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Respirator

Abstract

The present invention provides a respirator. The respirator (**100**) has an outer housing (**103**), a filter, and an end cover (**104**). The filter is arranged on the outer housing (**103**). Position-limiting devices matching each other are respectively provided on the end cover (**104**) and the outer housing (**103**), and are used for fixing the filter at the outer housing (**103**).

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application claims priority pursuant to 35 U.S.C. 119(a) to China Patent Application No. 202110162854.X, filed Feb. 5, 2021, which application is incorporated herein by reference in its entirety.

TECHNICAL FIELD

(2) The present invention relates to a respirator, and in particular to a respirator having a position-limiting device.

BACKGROUND

(3) Powered air purifying respirators (PAPRs) on the market have some disadvantages, and these disadvantages need to be eliminated from novel PAPR products.

(4) Inappropriate seal design of a PAPR filter causes the filter to leak when the filter is worn. Hard contact with an edge seal of a flat filter medium often results in a poor sealing effect. Scientific and innovative sealing materials, structures, and design should be developed to achieve a good sealing effect.

(5) User experience of current filter media is poor. The filter media cannot be easily mounted or removed. Novel structures that can be used easily should be developed to improve user experience.

(6) All PAPR products on the market are provided with exhalation valve design to allow for comfortable breathing. However, this design cannot be used for protection against COVID-19, because this design can only protect a wearer from external harm, and cannot prevent an infected person from spreading virus to the outside.

(7) A filtration area of an inhalation filter is small, so that inhalation resistance is high. Filter media

on the market are typically treated in a flat mode. High resistance affects a service life (battery life) and wearing experience of a wearer.
(8) CN 204128080 U relates to an air purifier, including a primary filter and a fan. An air outlet of the primary filter is connected to an inlet of the fan. An outlet of the fan is connected to an air pipe. The air pipe extends to a bottom portion of a box body containing a filter medium. An upper portion of the box body is an open air outlet structure. A negative ion generator is mounted at the open air outlet structure. The air purifier can continually suck in foul air. After undergoing primary filtration, filtration performed by a liquid filter medium, and treatment performed by negative ions, the foul air is changed into clean air. The air purifier has a composite air cleaning function, can remove 99.99% of PM2.5, kill harmful bacteria rapidly, decompose harmful gas in the air, and protect health of users, can be easily used, operates stably and reliably, and is applicable to air purification and filtration in offices, homes, and the like.

SUMMARY

(9) An objective of the present invention is to provide a respirator having a position-limiting function.
(10) Further, the present invention is intended to address or alleviate other technical problems present in the prior art.
(11) The present invention addresses the aforementioned problems by providing a respirator. Specifically, according to an aspect of the present invention, the present invention provides: the respirator has an outer housing, a filter, and an end cover, the filter being arranged on the outer housing, wherein position-limiting devices matching each other are respectively provided on the end cover and the outer housing, and are used for fixing the filter at the outer housing.
(12) Optionally, according to an embodiment of the present invention, the position-limiting device on the outer housing comprises a rod, the rod being fixed at the filter, a plurality of ribs being formed in a longitudinal direction of the rod and provided on an outer peripheral edge of the rod, the position-limiting devices on the end cover being recesses, and one end of the rib engaging with the recess.
(13) Optionally, according to an embodiment of the present invention, the ribs are evenly distributed on the outer peripheral edge of the rod.
(14) Optionally, according to an embodiment of the present invention, an opening is provided in a middle portion of the end cover, and the recesses are provided on the outer periphery of the opening.
(15) Optionally, according to an embodiment of the present invention, a through hole is provided in the middle of the filter, and the rod passes through the through hole.
(16) Optionally, according to an embodiment of the present invention, the respirator further has a threaded fastener having an unthreaded segment and a threaded segment, an aperture being provided in the middle of the rod, and the opening being provided with an inner thread, wherein the threaded fastener is inserted into the aperture by means of the unthreaded segment thereof, and engages with the inner thread by means of the threaded segment thereof.
(17) Optionally, according to an embodiment of the present invention, the rod is configured to retain a filter medium of the filter.
(18) Optionally, according to an embodiment of the present invention, the end cover is configured to be in the shape of a curved disc.
(19) Optionally, according to an embodiment of the present invention, the filter is configured to be an inhalation filter.
(20) Optionally, according to an embodiment of the present invention, the outer housing has a recessed portion that is recessed relative to an outside surface thereof, and the inhalation filter is accommodated in the recessed portion.
(21) The provided respirator has the following benefits: improved user experience, low resistance

to inhalation, the restricted positions of the filter and the end cover, no leakage, and no deformation on the filter.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) With reference to the accompanying drawings, the above and other features of the present invention will become apparent, wherein:

(2) FIG. **1** shows a schematic diagram of an inhalation filter according to the present invention;

(3) FIG. **2** shows a schematic diagram of an exhalation filter according to the present invention;

(4) FIG. **3** shows a schematic diagram of a respirator according to the present invention;

(5) FIG. **4** shows a schematic diagram of a middle frame of a respirator according to the present invention;

(6) FIG. **5** shows a schematic diagram of an integrated board of a respirator according to the present invention;

(7) FIG. **6** shows a schematic diagram of an outer housing of a respirator according to the present invention;

(8) FIG. **7** shows a schematic diagram of an end cover of a respirator according to the present invention;

(9) FIG. **8** shows a schematic partial view of an outer housing of a respirator according to the present invention;

(10) FIG. **9** shows an exploded view of a respirator according to the present invention;

(11) FIG. **10** shows a schematic diagram of another inhalation filter according to the present invention;

(12) FIG. **11** shows a schematic diagram of still another inhalation filter according to the present invention;

(13) FIG. **12** shows an exploded view of a respirator according to the present invention; and

(14) FIG. **13** shows a schematic diagram of a connection relationship between an integrated board and a middle frame according to the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

(15) It will be readily appreciated that in accordance with the technical solution of the present invention, a person of ordinary skill in the art can propose a variety of structural ways and implementations that can be replaced with one another without changing the essence or spirit of the present invention. Therefore, the following detailed description and the accompanying drawings are merely exemplary illustrations of the technical solution of the present invention, and are not to be considered as the entirety of the present invention or as a limitation or confinement on the technical solution of the present invention.

(16) The positional terms such as upper, lower, left, right, front, rear, front surface, back surface, top, bottom, etc. mentioned or possibly mentioned in the present specification are defined with respect to configurations shown in the accompanying drawings, are relative concepts, and thus may vary accordingly depending on different positions and different use statuses thereof. Therefore, these or other positional terms should not be interpreted as limiting terms. Further, the terms “first,” “second,” “third,” etc., or similar expressions are used merely for description and differentiation, and are not to be construed as indicating or implying relative importance of respective members.

(17) The present application relates to a filter. The filter is used in a respirator **100**. The filter has a filter medium **1**, and the filter medium **1** has a pleated structure.

(18) According to an example of the present application, the pleated structure is shown as a parallel structure, a radial structure, or a concentric circular ring structure when viewed in a cross section parallel to a filtration surface F of the filter.

(19) According to an example of the present application, the filter medium **1** is made of a HEPA material.
(20) According to an example of the present application, the filter medium **1** is further made of an antibacterial and antiviral material and/or an activated carbon fabric material.
(21) According to an example of the present application, the filter is configured to be an inhalation filter **10** and/or an exhalation filter **20**.
(22) According to an example of the present application, a ramp and/or step **2** is provided on a side wall of the filter.
(23) According to an example of the present application, a handle **4** is provided on the filter.
(24) According to an example of the present application, the filter has a housing **5** for accommodating the filter medium **1**, and the housing is configured to be a cylinder or a cuboid.
(25) According to an example of the present application, the cuboid has curved side surfaces.
(26) The present application relates to a respirator **100**. The respirator **100** has the filter according to the present application.
(27) According to an example of the present application, the respirator **100** is configured to be an electric supplied-air respirator or a face mask.
(28) According to an example of the present application, the respirator **100** has a facepiece, and one or more inhalation filters **10** including the filter are arranged at the facepiece.
(29) According to an example of the present application, the respirator **100** has a facepiece provided with one or more exhalation filters **20** including the filter.
(30) According to an example of the present application, the respirator **100** has a facepiece provided with one exhalation filter **20** including the filter and two inhalation filters **10** including the filter. The exhalation filter **20** is arranged in the middle of a lower portion of the facepiece at the mouth position of a user, and the inhalation filters **10** are arranged on two sides of the facepiece and above the exhalation filter **20** in a vertical direction.
(31) The present application relates to a method for manufacturing a filter. The filter is configured to be the filter according to the present application. The method includes the following steps of: pleating the filter medium **1** to form the pleated structure; shaping the pleated filter medium **1**; and forming the housing **5** of the filter on the shaped filter medium **1** so as to accommodate the filter medium **1**.
(32) According to an example of the present application, if the pleated structure is shown as a parallel structure when viewed in a cross section parallel to the filtration surface F of the filter and the filter is configured to be a cylinder, then formation of the housing **5** is performed by forming the housing **5** in the shape of an ellipse around the shaped filter medium **1**. A major axis direction of the ellipse is perpendicular to an extension direction of the parallel structure, and a minor axis direction of the ellipse is consistent with the extension direction of the parallel structure.
(33) The present application relates to a respirator **100**. The respirator **100** has an outer housing **103**, a middle frame **101**, and a facial seal **108**. The facial seal **108** is connected to the middle frame **101**, and is fit to and forms a seal to the face of a user when the respirator **100** is in use. The respirator **100** further has an integrated board **102**. The integrated board **102** is arranged between the outer housing **103** and the middle frame **101**, and is provided with a functional member **107** for the respirator **100**.
(34) According to an example of the present application, the middle frame **101** is formed by TPU; and/or the facial seal **108** is formed by silicone; and/or the integrated board **102** is formed by PA, PP, or ABS.
(35) According to an example of the present application, a connection between the integrated board **102** and the middle frame **101** is a tight connection, and the middle frame **101** is connected to the outer housing **103**.
(36) According to an example of the present application, the middle frame **101** is configured to be a frame provided with an accommodation portion in the middle. The integrated board **102** is inserted

in the accommodation portion. An erect edge frame is provided at a peripheral edge of the integrated board **102**. The shape of the edge frame of the integrated board **102** matches the shape of an edge of the accommodation portion of the middle frame **101**.
(37) According to an example of the present application, the integrated board **102** is bonded to the middle frame **101** by means of a glue.
(38) According to an example of the present application, the functional member **107** includes a blower fan, a battery, and/or a PCB for the respirator **100**.
(39) According to an example of the present application, the respirator **100** further has a filter, and the filter is arranged at the outer housing **103**.
(40) According to an example of the present application, the respirator **100** is configured to be an electric supplied-air respirator or a face mask.
(41) The present application relates to a respirator **100**. The respirator **100** has an outer housing **103**, a filter, and an end cover **104**. The filter is arranged on the outer housing **103**. Position-limiting devices matching each other are respectively provided on the end cover **104** and the outer housing **103**, and are used for fixing the filter at the outer housing **103**.
(42) According to an example of the present application, the position-limiting device on the outer housing **103** includes a rod **105**. The rod **105** is fixed at the filter. A plurality of ribs **1051** are formed in a longitudinal direction of the rod **105** and provided on an outer peripheral edge of the rod. The position-limiting devices on the end cover **104** are recesses **1041**. An end of the rib **1051** engages with the recess **1041**.
(43) According to an example of the present application, the ribs **1051** are evenly distributed on the outer peripheral edge of the rod **105**.
(44) According to an example of the present application, an opening **1042** is provided in a middle portion of the end cover **104**, and the recesses **1041** are provided on the outer periphery of the opening **1042**.
(45) According to an example of the present application, a through hole **3** is provided in the middle of the filter, and the rod **105** passes through the through hole **3**.
(46) According to an example of the present application, the respirator **100** further has a threaded fastener **106** having an unthreaded segment and a threaded segment. An aperture **1052** is provided in the middle of the rod **105**. The opening **1042** is provided with an inner thread. The threaded fastener **106** is inserted into the aperture **1052** by means of the unthreaded segment thereof, and engages with the inner thread by means of the threaded segment thereof.
(47) According to an example of the present application, the rod **105** is configured to retain the filter medium **1** of the filter.
(48) According to an example of the present application, the end cover **104** is configured to be in the shape of a curved disc.
(49) According to an example of the present application, the filter is configured to be an inhalation filter **10**.
(50) According to an example of the present application, the outer housing **103** has a recessed portion that is recessed relative to an outside surface thereof, and the inhalation filter **10** is accommodated in the recessed portion.
(51) Referring to FIG. **1** and FIG. **2**, FIG. **1** shows a schematic diagram of an inhalation filter **10** according to the present invention, and FIG. **2** shows a schematic diagram of an exhalation filter **20** according to the present invention.
(52) A filter medium **1** can be seen in the drawings. The filter medium **1** is used in the filter of the respirator **100**, and the filter medium **1** has a pleated structure.
(53) It should be appreciated that the pleated structure refers to a structure provided with pleats or wrinkles, and may be formed by, for example, providing a winding, sinuous, or uneven curved portion or bent portion on an originally flat material. As can be seen, design of the pleated structure can greatly increase an effective filtration area of the filter medium **1**, thereby increasing overall

filtration efficiency of the respirator. Further, the pleated structure can provide improved support for supporting, for example, the surrounding housing, so that the overall shape of the filter is stable. This effect cannot be achieved by a flat filter medium. Additionally, applying the filter medium **1** to the respirator **100** improves a filtration effect of the respirator **100**. This is different from a face mask and an orinasal mask employing a flat filter medium and an air purifier employing a pleated filter medium on the market.

(54) The filter medium **1** can be configured to be filter paper, thereby facilitating purchase and/or reducing economic and time costs of manufacturing. The filter medium **1** may also be made of a HEPA material. HEPA is a high-efficiency low-resistance material, and is a known material. The HEPA material can effectively filter PM2.5 particulate matter from air, and is an effective filter medium for pollutants such as smoke, dust, and bacteria. HEPA may specifically be PP filter paper, fiberglass, composite PP PET filter paper, a melt-blown non-woven polyester fabric, melt-blown fiberglass, offset paper, an aluminum membrane, etc. Filtration grades include: H11 to H14, U15, and U16 (EN 1822). Employing the HEPA material achieves high-efficiency filtration, thereby achieving a high protection level. In addition, low resistance (namely low resistance to inhalation and breathing) allows for great respiratory comfort, and extends a battery life for electric/powered respirators.

(55) In addition, in order to further improve performance and the protection level of the filter medium **1** (such as the filter medium for the inhalation filter **10**), the filter medium **1** can also be made by combining an antibacterial and antiviral material and/or an activated carbon fabric material with the HEPA material. The antibacterial and antiviral material can be treated with organic and inorganic antibacterial agents so as to improve bacteriostatic and bactericidal performance. The activated carbon fabric material is an optional material for providing an odor removal or deodorization function. For example, activated carbon can be an activated carbon cloth provided with granular activated carbon (GAC) and activated carbon fiber (ACF).

(56) Regarding specific configurations of the pleated structure, the pleated structure is, for example, a parallel structure, a radial structure, or a concentric circular ring structure. The concentric circular ring structure can also be seen in FIG. **10** (FIG. **10** shows a schematic diagram of another inhalation filter according to the present invention), and the radial structure can also be seen in FIG. **11** (FIG. **11** shows a schematic diagram of still another inhalation filter according to the present invention). Specifically, the pleated structure is configured to be shown as the parallel structure, the radial structure, or the concentric circular ring structure when viewed in the cross section of the filter medium **1**. The cross section herein refers to a cross section taken in a radial direction of the filter. These three structures are all economical. The parallel structure can be obviously seen in FIG. **1** and FIG. **2**, and the radial structure can also be referred to as a fan-shaped structure. In addition to having large filtration areas and being economical, these structures provide good support, are aesthetically pleasing, and have low breathing resistance. It should be appreciated that the filter as a whole has a filtration surface F. A filtration direction is perpendicular to the filtration surface F. Respiratory gas passes through the filter in the filtration direction. The filtration direction can be understood as a top view direction of the filter held horizontally. For example, if the filter is configured to be a cylinder, then the filtration direction is an axial direction, and the filtration surface is a disc surface.

(57) The present invention also relates to a filter. The filter has any one of the aforementioned filter media **1**. Therefore, the filter has features and characteristics corresponding to the filter medium **1**, which will not be described herein again. The filter can be configured to be an inhalation filter **10** and/or an exhalation filter **20**. Providing inhalation filters and exhalation filters separately has the following benefit: the respirator **100** may employ filters having different structural features and different numbers of filters to perform inhalation filtration and exhalation filtration respectively, so that filter design is directed in consideration of differences between inhalation features and exhalation features. For example, as shown in the drawings, the inhalation filter **10** is configured to

be a cylinder, because the inhalation filter **10** (together with a cover for covering the same) is visible to other individuals when in use, and is aesthetically pleasing when designed to be a cylinder. The exhalation filter **20** is generally provided inside the respirator **100**, and is therefore invisible to other individuals when in use. Therefore, the exhalation filter **20** can be designed to be, for example, a curved cube, and this differs from conventional rectangular design so as to reduce a footprint. In addition, uniform curvature and shape design achieves an aesthetic effect. It should be appreciated that, in order to be applicable to respirators of different types or shapes, the shape of the filter can be modified freely.

(58) It should be noted that, the cylinder, the cube, or other shapes referred to herein do not necessarily correspond to a cylinder, a cube, and the like in a mathematical sense, and certain errors, tolerances, and modifications to details are allowed, as long as the overall shape is substantially a cylinder or a cube. Therefore, for example, the inhalation filter **10** having an outer peripheral slope on the housing can still be a cylinder, and the curved exhalation filter **20** having a step **2** can still be regarded as a cube.

(59) In order to ensure and enhance a sealing effect between the filter and the respirator **100**, the present invention employs a plurality of methods. For example, a ramp and/or step **2** is provided on the filter (for example, on a side wall thereof) to form a seal between the filter and the respirator **100**. The step **2** is exemplarily provided on an outer side of the housing **5** of the exhalation filter **20**, and the ramp is exemplarily provided on an outer side of the housing **5** of the inhalation filter **10** (if the inhalation filter **10** is configured to be a cylinder, then the ramp can be embodied directly as a slope of the outer periphery of the cylinder). Certainly, objects and positions where the ramp and the step **2** are provided are not limited to examples shown in the drawings, and these sealing means can also be used on the individual filters in combination. Further, in an embodiment shown in the drawings, design of the ramp can specifically achieve an axial sealing effect between the inhalation filter **10** and the respirator **100**, and design of the step **2** can specifically achieve an axial sealing effect between the exhalation filter **20** and the respirator **100**. Additionally, the ramp and step also have aesthetic effects. Vertical and unified shape design employed in the prior art achieves poor adaptability to a respirator and poor use experience.

(60) In another example, the filter has the housing **5** for accommodating the filter medium **1**, and the housing **5** is made of a TPE material. TPE refers to a thermoplastic elastomer, and is also referred to as artificial rubber or synthetic rubber. A product thereof has exceptional properties of conventional crosslinked vulcanized rubber such as being highly elastic, anti-aging, and oil resistant, has features of conventional crosslinked vulcanized rubber such as being environmentally-friendly, being non-toxic, providing a comfortable hand feel, being aesthetically pleasing, and so on, and has features of ordinary plastic such as being easy to machine and adapted to a wide range of machining methods. Production can be performed by means of methods such as injection molding, extrusion, blow molding, and the like, thereby simplifying a machining process and reducing machining costs. Common thermoplastic elastomers include styrene-based TPE, olefine-based TPE, diene-based TPE, vinyl chloride-based TPE, and polyurethane-based TPE.

(61) It can thus be seen that the sealing effect between the filter and the respirator **100** can be improved due to high elasticity of the TPE material. Further, in an embodiment shown in the drawings, specifically, the axial sealing effect between the inhalation filter **10** and the respirator **100** and the axial sealing effect between the exhalation filter **20** and the respirator **100** can be respectively achieved. Further, the filter is designed and manufactured by using a TPE material having sufficient hardness and a TPE manufacturing process (such as injection molding), so as to provide a good appearance and a good sealing effect. A good sealing effect can provide a high protection level, and reduce leakage of respiratory gas.

(62) In order to facilitate assembly with the respirator **100**, a through hole **3** is provided on the filter (for example, in the middle thereof), and exemplarily, the through hole **3** is correspondingly provided on the inhalation filter **10**. Correspondingly, the respirator **100** can be provided with a pin,

and the pin is inserted into the through hole **3** during assembly, so as to complete assembly and fixation. The exhalation filter **20** is mounted inside the respirator **100** by means of engagement. Certainly, a variety of other assembly methods can be used to mount the filter. Design of the through hole **3** facilitates assembly and removal of the filter **10**, and enables the filter to match the cover for covering the filter. Design without a through hole in the prior art results in poor use experience, and design for fixing a cover for covering a filter is complex.

(63) In contrast to the assembly described above, in order to facilitate removal of the filter from the respirator **100**, a handle **4** can be provided on the filter. The handle **4** can be configured to be on an outer side of the housing **5** and to extend outwards from the housing **5**, or can be configured to be in an inward region of the housing **5**, as long as a user can operate (for example, holding or pushing) the handle to complete an action of removing the corresponding filter. It is particularly seen in FIG. **1** that the handle **4** of the inhalation filter **10** is provided on the outer periphery of the through hole **3**. Because a gap is present in the pleated structure, a user can push the handle **4** from the gap by a finger, so as to complete removal of the inhalation filter **10**. The position of the handle **4** facilitates hiding of the handle **4**, thereby achieving an aesthetic effect. The handle **4** can certainly also be configured to be on the outer side of the housing **5**, so that a user can easily grip the handle **4** directly from the outside. This design certainly does not affect the sealing effect between the filter and the respirator. The handle design facilitating removal is not present in the prior art, and user experience is therefore not good enough.

(64) Referring to FIG. **3**, FIG. **3** shows a schematic diagram of a respirator **100** according to the present invention.

(65) The respirator **100** has any one of the aforementioned filters, and therefore also has features and characteristics brought about by the filter. The filter of the present invention is applicable to a variety of respirators **100**, and therefore can be configured to have various adaptive shapes, such as a cylinder and a curved cube shown in the drawings. A specific shape can be determined according to a specific mounting position and/or aesthetic and spatial requirements of a respirator to which the filter is applied.

(66) For example, the respirator **100** is configured to be an electric supplied-air respirator or a face mask. It should be appreciated that, the electric supplied-air respirator refers to a respirator using a fan driven by power provided by a battery to assist a user in breathing, typically assists the user in inspiration, and therefore can be considered to be an active respirator. The face mask is a passive respirator.

(67) As described above, the filter is mounted in a housing of the respirator **100** in a radially and axially sealed manner. Radial sealing can be achieved by means of, for example, the housing **5** made of TPE. Axial sealing can be achieved by means of, for example, the ramp or step **2**. Optionally, the filter is mounted in and radially interferes with the housing of the respirator **100**, which may also be achieved by means of high elasticity of TPE. Design of radial interference improves a radial sealing effect between the filter and the respirator. A specific dimension of the radial interference can be, for example, 0.4 mm.

(68) The respirator **100** has a facepiece. One or more inhalation filters **10** including the filter are arranged at the facepiece, and one or more exhalation filters **20** including the filter may also be arranged at the facepiece. It can be seen obviously from FIG. **3** that the respirator **100** has a facepiece provided with one exhalation filter **20** including the filter and two inhalation filters **10** including the filter. The exhalation filter **20** is arranged in the middle of a lower portion (for example, on an inner side) of the facepiece at the mouth position of a user, and the inhalation filters **10** are arranged on two sides (for example, on an outer side) of the facepiece and above the exhalation filter **20** in a vertical direction. This design takes into account the aesthetic effect. In addition, using two inhalation filters **10** can halve inhalation resistance, and using the exhalation filter **20** can prevent a user having been infected with virus from spreading the virus to the outside. Therefore, this bidirectional protection achieves better safety than an orinasal mask or a face mask

having breather valve design on the market (the breather valve cannot prevent an infected wearer from spreading virus or bacteria to the outside). The positions, shapes, and numbers of the exhalation filters **20** and the inhalation filters **10** may be modified according to actual circumstances.

(69) In order to manufacture the filter of the present invention, the present invention provides a novel method. The method includes the following steps of: pleating the filter medium **1** to form the pleated structure; shaping the pleated filter medium **1**; and forming the housing **5** of the filter on the shaped filter medium **1** so as to accommodate the filter medium **1**.

(70) In each conventional manufacturing process of a filter: a housing of the filter is manufactured first, or the housing is prepared separately; then, a filter medium is shaped and then mounted in the housing, thereby completing manufacture of the filter. This method needs involvement of a glue, and therefore affects performance of the filter. However, in the method of the present invention, the filter medium is manufactured first, and then manufacture of the housing is completed on the basis of the filter medium. This manufacturing method is advantageous in that involvement of a glue is not required, thereby achieving better quality and allowing for more shape designs.

(71) Specifically, the shaping step can be performed by means of cutting or punching, and/or the step of forming the housing **5** is performed by means of surrounding injection-molding. A manufacturing process of cutting or punching does not affect the pleated structure of the filter medium. The surrounding injection-molding refers to injection-molding the housing **5** in a manner of surrounding the filter medium **1**. Further, the pleat height and pleat pitch of the pleated structure of the filter medium can be optimized for a largest breathing region, so as to achieve lower breathing resistance. In addition, properties (including the thickness and hardness) of the TPE housing (particularly an outer housing) can also be determined empirically or experimentally to achieve a better sealing effect and good appearance.

(72) It should be particularly mentioned that, if the pleated structure is configured to be shown as a parallel structure when viewed inthe cross section of the filter and the filter is configured to be a cylinder (for example, a shape shown in FIG. **1**), then formation of the housing **5** is performed by forming the housing **5** in the shape of an ellipse around the shaped filter medium **1**. A major axis direction of the ellipse is perpendicular to an extension direction of the parallel structure, and a minor axis direction of the ellipse is consistent with the extension direction of the parallel structure. This manufacturing manner takes into account the fact that stress distribution of the parallel structures is not uniform. That is, the parallel structure has a tendency of deformation of stretching in the extension direction thereof due to stress, and has a tendency of deformation of contracting in a perpendicular direction. Therefore, forming the aforementioned housing **5** in the shape of the ellipse can compensate for or cancel out such tendencies, thereby causing the completed filter to have extremely great roundness as a whole.

(73) Referring to FIG. **4** to FIG. **6**, FIG. **4** to FIG. **6** respectively show schematic diagrams of a middle frame **101**, an integrated board **102**, and an outer housing **103** of a respirator **100** according to the present invention.

(74) A respirator, such as a PAPR, is used for providing professional and fashionable protection against COVID-19. The respirator of the present application provides bidirectional protection, has a high protection level, low inhalation and exhalation resistance, great comfort, a high matching degree, and little leakage of facepiece design, and provides good use experience with mounting and removal.

(75) A typical PAPR should include three main members including a middle frame (in the middle) provided with a blower fan, a battery, a PCB, a button, or another functional member **107**/assembly, a facial seal **108** (on the face side) having a soft silicone ring for facial sealing, and an outer housing (located outside). Typically, the facial seal **108** forms a seal to the face of a user. However, when in use, part of the middle frame may also contact the face of the user, depending on a specific shape of the middle frame.

(76) In order to provide mechanical properties, the middle frame is typically made of a hard material, such as PA/PP/ABS. PA is a polyamide, commonly known as nylon. PP is polypropylene. ABS is an acrylonitrile-butadiene-styrene copolymer.
(77) However, a design scheme employing the prior art needs to be improved. For example, a hard material and structure cannot provide a wearer with a gentle wearing feel, and cannot provide good matching for different facial features of different wearers. Many functional members **107** are difficult to secure and assemble into a hard middle frame. “Hard contact” of the functional member **107** to the middle frame is prone to result in leakage at a joint.
(78) In order to address or alleviate one or more of the aforementioned problems, the present application employs a plurality of novel technical means. As can be seen in the drawings, the respirator **100** of the present application includes a middle frame **101**, an integrated board **102**, and an outer housing **103** connected in sequence to one another. A functional member **107** is provided on the integrated board **102**. Therefore, the functional member **107** is arranged by means of the additionally designed integrated board, which replaces the scheme in the prior art in which the functional member **107** is arranged by means of the middle frame, resulting in simple assembly.
(79) The functional member **107** can be arranged in the integrated board **102**, and therefore the integrated board **102** is correspondingly configured to be in the shape of a bowl. That is, an erect edge frame is provided at a peripheral edge. Similarly, the middle frame **101** can also be configured to be a frame having an accommodation portion. The integrated board **102** is assembled or inserted into the accommodation portion. The edge frame and an edge of the accommodation portion can be connected to each other by means of shape matching. It should be appreciated that, the shapes of the functional member **107**, the integrated board **102**, the middle frame **101**, and the outer housing **103** can be designed according to actual circumstances. For example, the shape of the integrated board **102** is designed according to arrangement of the functional member **107** to be provided thereon (for example, a ribbed portion is provided at the bottom of the integrated board to fix a battery of the functional member **107**). The shape of the middle frame **101** is designed according to the shape of the integrated board **102**.
(80) Further, according to the technical solution of the present application, the middle frame **101** can be formed by TPU. The meaning and features of TPU have been described in the foregoing, and will not be described herein again. Because the functional member **107** is configured to be borne by the integrated board **102**, the middle frame **101** can be made of soft TPU, thereby improving wearing comfort and reducing risk of leakage. Certainly, the middle frame **101** still needs to have certain hardness. The hardness can be, for example, **115**A for ensuring certain strength for assembly of the integrated board **102**.
(81) In contrast, in order to assemble the functional member **107**, the integrated board **102** is made of a hard material. Therefore, it can be seen that the hard material is no longer in the middle frame as in the prior art, and is transferred to the integrated board **102**, thereby resulting in the aforementioned advantage.
(82) Regarding a specific assembly method, reference can be made to FIG. **13** (FIG. **13** shows a schematic diagram of a connection relationship between an integrated board **102** and a middle frame **101** according to the present invention). Optionally, a connection between the integrated board **102** and the middle frame **101** is a tight connection, and for example, bonding is performed by means of a glue so as to improve tightness therebetween. The middle frame **101** is connected to the outer housing **103** by means of, for example, a screw. The integrated board **102** does not need to be directly connected to the outer housing **103**. A tight connection can also be achieved by means of another method, such as the aforementioned shape matching method. In another example, the bottom of the integrated board **102** is provided with a hole and a rib. The rib is used for supporting the functional member **107** (such as a battery). The integrated board **102** is further provided with a plurality of mounting holes. Thus, the integrated board **102** can also be tightly connected to the middle frame **101** by means of the mounting holes thereof.

(83) If the aforementioned material is adopted, then the soft middle frame **101** and the hard integrated board **102** are connected to each other by means of a glue, thereby achieving a soft-hard combination and therefore further improving the effect of preventing leakage of respiratory gas. Further, compared with conventional mechanical fastening, a bonded member has even stress distribution of internal stress transfer, high strength, and low costs, is lightweight, has less limitation on functions, and does not affect the overall appearance. Threaded fastening is a method for a removable fixed connection, and has advantages such as a simple structure, a reliable connection, easy removal, and the like. Threaded fastening includes, but is not limited to, bolt connection, screw connection, and fastener-assembly connection (such as an externally threaded fastener and a washer). Specific forms of a thread can be a triangular thread (common or inch), a cylindrical pipe thread, a rectangular thread, and the like.
(84) Further, the respirator includes a facial seal **108** that is fit to and forms a seal to the face of a user when in use. The facial seal **108** is made of a material softer than the middle frame, such as silicone. The facial seal **108** is connected to the middle frame. The design of the softer facial seal **108** achieves more comfortable matching with the face of a wearer, and is flexibly adapted to different facial features of different wearers.
(85) In sum, the respirator (such as the electric supplied-air respirator) of the present application has modular design that enables easy assembly, facial comfort resulted from the soft middle frame, adaptability to different facial seals **108** or faces resulted from the elastic material of the soft middle frame, and less leakage at the joint of mechanical members.
(86) Referring to FIG. **7**, FIG. **7** shows a schematic diagram of an end cover **104** of a respirator according to the present invention.
(87) The end cover **104** is used for covering the filter, such as the inhalation filter **10**, so as to protect the filter against interference from the outside. It should be appreciated that, a gap should be provided between the end cover **104** and the filter so as to allow a wearer to inhale. Therefore, the shape of the end cover **104** can be configured to be consistent with the shape of the filter medium to be protected, and can be configured to be, for example, circular.
(88) The present application performs shape design for both the end cover **104** and the respirator **100**. Specifically, the end cover **104** is configured as a whole to be in the shape of a curved disc, such that a good aesthetic effect is achieved, and furthermore, curvature provides a space for allowing for free design of other components. An opening **1042** is provided in a middle portion of the end cover **104**. The opening **1042** can be specifically configured to be a through hole or a blind hole, and is a blind hole in this example. The opening is used for accommodating a threaded fastener **106** to be further described below.
(89) In particular, in order to define the gap between the end cover **104** and the filter (such as the filter medium thereof), position-limiting devices used in cooperation with each other are provided on both the end cover **104** and the outer housing **103** of the present application, and are used for fixing the filter to the outer housing **103**. By means of the position-limiting device, when the end cover **104** is mounted and moved towards the filter, the end cover **104** can be restricted so as to control the size of the gap.
(90) Referring to FIG. **8**, FIG. **8** shows a schematic partial view of an outer housing **103** of a respirator **100** according to the present invention.
(91) Referring to both FIG. **7** and FIG. **8**, exemplarily, recesses **1041** are provided in a middle portion of the end cover **104**, for example on the outer periphery of the opening, and is used as a position-limiting device, and an rod **105** is provided on a portion located on the outer housing **103** and used to accommodate the filter (the portion is configured to be a recessed portion relative to an outer surface of the outer housing **103**, and matches the shape of the filter), and is used as a position-limiting device. The rod **105** is fixed at the filter. Ribs **1051** are formed in a longitudinal direction of the rod **105** and provided around the outer periphery of the rod. Optionally, the ribs are distributed evenly. The rib **1051** matches the recess **1041** to function. That is, in a process of

mounting the end cover **104** to the filter, one end of the rib **1051** can eventually be joined into the recess **1041**, thereby completing position-limiting. Further, due to engagement-based mating between the rib **1051** and the recess **1041**, completion of the joining can also generate an acoustic or tactile feedback, so as to inform mounting personnel in time that the end cover **104** has been mounted in a predetermined position, thereby preventing the filter from being damaged due to over tightness of mounting, and thus providing good use experience. Further, such engagement-based mating also has the effect of preventing the respirator from leaking.

(92) Referring to FIG. **9** and FIG. **12**, FIG. **9** and FIG. **12** each show an exploded view of a respirator **100** according to the present invention.

(93) In order to complete the assembly of the end cover **104** and the respirator **100**, it can be seen that an aperture **1052** is provided in the middle of the rod **105**. The **1052** matches the threaded fastener **106**, and the size of the through hole **3** of the filter is configured to be greater than the size of the rod **105** and the threaded fastener **106**. Therefore, in an assembly process, the filter is assembled on the rod by means of the through hole **3**, and is then accommodated in the recessed portion. Then, the threaded fastener **106** is inserted into the aperture **1052** by means of the unthreaded segment thereof via the through hole **3**. Then, the end cover **104** is assembled on the threaded segment of the threaded fastener **106** by means of an opening **1042** thereof. In this regard, the opening **1042** can be provided with an inner thread matching the threaded segment, and therefore the end cover **104** can be mounted and fixed on the threaded segment by means of screwing. As mentioned in the foregoing, the ribs **1051** are joined to the recesses **1041**, thereby completing assembly. After the assembly is completed, squeezing operation can also be performed so that the end cover **104** has interference with the threaded fastener **106**, thereby further improving assembly and gas leakage prevention effects. The final gap can be made to, for example, 0.5-0.8 mm.

(94) Further, the rod **105** can be configured to be slightly smaller than the through hole **3**, so that when assembly is completed, the rod **105** has the function of retaining the filter and the filter medium **1** thereof, and prevents the same from deforming during assembly and use.

(95) It should be appreciated that, other forms of assembly of the end cover **104** and the respirator **100** are also feasible, for example, performing mounting by means of direct shape matching between the filter and the recessed portion, completing fixation of the end cover **104** with a gap by means of engagement-based mating between the end cover **104** and the filter, and so on. In addition, the threaded fastener is a general term of a mechanical part having an inner thread or an outer thread, and is used as a fastener. Most common threaded fasteners are screws, nuts, and bolts. Other threaded fasteners, such as cage nuts, threaded inserts, threaded rods, and the like, are also available.

(96) The assembly design ensures low-resistance and high-efficiency breathing, ensures a good sealing effect with respect to assembly, and ensures that no damage occurs between the filter medium and the corresponding connecting structure (such as the rod). Additionally, stop design of the end cover ensures a sufficient gas input area and a good frontal waterproof effect.

(97) Therefore, the present application develops an innovative pleated filter medium, thereby allowing an air purifying respirator (PAPR/APR) product to achieve a high protection level, low inhalation and exhalation resistance, great comfort, good facepiece adaptability, easy use with respect to mounting and removal, and enabling a PAPR/APR respirator product to provide professional and fashionable protection against COVID-19. According to evaluation, performance of the filter medium meets design requirements. Filtration efficiency is 95%+, providing a good protection level. In addition, inhalation resistance of the filter medium is 70-80 Pa lower than inhalation resistance, 400 pa, of a current flat filter medium. A sealing effect has also been verified by means of assembly and testing. A good mating coefficient indicates that the filter medium has a better sealing effect on a PAPR apparatus. An actual wearing test also indicated that good user experience has been achieved, and the novel design facilitates mounting and removal.

(98) It should be appreciated that, all of the above preferred embodiments are exemplary and non-limiting, and various modifications or variations made, on the basis of the concept of the present invention, to the specific embodiments described above should all fall within the scope of legal protection of the present invention.

Claims

1. A respirator, wherein the respirator comprises an outer housing, a filter, an end cover, the filter being arranged on the outer housing, and a plurality of position-limiting devices matching each other, wherein a position-limiting device of the plurality of position-limiting devices is provided on the end cover, wherein the other position-limiting device of the plurality of position-limiting devices is provided on the outer housing, wherein the plurality of position-limiting devices is used for fixing the filter at the outer housing, and wherein the position-limiting device on the outer housing comprises a rod, the rod being fixed at the filter, a plurality of ribs being formed in a longitudinal direction of the rod and provided on an outer peripheral edge of the rod, the position-limiting device on the end cover comprising recesses, and one end of the plurality of ribs engaging with the recesses.
2. The respirator according to claim 1, wherein the plurality of ribs is evenly distributed on the outer peripheral edge of the rod.
3. The respirator according to claim 1, wherein an opening is provided in a middle portion of the end cover, and the recesses are provided on an outer periphery of the opening.
4. The respirator according to claim 1, wherein a through hole is provided in a middle of the filter, and the rod passes through the through hole.
5. The respirator according to claim 1, wherein the respirator further has a threaded fastener having an unthreaded segment and a threaded segment, an aperture being provided in the middle of the rod, and an opening being provided with an inner thread, wherein the threaded fastener is inserted into the aperture by means of the unthreaded segment thereof, and engages with the inner thread by means of the threaded segment thereof.
6. The respirator according to claim 1, wherein the rod is configured to retain a filter medium of the filter.
7. The respirator according to claim 1, wherein the end cover is configured to be in a shape of a curved disc.
8. The respirator according to claim 1, wherein the filter is configured to be an inhalation filter.
9. The respirator according to claim 8, wherein the outer housing has a recessed portion that is recessed relative to an outside surface thereof, and the inhalation filter is accommodated in the recessed portion.