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(54) **FILTERING FACE-PIECE RESPIRATOR HAVING WELDED INDICIA HIDDEN IN PLEAT**

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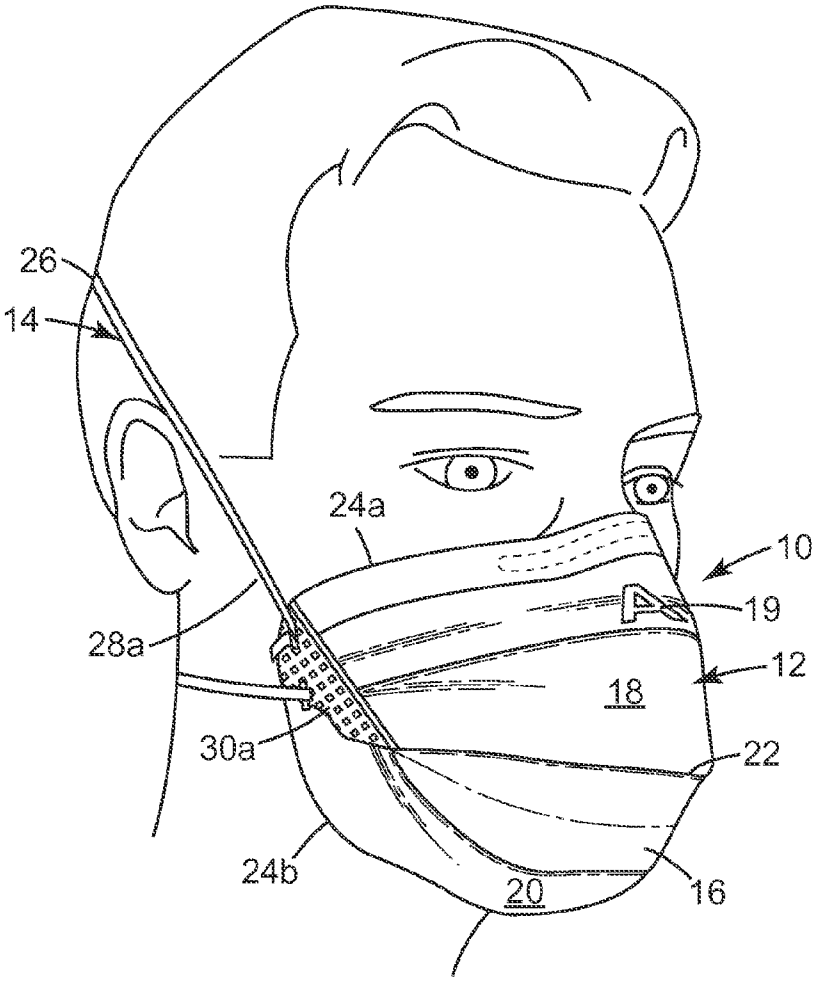
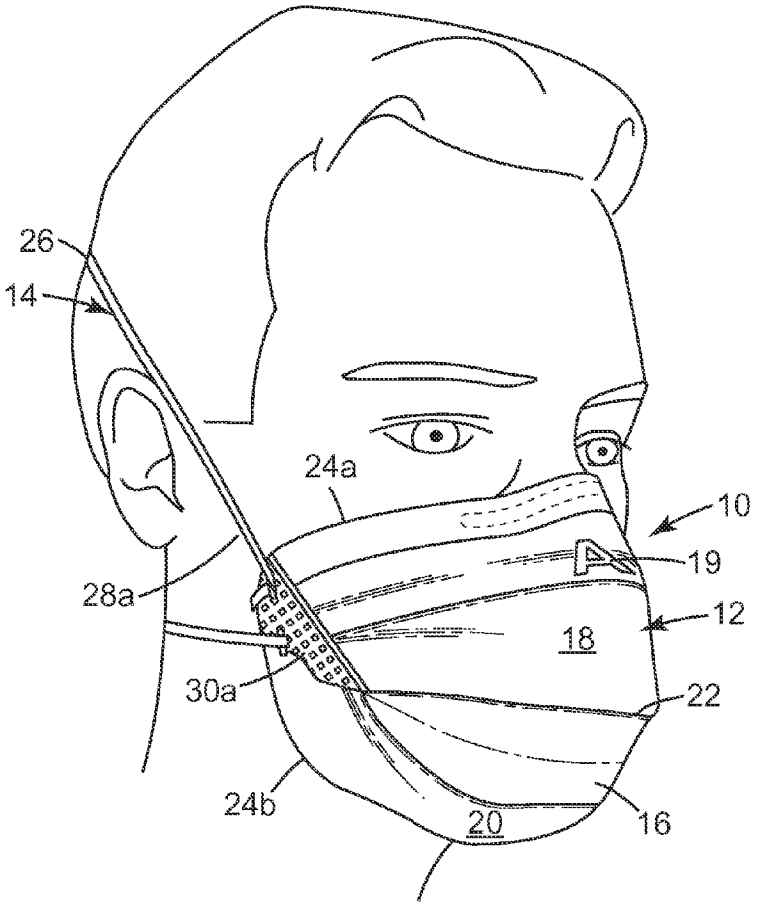
(57) **ABSTRACT**

A filtering face-piece respirator **10** that comprises a harness **14** and a mask body **12** that has a pleats **21**. The mask body **12** has an indicia **19** located within the pleat **21** in at least a partially non-visible location when the pleat **21** is folded. The indicia **19** is made from a weld pattern and is fully visible when the pleat **21** is unfolded. The fully visible indicia **19** provides an indication to the wearer that the mask body is in its proper unfolded condition. The indicia **19** also includes welded lines that extend normally across the pleat to improve collapse resistance.




26
14
24a
10
19
28a
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22
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16

Fig. 1

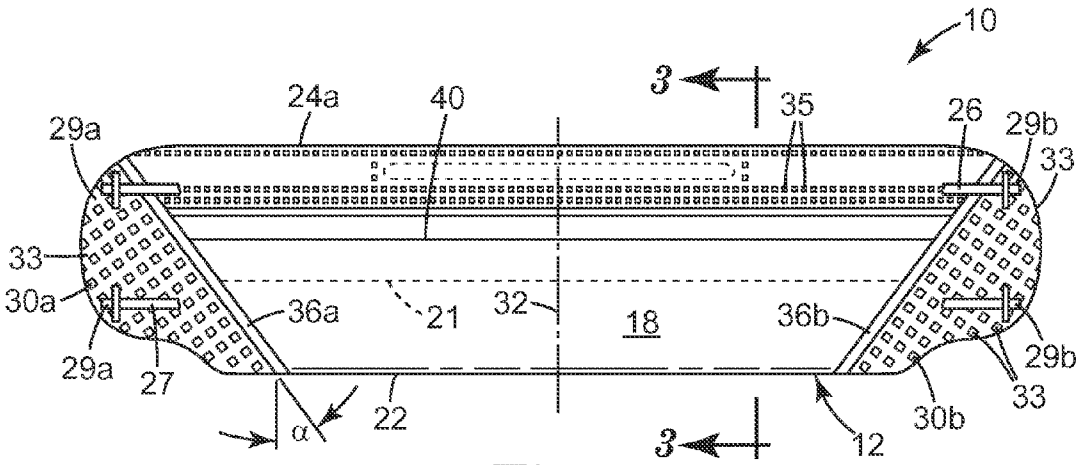
10
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Fig. 2a

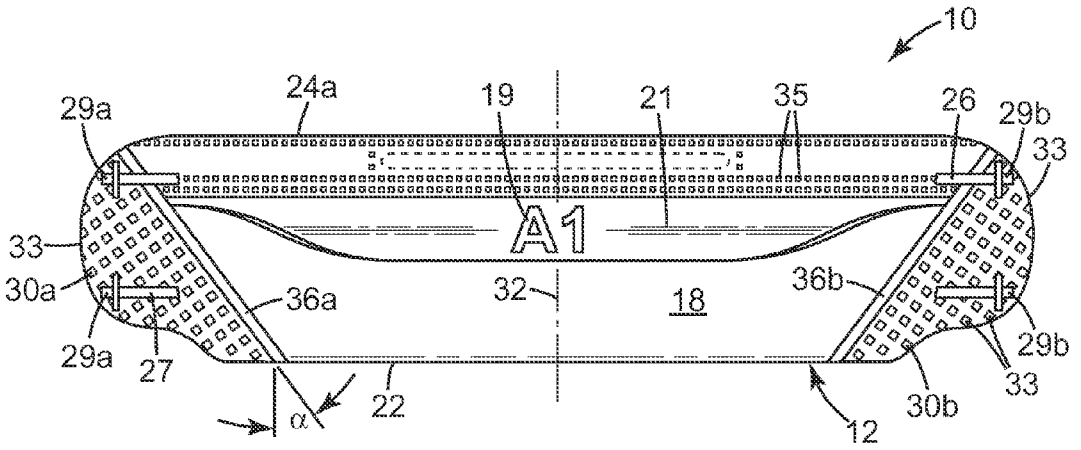

Fig. 2b

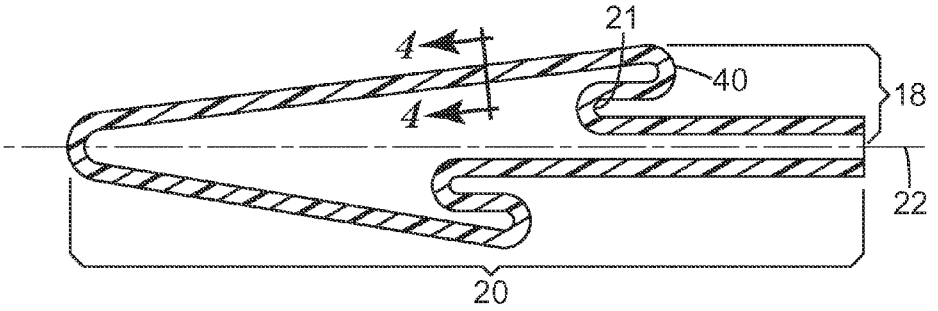

Fig. 3

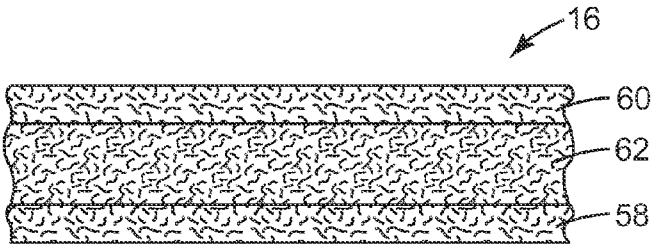

Fig. 4

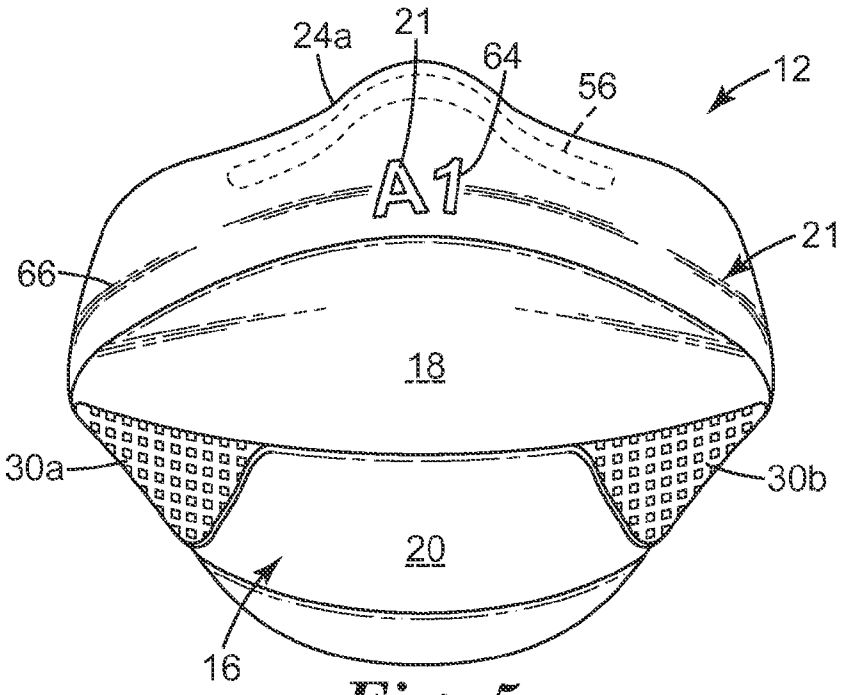

Fig. 5

FILTERING FACE-PIECE RESPIRATOR HAVING WELDED INDICIA HIDDEN IN PLEAT

[0001] The present invention pertains to a filtering face-piece respirator that has a welded indicia hidden in a pleat of the filtering structure. The welded indicia becomes visible when the pleat is opened into its in use configuration.

BACKGROUND

[0002] Respirators are commonly worn over a person's breathing passages for at least one of two common purposes: (1) to prevent impurities or contaminants from entering the wearer's respiratory system; and (2) to protect other persons or things from being exposed to pathogens and other contaminants exhaled by the wearer. In the first situation, the respirator is worn in an environment where the air contains particles that are harmful to the wearer, for example, in an auto body shop. In the second situation, the respirator is worn in an environment where there is risk of contamination to other persons or things, for example, in an operating room or clean room.

[0003] A variety of respirators have been designed to meet either (or both) of these purposes. Some respirators have been categorized as being "filtering face-pieces" because the mask body itself functions as the filtering mechanism. Unlike respirators that use rubber or elastomeric mask bodies in conjunction with attachable filter cartridges (see, e.g., U.S. Pat. No. RE39,493 to Yuschak et al.) or insert-molded filter elements (see, e.g., U.S. Pat. No. 4,790,306 to Braun), filtering face-piece respirators are designed to have the filter media cover much of the whole mask body so that there is no need for installing or replacing a filter cartridge. These filtering face-piece respirators commonly come in one of two configurations: molded respirators and flat-fold respirators.

[0004] Molded filtering face piece respirators have regularly comprised non-woven webs of thermally-bonding fibers or open-work plastic meshes to furnish the mask body with its cup-shaped configuration. Molded respirators tend to maintain the same shape during both use and storage. These respirators therefore cannot be folded flat for storage and shipping. Examples of patents that disclose molded, filtering, face-piece respirators include U.S. Pat. No. 7,131,442 to Kronzer et al, U.S. Pat. Nos. 6,923,182, 6,041,782 to Angadjivand et al., U.S. Pat. No. 4,807,619 to Dyrud et al., and U.S. Pat. No. 4,536,440 to Berg.

[0005] Flat-fold respirators—as their name implies—can be folded flat for shipping and storage. They also can be opened into a cup-shaped configuration for use. Examples of flat-fold respirators are shown in U.S. Pat. Nos. 6,568,392 and 6,484,722 to Bostock et al., and U.S. Pat. No. 6,394,090 to Chen.

[0006] Although flat-fold respirators are convenient in that they can be folded flat for shipping and storage, persons using these respirators must take care to ensure that the mask body is properly opened into its in-use configuration. If the mask is so opened properly, for example, if some of the pleats remain closed, the respirator may not make full use of its available surface area for filtering. Such a situation could cause an increase in pressure drop or a decrease in product service life. The mask body also may not be fully spaced from the wearer's face, making the respirator touch the wearer's face, causing comfort issues.

SUMMARY OF THE INVENTION

[0007] The present invention provides a filtering face-piece respirator that comprises a harness and a mask body that has a filtering structure that contains one or more pleats. The mask body has an indicia located within the pleat(s) in at least a partially non-visible location when the pleat is folded. The indicia is made from a weld pattern and is fully visible when the pleat is unfolded.

[0008] The present invention is beneficial in that the fully visible indicia provides an indication to the wearer that the mask body is in its properly unfolded condition. When the indicia is hidden or non-visible, the wearer is, in effect, notified that the mask body is not in its proper open configuration for use. The wearer can then make adjustments to the mask body to cause the pleat to become fully opened so that the full surface area of the mask body can be available for filtration. The indicia, because it is welded into the pleated filtering structure also assists in keeping the pleat in its open configuration once expanded. The weld pattern can provide a beam-type affect across the pleat which assists in keeping it open.

Glossary

[0009] The terms set forth below will have the meanings as defined:

[0010] "comprises (or comprising)" means its definition as is standard in patent terminology, being an open-ended term that is generally synonymous with "includes", "having", or "containing" Although "comprises", "includes", "having", and "containing" and variations thereof are commonly-used, open-ended terms, this invention also may be suitably described using narrower terms such as "consists essentially of", which is semi open-ended term in that it excludes only those things or elements that would have a deleterious effect on the performance of the inventive respirator in serving its intended function;

[0011] "clean air" means a volume of atmospheric ambient air that has been filtered to remove contaminants;

[0012] "contaminants" means particles (including dusts, mists, and fumes) and/or other substances that generally may not be considered to be particles (e.g., organic vapors, et cetera) but which may be suspended in air;

[0013] "crosswise dimension" is the dimension that extends laterally across the respirator, from side-to-side when the respirator is viewed from the front;

[0014] "cup-shaped configuration" means any vessel-type shape that is capable of adequately covering the nose and mouth of a person;

[0015] "exterior gas space" means the ambient atmospheric gas space into which exhaled gas enters after passing through and beyond the mask body and/or exhalation valve;

[0016] "filtering face-piece" means that the mask body itself is designed to filter air that passes through it; there are no separately identifiable filter cartridges or insert-molded filter elements attached to or molded into the mask body to achieve this purpose;

[0017] "filter" or "filtration layer" means one or more layers of air-permeable material, which layer(s) is adapted for the primary purpose of removing contaminants (such as particles) from an air stream that passes through it;

[0018] "filter media" means an air-permeable structure that is designed to remove contaminants from air that passes through it;

[0019] "filtering structure" means a generally air-permeable construction that filters air;

[0020] "first side" means an area of the mask body that is located on one side of a plane that bisects the mask body normal to the cross-wise dimension;

[0021] "flange" means a protruding part that imparts structural integrity or strength to the body from which it protrudes;

[0022] "folded inwardly" means being bent back towards the part from which extends;

[0023] "frontally" means extending away from the mask body perimeter;

[0024] "harness" means a structure or combination of parts that assists in supporting the mask body on a wearer's face;

[0025] "hidden" means not visible or only partially visible;

[0026] "integral" means being manufactured together at the same time; that is, being made together as one part and not two separately manufactured parts that are subsequently joined together;

[0027] "interior gas space" means the space between a mask body and a person's face;

[0028] "leading edge" an unattached edge;

[0029] "line of demarcation" means a fold, seam, weld line, bond line, stitch line, hinge line, and/or any combination thereof;

[0030] "major portion" means the cup-shaped portion of the mask body;

[0031] "mask body" means an air-permeable structure that is designed to fit over the nose and mouth of a person and that helps define an interior gas space separated from an exterior gas space (including the seams and bonds that join layers and parts thereof together);

[0032] "match" means to substantially follow a similar path as;

[0033] "nose clip" means a mechanical device (other than a nose foam), which device is adapted for use on a mask body to improve the seal at least around a wearer's nose;

[0034] "perimeter" means the outer edge of the mask body, which outer edge would be disposed generally proximate to a wearer's face when the respirator is being donned by a person;

[0035] "pleat" means a portion that is designed to be or is folded back upon itself;

[0036] "polymeric" and "plastic" each mean a material that mainly includes one or more polymers and that may contain other ingredients as well;

[0037] "plurality" means two or more;

[0038] "respirator" means an air filtration device that is worn by a person to provide the wearer with clean air to breathe;

[0039] "second side" means an area of the mask body that is located on one side of a plane that bisects the mask body normal to the cross-wise dimension (the second side being opposite the first side);

[0040] "snug fit" or "fit snugly" means that an essentially air-tight (or substantially leak-free) fit is provided (between the mask body and the wearer's face);

[0041] "tab" means a part that exhibits sufficient surface area for attachment of another component; and

[0042] "transversely extending" means extending generally in the crosswise dimension.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] FIG. **1** is a front perspective view of a flat-fold filtering face-piece respirator **10**, in accordance with the present invention, being worn on a person's face;

[0044] FIG. **2***a* is a top view of the respirator **10** of FIG. **1**, showing the upper pleat **19** in a folded condition ;

[0045] FIG. **2***b* is a top view of the respirator **10** shown in FIG. **1**, showing the upper pleat **19** in a opened configuration;

[0046] FIG. **3** is a cross-sectional view of the mask body **12** taken along lines **3-3** of FIG. **2***a;*

[0047] FIG. **4** is a cross-sectional view of the filtering structure **16** taken along lines **4-4** of FIG. **3**; and

[0048] FIG. **5** is a front view of the mask body **12**, which may be used in connection with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0049] In practicing the present invention, a filtering face-piece respirator is provided where an indicia made from a weld pattern and becomes fully visible when the pleat is unfolded. The fully visible pleat provides an indication to the wearer that the mask body is in its proper unfolded condition for use over a wearer's nose and mouth. The welded indicia is further beneficial in that it helps keep the pleated mask body in its expanded shape during use.

[0050] FIG. **1** shows an example of a filtering face-piece respirator **10** that may be used in connection with the present invention to provide clean air for the wearer to breathe. The filtering face-piece respirator **10** includes a mask body **12** and a harness **14**. The mask body **12** has a filtering structure **16** through which inhaled air must pass before entering the wearer's respiratory system. The filtering structure **16** removes contaminants from the ambient environment so that the wearer breathes clean air. The mask body **12** includes a top portion **18** and a bottom portion **20**. A welded indicia pattern **19** (in this instance it includes the capital letter "A") is seen on the top portion **18** when the mask body is opened in an in-use configuration. The indicia **19** becomes visible when the pleat **21** (FIGS. **2***a* and **2***b*) is unfolded. The top portion **18** and the bottom portion **20** are separated by a line of demarcation **22**. In this particular embodiment, the line of demarcation **22** is a fold or pleat that extends transversely across the central portion of the mask body from side-to-side. The mask body **12** also includes a perimeter **24** that includes an upper segment **24***a* and a lower segment **24***b*. The harness **14** also has a first and second straps **26** and **27** that are secured to a first flange **30***a*. The harness straps **26**, **27** each have first and second ends **29***a*, **29***b* that are secured to the first flange **30***a* in a spaced apart relationship so that the first strap **26** has a first segment that follows a path above the wearer's ear and the second strap **27** has a second segment that follows a path below the wearer's ear when the respirator is being donned. The straps **26**, **27** are each placed in tension when the respirator is donned, and such tension, particularly the tension on strap **27**, causes the flaps **30***a* to be folded downwardly into contact with the major portion **28** of mask body **12** during respirator use.

[0051] FIG. **2***a* shows the mask body **12** in a condition where the pleat **21** is folded thereby hiding the indicia **19** (FIGS. **1**, **2***b*) from view. A second flange **30***b* is shown on an opposing side **31***b* of the mask body **12** from side **31***a*. A plane **32** bisects the mask body **12** to define the first and second sides **31***a*, **31***b*. The flanges **30***a*, **30***b* can have welds or bonds **35** provided thereon to increase flange stiffness. The flanges

30*a*, **30***b* may be integrally or non-integrally connected to the major portion of the mask body **12** and may comprise one or more or all of the various layers that comprise the mask body filtering structure **16**. The mask body perimeter **24***a* also may have a series of bonds or welds **35** to join the various layers of the mask body **12** together. The perimeter therefore may not be very fluid permeable. The remainder of the filtering structure **16**—inwardly from the perimeter—may be fully fluid permeable over much of its extended surface, with the possible exception of areas where there are bonds, welds, or fold lines. The mask body **12** also includes first and second lines of demarcation **36***a*, **36***b* located on first and second sides of the mask body **12**. The first and second flanges **30***a*, **30***b* are joined to the mask body **12** at the first and second lines of demarcation **36***a*, **36***b* and may be rotated or folded about an axis generally parallel to these demarcation lines, respectively. The top portion **18** of the mask body **12** may include one or more pleat lines that extend from the first line of demarcation **36***a* to the second line of demarcation **36***b* transversely.

[0052] FIG. **2***b* shows the pleat **21** being opened so that the indicia **19** "A1" located therein can be seen. When the mask is in a non-use condition, the indicia **19** is located within the folded pleat **31** not visible from the exterior. Once the pleat **21** is opened, however, the indicia **19** is visible from the front of the mask body **12**. Having seen the indicia **19**, the wearer can be assured that the upper portion **18** of the mask body **12** is adequately opened and ready for use. Similar or other indicia may be used in the other pleats of the upper and lower portions **18** and **20** to provide indications that those pleats are in a full open position as well.

[0053] FIG. **3** illustrates an example of a pleated configuration of a mask body **12** in accordance with the present invention. As shown, the upper portion or panel **18** of the mask body **12** may include the inner pleat **21** in which the indicia **19** is hidden when the pleat **21** is folded. The upper panel **18** also has an outer pleat **38** and half of the outer fold **22**, which separates the upper portion **18** from the lower portion **20**. The lower portion or panel **20** of the mask body **12** may include pleats **42** and **44** and half of pleat **22**. Pleat **22** separates the upper and lower portions **18** and **20** of mask body **12**. The lower portion **20** of the mask body **12** may include less, more, or the same amount of filter media surface area as the upper portion **18**. The mask body **12** also may include a perimeter web that is secured to the mask body along its perimeter. The perimeter web may be folded over the mask body at the perimeter **24***a*, **24***b*. The perimeter web also may be an extension of an inner cover web folded and secured around the edge of **24***a* and **24***b*. A nose clip **56** (FIG. **5**) may be disposed on the upper portion **18** of the mask body centrally adjacent to the perimeter between the filtering structure **16** and the perimeter web. The nose clip **56** may be made from a pliable metal or plastic that is capable of being manually adapted by the wearer to fit the contour of the wearer's nose.

[0054] FIG. **4** shows that the filtering structure **16** may include one or more layers such as an inner cover web **58**, an outer cover web **60**, and a filtration layer **62**. The inner and outer cover webs **58** and **60** may be provided to protect the filtration layer **62** and to preclude fibers from the filtration layer **62** from coming loose and entering the mask interior. During respirator use, air passes sequentially through layers **60**, **62**, and **58** before entering the mask interior. The air that is disposed within the interior gas space of the mask body may then be inhaled by the wearer. When a wearer exhales, the air passes in the opposite direction sequentially through layers **58**, **62**, and **60**. Alternatively, an exhalation valve (not shown) may be provided on the mask body to allow exhaled air to be rapidly purged from the interior gas space to enter the exterior gas space without passing through filtering structure **16**. Typically, the cover webs **58** and **60** are made from a selection of nonwoven materials that provide a comfortable feel, particularly on the side of the filtering structure that makes contact with the wearer's face. The construction of various filter layers and cover webs that may be used in conjunction with the support structure of the present invention are described below in more detail. To improve wearer fit and comfort, an elastomeric face seal can be secured to the perimeter of the filtering structure **16**. Such a face seal may extend radially inward from the mask body perimeter to contact the wearer's face when the respirator is being donned. Examples of face seals are described in U.S. Pat. No. 6,568,392 to Bostock et al., U.S. Pat. No. 5,617,849 to Springett et al., and U.S. Pat. No. 4,600,002 to Maryyanek et al., and in Canadian Patent 1,296,487 to Yard. The mask body perimeter **24** also may be folded upon itself in the nose region to achieve a snug fit—see U.S. Patent Application Publication 2011/0315144A1. FIG. **5** shows the mask body **12** in an in-use configuration. During use, the pleat **19** on the major portion **28** of mask body **12** is opened so that the indicia "A1" is fully visible from a front view of the mask body **12**. The indicia **19** may include a combination of numerals and/or letters or any other characters suitable to be visible to a person when the pleat **19** is opened. The indicia **19** also may be a trademark such as the brand identifier of the respirator manufacturer. The indicia **19** therefore may be, for example, the trademark "3M", representing the company who makes the inventive respirator. The indicia **19** is made from a weld pattern that is disposed on the major portion **28** of the mask body **12**. The weld pattern can be made by welding the various layers that comprise the filtering structure **16**. The welding can be achieved using, for example, an ultrasonic welder, which causes the polymeric materials in the filtering layers and cover webs to melt and bond to each other. Weld lines may be created using ultrasonic welding in either a "plunge" or "rotary" welding process. In general, a vibrating horn on the ultrasonic welder causes the filtering structure **16** to compress, melt, and then solidify in a region that is against an anvil that contains the weld line pattern. This process can take a filtering structure **16** with an original thickness A and bond it together to a thickness C (thickness C being less than thickness A) in the regions of contact between the horn and anvil. In plunge welding, the horn and anvil typically come into contact in an up and down motion with the filtering structure **16** in-between these parts; while in rotary welding, the filtering structure **16** is continuously fed between the horn and anvil in a rotary fashion. Other means are possible to bond the filtering structure **16** into weld lines, such as using heat and pressure with appropriate tooling. Ultrasonic welders suitable for making the indicia, perimeter welds, and other weld lines include the ultrasonic welders sold by Emerson Industrial Automation under the Branson™ brand. The indicia includes at least one line **64** that extends across the fold line **66** of the pleat. The at least one line **64** that extends across the fold line **66** of the pleat **21** may be normal (or at least generally normal) to the fold line to improve the collapse resistance of the mask body **12**. The at least one line that extends normally across the fold line of the pleat is at least one centimeter long, more typically at least two cm long. The characters that comprise the indicia may be

a of the single solid line type or that may be of a parallel line configuration like the lines disclosed in U.S. Patent application 2011/0094515 A1 to Duffy. The parallel lines may be spaced apart by a distance of about 0.5 to 5 millimeters (mm) More preferably, the parallel weld lines are spaced apart about 1 to 4mm, and still more preferably are spaced apart at about 1.5 to 3 mm. Typically, the spaced parallel weld lines are at least 0.5 cm long, and more typically greater than 1 cm long. The indicia may be about 0.5 to 2 centimeters (cm) high by up to about 0.5 to 4 centimeters (cm) wide. More typically, the indicia **19** is about 1 to 2 cm high by 2 to 3 cm wide. The weld lines may be created such that the various layers of the filtering structure are fused together to stiffen those layers in the weld line. Three or more parallel weld lines also may be used in a spaced apart relationship to create two or more substantially continuous regions between the weld lines. The weld lines that comprise the indicia also may assist in keeping the pleat in its unfolded condition for use to increase collapse resistance of the respirator mask body. Increased densification in the weld lines and in regions disposed between closed welded areas may improve the beam stiffness and hence the collapse resistance of the major portion **28** of mask body **12**. The region between each of the weld lines may be densified such that the thickness of the plurality of layers of the nonwoven material between the weld lines is less than the thickness of those layers outside the weld lines. The thickness of the layer(s) of nonwoven fibrous media that comprise the filtering structure **16** typically has a thickness of about 0.3 mm to 5 mm, more typically about 0.5 mm to 2.0 mm, and still more typically about 0.75 mm to 1.5 mm. If parallel weld lines are used, each individual weld line in the parallel set may have a width dimension that may be about 0.5 to 2 mm wide, more commonly about 0.75 to 1.5 mm wide. The total width of single or parallel weld lines (taken in combination) typically is about 1.5 mm to 7.0 mm, more typically is about 2.0 mm to 5 mm, and still more typically is about 2.5 mm to 4.0 mm.

The Filtering Structure

[0055] The filtering structure that is used in connection with the present invention may take on a variety of different shapes and configurations. The filtering structure typically is adapted so that it properly fits against or within the support structure. Generally the shape and configuration of the filtering structure corresponds to the general shape of the mask body. Although a filtering structure has been illustrated with multiple layers that include a filtration layer and two cover webs, the filtering structure may simply comprise a filtration layer or a combination of filtration layers. For example, a pre-filter may be disposed upstream to a more refined and selective downstream filtration layer. Additionally, sorptive materials such as activated carbon may be disposed between the fibers and/or various layers that comprise the filtering structure. Further, separate particulate filtration layers may be used in conjunction with sorptive layers to provide filtration for both particulates and vapors. The filtering structure may include one or more stiffening layers that assist in providing a cup-shaped configuration. The filtering structure also could have one or more horizontal and/or vertical lines of demarcation that contribute to its structural integrity. The first and second flanges when used in accordance with the present invention, however, may make unnecessary the need for such stiffening layers and lines of demarcation.

[0056] The filtering structure that is used in a mask body of the invention can be of a particle capture or gas and vapor type filter. The filtering structure also may be a barrier layer that prevents the transfer of liquid from one side of the filter layer to another to prevent, for instance, liquid aerosols or liquid splashes (e.g. blood) from penetrating the filter layer. Multiple layers of similar or dissimilar filter media may be used to construct the filtering structure of the invention as the application requires. Filters that may be beneficially employed in a layered mask body of the invention are generally low in pressure drop (for example, less than about 195 to 295 Pascals at a face velocity of 13.8 centimeters per second) to minimize the breathing work of the mask wearer. Filtration layers additionally may be flexible and may have sufficient shear strength so that they generally retain their structure under the expected use conditions. Examples of particle capture filters include one or more webs of fine inorganic fibers (such as fiberglass) or polymeric synthetic fibers. Synthetic fiber webs may include electret-charged, polymeric microfibers that are produced from processes such as meltblowing. Polyolefin microfibers formed from polypropylene that has been electrically-charged provide particular utility for particulate capture applications. An alternate filter layer may comprise a sorbent component for removing hazardous or odorous gases from the breathing air. Sorbents may include powders or granules that are bound in a filter layer by adhesives, binders, or fibrous structures—see U.S. Pat. No. 6,334,671 to Springett et al. and U.S. Pat. No. 3,971,373 to Braun. A sorbent layer can be formed by coating a substrate, such as fibrous or reticulated foam, to form a thin coherent layer. Sorbent materials may include activated carbons that are chemically treated or not, porous alumna-silica catalyst substrates, and alumna particles. An example of a sorptive filtration structure that may be conformed into various configurations is described in U.S. Pat. No. 6,391,429 to Senkus et al.

[0057] The filtration layer is typically chosen to achieve a desired filtering effect. The filtration layer generally will remove a high percentage of particles and/or or other contaminants from the gaseous stream that passes through it. For fibrous filter layers, the fibers selected depend upon the kind of substance to be filtered and, typically, are chosen so that they do not become bonded together during the molding operation. As indicated, the filtration layer may come in a variety of shapes and forms and typically has a thickness of about 0.2 millimeters (mm) to 1 centimeter (cm), more typically about 0.3 mm to 0.5 cm, and it could be a generally planar web or it could be corrugated to provide an expanded surface area—see, for example, U.S. Pat. Nos. 5,804,295 and 5,656,368 to Braun et al. The filtration layer also may include multiple filtration layers joined together by an adhesive or any other means. Essentially any suitable material that is known (or later developed) for forming a filtering layer may be used as the filtering material. Webs of melt-blown fibers, such as those taught in Wente, Van A., *Superfine Thermoplastic Fibers,* 48 Indus. Engn. Chem., 1342 et seq. (1956), especially when in a persistent electrically charged (electret) form are especially useful (see, for example, U.S. Pat. No. 4,215,682 to Kubik et al.). These melt-blown fibers may be microfibers that have an effective fiber diameter less than about 20 micrometers (μm) (referred to as BMF for "blown microfiber"), typically about 1 to 12 μm. Effective fiber diameter may be determined according to Davies, C. N., *The Separation Of Airborne Dust Particles,* Institution Of Mechanical Engineers, London, Proceedings 1B, 1952. Particularly preferred

are BMF webs that contain fibers formed from polypropylene, poly(4-methyl-l-pentene), and combinations thereof. Electrically charged fibrillated-film fibers as taught in van Turnhout, U.S. Pat. No. Re. 31,285, also may be suitable, as well as rosin-wool fibrous webs and webs of glass fibers or solution-blown, or electrostatically sprayed fibers, especially in microfilm form. Electric charge can be imparted to the fibers by contacting the fibers with water as disclosed in U.S. Pat. No. 6,824,718 to Eitzman et al., U.S. Pat. No. 6,783,574 to Angadjivand et al., U.S. Pat. No. 6,743,464 to Insley et al., U.S. Pat. Nos. 6,454,986 and 6,406,657 to Eitzman et al., and U.S. Pat. Nos. 6,375,886 and 5,496,507 to Angadjivand et al. Electric charge also may be imparted to the fibers by corona charging as disclosed in U.S. Pat. No. 4,588,537 to Klasse et al. or by tribocharging as disclosed in U.S. Pat. No. 4,798,850 to Brown. Also, additives can be included in the fibers to enhance the filtration performance of webs produced through the hydro-charging process (see U.S. Pat. No. 5,908,598 to Rousseau et al.). Fluorine atoms, in particular, can be disposed at the surface of the fibers in the filter layer to improve filtration performance in an oily mist environment—see U.S. Pat. Nos. 6,398,847 B1, 6,397,458 B1, and 6,409,806 B1 to Jones et al. Typical basis weights for electret BMF filtration layers are about 10 to 100 grams per square meter. When electrically charged according to techniques described in, for example, the '507 Angadjivand et al. patent, and when including fluorine atoms as mentioned in the Jones et al. patents, the basis weight may be about 20 to 40 g/m^2 and about 10 to 30 g/m^2, respectively.

[0058] An inner cover web can be used to provide a smooth surface for contacting the wearer's face, and an outer cover web can be used to entrap loose fibers in the mask body or for aesthetic reasons. The cover web typically does not provide any substantial filtering benefits to the filtering structure, although it can act as a pre-filter when disposed on the exterior (or upstream to) the filtration layer. To obtain a suitable degree of comfort, an inner cover web preferably has a comparatively low basis weight and is formed from comparatively fine fibers. More particularly, the cover web may be fashioned to have a basis weight of about 5 to 50 g/m^2 (typically 10 to 30 g/m^2), and the fibers may be less than 3.5 denier (typically less than **2** denier, and more typically less than 1 denier but greater than 0.1). Fibers used in the cover web often have an average fiber diameter of about 5 to 24 micrometers, typically of about 7 to 18 micrometers, and more typically of about 8 to 12 micrometers. The cover web material may have a degree of elasticity (typically, but not necessarily, 100 to 200% at break) and may be plastically deformable.

[0059] Suitable materials for the cover web may be blown microfiber (BMF) materials, particularly polyolefin BMF materials, for example polypropylene BMF materials (including polypropylene blends and also blends of polypropylene and polyethylene). A suitable process for producing BMF materials for a cover web is described in U.S. Pat. No. 4,013,816 to Sabee et al. The web may be formed by collecting the fibers on a smooth surface, typically a smooth-surfaced drum or a rotating collector—see U.S. Pat. No. 6,492,286 to Berrigan et al. Spun-bond fibers also may be used.

[0060] A typical cover web may be made from polypropylene or a polypropylene/polyolefin blend that contains **50** weight percent or more polypropylene. These materials have been found to offer high degrees of softness and comfort to the wearer and also, when the filter material is a polypropylene BMF material, to remain secured to the filter material without requiring an adhesive between the layers. Polyolefin materials that are suitable for use in a cover web may include, for example, a single polypropylene, blends of two polypropylenes, and blends of polypropylene and polyethylene, blends of polypropylene and poly(4-methyl-1-pentene), and/or blends of polypropylene and polybutylene. One example of a fiber for the cover web is a polypropylene BMF made from the polypropylene resin "Escorene 3505G" from Exxon Corporation, providing a basis weight of about 25 g/m^2 and having a fiber denier in the range 0.2 to 3.1 (with an average, measured over 100 fibers of about 0.8). Another suitable fiber is a polypropylene/polyethylene BMF (produced from a mixture comprising 85 percent of the resin "Escorene 3505G" and 15 percent of the ethylene/alpha-olefin copolymer "Exact 4023" also from Exxon Corporation) providing a basis weight of about 25 g/m^2 and having an average fiber denier of about 0.8. Suitable spunbond materials are available, under the trade designations "Corosoft Plus 20", "Corosoft Classic 20" and "Corovin PP-S-14", from Corovin GmbH of Peine, Germany, and a carded polypropylene/viscose material available, under the trade designation "3 70/15", from J. W. Suominen OY of Nakila, Finland.

[0061] Cover webs that are used in the invention preferably have very few fibers protruding from the web surface after processing and therefore have a smooth outer surface. Examples of cover webs that may be used in the present invention are disclosed, for example, in U.S. Pat. No. 6,041,782 to Angadjivand, U.S. Pat. No. 6,123,077 to Bostock et al., and WO 96/28216A to Bostock et al.

Respirator Components

[0062] The strap(s) that are used in the harness may be made from a variety of materials, such as thermoset rubbers, thermoplastic elastomers, braided or knitted yarn/rubber combinations, inelastic braided components, and the like. The strap(s) may be made from an elastic material such as an elastic braided material. The strap preferably can be expanded to greater than twice its total length and be returned to its relaxed state. The strap also could possibly be increased to three or four times its relaxed state length and can be returned to its original condition without any damage thereto when the tensile forces are removed. The elastic limit thus is preferably not less than two, three, or four times the length of the strap when in its relaxed state. Typically, the strap(s) are about 20 to 30 cm long, 3 to 10 mm wide, and about 0.9 to 1.5 mm thick. The strap(s) may extend from the first tab to the second tab as a continuous strap or the strap may have a plurality of parts, which can be joined together by further fasteners or buckles. For example, the strap may have first and second parts that are joined together by a fastener that can be quickly uncoupled by the wearer when removing the mask body from the face. An example of a strap that may be used in connection with the present invention is shown in U.S. Pat. No. 6,332,465 to Xue et al. Examples of fastening or clasping mechanism that may be used to joint one or more parts of the strap together is shown, for example, in the following U.S. Pat. No. 6,062,221 to Brostrom et al., U.S. Pat. No. 5,237,986 to Seppala, and EP1,495,785A1 to Chien. The harness also may be in the form of a reusable carriage or an adhesive layer that is provided on the internal surface of the perimeter.

[0063] As indicated, an exhalation valve may be attached to the mask body to facilitate purging exhaled air from the interior gas space. The use of an exhalation valve may improve wearer comfort by rapidly removing the warm moist

exhaled air from the mask interior. See, for example, U.S. Pa. Nos. 7,188,622, 7,028,689, and 7,013,895 to Martin et al.; U.S. Pat. Nos. 7,428,903, 7,311,104, 7,117,868, 6,854,463, 6,843,248, and 5,325,892 to Japuntich et al.; U.S. Pat. No. 6,883,518 to Mittelstadt et al.; and RE37,974 to Bowers. Essentially any exhalation valve that provides a suitable pressure drop and that can be properly secured to the mask body may be used in connection with the present invention to rapidly deliver exhaled air from the interior gas space to the exterior gas space.

[0064] A nose clip that is used in the present invention may be essentially any additional part that assists in improving the fit over the wearer's nose. Because the wearer's face exhibits in the nose region, a nose clip may be used to better assist in achieving the appropriate fit in this location. The nose clip may comprise, for example, a pliable dead soft band of metal such as aluminum, which can be shaped to hold the mask in a desired fitting relationship over the nose of the wearer and where the nose meets the cheek. An example of a suitable nose clip is shown in U.S. Pat. No. 5,558,089 and Des. 412, 573 to Castiglione. Other nose clips are described in U.S. patent application Ser. No. 12/238,737 (filed Sep. 26, 2008); U.S. Publications 2007-0044803A1 (filed Aug. 25, 2005); and 2007-0068529A1 (filed Sep. 27, 2005).

[0065] This invention may take on various modifications and alterations without departing from its spirit and scope. Accordingly, this invention is not limited to the above-described but is to be controlled by the limitations set forth in the following claims and any equivalents thereof

[0066] This invention also may be suitably practiced in the absence of any element not specifically disclosed herein.

[0067] All patents and patent applications cited above, including those in the Background section, are incorporated by reference into this document in total. To the extent there is a conflict or discrepancy between the disclosure in such incorporated document and the above specification, the above specification will control.

What is claimed is:

1. A filtering face-piece respirator that comprises:

(a) a harness; and

(b) a mask body that has a filtering structure that contains one or more pleats, a welded indicia is located within the pleat(s) in at least a partially non-visible location when the pleat is folded, the indicia being fully visible when the pleat is unfolded.

2. The filtering face-piece respirator of claim **1**, wherein the indicia includes at least one line that extends across the fold line of the pleat.

3. The filtering face-piece respirator of claim **2**, wherein the at least one line that extends across the fold line of the pleat is normal to the fold line.

4. The filtering face-piece respirator of claim **3**, wherein the at least one line that extends normally across the fold line of the pleat is at least one centimeter long.

5. The filtering face-piece respirator of claim **4**, wherein the at least one line that extends normally across the fold line of the pleat is at least two cm long.

6. The filtering face-piece respirator of claim **5**, wherein the at least one line that extends normally across the fold line of the pleat includes at least two closely-spaced parallel weld lines.

7. The filtering face-piece respirator of claim **6**, wherein the indicia comprises a trademark of the respirator manufacturer.

8. The filtering face-piece respirator of claim **5**, wherein the indicia includes a numeral, a letter, or a combination thereof

9. The filtering face-piece respirator of claim **2**, wherein the filtering structure comprises a plurality of layers which includes a filtering layer and first and second cover webs, and wherein the indicia is a weld pattern that is made by welding the plurality of layers that comprise the filtering structure together.

10. The filtering face-piece respirator of claim **2**, wherein the indicia comprises closely-spaced parallel lines that are spaced apart by a distance of about 0.5 to 5 millimeters (mm), the spaced parallel weld lines are at least 1 cm in length, and wherein the indicia is 0.5 to 2 centimeters (cm) high by up to about 0.5 to 4 centimeters (cm) wide.

11. The filtering face-piece respirator of claim **2**, wherein the total width of single or a parallel set of weld lines is 1.5 mm to 7.0 mm.

12. The filtering face-piece respirator of claim **5**, wherein the indicia is ultrasonically welded into the filtering structure, and wherein the indicia is 1 to 2 cm high by 2 to 3 cm wide.

13. The filtering face-piece respirator of claim **6**, wherein the region between each of the weld lines may be densified such that the thickness of the plurality of layers of the nonwoven material between the parallel weld lines is less than the thickness of those layers outside the weld lines.

14. The filtering face-piece respirator of claim **2**, wherein the mask body comprises a plurality of transversely extending pleats, and wherein there is a indicia in the plurality of pleats.

15. The filtering face-piece respirator of claim **2**, wherein the indicia is located in a pleat that extends transversely across the mask body from a first side to a second side.

16. A filtering face-piece respirator that comprises:

(a) a harness; and

(b) a mask body that has a filtering structure that comprises a plurality of layers, which plurality of layers includes a filtering layer and first and second cover webs, the filtering structure also containing one or more transversely-extending pleats, a welded indicia is located within the pleat(s) in at least a partially non-visible location when the pleat is folded, the indicia being fully visible when the pleat is unfolded, wherein the welded indicia is made by welding the plurality of layers that comprise the filtering structure together, and wherein the indicia comprises at least line that is at least one centimeter long and extends across the pleat normally thereto.

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