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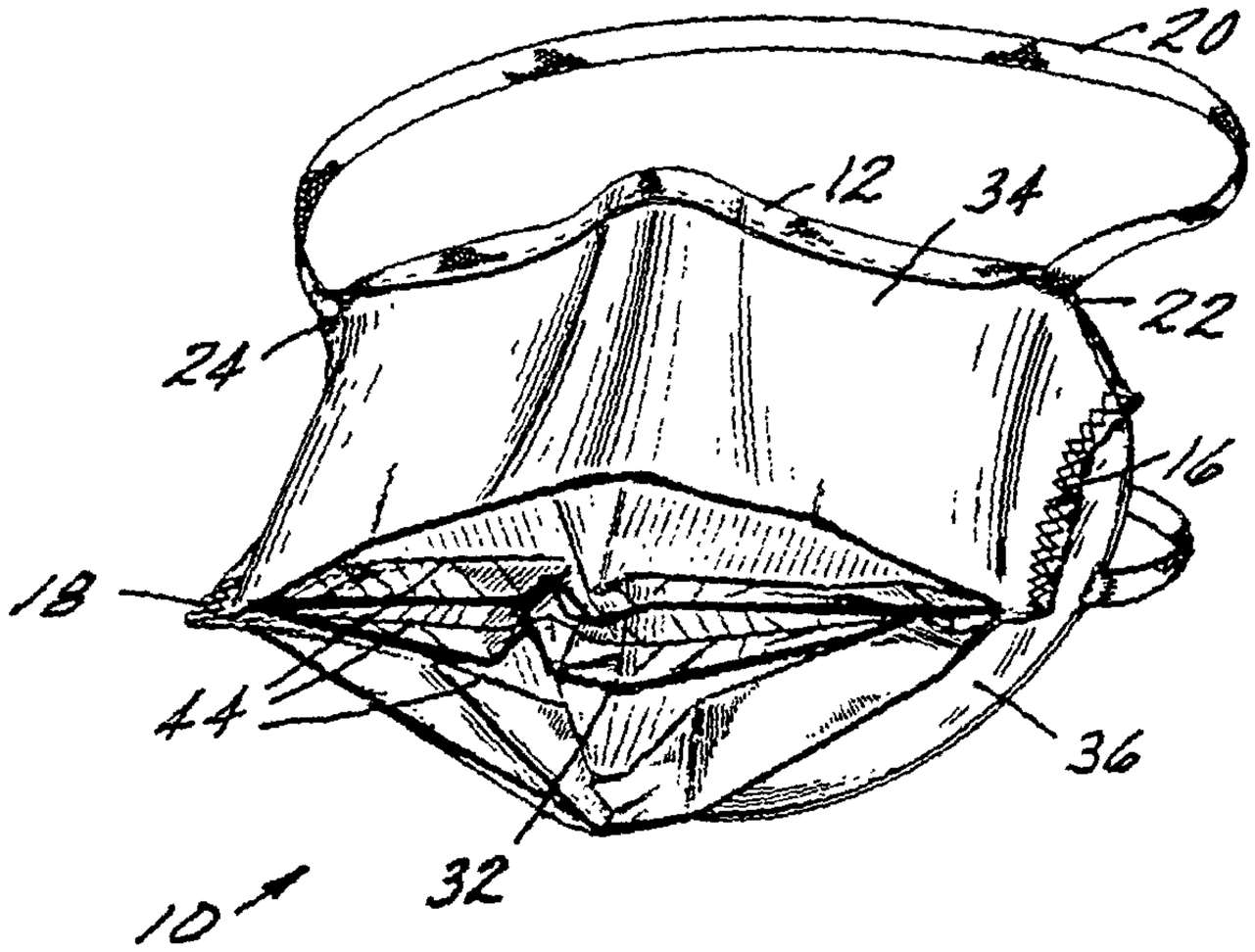
(54) Title: DISPOSABLE RESPIRATOR



(57) Abrégé/Abstract:
A disposable respirator (10) including peripheral bindings of filter material providing breathable filter protection along the periphery of the respirator, portions of that periphery (34, 36) being set against the face of the wearer. The respirator further includes filter material (32) pleated a plurality of times and set away from the face of the wearer by lengths of ultrasonically welded or heat sealed side welds (16, 18). The additional pleats advantageously provide high filtering surface area and a low filtering load across the periphery and pocket of the respirator. The result is superior breathability and comfort.

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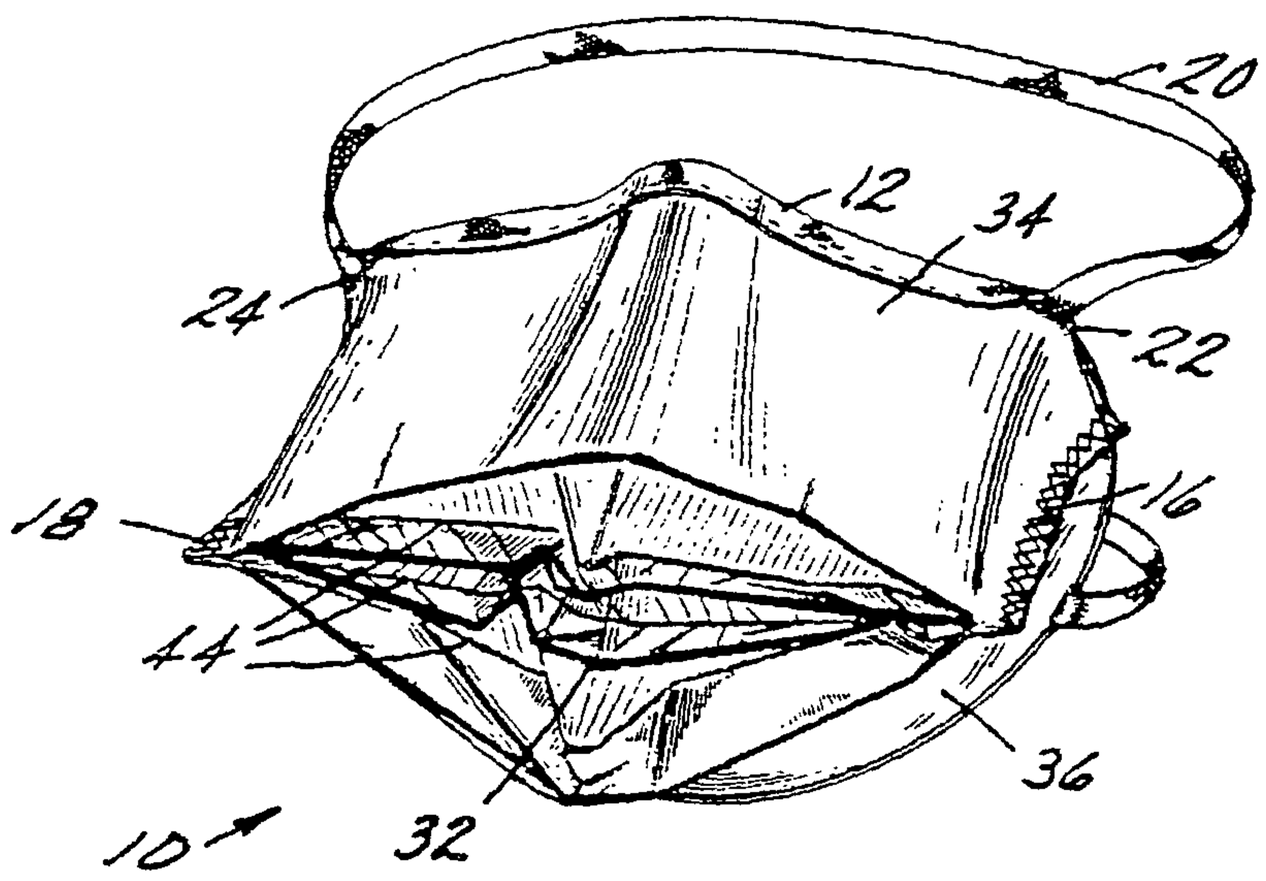
(54) Title: DISPOSABLE RESPIRATOR



(57) Abstract: A disposable respirator (10) including peripheral bindings of filter material providing breathable filter protection along the periphery of the respirator, portions of that periphery (34, 36) being set against the face of the wearer. The respirator further includes filter material (32) pleated a plurality of times and set away from the face of the wearer by lengths of ultrasonically welded or heat sealed side welds (16, 18). The additional pleats advantageously provide high filtering surface area and a low filtering load across the periphery and pocket of the respirator. The result is superior breathability and comfort.

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DISPOSABLE RESPIRATOR

TECHNICAL FIELD

The present invention relates generally to respirators and, in particular, to an improved disposable respirator.

BACKGROUND OF THE INVENTION

Respirators are used in a wide variety of applications when it is desired to protect a human's respiratory system from particulates or noxious gases. Disposable respirators find particular application in the heath care and related industries to protect a patient and/or physician from viral or bacterial sources and in the industrial industries to protect wearers from particulates and other industrial contaminants.

Non-powered air-purifying particulate respirators utilize the wearer's negative inhalation pressure to draw ambient air through the air purifying filter elements (filters) to remove particulates from the ambient air. They are designed for use as respiratory protection against atmospheres with particulate contaminants (e.g., dusts, fumes, mists) that are not immediately dangerous to life or health and that contain adequate oxygen to support life.

Such respirators generally serve the wearer in two respects. First, the respirator filters exhaled air, limiting viral and bacterial release in aerosol or other form. Second, the respirator filters the air drawn from ambient supply, limiting the wearer's intake of ambient contaminants.

Disposable respirators are also used in the industrial and consumer applications such as mill manufactures or in home use such as sanding joint compound. A layer of nuisance odor material is often added to adsorb low levels of organic or acid gases.

U.S. Patent No. 5,699,791 to Sukiennik et al. describes a substantially flat respirator mask configured to assume a contoured, three-dimensional shape in conformity with an individual wearer's face. To obviate the problems of mask "blow by," or the circulation of air around the periphery of the mask, the mask uses a tensioned chinstrap, side gathers, integral supports and adhesives to achieve a tight seal of the mask to the wearer. Such a design prevents air circulation at the bindings of the mask, ensuring that air passes only through the filter material of the mask.

However, this design suffers from high filtration loads over the filtering portions of the mask, resulting in reduced breathability and generally promoting mask discomfort. These problems are persistent in the art.

The use of pleats on surgical style masks to prevent collapsing of the mask during inhalation is also known in the art. Collapsing has been known to occur when the mask is used in a dusty environment. In such an environment, the mask will clog up with dust, which increases the breathing resistance and eventually causes the mask to collapse.

U.S. Patent No. 4,606,341 to Hubbard et al. describes a non-collapsing, single pleat facemask. The pleat is configured such that the mask provides a close fit to the wearer, but does not collapse during inhalation. The close fit does require the creases of the pleat to contact portions of the wearer's face.

U.S. Patent No. 4,688,566 to Boyce similarly describes a non-collapsing, pleated mask for holding the filter material away from the wearer's face. While filter material is held away from the wearer's face, creases of the pleats necessarily contact portions of the face, promoting irritation and moisture buildup. These problems are persistent throughout the prior art.

What is needed in the art is a pleated respirator having an inner pocket that does not contact the wearer's face and one that provides substantially complete filtration of both inhaled and exhaled air.

SUMMARY OF THE INVENTION

The above discussed and other drawbacks and deficiencies of the prior art are overcome or alleviated by the disposable respirator of the present invention. The respirator includes bindings of filter material providing breathable filter protection along the periphery of the respirator, including portions of the periphery set against the

face of the wearer (hereinafter the "facial contact region"). Sewn or welded into the bindings incident to the face are head and neck straps for securing the respirator to the face of the wearer.

The respirator further includes filter material pleated a plurality of times and set away from the face of the wearer by the lengths of side welds. The additional pleats advantageously provide high filtering surface area and low filtering loads across the periphery and pocket of the respirator. The result is superior breathability.

In a preferred embodiment, disposable respirator contains four pleats secured away from the face of the wearer by two ultrasonic side welds. Both ends of an elastic headband are sewn into the upper facial contact region of the mask. Both ends of an elastic neckband are sewn into the lower facial contact region of the mask. Also sewn into the upper facial contact region is a deformable material, preferably a metal and/or plastic. This deformable material provides contouring of the upper facial contact region to the face of the wearer.

A preferable configuration provides a five-piece construction. Sidewalls, pleats and side welds are preferably formed from one solid or one composite piece of filter material. A second piece of filter material is sewn or welded along upper and lower facial contact regions around deformable material (the third piece) and first filter material. Upper and lower elastic bands (fourth and fifth pieces) are sewn into or incident to upper and lower facial contact regions, respectively.

The above description and other features and advantages of the present invention will be appreciated and understood by those skilled in the art from the following detailed description, drawings, and appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings wherein like elements are numbered alike in the several FIGURES:

FIGURE 1 is a rear aspect view (wearer's perspective) of a disposable respirator ready for fitting;

FIGURE 2 is a front aspect view of the disposable respirator of FIGURE 1;

FIGURE 3 is a front aspect view of the disposable respirator of FIGURE 1 in a collapsed, or stored, state;

FIGURE 4 is a longitudinal aspect view of the disposable respirator of FIGURE 1 in a collapsed, or stored, state;

FIGURE 5 is a top aspect view of the respirator of FIGURE 1 showing the respirator in a collapsed, or stored, state;

FIGURE 6 is a cross-sectional view of side welds for the respirator of FIGURE 5;

FIGURE 7 is a cross-sectional view of upper and lower facial contact regions of the respirator of FIGURE 5;

FIGURE 8 is a cross-sectional view of upper and lower facial contact regions of the respirator of FIGURE 5, emphasizing the inclusion of deformable material in the upper facial contact region of the respirator;

FIGURE 9 is a graphical representation of breathing resistance as a function of loading for three disposable masks having surface areas of 62 square centimeters, 100 square centimeters and 180 square centimeters, respectively; and

FIGURE 10 is a graphical representation of pressure drop across filter material at an air flow rate of 85 liters per minute shown as a function of surface area for three disposable masks having surface areas of 62 square centimeters, 100 square centimeters and 180 square centimeters, respectively.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIGURE 1, a disposable respirator for filtering airborne contaminants is generally shown at 10. Upper facial contact region 12 is joined to lower facial contact region 14 along first and second side welds 16, 18. Headband 20 is shown joined to upper facial contact region 12 at first and second contact points 22, 24. Neckband 26 is shown in cutaway form attached to lower facial contact region 14 at third and fourth contact points 28, 30. As is preferred, filter material pleats 32 are contiguous with first and second filter material sidewalls 34, 36. Upper and lower facial contact regions 12, 14 (collectively 'the periphery') are shown to be a separate layer of filter material 39 sewn over sidewalls 34, 36 along stitch-line 38.

Referring now to FIGURE 2, a front view aspect is generally shown at 10. Headband 20 is shown stitched to upper facial contact region 12 at contact points 22, 24. As is preferred, first and second sidewalls 34, 36 are shown ultrasonically welded

at first and second side welds 16, 18. Pleats 32 are shown welded into first and second side welds16, 18.

Referring now to FIGURE 3, the disposable respirator of FIGURE 1 is shown generally at 10 in a front aspect view illustrating the respirator's collapsed, or stored, state. Pleats 32 are folded within first and second sidewalls 34, 36. First and second side welds are shown at 16 and 18 respectively. Headband is shown at 20. Neckband is shown at 26.

Referring now to FIGURE 4, the disposable respirator of FIGURE 1 is shown at 10 in a longitudinal aspect view further illustrating the collapsed, or stored, state. First and second sidewalls 34, 36 are joined at side weld 16. Upper and lower facial contact regions 12, 14 are shown to be a separate layer of filter material sewn over sidewalls 34, 36 along stitch-line 38.

Referring now to FIGURE 5, the preferred ultrasonic weld is shown along side welds 16, 18. Ultrasonic weld further extends to include the edges of upper and lower facial contact region 12, 14 across stitch-line 38. Deformable material 40 is shown in phantom as stitched into the filtering fabric of upper facial contact region 12. Stitch-line 38 ensures that deformable material 40 is positioned under or within filter material of upper facial contact region 12.

Referring now to FIGURE 6, a cross-sectional view along A-A of FIGURE 5 is illustrated. Pleat 32 is shown folded within a cross-sectional portion of side weld 16.

Turning now to FIGURE 7, a cross-sectional view along B-B of FIGURE 5 is illustrated. Cross-sections of upper facial contact region 12 and lower facial contact region 14 are shown separately. Outer filter material 39 of upper and lower facial contact regions 12, 14 is shown secured over first and second sidewalls 34, 36 respectively.

Referring now to FIGURE 8, a cross-sectional view along C-C of FIGURE 5 is illustrated. Upper facial contact region 12 is distinguished from upper facial contact region 14 in that upper facial contact region 12 further includes deformable material 40 within outer filter material 39 and above stitch-line 38.

Referring now to FIGURE 9, breathing resistance is shown as a function of loading for three disposable masks having surface areas of 62 square centimeters, 100 square centimeters and 180 square centimeters, respectively. As can be seen from the FIGURE, as sodium chloride (the test particulate material) accumulates on the

respirator (shown as milligrams of NaCl), the breathing resistance of the respirator increases (millimeters of H_2O). This increase in breathing resistance is minimal at 40 milligrams of sodium chloride for the mask having a surface area of 180 square centimeters, moderate for the respirator having a surface area of 100 square centimeters, and severe for the respirator having a surface area of 62 square centimeters. Because low breathing resistance is desired at high loadings, it is preferred that the present disposable respirator have a surface area above about 180 square centimeters.

Referring now to FIGURE 10, pressure drop across the filter material at an air flow rate of 85 liters per minute is shown as a function of surface area for three disposable masks having surface areas of 62 square centimeters, 100 square centimeters and 180 square centimeters, respectively. As can be seen from the FIGURE, the 62 square centimeter respirator shows a pressure differential of more than 8 millimeters of H_2O. The 100 square centimeter respirator shows a pressure differential of between 5 and 6 millimeters of H_2O. The 180 square centimeter respirator shows a pressure differential of less than 3 millimeters of H_2O. Because a lower pressure differential/drop will prevent mask collapse and blow-by, it is preferred that the present mask have a surface area of above about 180 square centimeters.

The present respirator provides a compact, disposable device with good filtration of exhaled and inhaled ambient air. Outer filter material 39 over upper and lower facial contact regions 12, 14 ensure that filtration occurs around the periphery of the facial contact regions and causes low filtration loads over the remainder of the respirator. Side welds 16, 18 extend away from the face of the wearer, preventing collapse of the respirator and holding filtering material away from the wearer's mouth and nose. Pleats 32 provide additional surface area for filtration of air.

Pleats 32 are preferably provided as a plurality of folds, shown individually at 44 on FIGURES 1 and 2, which are held away from the wearer's face by ultrasonically stitched side welds 16, 18. Contrary to prior art teachings, the present respirator teaches that a plurality of pleats 32 (four or more) is particularly preferred, not to hold the respirator away from the wearer's face, but instead to provide a less constrained, thus more comfortable, respirator fit for the area of the wearer's face opposite the pleats, and more importantly, to provide a high filtering surface area for the respirator.

Prior art masks suffered from uncomfortable designs emphasizing close fits, whereby pleats or other filter materials pressed against the wearer's face during use. Prior art masks also suffered from high filtering loads, caused by such tight fits (less material) and resulting in both wearer discomfort and peripheral leakage, or 'blowby'.

All of these issues are prevalent in field, and particular concern has been expressed over the problems of peripheral leakage. Construction of a respirator with a plurality of pleated filter material set away from the wearer's face, as is done by the present respirator, advantageously results in a device with a surface area two to four times the surface area of prior art masks.

The particularly preferred construction, as illustrated by FIGURES 1 and 2, includes four pleats 32. This particularly preferred configuration results in a surface area of roughly three times the surface area of prior art masks and about half the breathing resistance. Thus, the surface area of the present respirator is generally above about 180 square centimeters. In a particularly preferred embodiment, the surface area of the present respirator is above about 350 square centimeters. It is most preferred that the surface area of the present respirator be above about 590 square centimeters.

Further with regard to the present respirator, incorporation of filtering material along the periphery 12, 14 of the respirator and incorporation of multiple pleats set away from the wearer's face obviates the need to ensure a good "seal" between the respirator and the face. Instead, emphasis is placed on equalizing filtration load across the entirety of the respirator, including the peripheral portions.

Preferred filtering materials useful for the present respirator include weld-able materials, such as polypropylene and polyester, among others, including materials such as are described by U.S. Patent No. 5,883,026 to Reader et al., including spunbonded/meltblown/spunbonded (SMS) laminates, electret meltblown layers, spunbonded layers, or wet-laid layers. Lighter weight materials aid in breathability, and are particularly preferred. In an exemplary embodiment, filtering material is a melt-blown thermoplastic layer (such as polypropylene, polyester, or expanded polytetraflouroethylene (PTFE)), which can be electrostatically charged to attract particulates or chemically treated to have a low surface tension (i.e., hydrophobic). It is also preferred that the filter material incorporate carbon particles or fibers capable of absorbing non-toxic levels of organic vapors and/or acidic or basic gases.

Regardless of the material used, it is preferred that the filter material have above about a 95 percent efficiency for filtering particles having a median diameter range of about 0.1 to about 0.3 microns.

The present respirator is preferably constructed in a five-piece assembly process. Sidewalls 34, 36, pleats 32 and side welds 16, 18 are preferably formed from one solid or one composite piece of filter material. A second piece of filter material is sewn or welded along upper and lower facial contact regions 12, 14 around deformable material 40 (the third piece) and first filter material. Upper and lower elastic bands 20, 26 (fourth and fifth pieces) are sewn into or incident to upper and lower facial contact regions 12, 14, respectively.

The filtering material of the pocket is pleated by folding the filtering material in alternating directions along parallel fold lines. Pleats 32 are secured by the formation of side welds 16, 18 at the ends of the parallel fold lines. The sides can be ultrasonically welded or heat sealed. In this preferred configuration, pleats 32, side welds 16, 18, and sidewalls 34, 36 fold down to a compact tetragonal shape for ease of storage and portability.

Thus the present respirator advantageously provides a compact, fully filtering, pleated respirator in that filtering loads are spread across the entire respirator and are shared with the peripheral material in contact with the wearer's face. High filtering material surface areas result in breathabilities more than twice that of prior art masks. Use of soft filtering material in contact with the wearer's face not only ensures that air passing between the face and the mask is filtered, but also provides a comfortable fit of the respirator to the wearer's face, which is important for wearer's that must use the respirator for prolonged periods of time.

While preferred embodiments have been shown and described, various modifications and substitutions may be made thereto without departing from the spirit and scope of the invention. Accordingly, it is to be understood that the present invention has been described by way of illustration and not by limitation.

CLAIMS

What is claimed is:

1. A disposable respirator wearable over the face of a human, comprising:

a filtering body including a periphery and a pleated pocket, the pleats of the pocket set away from the periphery by first and second side welds, thereby defining the depth of the pocket, and wherein the periphery of the respirator consists essentially of filter material; and

first and second securing straps, each adjustable to the head or neck of a wearer.

2. The disposable respirator of claim 1, wherein the periphery further includes an upper and a lower facial contact region joined at the first and second side welds, the upper facial contact region positionable over the nose and cheeks of a wearer's face and the lower facial contact region positionable underneath the chin and across the jawbones of the wearer's face.

3. The disposable respirator of claim 2, wherein the upper facial contact region further comprises a material deformable to the contours of a wearer's nose and cheeks, the deformable material enclosed within the filter material of the periphery.

4. The disposable respirator of claim 3, wherein the deformable material is a metal and/or plastic.

5. The disposable respirator of claim 1, wherein first and second securing straps are elastic.

6. The disposable respirator of claim 1, wherein filtering material selectively filters at least 95% of particles having a mass median diameter of about 0.1 microns and above.

7. The disposable respirator of claim 1, wherein filtering material is an electrostatic polypropylene material.

8. The disposable respirator of claim 1, wherein filtering material further comprises carbon material in the form of fibers or particles.

9. The disposable respirator of claim 1, wherein the periphery filtering material is contiguous with the filtering material of the pleated pocket.

10. The disposable respirator of claim 1, wherein the filtering material is a weldable material and wherein the first and second side welds comprise filtering material of the pleated pocket that has been ultrasonically welded together.

11. The disposable respirator of claim 1, wherein the pleated pocket comprises four pleats, the edges of the pleats secured within the first and second side welds.

12. The disposable respirator of claim 1, wherein the surface area of the filtering body is above about 180 square centimeters.

13. The disposable respirator of claim 12, wherein the surface area of the filtering body is above about 350 square centimeters.

14. The disposable respirator of claim 13, wherein the surface area of the filtering body is above about 590 square centimeters.

15. A disposable respirator wearable over the face of a human, comprising:

a filtering material formed as:

an upper facial contact region;

a lower facial contact region, where the upper and lower facial contact regions are joined at first and second side welds; and

a pocket pleated at an end away from the upper and lower facial contact regions, where the upper and lower facial contact regions form the periphery of the pleated pocket, and where the depth of the pleated pocket is defined by the length of first and second side welds, which extend away from the upper and lower facial contact regions to form the pleated pocket; and

first and second securing straps, each adjustable to the head or neck of a wearer.

16. The respirator of claim 15, wherein the filtering material is a weldable material and wherein first and second side welds are ultrasonically welded or heat sealed.

17. The respirator of claim 16, wherein the filtering material is a meltblown electrostatic polypropylene material.

18. The respirator of claim 16, wherein filtering material selectively filters at least 95% of particles having a mass median diameter of about 0.1 microns and above.

19. The respirator of claim 18, wherein filtering material further comprises a carbon material in the form of fibers or particles.

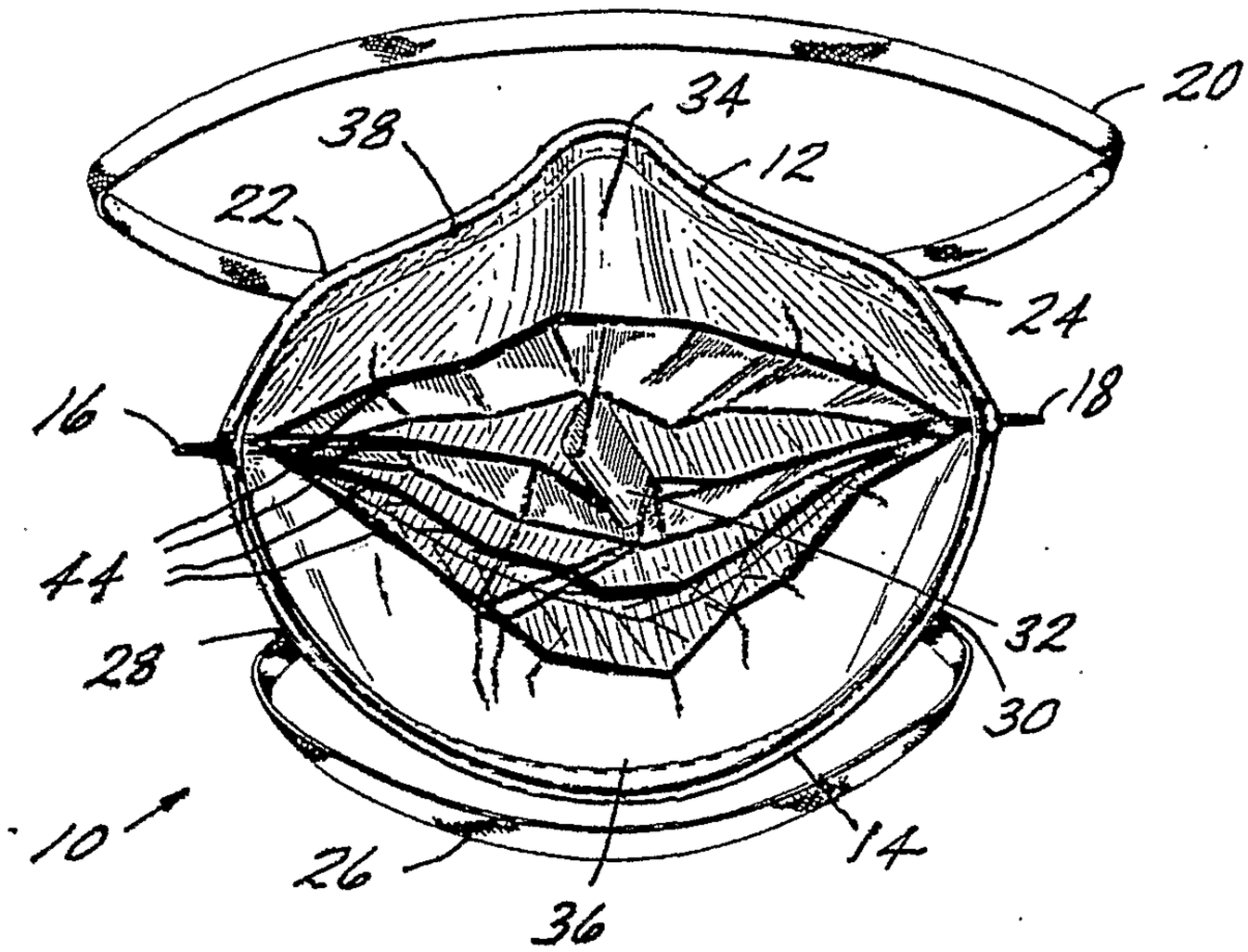
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FIG. 1

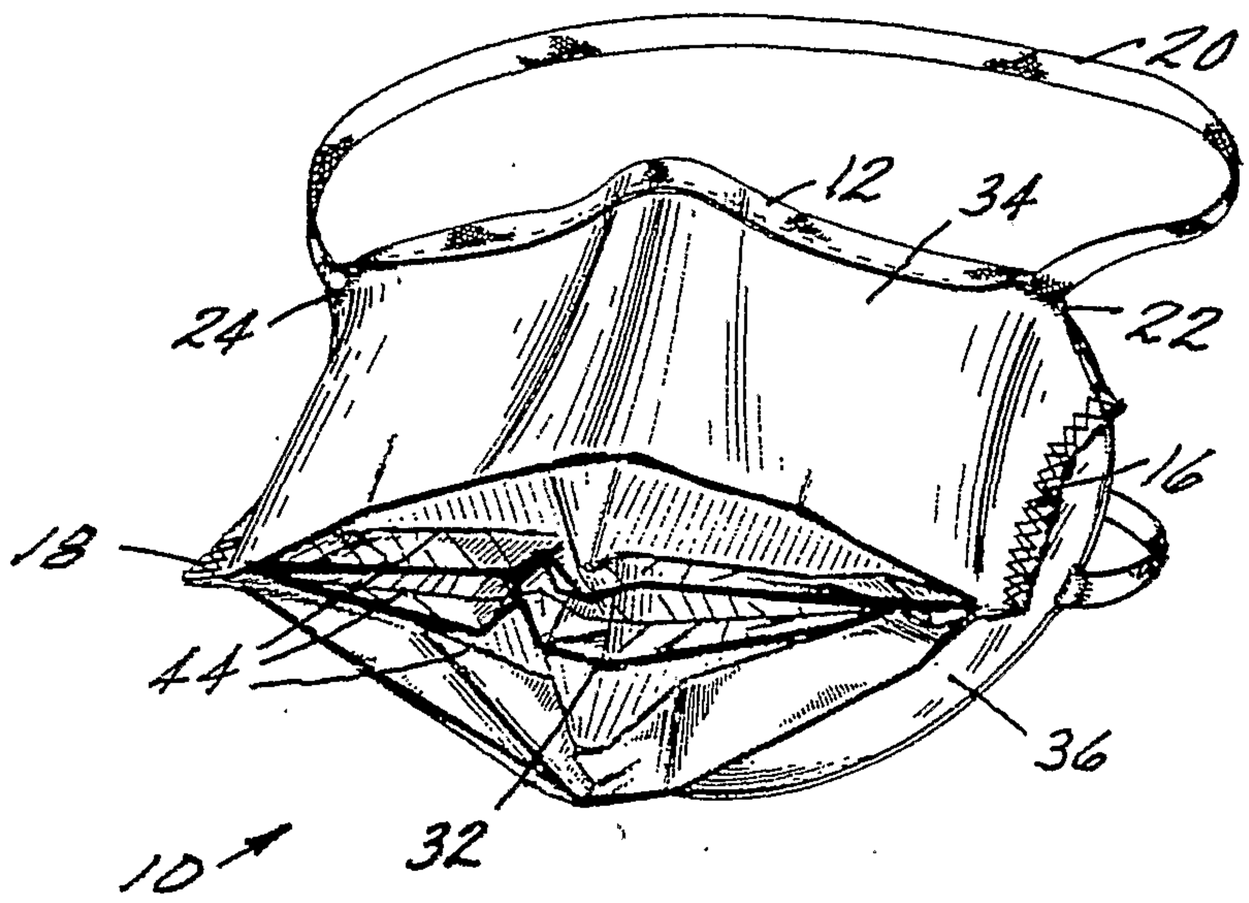
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FIG. 2

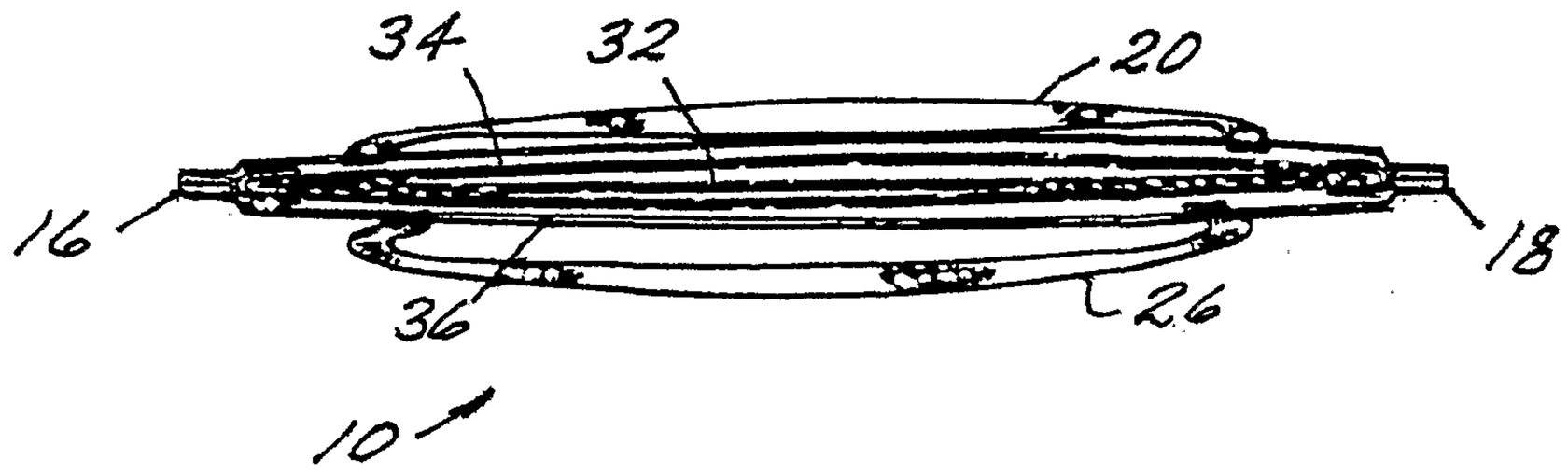


FIG. 3

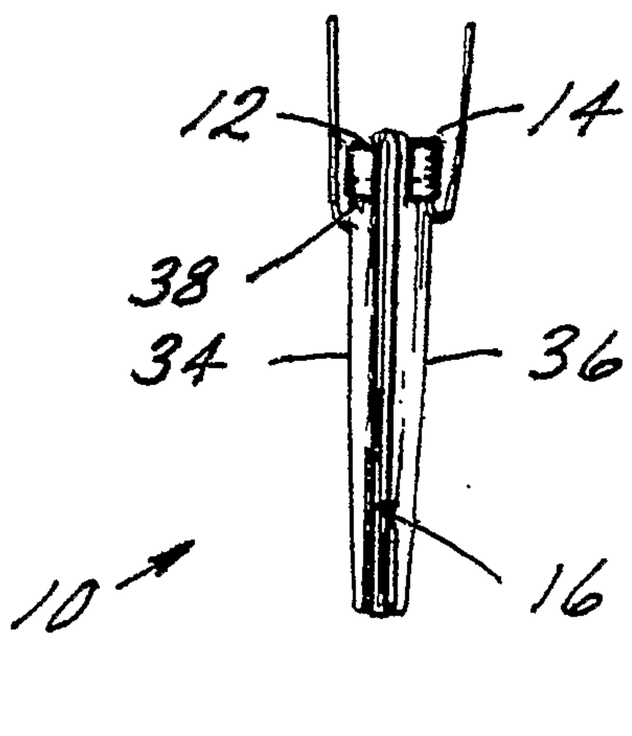


FIG. 4

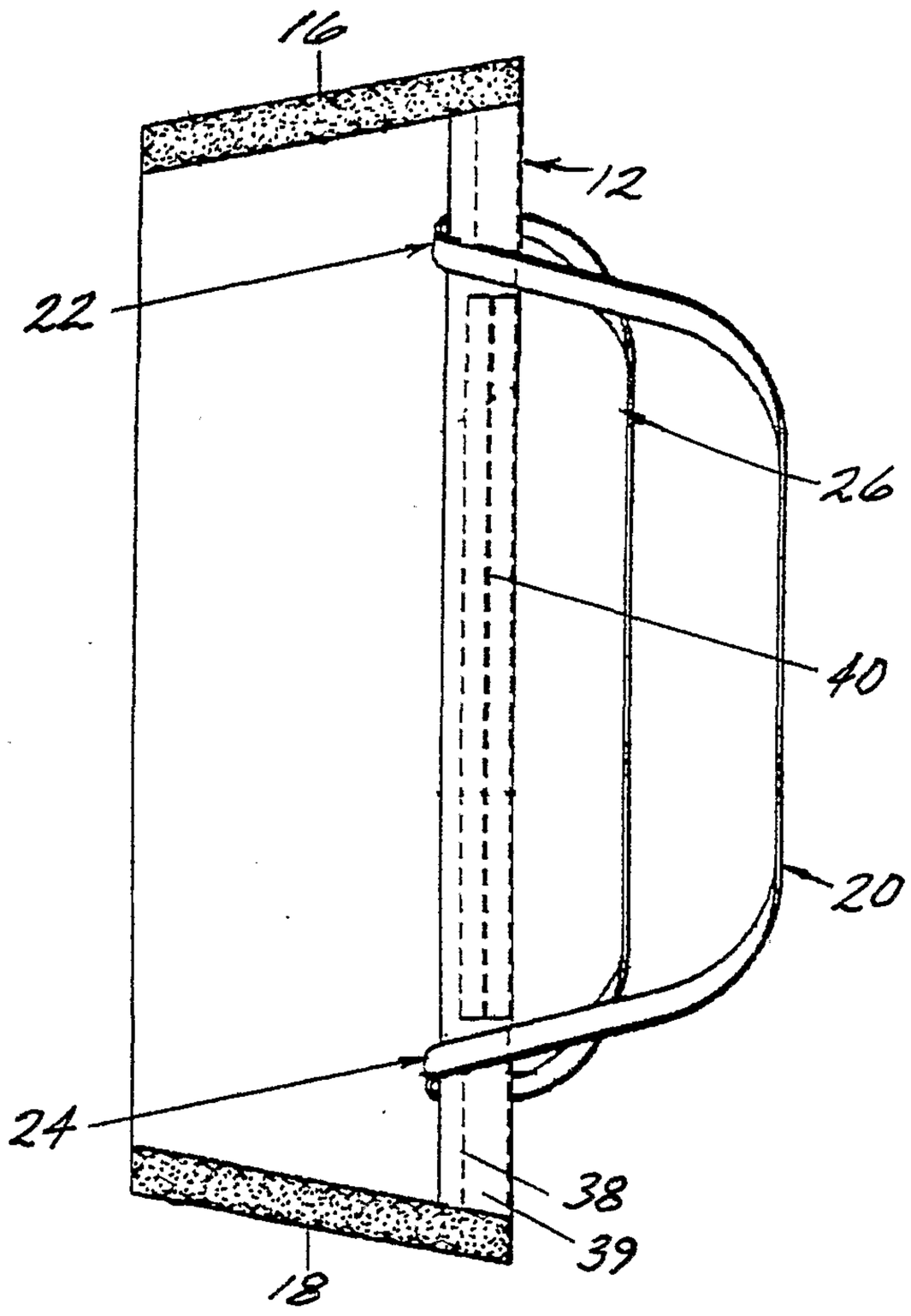


FIG. 5

FIG. 6

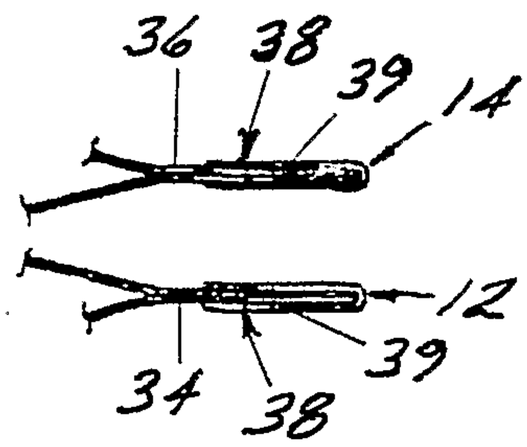


FIG. 7

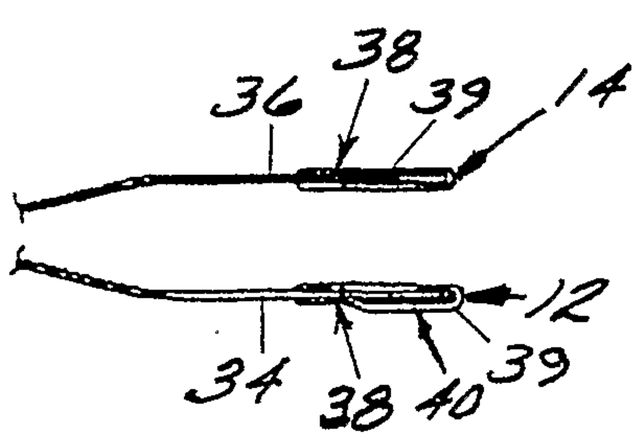
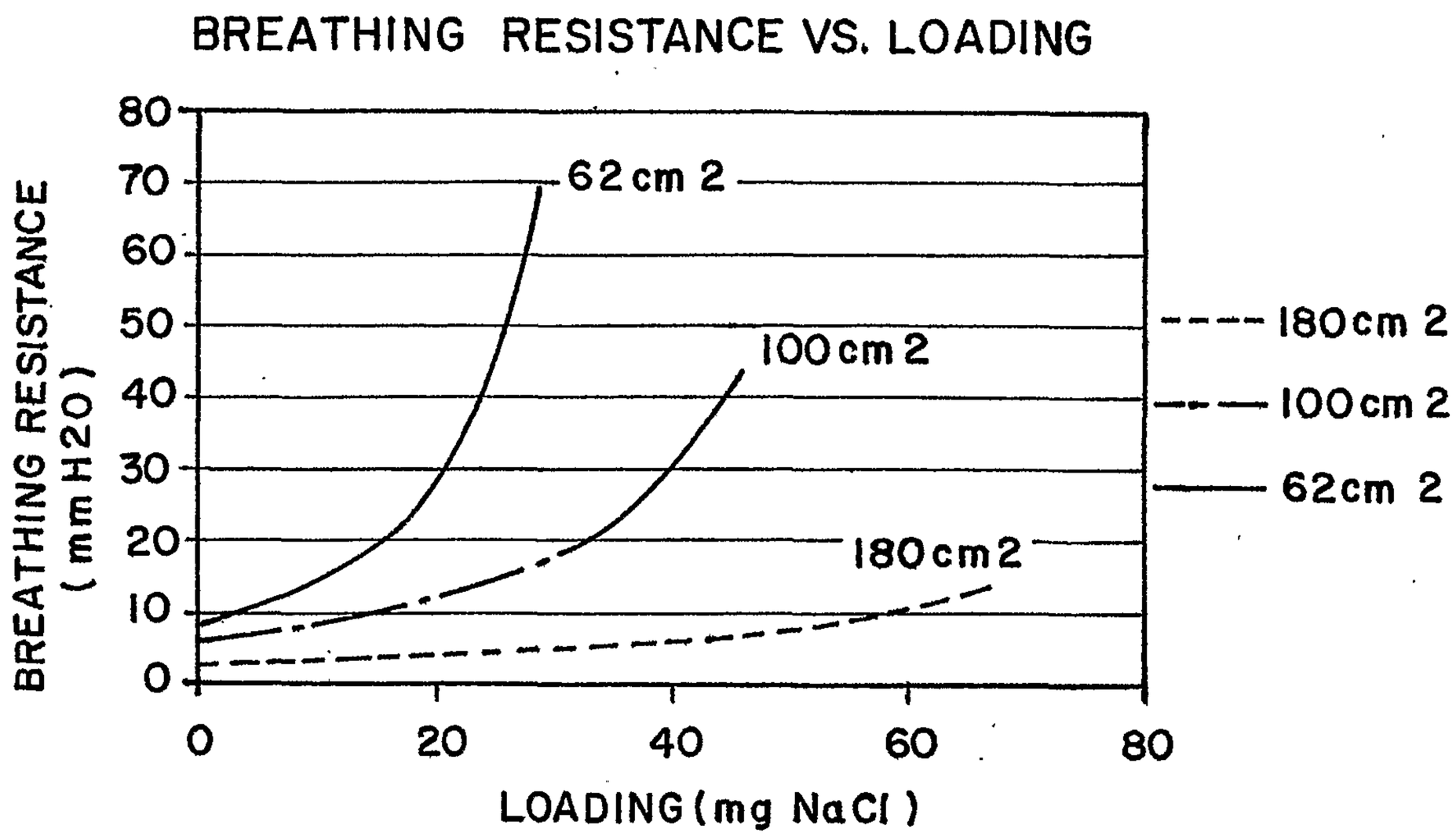


FIG. 8


BREATHING RESISTANCE VS. LOADING
BREATHING RESISTANCE (mm H20)
80
70
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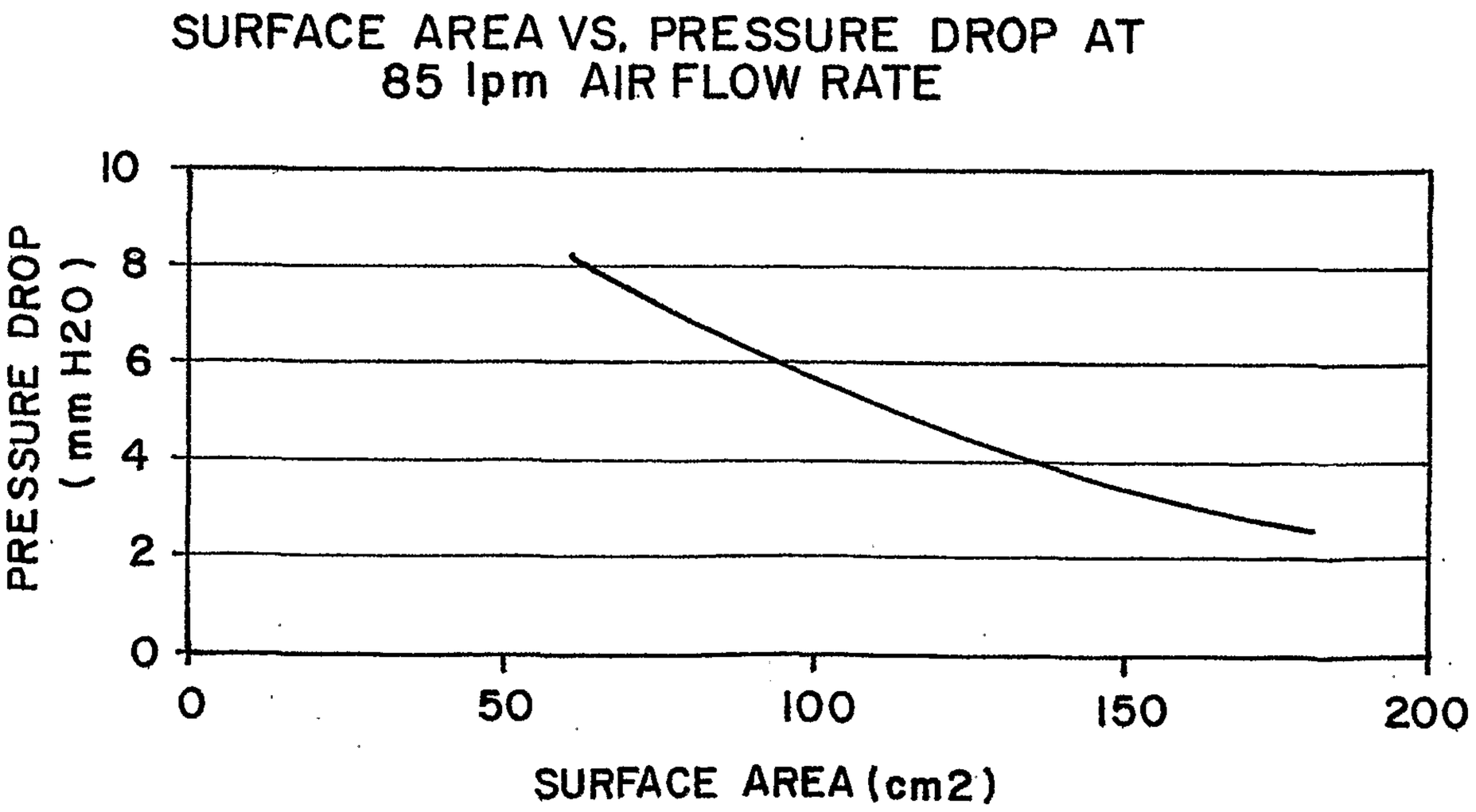
LOADING (mg NaCl)
62 cm 2
100 cm 2
180 cm2
180 cm 2
100 cm 2
62 cm 2

FIG. 9


SURFACE AREA VS. PRESSURE DROP AT
85 lpm AIR FLOW RATE
PRESSURE DROP (mm H20)
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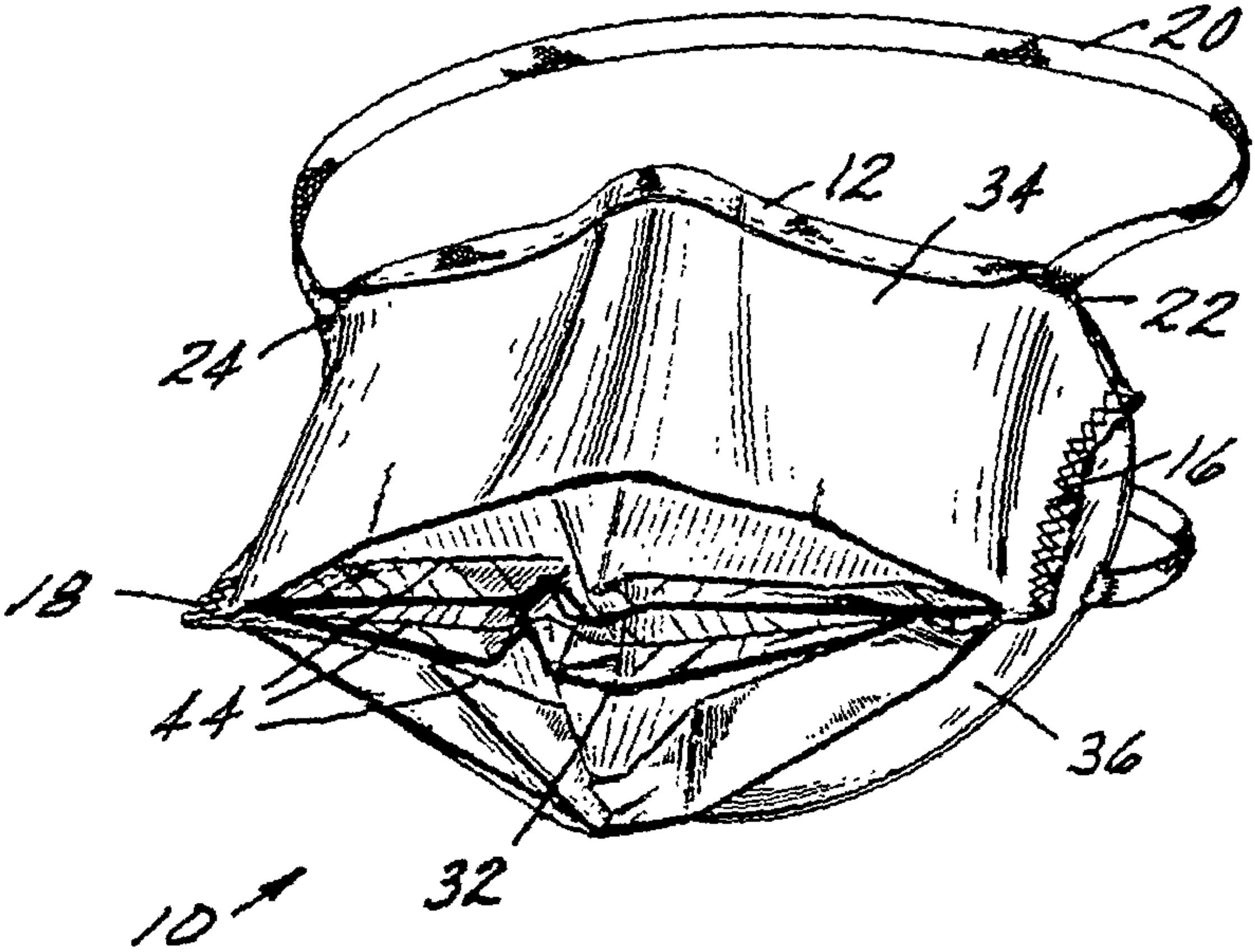
SURFACE AREA (cm2)

FIG. 10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