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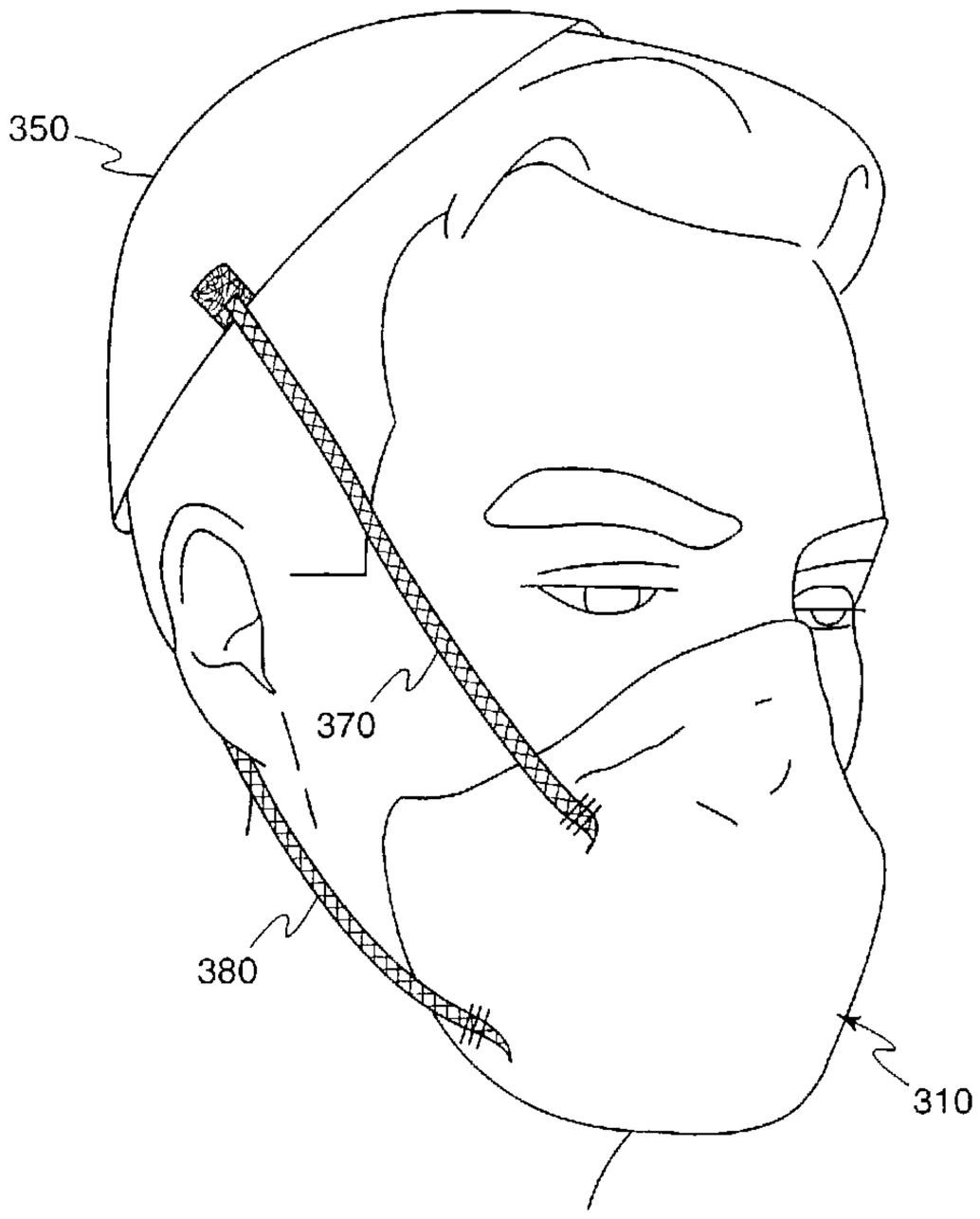
(54) Title: HALF-MASK RESPIRATOR WITH HEAD HARNESS ASSEMBLY



(57) Abrégé/Abstract:
A half-mask respirator is retained on a wearer's head by upper and lower straps and a strap support. The upper and lower straps connect to the strap support at upper and lower strap attachment points on each side of the strap support. The distances between the attachment points on each opposing side of the strap support are fixed when the strap support is located on the wearer's skull and the half-mask respirator is mounted over the wearer's nose and mouth. As a result, the lower strap is supported above the neck of the wearer which eliminates a potential source of discomfort for the wearer.

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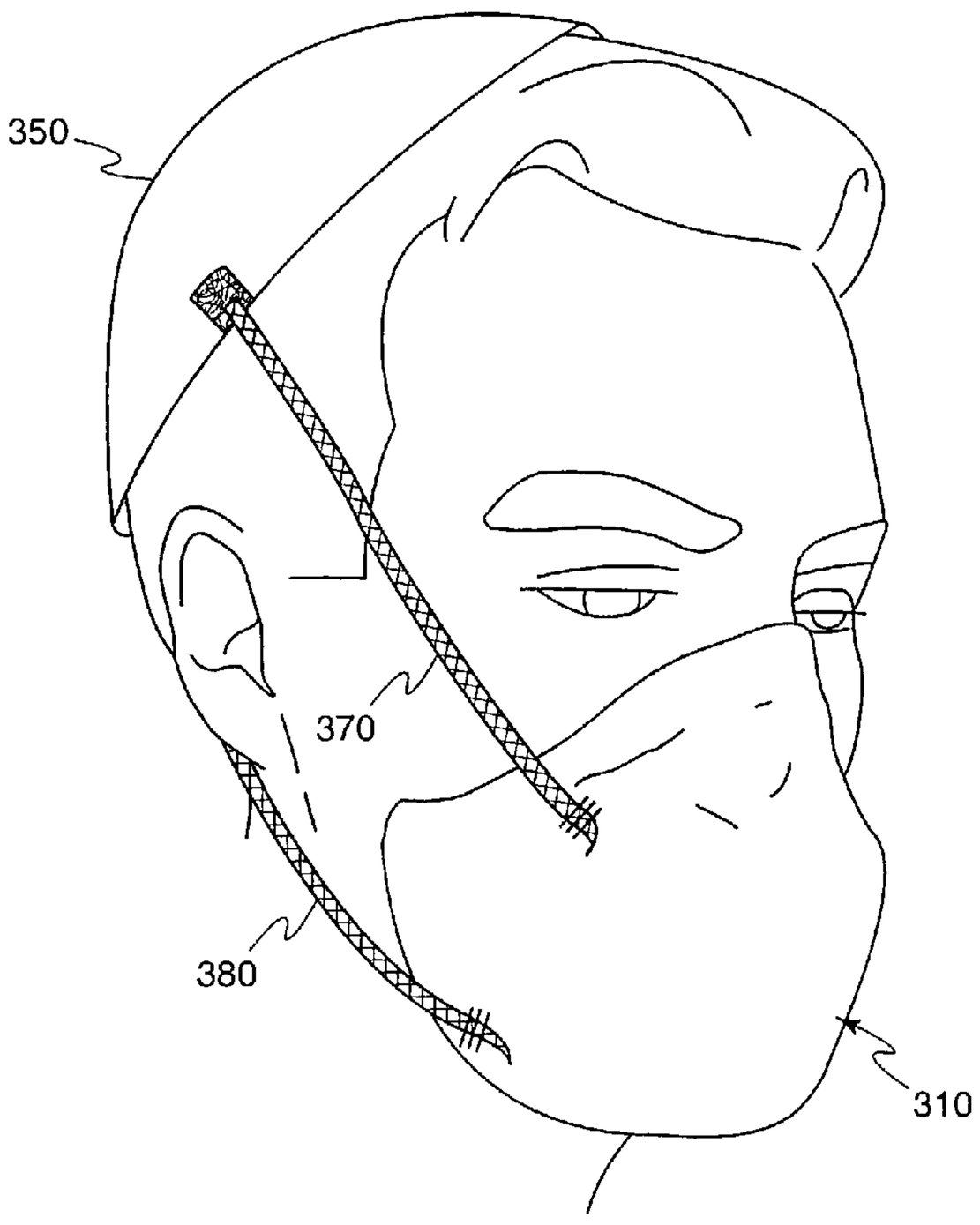
(54) Title: HALF-MASK RESPIRATOR WITH HEAD HARNESS ASSEMBLY



(57) Abstract: A half-mask respirator is retained on a wearer's head by upper and lower straps and a strap support. The upper and lower straps connect to the strap support at upper and lower strap attachment points on each side of the strap support. The distances between the attachment points on each opposing side of the strap support are fixed when the strap support is located on the wearer's skull and the half-mask respirator is mounted over the wearer's nose and mouth. As a result, the lower strap is supported above the neck of the wearer which eliminates a potential source of discomfort for the wearer.

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HALF-MASK RESPIRATOR WITH HEAD HARNESS ASSEMBLY

Background

The present invention generally relates to respirators, and more particularly, to a half-mask respirator including a head harness assembly having pairs of upper and lower straps connected to a strap support.

Half-mask respirators (sometimes referred to as "face masks") are worn over the mouth and nose, but not eyes, of a person for two common purposes: (1) to prevent impurities or contaminants from entering the wearer's breathing tract; and/or (2) to protect others 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 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 a high risk of infection, for example, in an operating room.

To accomplish either of these purposes, a snug fit to the wearer's face must be maintained. The desired fit is achieved in many half-mask respirators by using a pair of straps, with a first strap extending laterally from the respirator body around the back of the wearer's head above the ears and a second strap extending laterally from the respirator body around the back of the wearer's neck.

One problem with this design is that the strap that extends around the wearer's neck can irritate the wearer. The irritation is caused by the strap rubbing against the wearer's skin as the wearer's head rotates from side-to-side. That irritation is undesirable because of the negative affect it can have on the wearer's motivation to use the respirator as directed. For example, if the lower strap is loosened to reduce the irritation, improper tension from strap may exert forces that skew the mask from its intended wearing configuration. This can cause leaks around the respirator perimeter, creating potential safety concerns.

Summary of the Invention

The present invention provides a half-mask respirator that is retained on a wearer's head by a head harness assembly including upper and lower straps and a strap support. The upper and lower straps connect to the strap support at upper and lower strap attachment points on each side of the strap support. The distances between the attachment points on each side of the strap support are fixed when the strap support is located on the wearer's skull and the half-mask respirator is mounted over the wearer's nose and mouth. Because the distances between the upper and lower straps are fixed by the strap support, the lower strap can be supported above the wearer's neck to eliminate a potential source of discomfort for the wearer.

The respirator body of the half-mask respirators of the invention can take many different forms. For example, the respirator body can be provided in a drop down configuration that may or may not include a carriage. The respirator body may be provided in the form of a porous filtering face mask or it may be a respirator including a non-porous body and filter cartridges.

In all embodiments, however, the half-mask respirators of the invention include the strap support and upper and lower straps in a configuration that removes the lower strap from the back of the wearer's neck when the half-mask respirator is in position over the wearer's nose and mouth.

In those embodiments in which at least one pair of support straps is removably attached to the strap support, one advantage of the present invention is that the respirator body is capable of being retained at multiple positions without completely removing the half-mask respirator. The respirator body is able to be retained at a first position covering the nose and mouth of the wearer and at a second position dropped down from the face of the wearer without moving the strap support from the head of the wearer. The half-mask respirator may hang near the user's body in the dropped down position. This is advantageous in situations where the user needs access to his or her mouth and does not have to take the time to set the half-mask respirator down and re-don the half-mask respirator when needed. Also, the half-mask respirator is out of the user's way when hanging near

the body, thereby allowing substantially unobstructed working conditions. This flexibility saves time and protects the half-mask respirator and accompanying filters from contamination. In addition, the half-mask respirator is easily adjusted and conforms to multiple facial configurations.

Another advantage is that the half-mask respirator may be retained against the face of the wearer at four points by the upper and lower straps of the head harness assembly. Such a four point seal can provide greater protection against contaminants.

In brief summary, in one aspect, the present invention provides a half-mask respirator that includes a body configured to cover the nose and mouth of the wearer. The respirator also includes a strap support located on the wearer's skull when the respirator body is in position over the nose and mouth of the wearer. The respirator body is held in place by at least two upper straps that extend from opposite sides of an upper portion of the respirator body to opposing sides of the strap support, the upper straps connected to the strap support at upper strap attachment points. Also holding the respirator body in place are at least two lower straps that extend from opposite sides of a lower portion of the respirator body to opposing sides of the strap support, the lower straps connected to the strap support at lower strap attachment points. The distances between the upper and lower strap attachment points on each opposing side of the strap support are fixed when the strap support is located on the wearer's skull and the respirator body is in position over the nose and mouth of the wearer. As a result, the lower straps do not extend around the back of the wearer's neck.

In brief summary, in another aspect, the present invention provides a half-mask respirator that includes a body configured to cover the nose and mouth of the wearer. The respirator also includes a support crown located on the wearer's skull when the respirator body is in position over the nose and mouth of the wearer. The respirator body is held in place by at least two upper straps that extend from opposite sides of an upper portion of the respirator body to opposing sides of the support crown, the upper straps connected to the support crown at upper strap attachment points. Also holding the respirator body in place are at least two lower

straps that extend from opposite sides of a lower portion of the respirator body to opposing sides of the support crown, the lower straps connected to the support crown at lower strap attachment points. The distances between the upper and lower strap attachment points on each opposing side of the support crown are fixed when the support crown is located on the wearer's skull and the respirator body is in position over the nose and mouth of the wearer. As a result, the lower straps do not extend around the back of the wearer's neck. Additionally, the lower straps are connected to the respirator body below support crown when the support crown is located on the wearer's skull and the respirator body is in position over the nose and mouth of the wearer.

These features of novelty and various other advantages which characterize the invention are pointed out with particularity in the claims annexed hereto and forming a part hereof. However, for a better understanding of the invention and its advantages, reference should be made to the drawings which form a further part hereof, and to the accompanying descriptive matter, in which illustrative embodiments of the invention are described.

Brief Description of the Drawings

FIG. 1 shows a front perspective view of one half-mask respirator **100** according to the principles of the present invention;

FIG. 2 shows a perspective view of a carriage **26** detached from the half-mask respirator **100**;

FIG. 3 shows a perspective view of the half-mask respirator **100** of FIG. 1 in the dropped down position on a wearer.

FIG. 4 shows a perspective view of another half-mask respirator **110** attached to a strap support **150** that is, in turn, attached to a hard hat **151** according to the present invention.

FIG. 5 illustrates another embodiment of a strap support **250** for use with the half-mask respirators of the present invention.

FIG. 6 illustrates an another half-mask respirator **310** attached to a strap support **350** according to the present invention.

Detailed Description of Illustrative Embodiments of the Invention

Illustrative embodiments of the invention will be described in detail with reference to the drawings, wherein like reference numerals represent like parts and assemblies throughout the several views. Reference to these illustrative embodiments does not limit the scope of the invention, which is limited only by the scope of the claims attached hereto.

In general, the present invention relates to a half-mask respirator with a head harness assembly that includes upper and lower straps for retaining the half-mask respirator on a wearer's head. More particularly, the present invention relates to a half-mask respirator that is retained on a wearer by upper and lower straps and a strap support. The upper and lower straps connect to the strap support at upper and lower strap attachment points on each side of the strap support.

Although the half-mask respirators of the present invention are described as having pairs of upper and lower support straps that extend from a respirator body to a strap support, it should be understood that a single continuous integral strap body may be used to provide two or more of the upper and/or lower straps. As used in connection with the invention, "strap" means a section of one continuous elongate strap body that is attached at the respirator body at one end and which extends to the strap support where it is attached at its opposite end to provide a force that holds the respirator body in position against a wearer's face. Each strap body may continue past any one of the attachment points on either respirator body or the strap support, as long as that section of the strap body located between the corresponding attachment points on the respirator body and the strap support supplies the desired retention force.

Referring now to FIGS. 1 and 2, a half-mask respirator generally shown as **100**, is configured to fit over the mouth and nose of a wearer. The half-mask respirator **100** has a respirator body **10**. Many such respirator bodies are known, such as the Series 6000™ by Minnesota Mining and Manufacturing Company, the 5500 by North Safety Products, and the Advantage 200 by MSA. The illustrated respirator body has a seal portion **12** and a central portion **14**. The seal portion **12**

is configured to provide a seal against the wearer's face. The seal portion **12** may be constructed of rubber-like material and may also be generally contoured to serve as a sealing surface. The central portion **14** may be constructed of rigid material and to serve as a support for the seal portion **12**.

An exhalation port **16** is typically located on the central portion **14**. A lip member **18** may be located on the outer circumferential wall of the exhalation port **16**. The lip member **18** is recessed away from the respirator body **10**. The lip member **18** may have four grooves **19** located on the outer wall. A valve **20** is positioned across the outside of exhalation port **16** such that the valve **20** covers the entire port **16**, thereby forming a substantially airtight seal. The valve **20** acts as a one-way valve, allowing air to exit out of the respirator body, but preventing air from entering the respirator body when the wearer breathes in. Such valves are well understood in the art.

Inhalation ports **22a** and **22b** are typically disposed on opposite sides of the exhalation port **16**. Inhalation valves **23a** and **23b** are located across ports **22a** and **22b**, respectively, thereby forming a substantially airtight seal. The inhalation valves **23a** and **23b** act as a one-way valve allowing air to enter the respirator body when the wearer breathes in, but preventing air from escaping the respirator body when the wearer exhales. Inhalation seals **24a** and **24b** are located within inhalation ports **22a** and **22b** and proximal to inhalation valves **23a** and **23b**, respectively. Inhalation seals **24a** and **24b** seal off the inhalation ports **22a** and **22b** such that substantially all inhaled air passes through inhalation valves **23a** and **23b**, respectively. Filters (not shown) may be placed over the inhalation ports **22a** and **22b** to remove particulates, vapors, aerosols, or other toxins from incoming air as is well known in the art. The particular filter may take a variety of different forms depending upon the impurities to be filtered. For example, a filter cartridge, as is well known in the art, is attached to each inhalation port, thereby providing filtering capabilities.

A carriage **26** is associated with the respirator body **10**. The carriage may be permanently or detachably connected to the respirator body. In a preferred embodiment, the carriage **26** is configured to substantially match the contours of the

respirator body **10**, such that the carriage fits over the respirator body **10**. The carriage **26** is removably connected to the respirator body **10** by conventional connecting means. The carriage **26** is constructed of substantially rigid material such as plastic. A port **28** is located on the carriage **26** such that the air exiting the exhalation port **16** is channeled through the port **28**.

In one configuration, the port **28** is located to align with the exhalation port **16** of the respirator body **10**. A lip member **30** is located on the outer circumferential wall of the port **28**. The lip member **30** has four protrusions **31** located on the inner circumferential wall of the lip member **30**. The protrusions **31** are configured to connect with the grooves **19** of the lip member **18**, thereby connecting the respirator body **10** and the carriage **26**. The size of the lip **18**, grooves **19**, lip **30**, and protrusions **31** are designed such that the respirator body **10** snaps into the carriage **26** to form an attachment. The attachment is such that a force encountered under ordinary working conditions will not disengage the carriage **26** from the respirator body **10**. The respirator body **10** and the carriage **26** are detached by manually forcing the carriage **26** away from the respirator body **10**. Other conventional attachment means can be used and the present invention is not limited to the lip-to-lip attachment system disclosed. For example, that attachment may involve a number of protrusions snapping into a complimentary number of recesses. Furthermore, the attachment system is not limited to being located on the exhalation or inhalation ports. The attachment systems allows for the attachment of different respirator bodies with different seal and filter characteristics to the carriage **26**.

The carriage **26** may be permanently or detachably connected to the respirator body **10**. In the illustrated embodiment, the carriage **26** is detachably connected to respirator body **10**. The carriage **26** has an upper portion **32** and a lower portion **34**. The upper portion **32** matches the shape of the respirator body **10** and angles back near the seal portion **12**. The lower portion **34** matches the general shape of the respirator body **10** and angles back near the seal portion **12**. The upper portion **32** has a first upper guide **36** and a second upper guide **38**. The lower portion **34** has a first lower guide **40** and a second lower guide **42**. The

guides are designed to accommodate a strap and may take the form of slots, eyelets, or any structure having a suitable opening that permits the strap to move within the opening.

The lower guides **40**, **42** are angled to permit the respirator body to be pulled in an up and down direction relative to the wearer's face and the strap(s) to be pulled about the wearer's head without substantially binding and consequently damaging the straps.

The first strap **44** and the second strap **46** have proximal and distal ends. The proximal ends of the first strap **44** and the second strap **46** are connected to a strap support in the form of a support crown **50**. The support crown **50** is generally oval shaped and configured to fit and conform to the head of the wearer. The support crown **50** may preferably be constructed of substantially flexible material to conform to the wearer's head. The support crown **50** may be designed such that protective head gear can be fitted over the support crown **50** without causing undue discomfort because it is often necessary to wear protective head gear, such as a hard hat, in conjunction with a half-mask respirator. Alternative strap supports can be used, with some alternative embodiments depicted in, e.g., FIGS. 4-6.

The first strap **44** and second strap **46** may be formed of elastic fabric material as is well known in the art. In an alternative embodiment, the straps may be formed of rigid materials that are flexibly connected to the support crown **50** so to provide resiliency.

The distal ends of the straps **44** and **46** connect to the support crown 50 behind the head of the wearer as will be described in connection with various embodiments below. This has the advantage of increased comfort, as straps more freely turn with head and support crown movement. This is advantageous when the movement of the support crown **50** is severely restricted, such as when the user is wearing protective head gear. If the distal ends of the straps **44** and **46** are connected to each other behind the wearer's neck as in conventional designs, the portions of the straps **44** and **46** located on the wearer's neck move relative to the skin. That relative movement can cause irritation and discomfort on the back of the head of the wearer.

Referring now to FIG. 3, the respirator body of the half-mask respirator **100** is dropped down to a position below the face of the wearer. The respirator body is dropped down by disconnecting straps **44** and **46** from the support crown (not shown). The respirator body can then be slid down straps **44** and **46** to a suitable position. The respirator body hangs near the wearer's body. The support crown remains on the wearer's head. With the body in the dropped down position, the wearer can perform tasks while having access to his or her mouth. Also, since the half-mask respirator hangs near the wearer's body, the wearer's view is relatively unobstructed.

When the filtered breathing is needed, the wearer simply slides the respirator body up to his or her nose and mouth and connects straps **44** and **46** to the support crown. This provides for quick donning which is highly advantageous. Often, environments become quickly contaminated, and the wearer must be able to quickly don the half-mask respirator. This is not possible where the wearer must retrieve the half-mask respirator, or where the wearer must spend time readjusting the straps.

FIG. 4 illustrates another half-mask respirator of the invention connected including a support crown **150** preferably attached to a hard hat **151** (that is partially cut-away in FIG. 4 to expose the support crown **150**). The respirator body **110** is attached to a pair of upper straps **170** that extend from the respirator body **110** to the support crown **150**. At the points at which each of the upper straps **170** attach to the support crown **150**, both upper straps **170** are attached by a mechanism that, in the illustrated embodiment, includes a hook **162** at the end of each upper strap **170** and complementary loops **166** on the support crown **150**.

A pair of lower straps **180** are attached to the respirator body **110** at points that are lower on the respirator body **110** than the points at which the upper straps **170** are attached to the respirator body **110**. The lower straps **180** extend from the respirator body **110** to the support crown **150**. At the points at which each of the lower straps **180** attach to the support crown **150**, both lower straps **180** are attached by hooks and loops as illustrated in connection with the upper straps **170**.

Although both the upper straps **170** and the lower straps **180** are depicted as being removably attached to the support crown **150**, one or more of the straps **170** and **180** could alternatively be permanently attached to the support crown **150** (see, e.g., the attachment of the proximal ends of straps **44** and **46** in the embodiment depicted in FIGS. 1 and 2).

Removably attaching at least one of the straps **170** and **180** to the support crown **150** may allow a wearer to remove the respirator body **110** from the face without completely removing the support crown **150** from the head. For example, if the lower straps **180** were permanently attached to the support crown **150**, detachment of the upper straps **170** from the support crown **150** could allow the respirator body **110** to be dropped from the wearer's face and suspended from the support crown **150** by the lower straps **180**. In yet another alternative, the upper strap **170** and lower strap **180** on one side of the half-mask respirator could be detachable, thus allowing the respirator body **110** to be suspended from one side of the support crown **150**.

Another optional feature illustrated in FIG. 4 is that the support crown **150** may include a plurality of loops **166** that allow the wearer to adjust the positions at which the upper and lower straps **170** and **180** attach to the strap support **150**. That adjustment may further improve the comfort of the half-mask respirator for the wearer. Alternatively, the location of one pair of loops **166** on each side of the strap support **150** may be adjustable by, e.g., mounting a single pair of loops **166** on mechanisms that slide along the strap support **150**. A variety of other adjustment mechanisms that allow for adjustments in the distance between the attachment points of the upper and lower straps **170** and **180** to the strap support **150** could be substituted for those specifically described in illustrative embodiments of the invention. Examples of some alternative mechanisms for attaching the straps to either the respirator body of the strap support can be found in, e.g., International Publication WO 99/06116 (FILTERING FACE MASKS HAVING ONE OR TWO STRAPS).

In an alternative embodiment, protective head gear, such as a hard hat with its own attached support crown, may also function as a strap support in accord with

the principles of the invention. A separate strap support would not be required because the straps could connect directly to the hard hat rather than the support crown. In such an embodiment, the hard hat and straps have suitable mechanisms, typically similar to those described in connection with the support straps to connect to the straps to the hard hat. This may be advantageous in an environment that requires the constant use of a hard hat.

FIG. 5 depicts an alternative strap support **250** in a flattened configuration for illustration purposes. The strap support **250** includes upper strap attachment points **266a** and lower strap attachment points **266b**. A series of apertures **251** may be formed in proximate end **252** along with a series of complementary posts **253** proximate opposing end **254** in the strap support **250**. The apertures **251** and complementary posts **253** provide one example of a mechanism for adjusting the distance between the upper strap attachment points **266a** on opposing sides of the strap support **250**. In addition, the apertures **251** and posts **253** provide a mechanism for adjusting the circumference of the strap support **250** to fit heads of various sizes in a manner similar to that used in, e.g., hardhats, baseball caps and other headwear.

Also included in the strap support **250** are similar complementary posts/apertures **255** (depicted assembled) located between lower strap attachment points **266b**. This adjustment mechanism provides the ability to vary the distance between the lower strap attachment points **266b** on opposing sides of the strap support **250**. In addition, the posts/apertures **255** provide a mechanism for adjusting the circumference of the strap support **250**.

Other optional adjustment mechanisms illustrated in FIG. 5 are the groups of posts/apertures **257** located between each pair of upper and lower strap attachment points **266a** and **266b** on each side of the strap support **250**. These adjustment mechanisms provide the ability to vary the distances between the upper and lower strap attachment points **266a** and **266b** on opposing sides of the strap support **250**. In addition, the posts/apertures **257** provide yet another mechanism for adjusting the circumference of the strap support **250**.

Although the adjustment mechanisms illustrated in connection with strap support **250** in FIG. 5 are complementary sets of posts and apertures, any other suitable mechanisms could be used in place of the posts and apertures. For example, buckles, hook and loop closure materials, etc. could all be used in place of one or more of the sets of complementary posts and apertures.

FIG. 6 depicts another half-mask respirator of the present invention in which the respirator body **310** is in the form of a porous filtering face mask. Examples of some porous filtering mask bodies are described in, e.g., U.S. Patents 5,307,706 to Kronzer et al., 4,807,619 to Dyrud, 4,536,440 to Berg, 5,724,677 to Bryant et al., and D285,374 to Huber et al., as well as in International Publication No. WO 98/58558 by Angadjivand et al. Commercially available products include the 1800™, 1812™, 1838™, 1860™, and 8210™ brand masks sold by the 3M Company.

When a wearer inhales, air is drawn through the filtering material that is integral to the mask body **310**. The filtering material may include a fibrous non-woven filtering material. Filtering materials that are commonplace on negative pressure half mask respirators like the respirator body **310** shown in FIG. 6 contain an entangled web of electrically charged melt-blown microfibers (BMF). BMF fibers typically have an average fiber diameter of about 20 micrometers (μm) or less, preferably about 2 to about 15 μm. When randomly entangled in a web, they have sufficient integrity to be handled as a mat. Examples of fibrous materials that may be used as filters in a mask body are disclosed in U.S. Patent No. 5,706,804 to Baumann et al., U.S. Patent No. 4,419,993 to Peterson, U.S. Reissue Patent No. Re 28,102 to Mayhew, U.S. Patents 5,472,481; 5,411,576 to Jones et al.; and 5,908,598 to Rousseau et al.

The fibrous materials may contain additives to enhance filtration performance, such as the additives described in U.S. Patents 5,025,052 and 5,099,026 to Crater et al., and may also have low levels of extractable hydrocarbons to improve performance; see, for example, International Publication No. WO 99/16945 by Rousseau et al. Fibrous webs also may be fabricated to have increased oily mist resistance using the techniques described in U.S. Patent 4,874,399 to Reed

et al., and in International Publication Nos. WO 99/16532 and WO 99/16533, both by Rousseau et al. Electric charge can be imparted to nonwoven BMF fibrous webs using techniques described in, for example, U.S. Patent 5,496,507 to Angadjivand et al., U.S. Patent 4,215,682 to Kubik et al., and U.S. Patent 4,592,815 to Nakao.

The respirator body **310** may include multiple layers such as a filter layer, an outer cover web, and an inner shaping layer. The cover web may protect the filter layer from abrasive forces and may also retain any fibers that may come loose from the filter layer. The cover web may also have filtering abilities, although typically not nearly as good as the filtering layer. The cover web may be made, e.g., from nonwoven fibrous materials containing polyolefins and polyesters (see, e.g., U.S. Patents 4,807,619 and 4,536,440, as well as International Publication No. WO 98/58558 by Angadjivand et al.).

The shaping layer may provide structure to the mask body and support for filter layer. The shaping layer may be located on the interior or the exterior of the mask body, or it may be located on both sides of filter layer. The shaping layer can be made, for example, from a nonwoven web of thermally-bondable fibers molded into a cup-shaped configuration. The shaping layer can be molded in accordance with known procedures (see, e.g., U.S. Patent No. 5,307,796 to Kronzer et al.). The shaping layer or layers typically are made of bicomponent fibers that have a core of a high melting material, such as polyethylene terephthalate, surrounded by a sheath of lower melting material so that when heated in a mold, the shaping layer conforms to the shape of the mold and retains this shape when cooled to room temperature. When pressed together with another layer, such as the filter layer, the low melting sheath material can also serve to bond the layers together.

Filtering face masks of the invention may also include a thermochromic fit indicating seal at its periphery to allow the wearer to easily ascertain if a proper fit has been established – see U.S. Patent 5,617,849 to Springett et al. The face masks may also include additional layers, valves (see, e.g., U.S. Patent No. 5,509,436), etc.

The respirator body **310** can be retained on a wearer's head by, on the depicted side, an upper strap **370** and a lower strap **380**, both of which are

connected to a strap support **350** in the form of a skull cap, which may be provided in the form of netting or any other suitable material.

In one embodiment, the strap support **350** and the ends of the upper and lower straps **370** and **380** may include, e.g., complementary hook and loop closure materials. As a result, the attachment points at which the upper and lower straps **370** and **380** attach to the strap support **350** may be adjusted. Once in place on the wearer, however, the distances between those attachment points on the strap support **350** are fixed to prevent the lower strap **380** from extending around the back of the wearer's neck.

The preceding specific embodiments are illustrative of the practice of the invention. This invention may suitably be practiced in the absence of any element or item not specifically described in this document. The complete disclosures of all patents, patent applications, and publications identified herein are incorporated into this document by reference in their entirety as if individually incorporated.

Various modifications and alterations of this invention will become apparent to those skilled in the art without departing from the scope of this invention, and it should be understood that this invention is not to be unduly limited to the illustrative embodiments set forth herein.

CLAIMS:

1. A half-mask respirator that comprises:

a half-mask respirator body configured to cover the nose and mouth of the wearer;

a strap support located on the wearer's skull when the respirator body is in position over the nose and mouth of the wearer;

at least two upper straps that extend from opposite sides of an upper portion of the respirator body to opposing sides of the strap support, the upper straps connected to the strap support at upper strap attachment points; and

at least two lower straps that extend from opposite sides of a lower portion of the respirator body to opposing sides of the strap support, the lower straps connected to the strap support at lower strap attachment points;

wherein the distances between the upper and lower strap attachment points on each opposing side of the strap support are fixed when the strap support is located on the wearer's skull and the respirator body is in position over the nose and mouth of the wearer.

2. The respirator of claim 1, wherein the strap support comprises a support crown and a skull cap.

3. The respirator of claims 1-2, further comprising a hard hat attached to the strap support.

4. The respirator of claims 1-2, wherein the strap support comprises an adjustment mechanism, wherein the distances between the upper and lower strap attachment points on each opposing side of the strap support are adjustable.

5. The respirator of claims 1-2, wherein the lower straps are connected to the respirator body below the strap support when the strap support is located on

the wearer's skull and the respirator body is in position over the nose and mouth of the wearer.

6. The respirator of claims 1-2, wherein the strap support comprises an adjustment mechanism, wherein the distances between the upper strap attachment points on opposite sides of the strap support are adjustable, and or wherein the distances between the lower strap attachment points on opposite sides of the strap support are adjustable.

7. The respirator of claims 1-2, wherein the strap support comprises a plurality of upper strap attachment points, plurality of lower strap attachment points, or a plurality of upper strap attachment points and a plurality of lower strap attachment points.

8. The respirator of claims 1-2, wherein at least two of the upper and lower straps comprise a single continuous integral strap body.

9. The half-mask respirator of claim 1, wherein the strap support comprises:

a support crown that is located on the wearer's skull when the respirator body is in position over the nose and mouth of the wearer;

wherein at least two upper straps are connected to the support crown at upper strap attachment points; and wherein the

at least two lower straps are connected to the support crown at lower strap attachment points, and further wherein the lower straps are connected to the respirator body below support crown when the support crown is located on the wearer's skull and the respirator body is in position over the nose and mouth of the wearer.

10. The respirator of claim 9, wherein the support crown comprises an adjustment mechanism, wherein the distances between the upper and lower strap attachment points on each opposing side of the support crown are adjustable.

FIG. 1

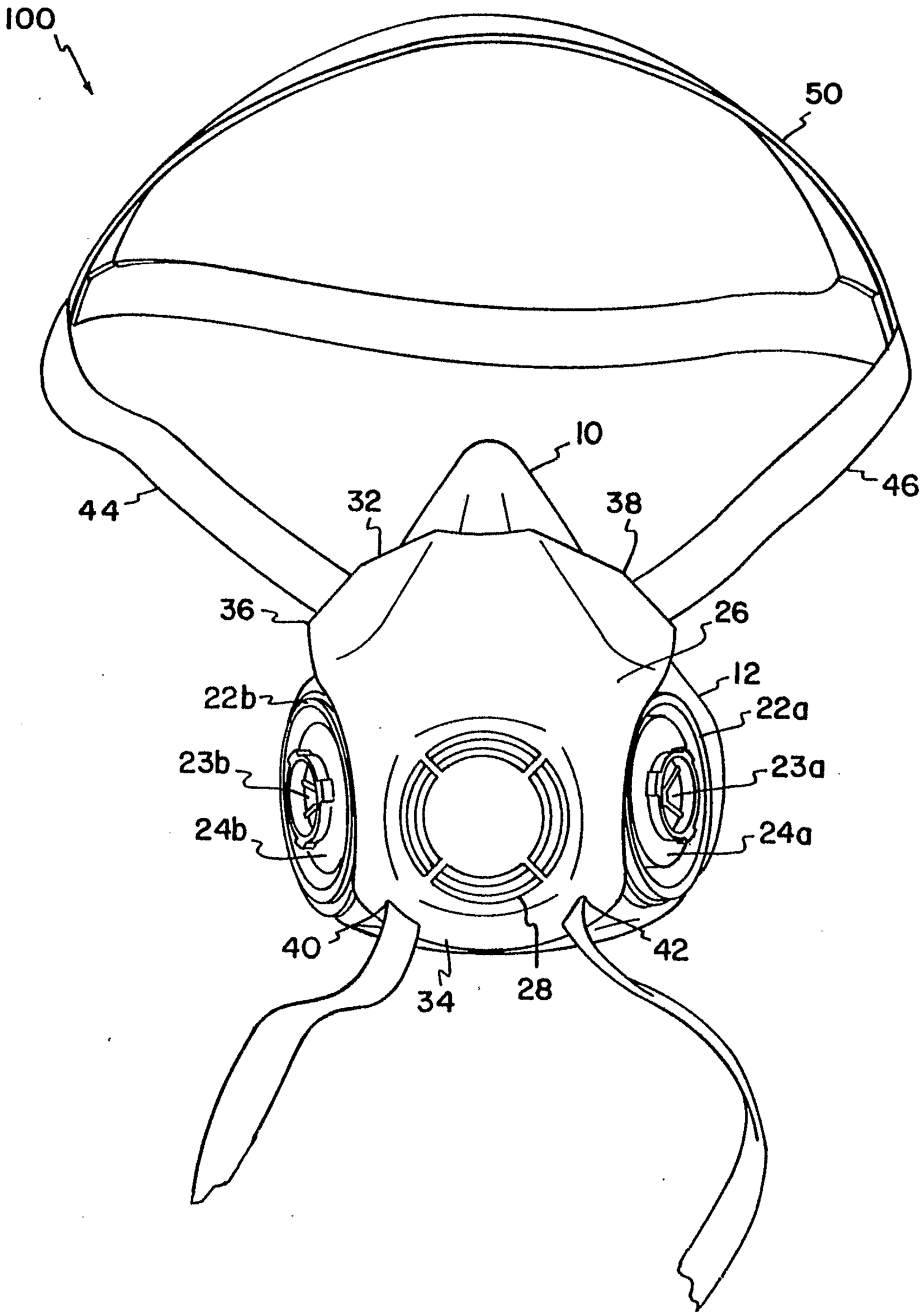
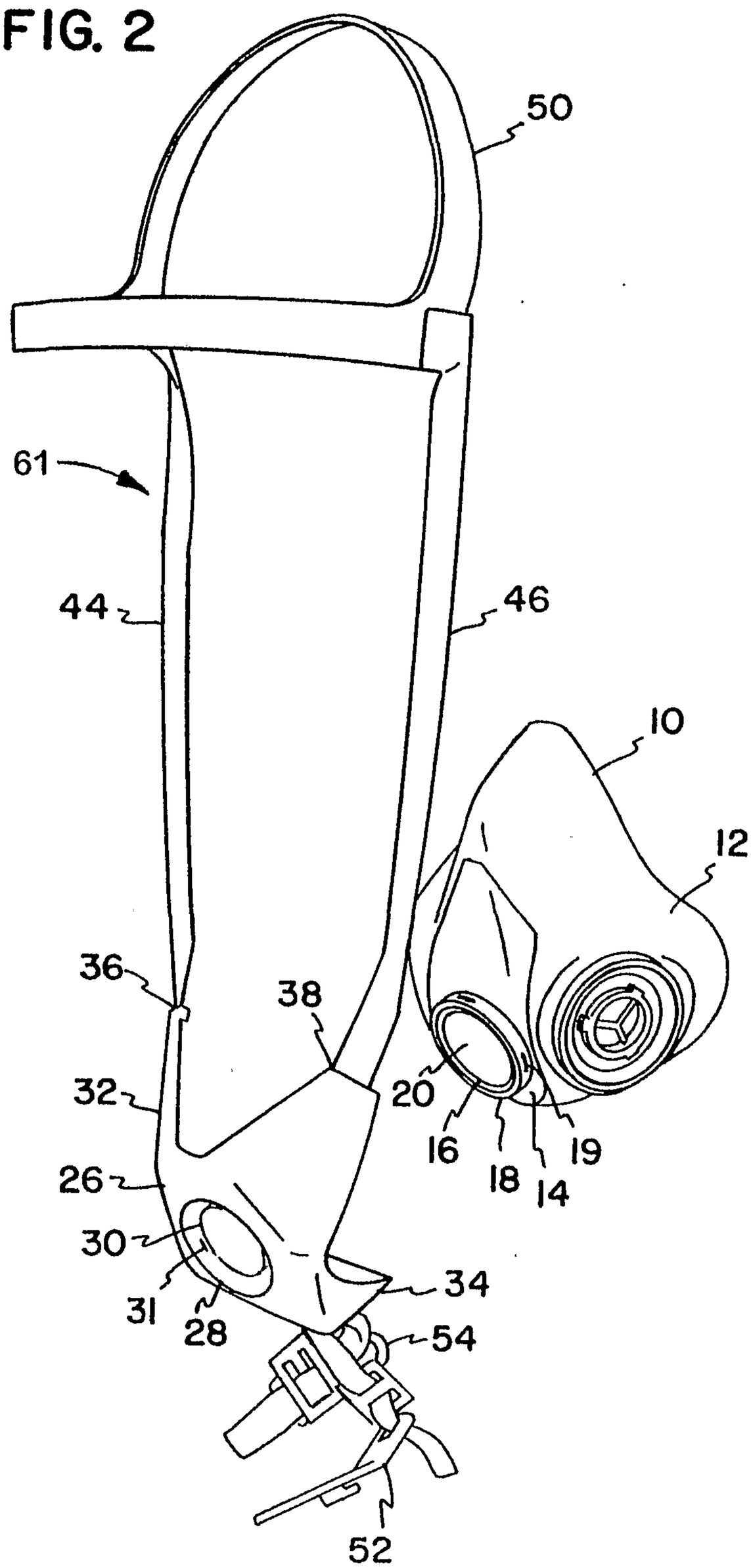


FIG. 2



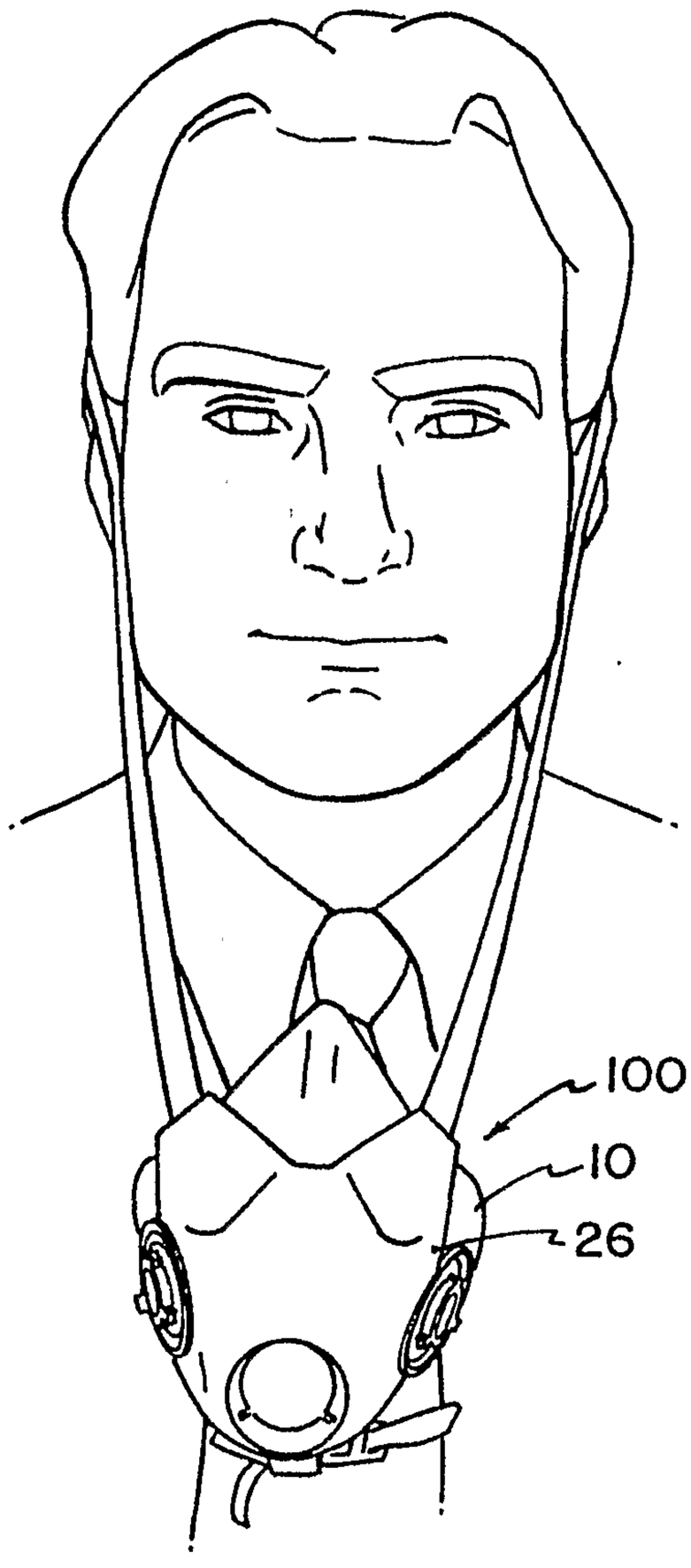


FIG. 3

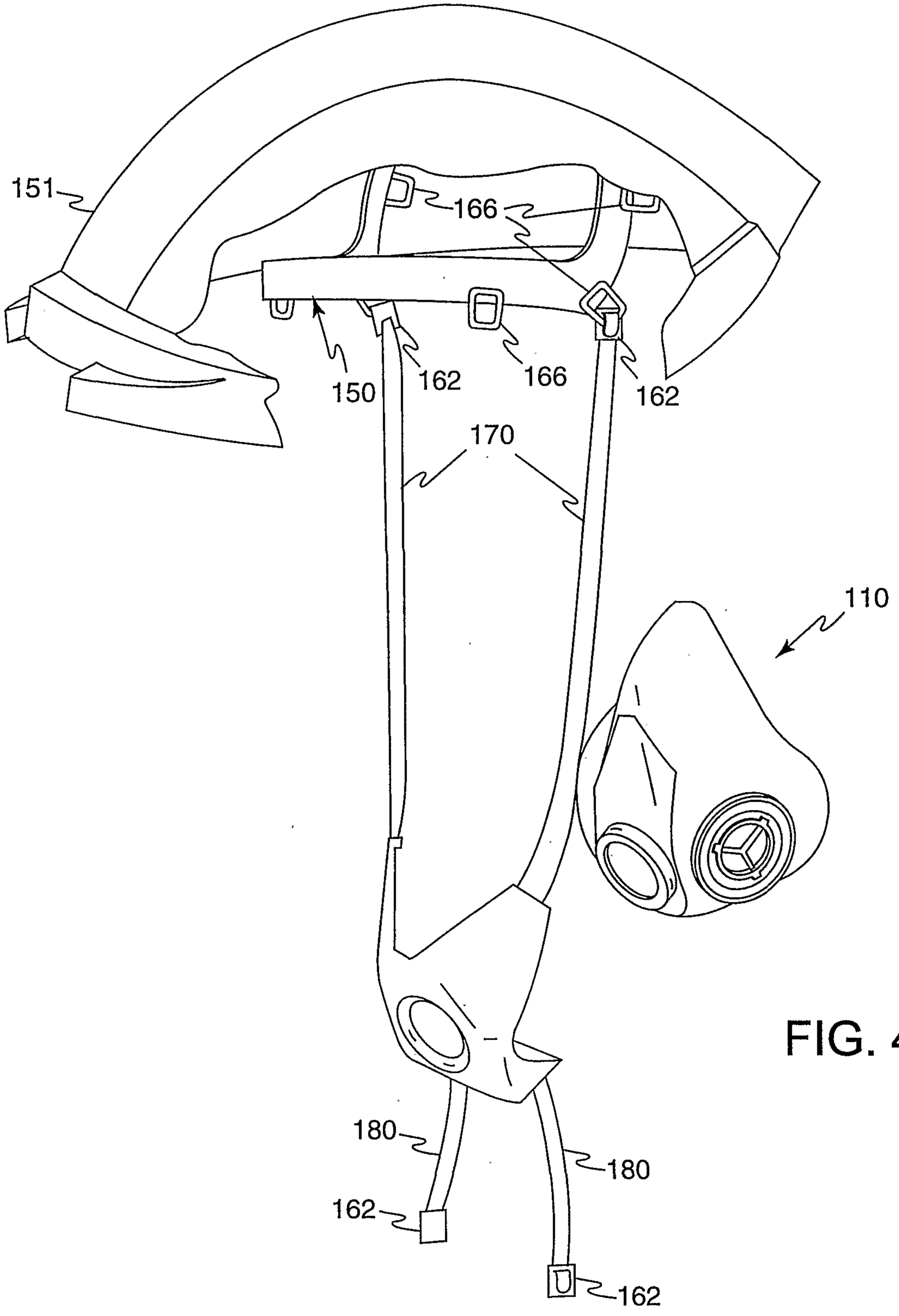


FIG. 4

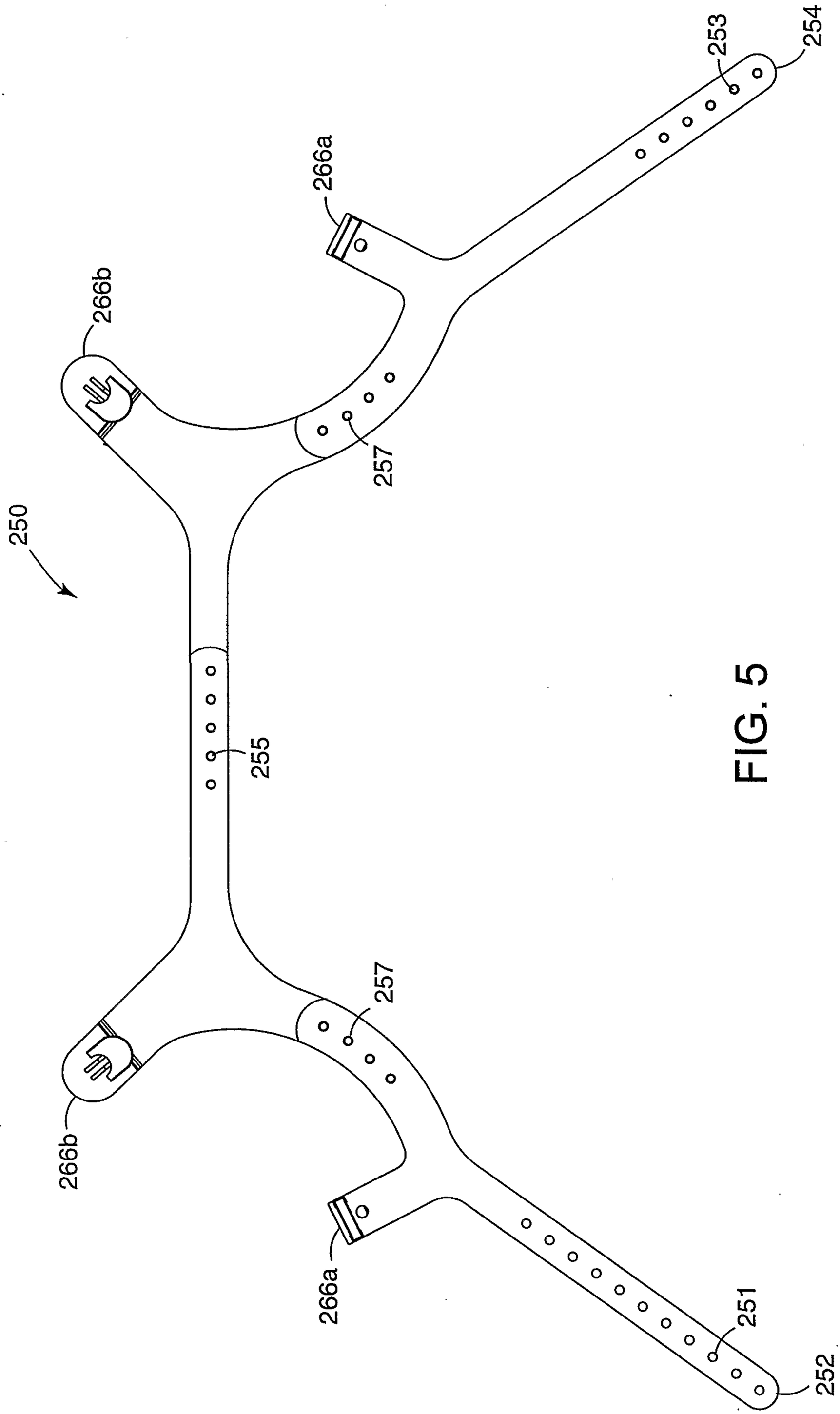


FIG. 5

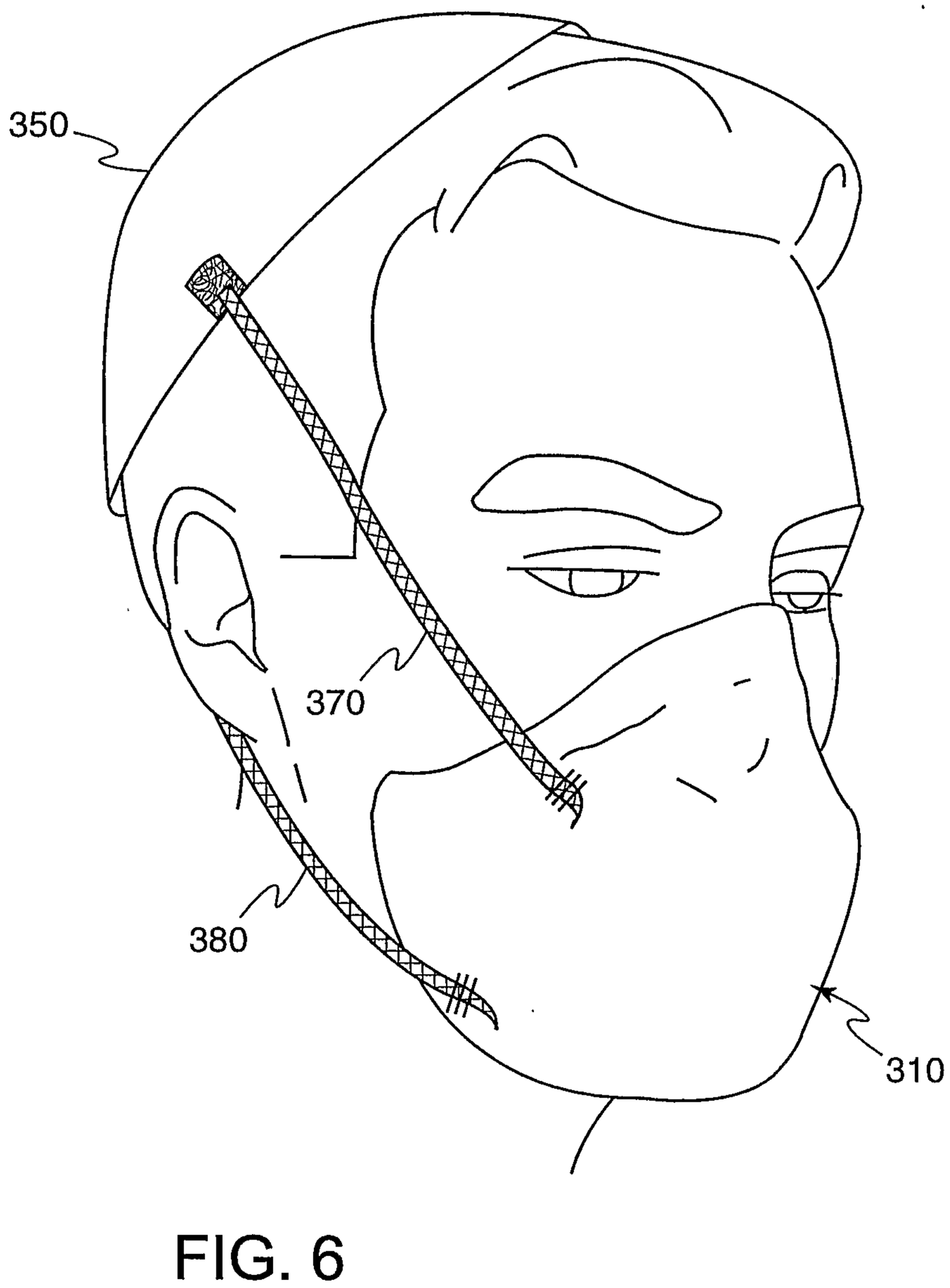
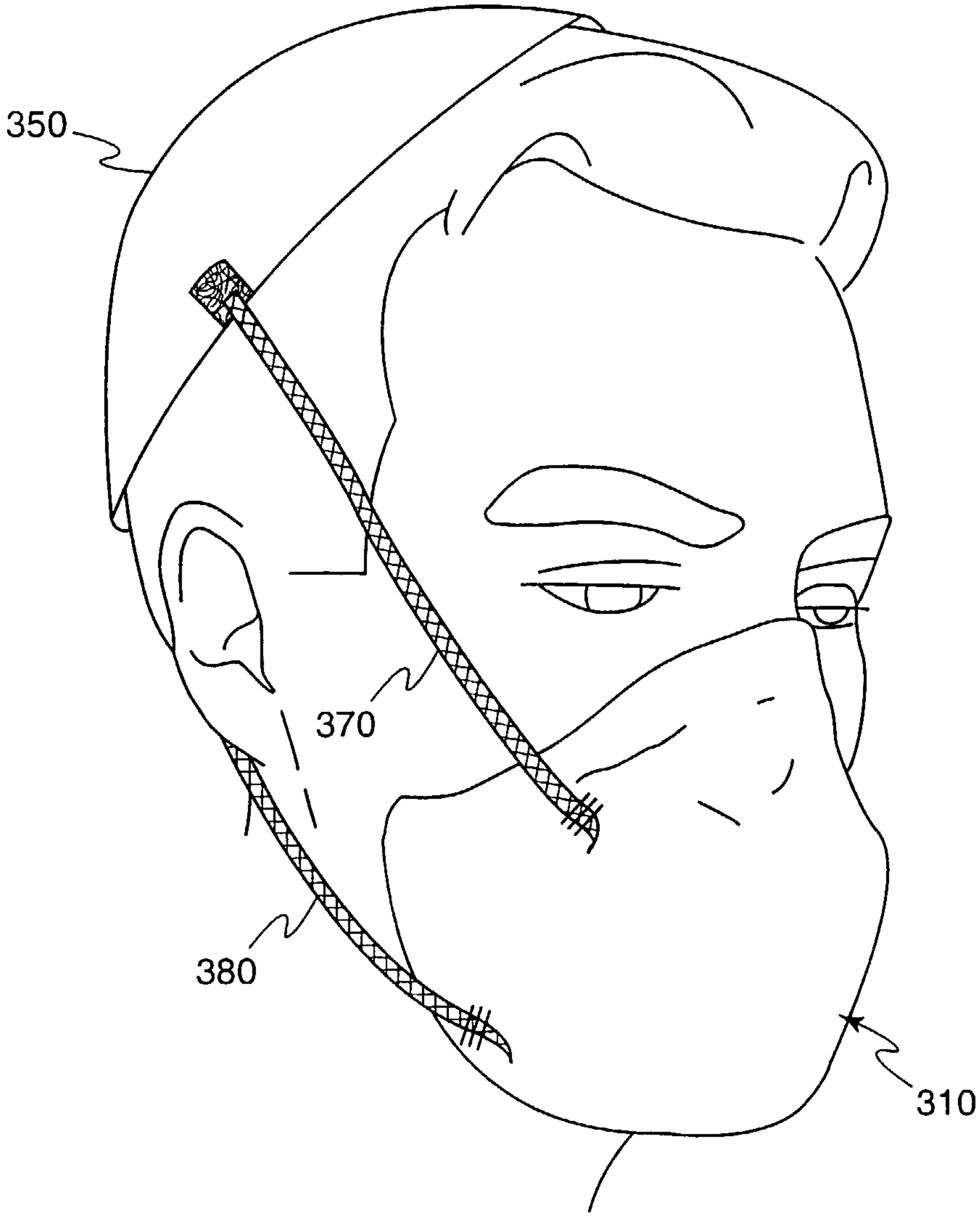


FIG. 6


350
370
380
310