

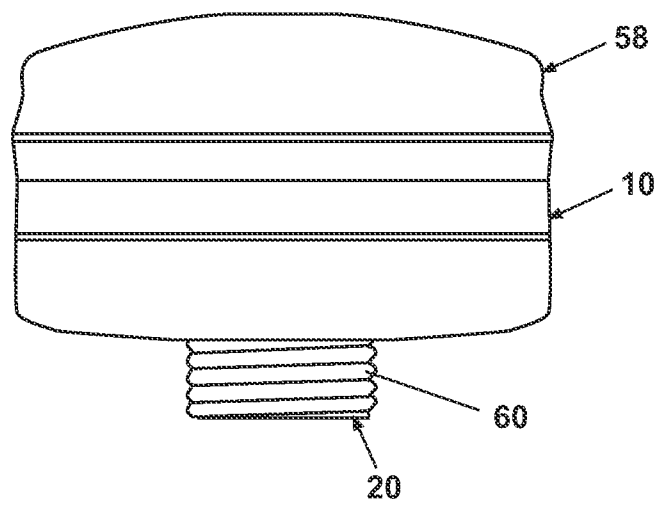


Fig. 4B

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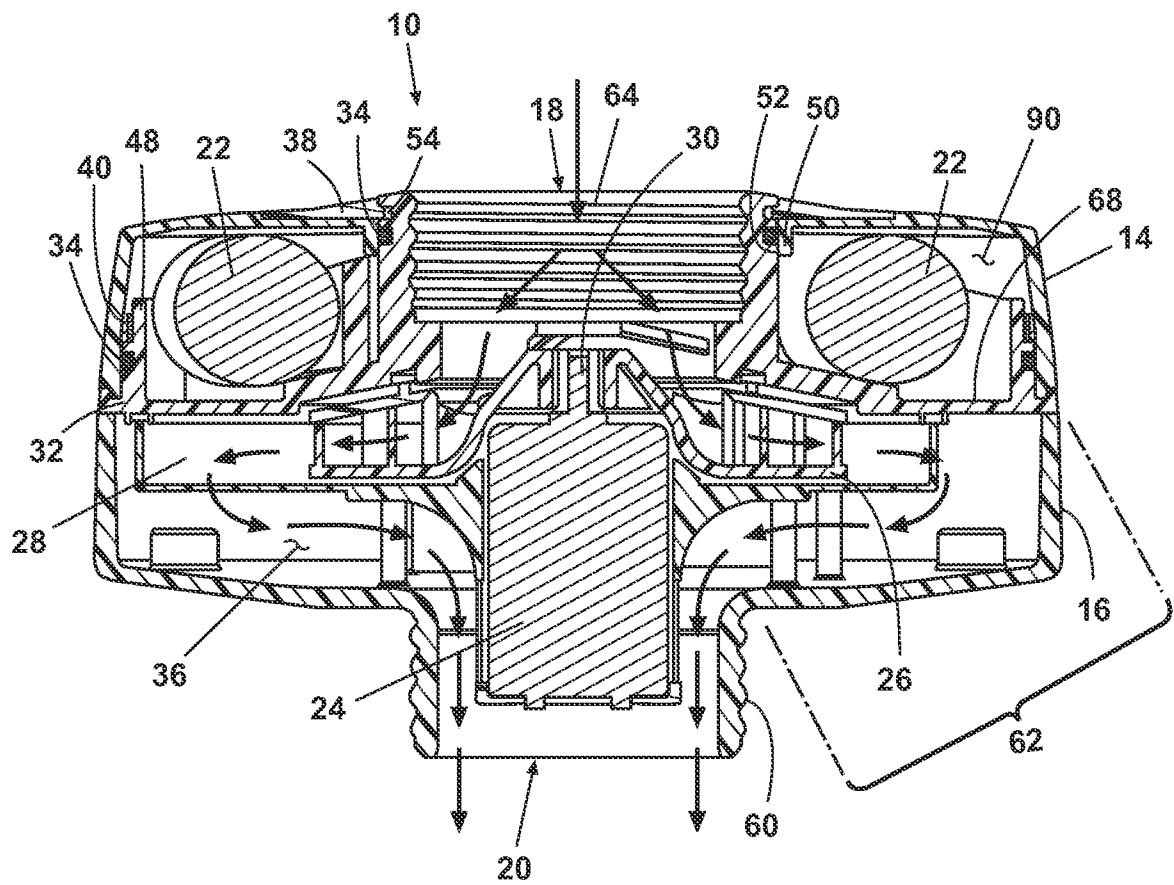


Fig. 5

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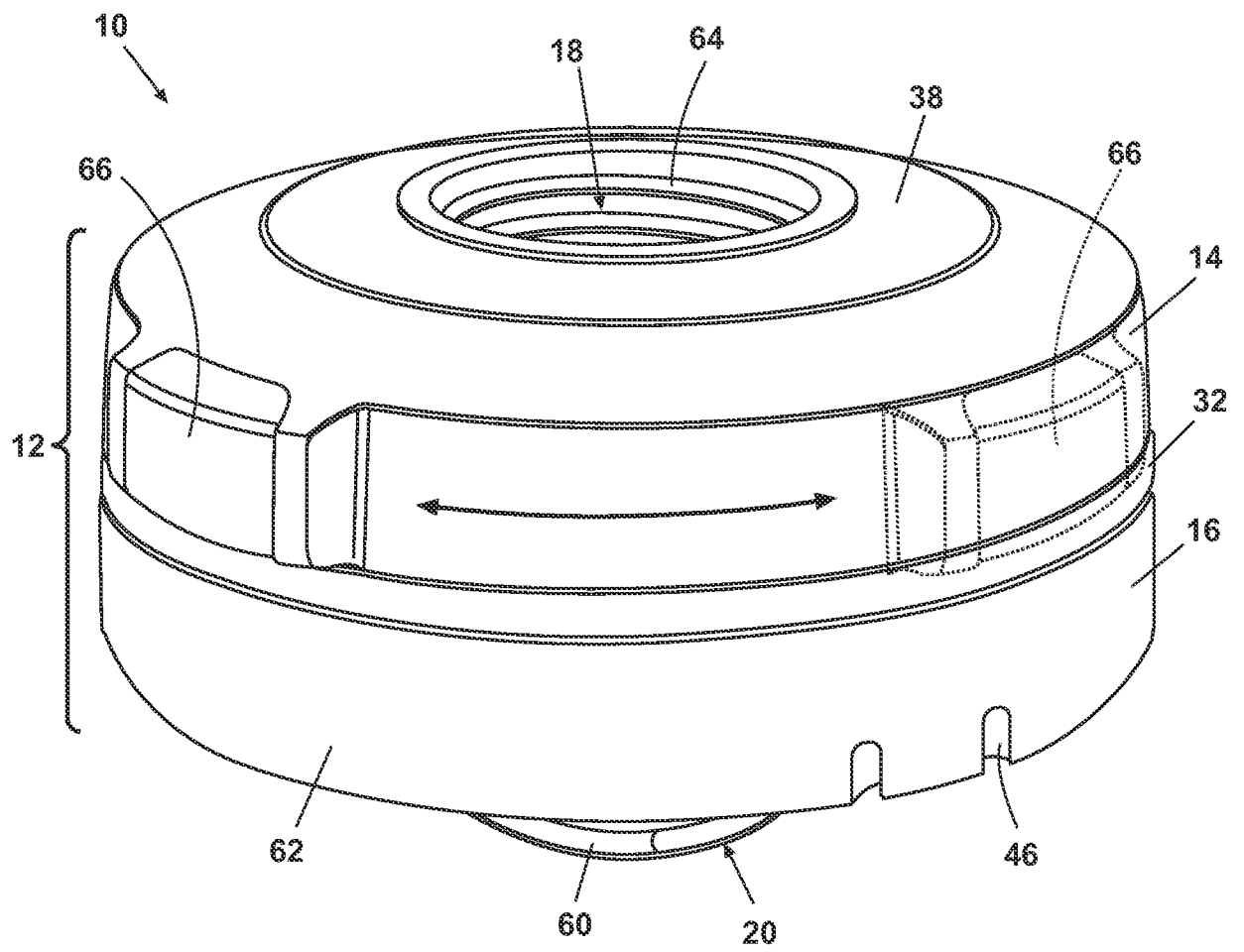


Fig. 6

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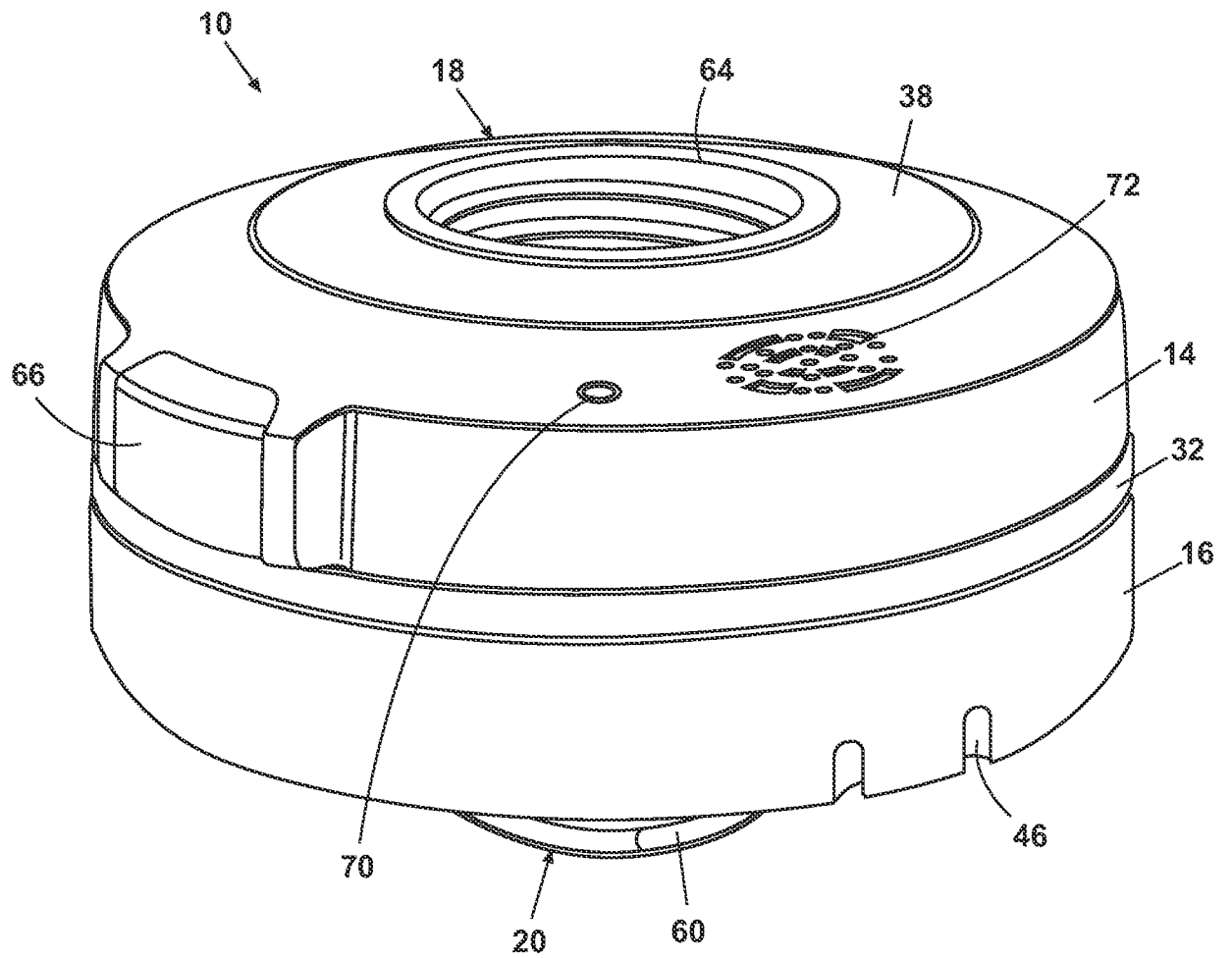


Fig. 7

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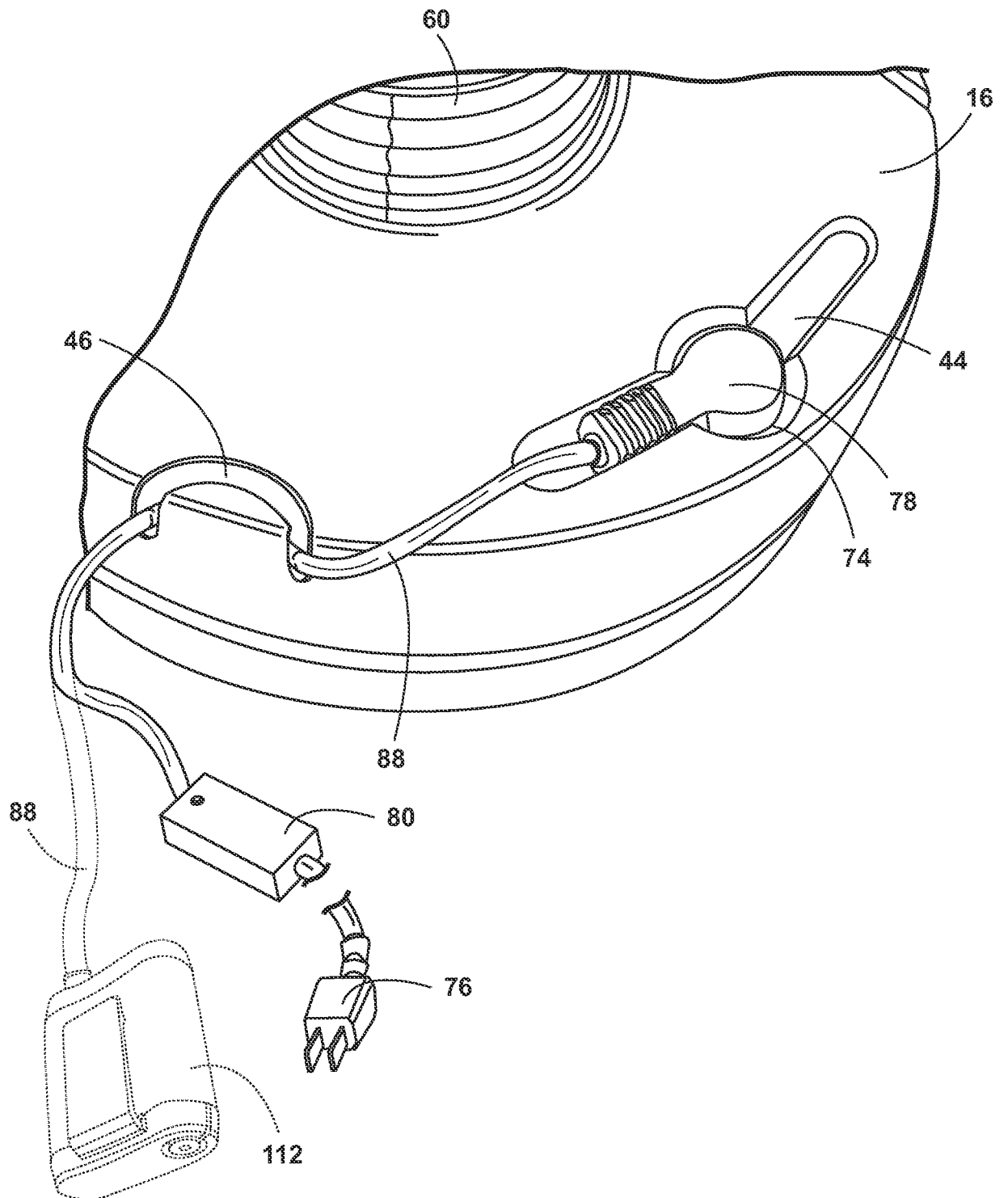


Fig. 8

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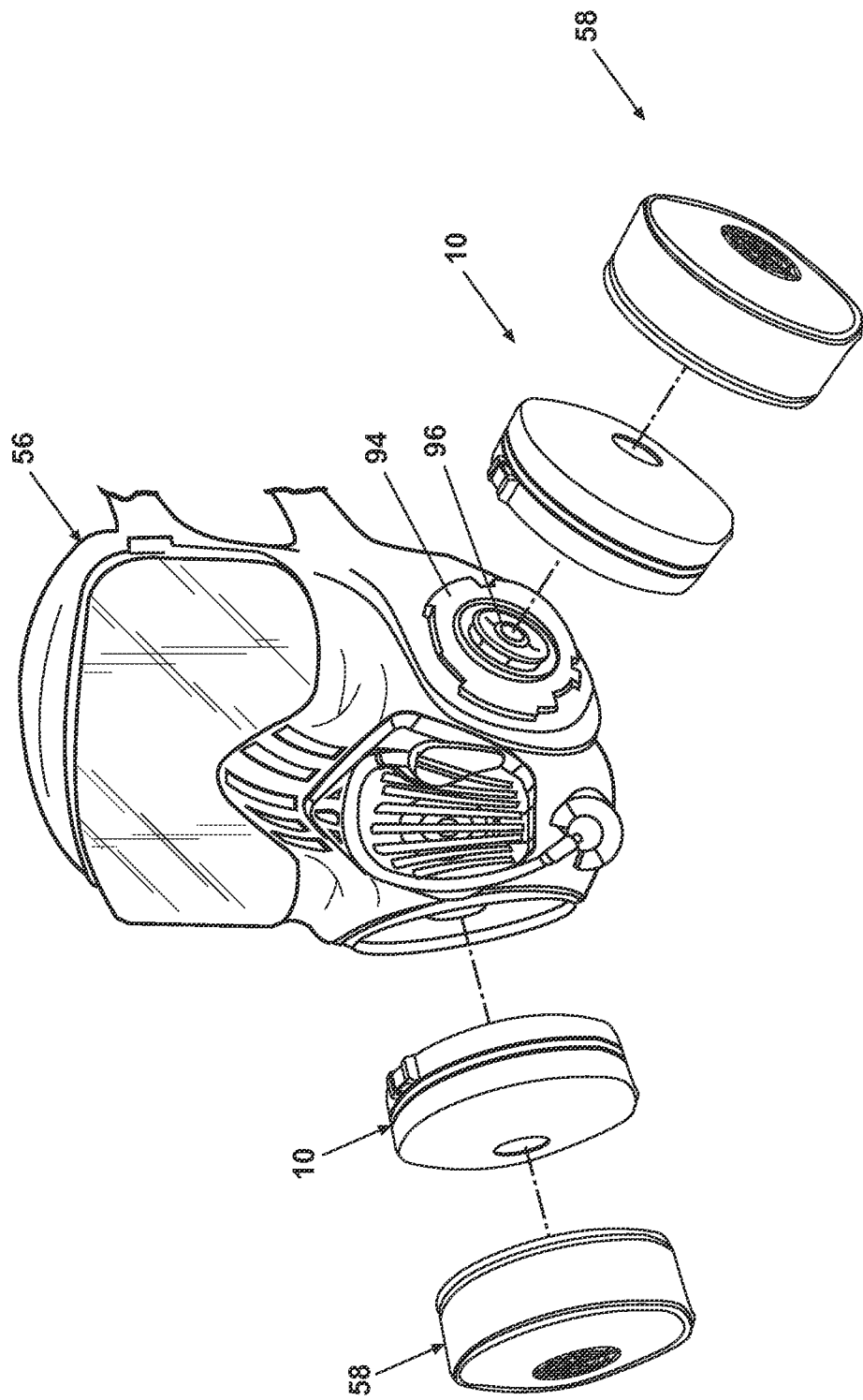


Fig. 9

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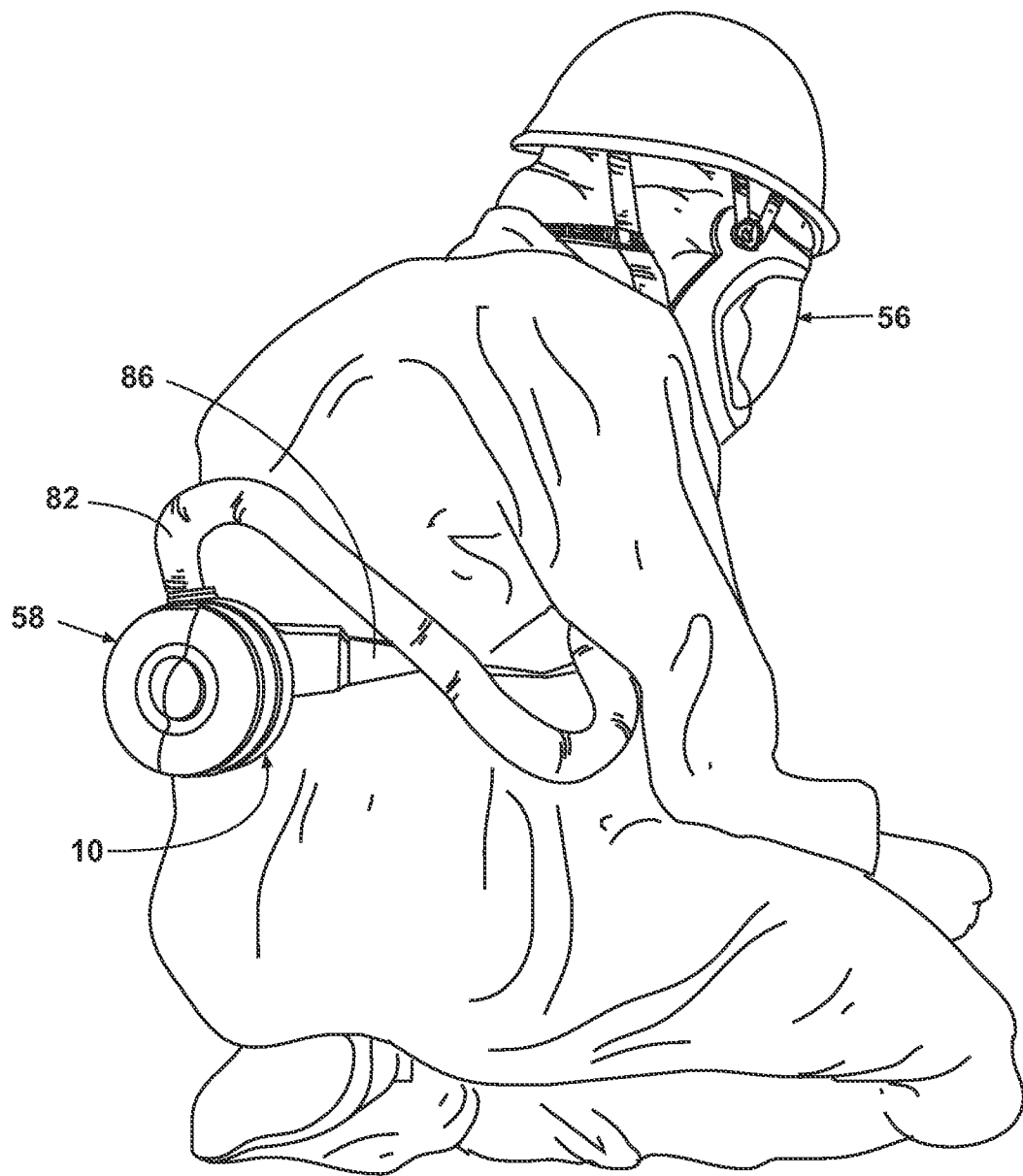


Fig. 10

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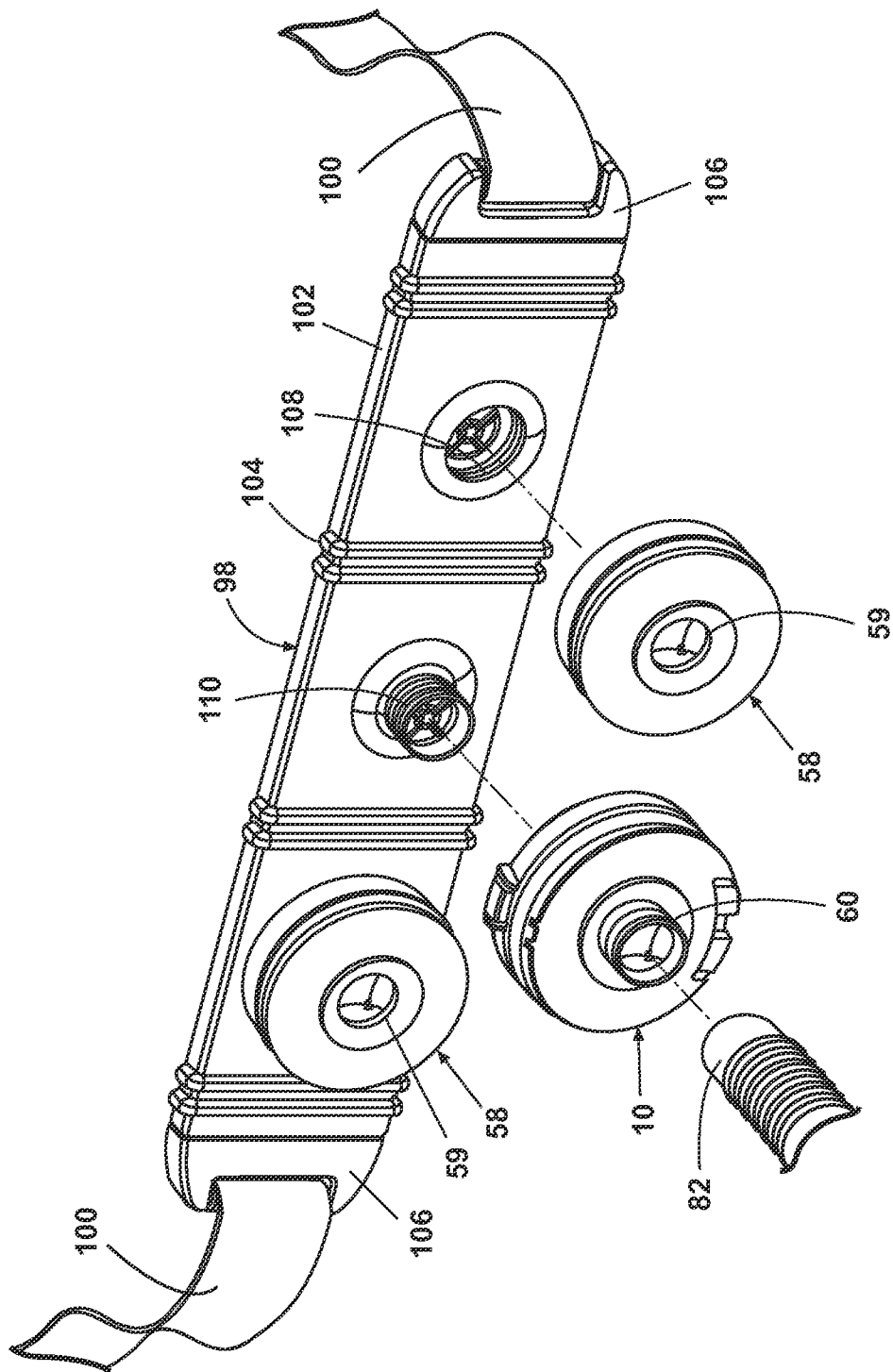


Fig. 11

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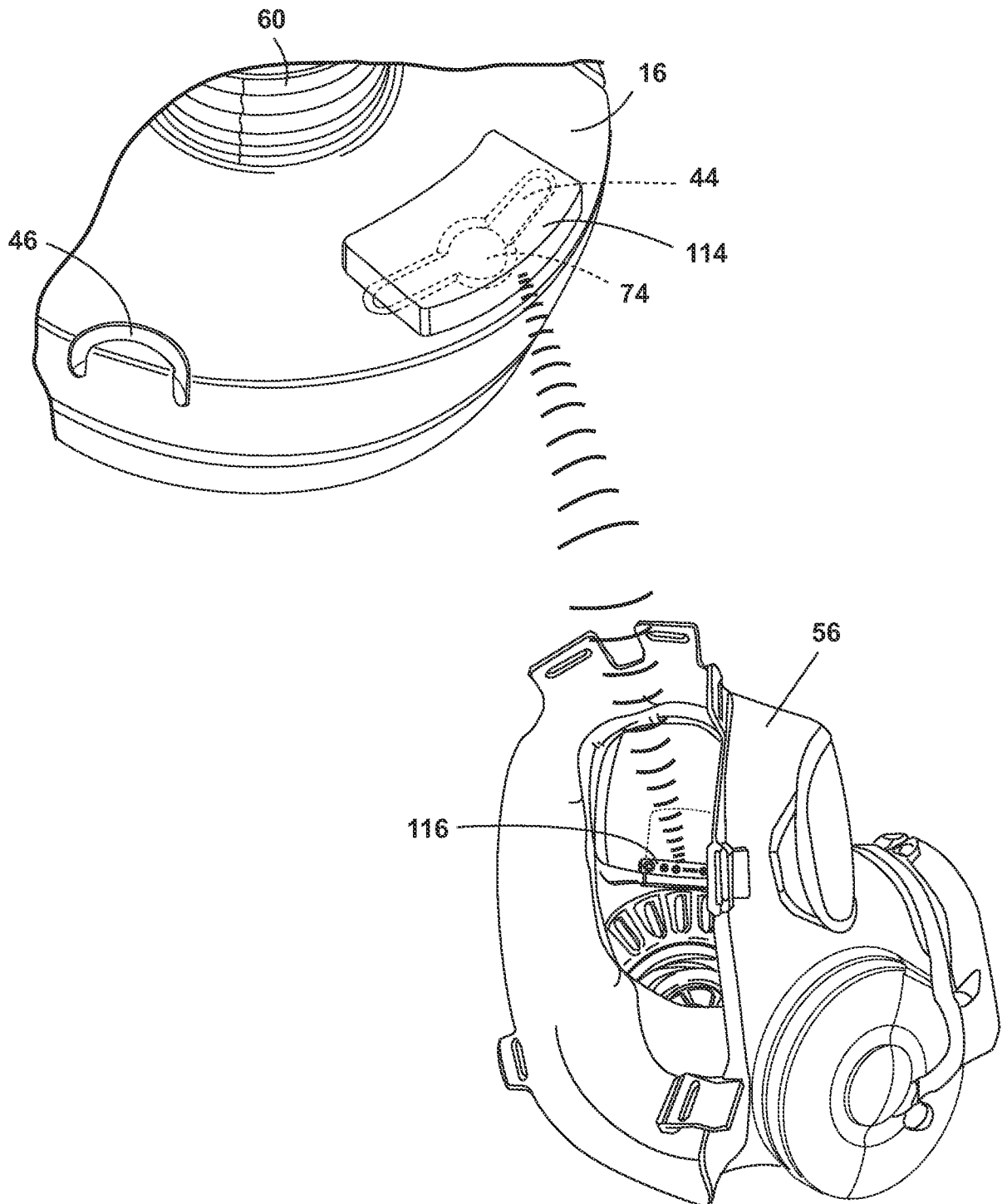


Fig. 12

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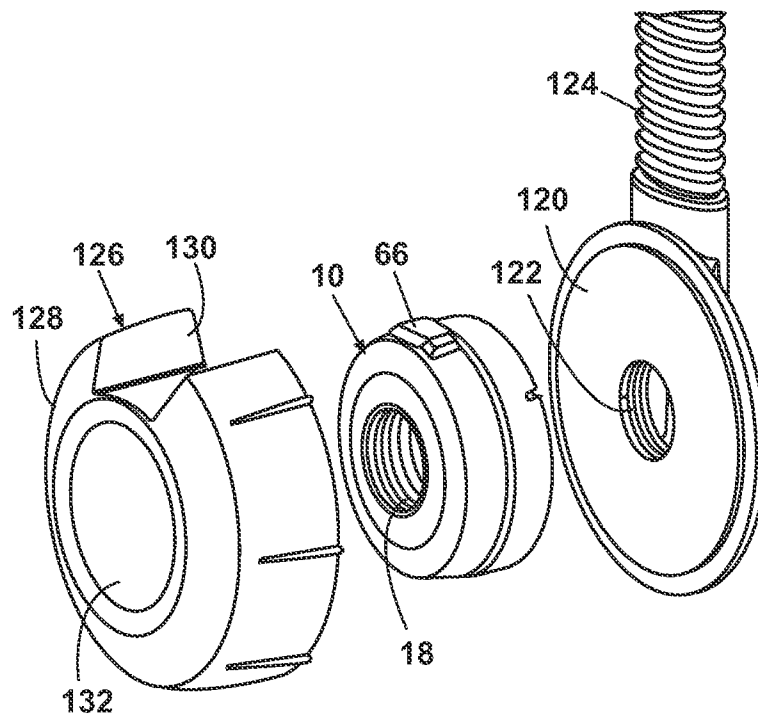


Fig. 13

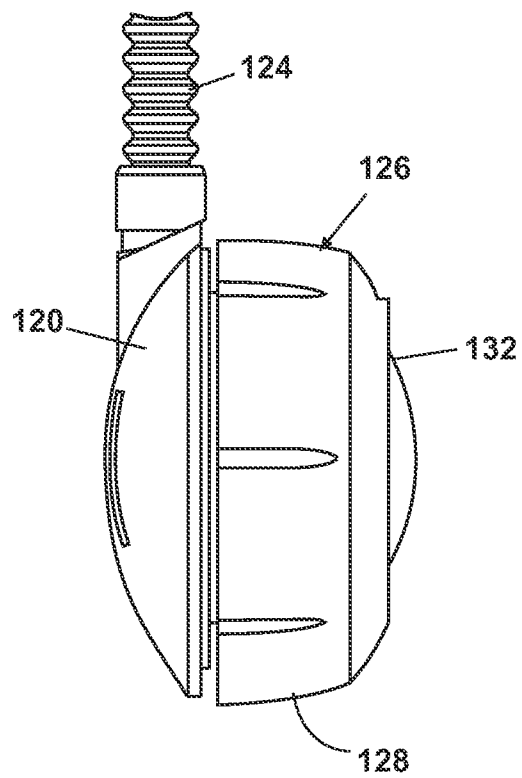


Fig. 14

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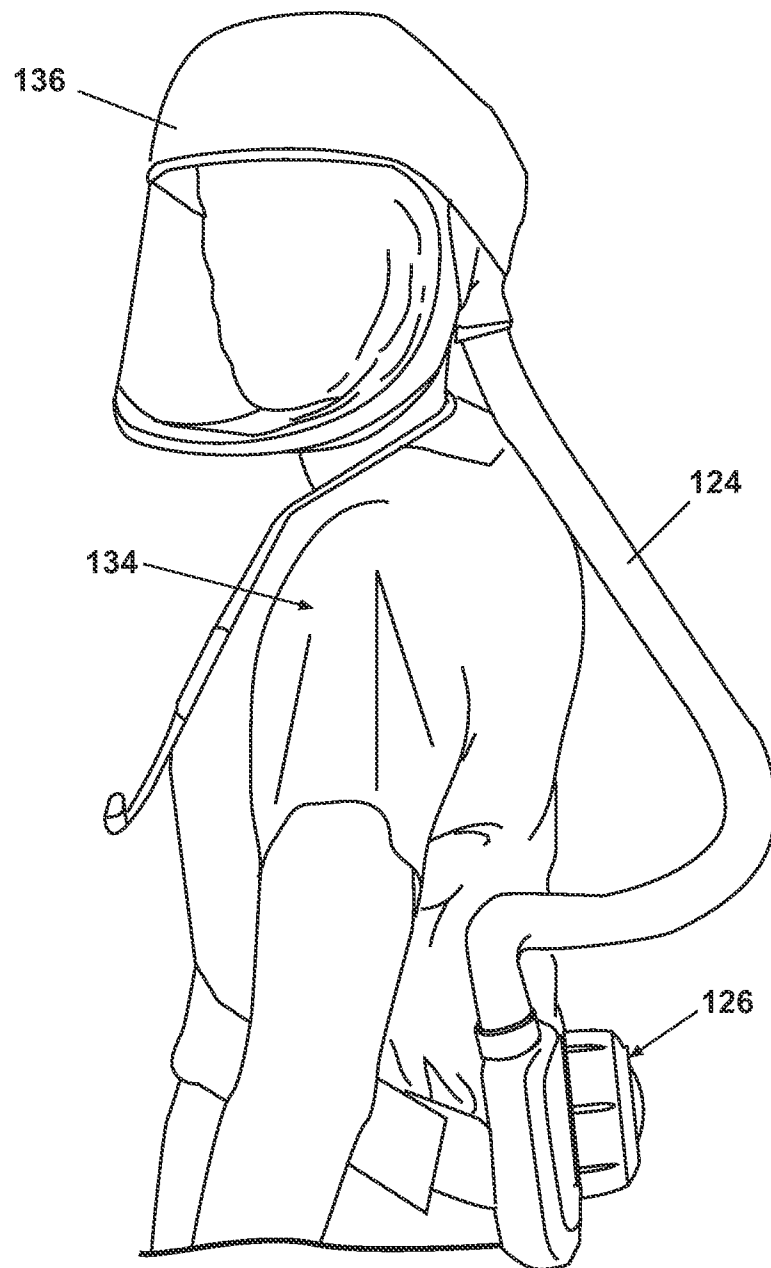


Fig. 15

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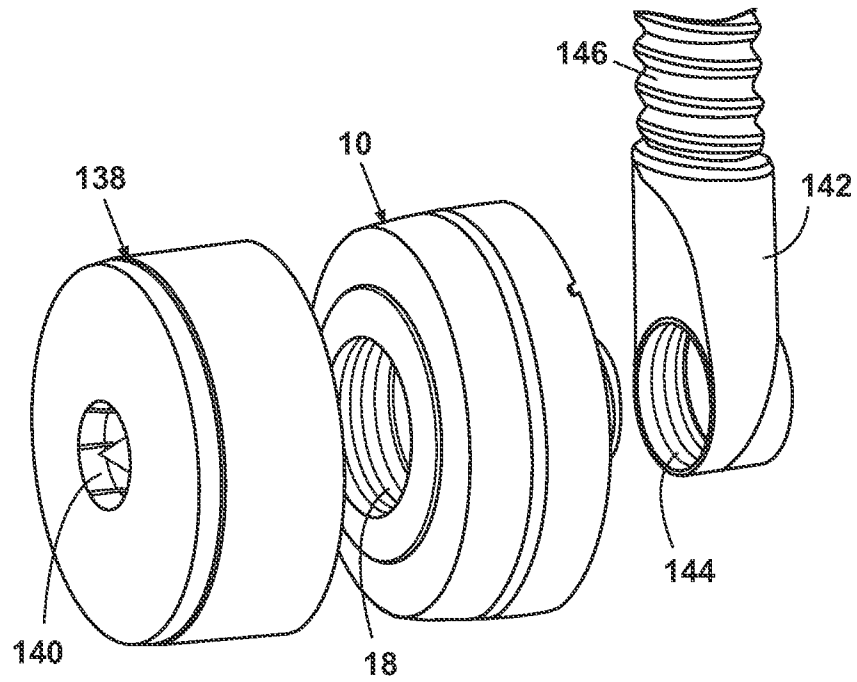


Fig. 16

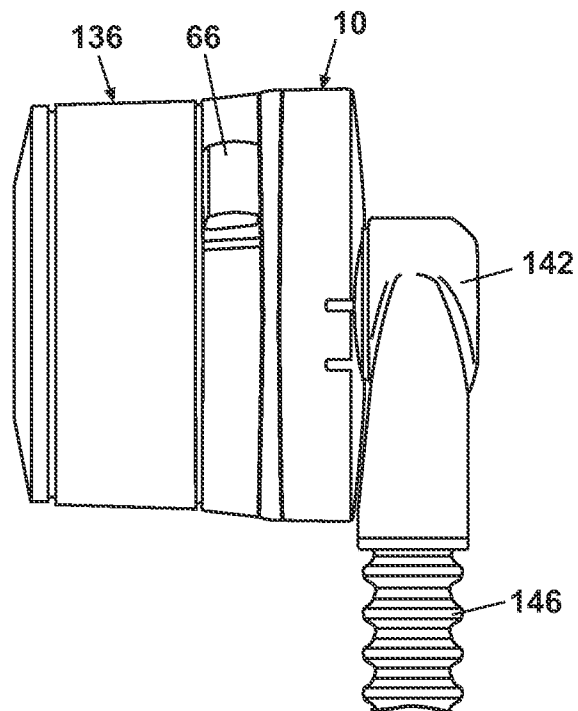


Fig. 17