(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 109 514**
A1

(12) # EUROPEAN PATENT APPLICATION

(21) Application number: **83109639.1**

(51) Int. Cl.³: **A 62 B 18/02**

(22) Date of filing: **27.09.83**

(30) Priority: **08.11.82 US 439930**

(43) Date of publication of application:
30.05.84 Bulletin 84/22

(84) Designated Contracting States:
AT BE CH DE FR GB IT LI LU NL SE

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(54) **Improved single-element filter and respirator.**

(57) This invention relates to an improved, single-element, filter (14) and reusable respirator (10), which can be worn in silica dust, silica mist and asbestos environments, while providing increased visibility, safety and comfort for the respirator wearer. A significant feature of the respirator (10) is a triangular shaped filter housing (22) which allows the area of the filter media to be increased while at the same time reducing filter housing obstructions to the vision of the respirator wearer.

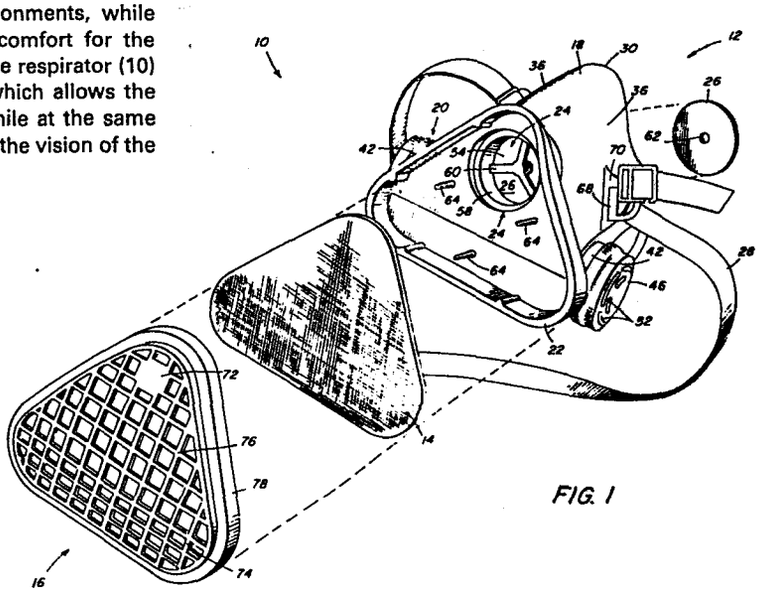

FIG. 1

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IMPROVED SINGLE-ELEMENT FILTER AND RESPIRATOR

BACKGROUND OF THE INVENTION

This invention relates to a respirator and disposable filter with improved filtering capabilities, and improved wearer comfort, visibility and safety.

Prior-art, single-element respirators generally have a large, circular filter element which protrudes directly in front of the wearer's nostrils and mouth, as described in U.S. Patent 2,823,671. The awkward position, shape, and large size of the filter element obstruct much of the wearer's forward vision and can cause discomfort. No known prior-art, single-element respirator is able to meet the National Institute for Occupational Safety and Health (NIOSH) requirements for silica dust, silica mist and asbestos, said requirements being; an initial inhalation resistance prior to testing of 18 millimeters of water maximum, a final inhalation resistance at the completion of testing of 25 millimeters of water maximum, and an exhalation resistance of 15 millimeters or a penetration of 1.5 milligrams of silica dust.

A dual-element, one-half facepiece, molded, reusable respirator or a disposable respirator which covers much of the face, is generally used for silica dust, silica mist and asbestos environments. Dual-element, reusable respirators generally have two circular filter elements which protrude next to or under the wearer's cheeks. The positioning of these filter elements obstructs a considerable portion of the wearer's sideward and downward vision. When these filters are in use, most of the radius through which arms, hands, or feet move cannot be seen by the wearer. Thus, working in or even walking close to potentially dangerous industrial areas requires extra caution when wearing this type of respirator. Other problems in having two filter elements are an added complexity and expense for each respirator because of additional parts requirements.

Disposable respirators, used in silica dust, silica mist and asbestos environments, also have inherent problems. They tend to cause wearer discomfort because they cover such a large area of the face. Disposable respirators are not as durable as molded reusable respirators, and may acquire holes or leaks, which could endanger the wearer's health. In addition, daily or frequent disposal of these respirators can be extremely costly.

SUMMARY OF THE INVENTION

The present invention provides a solution to several of the aforementioned problems of prior-art respirators, such as inadequate filtering capability, poor visibility, and discomfort for the wearer. Specifically, the present invention relates to an improved, one-quarter facepiece, molded, reusable respirator, with an improved, single, triangular-shaped filter housing, said filter housing sloping in at the top and bottom towards the respirator facepiece. The top of the respirator facepiece sits comfortably across the bridge of the nose, following the contours of the nose; and the bottom of the respirator facepiece sits between the mouth and chin, curving in from the cheeks to follow the facial curvature. Two exhalation valves are located on each side near the bottom of the respirator facepiece behind and perpendicular to the filter element. Adjustable straps hold the respirator facepiece firmly onto the face. An increased filter element area and an improved filter media reduce the inhalation resistance. A new rubber compound used to manufacture the exhalation valve reduces the exhalation resistance, enabling the respirator to be worn in silica dust, silica mist and asbestos environments. The respirator provides comfort to the respirator wearer and minimal obstruction of the wearer's vision, even with an increased filter element area, because of: 1) the particular location and geometry of the filter element (triangular-shaped

and sloping); 2) the structure, positioning and size of the respirator facepiece; 3) the location and small size of the exhalation valves; and 4) the positioning of the straps. This improved vision which results enables the wearer to function more safely.

Accordingly, it is an object of the present invention to provide a respirator with a replaceable single-filter element with improved effectiveness to dust, and in particular, with improved effectiveness to silica dust, silica mist and asbestos, because of an increased filter-element area.

It is a further object of this invention to provide a one-quarter facepiece, molded, reusable respirator with improved comfort, visibility, and safety for the respirator wearer.

Other objects and further scope of applicability of the present invention will become apparent from the detailed description to follow, taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is an exploded perspective view of the respirator, showing the filter cover, filter, facepiece with attached filter holder, and inhalation valve flap;

Fig. 2 is a side elevation view of the respirator of the present invention;

Fig. 3 is a rear plan view of the respirator;

Fig. 4 is a cross-sectional side view of the respirator; and

Fig. 5 is a cross-sectional view of the exhalation valve mechanism of the respirator.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The respirator 10 of this invention is illustrated in Figs. 1-4. Fig. 1, which is an exploded view, illustrates the three main separable pieces of the

respirator 10; the facepiece 12, the filter 14, and the filter cover 16.

The facepiece 12, as illustrated in Figs. 1-4, contains a facepiece body 18, two exhalation valves 20, a filter holder or housing 22 with a contained inhalation valve 24 and inhalation valve flap 26, and an elastic band 28.

The facepiece body 18, is made of a firm, flexible, molded material such as rubber and fits firmly and comfortably on the wearer's face. An upper portion 30 of the facepiece body 18 is formed with an inwardly folding ridge 32 (Figs. 3 and 4) which conforms to the bridge of the wearer's nose. This inward folding ridge 32 extends around the inner perimeter of the facepiece body 18 in order to provide a good air seal during inhalation and exhalation so that air will pass only through the respirator inhalation valve 24 and exhalation valves 20, thus providing effective filtering. This ridge 32 provides a flexible, non-irritating surface which conforms comfortably to the wearer's face.

An outer ridge 34 of the facepiece body 18 interior extends outwardly away from the inward folding ridge 32 around the perimeter of the facepiece body 18 where it is in contact with the wearer's face. This outer ridge 34 becomes wider in the region where the facepiece body 18 respirator covers the wearer's cheeks, causing a material stiffness which maintains the respirator's shape over this region while providing a second air seal. The outer ridge 34 is rounded to provide a non-irritating, good contact with the wearer's face.

Side sections 36 of the facepiece body 18 are indented to fit along either side of the nose bridge just above the nostrils to give a snug fit. A lower portion 38 of the facepiece body 18 is contoured to fit immediately above the wearer's chin. The facepiece body 18 is cupped outward to keep it away from the

wearer's nostrils and mouth, yet not so far as to cause visual obstruction.

Two exhalation valve mechanisms 20 are situated through circular holes in the facepiece body 18 in opposing positions on either side of the wearer's mouth. The inner circumference of the rubber defining the circular holes is flanged out, forming an extended collar 40 in the facepiece body 18 to stabilize the exhalation valve mechanisms 20.

A cross-sectional view of the exhalation valve mechanisms 20, which are identical in construction, is shown in Fig. 5. Each exhalation valve mechanism 20 consists essentially of a rigid, molded plastic, cylindrical valve seat 42 upon which a flexible valve flap 44 is seated, and a semi-rigid, molded plastic, protective, perforated valve cover 46. The valve flap 44 is seated during inhalation, and because of its flexible properties, it opens by flexing outward when the wearer exhales. A suitable rubber for forming valve flap 44 is identified as compound #R-47529 by Acushnet Company, New Bedford, Massachusetts. A valve flap stem 48, which is the end section of the valve flap 44, is held in position by a rigid plastic ring-and-spoke system 50, allowing free movement of exhaled breath to act upon the flap 44. The valve flap 44, made of a flexible material such as rubber, is protected from external damage and dirt by a valve cover 46 which is perforated by an array of holes 52 to allow free passage of exhaled breath.

A single inhalation valve mechanism 24 is positioned through a circular hole 54 in the facepiece body 18 in front of the wearer's nostrils. By placing hole 54 adjacent triangular filter housing (as opposed to centrally as is done in many prior art devices) as shown, lowering of the housing is possible enabling better viewing. The inner circumference of this hole 54 is flanged out to form an extended collar 56 in

the facepiece body 18 to stabilize the inhalation valve mechanism 24.

The inhalation valve mechanism 24, shown in Figs. 1, 3 and 4, consists essentially of a rigid, molded plastic, cylindrical valve seat 58 upon which a flexible valve flap 26 is seated; and a spoke-and-button system 60 which anchors the valve flap 26. The inhalation valve flap 26, made of a thin flexible material such as rubber, is seated during exhalation and is flexed open during inhalation towards the wearer's nostrils. This valve flap 26 is fastened to a cylindrical button in the center of the spoke-and-button system 60 through a small cylindrical hole 62 in the inhalation valve flap 26, allowing free movement of inhaled, filtered air. The intake of the inhalation valve mechanism 24 extends outward from the facepiece body 18 to become a contained part with the back of the filter holder 22. Three posts 64 extending from the filter holder 22 hold a felt filter 14 in place within the filter housing element. Pins or posts 64 prevent sagging of the filter element against the rear wall of housing 22. Without the support provided by pins 64, increased breathing resistance would be produced by a lack of free space over and around hole 54 of the inhalation valve. In connection with the foregoing, it should be noted that many prior art respirators have designs which do not prevent sagging of filter components against or toward inhalation valves.

In order to hold the respirator 10 onto the wearer's face, an adjustable elastic band 28 loops from the facepiece body 18 to around the wearer's head and upper neck (Fig. 1). The elastic band 28 passes through a D-shaped hole 66 in the end of a metal clip 68 (Figs. 1-3) on each side of the facepiece body 18, allowing band movement, and thus adjustment. The opposite end of each metal clip 68 is embedded within a slot, located in an outward-extended tab 70 of the facepiece body 18.

The felt fiber 14 (Figs. 1 and 4) is triangular shaped and approximately 1 cm. thick. It is made of a new low resistance felt material as supplied by American Felt and Filter. This filter 14 has a larger area than conventional single element filters, and is thus effective in silica dust, silica mist and asbestos environments.

A triangular-shaped filter cover 16 (Figs. 1, 2 and 4) snaps onto the filter holder 22 to contain and protect the felt filter 14, while allowing air for breathing to flow into the respirator 10. The top face of the filter cover screen 72 and the bottom face of the filter cover screen 74 are canted or slanted backward away from the plane of the center filter cover screen 76 toward the respirator facepiece 12 or wearer. The enclosed filter 14, the filter cover rim 78, and the lower portion of the filter holder 22 also maintain this backward cant, producing a wraparound shape (Figs. 2 and 4) for the entire filter housing element, and thus providing improved visibility, safety and comfort for the respirator wearer.

EXAMPLE 1

A prior-art, circular, single-element filter (detached from a respirator) was mounted to a tapered adaptor, and tested in accordance with NIOSH silica dust and airflow resistance test requirement as specified by 30 CFR 11, Subpart K, Sections 11.140-4 and -9, summarized as follows: 11.140-4 Silica dust test; single-use or reusable filters; minimum requirements. a) Three respirators with single-use filters are tested for periods of 90 minutes each at continuous airflow rate of 32 liters per minute. b) The relative humidity in the test chamber is 20-80 percent, and the room temperature is approximately 25°C. c) The test suspension in the chamber is not less than 50 nor more than 60 milligrams of flint (99+ percent free silica) per cubic

meter of air. d) The flint in suspension is ground to pass 99+ percent through a 270-mesh sieve. e) The particle-size distribution of the test suspension has a geometric mean of 0.4 to 0.6 micrometer, and the standard geometric deviation does not exceed 2. f) The total amount of unretained test suspension in samples taken during testing shall not exceed 1.5 milligrams. 11.140-9 Airflow resistance tests; all dust, fume, and mist respirators; minimum requirements. g) Resistance to airflow is measured in the facepiece of a dust, fume or mist respirator mounted on a test fixture with air flowing at a continuous rate of 85 liters per minute, both before and after each test conducted in accordance with 11.140-4.

Conventional respirator felt material was used for the filter media. Average test results for 22 tests performed are listed in Table 1.

Table 1

Resistance and Penetration - Prior Art,
Circular Filter Element - Silica Dust

	INHALATION RESISTANCE* Initial (mm H_2O)	Final (mm H_2O)	PENETRATION (mg H_2O)
Prior Art, Tests:			
Average	10.9	22.8	0.2
Range	10.0-12.5	19.0-28.0	0.0-0.4
NIOSH Standard:			
Regular Dust (max)	30.0	50.0	1.5
Asbestos Dust (max)	18.0	25.0	1.5

From Table 1 (and adjusting values according to *), it can be seen that a prior art, circular, single-element respirator, although adequate for regular dust environments, is unacceptable for asbestos dust environments, because test results exceed the final inhalation resistance value of the NIOSH standard for asbestos dust.

*The NIOSH standard for inhalation resistance as specified is for a full assembly respirator (filter element attached to a respirator). Note that a facepiece adds 3 millimeters of water resistance. The Table shows actual test results; thus, 3 millimeters must be added to test values to appropriately compare results with NIOSH standards.

EXAMPLE 2

Respirator exhalation valves of the present invention were tested for exhalation with airflow resistance and exhalation valve leakage in accordance with NIOSH test requirements as specified by 30 CFR 11, Subpart K, Section 11.140-9 as listed in Example 1 and Section 11.140-10, summarized as follows: 11.140-10 Exhalationvalve leakage test; minimum requirements. a) Dry exhalation valves and valve seats are subjected to a suction of 25 millimeters water column height while in a normal operating position. b) Leakage between the valve and valve seat shall not exceed 30 milliliters per minute.

An average exhalation valve flap resistance of 8.9 millimeters of water was the result of 75 tests performed. There were no leakage failures.

EXAMPLE 3

Following the procedures and NIOSH test specifications of Example 1, the triangular-shaped filter element of this invention, with an improved low resistance felt material filter media as supplied by American Felt and Filter Company of Newburgh, New York, was tested. The felt is identified as felt FFM47. Average test results for 48 tests performed are listed in Table 2.

Table 2

Resistance and Penetration - Triangular-Shaped Filter Element - Improved Filter Media - Silica Dust

	INHALATION RESISTANCE* Initial (mm H_2O)	Final (mm H_2O)	PENETRATION (mg H_2O)
Triangular-shaped, Tests:			
Average	7.9	14.2	0.1
Range	7.0-9.0	11.0-19.0	0.0-0.4
NIOSH Standard:			
Regular Dust (max)	30.0	50.0	1.5
Asbestos Dust (max)	18.0	25.0	1.5

Comparing test results of Examples 2 and 3, it can be seen that the filter media improvement of Example 3 lowers the resistance and penetration values, thus making the filter element even more acceptable for an asbestos dust environment.

EXAMPLE 4

Following the procedures and NIOSH test specifications of Example 3 and using similar triangular-shaped filter elements and filter media materials, filter elements were tested by a different laboratory to compare results. Average test results for 36 tests performed are listed in Table 3.

*See footnote in Example 1.

Table 3

Resistance and Penetration - Triangular-Shaped Filter Element - Improved Filter Media
Different Lab - Silica Dust

	INHALATION RESISTANCE Initial (mm H_2O)	Final (mm H_2O)	PENETRATION (mg H_2O)
Triangular-shaped, Tests:			
Average	7.6	12.8	0.1
Range	6.0-9.0	10.0-16.0	0.0-0.4

Comparing test results of Examples 3 and 4, values are fairly close.

EXAMPLE 5

The triangular-shaped filter element of this invention, with an improved felt material filter media, was mounted to a tapered adaptor and tested for silica mist in accordance with NIOSH silica mist test regulations as specified by 30 CFR 11, Subpart K, Section 11.140-7, summarized as follows: 11.140-7 Silica mist test; minimum requirements. a) Three respirators are tested for a period of 312 minutes each at a continuous airflow rate of 32 liters per minute. b) The room temperature in the test chamber is approximately 25°C. c) The test suspension in the test chamber is not less than 20 nor more than 25 milligrams of silica mist, weighed as silica dust, per cubic meter of air. d) Mist is produced by spraying an aqueous suspension of flint (99+ percent free silica), and the flint is ground to pass 99+ percent through a 270-mesh sieve. e) Samples of the test suspension are taken during each test period for analysis. f) The total amount of silica mist unretained in the sample taken during testing weighed as silica dust, shall not exceed 2.5 milligrams.

Average test results for 24 tests performed are listed in Table 4.

Table 4

Resistance and Penetration - Triangular Shaped Filter Element - Improved Filter Media - Silica Mist

	INHALATION RESISTANCE* Initial (mm H_2O)	Final (mm H_2O)	PENETRATION (mg H_2O)
Triangular-shaped, Tests:			
Average	8.2	12.0	0.1
Range	7.5-9.0	9.0-15.0	0.0-0.4
NIOSH Standard:			
Silica Mist	30.0	50.0	2.5

As can be seen from the results of Table 4, the respirator of this invention, with a triangular-shaped filter element and an improved filter media, is acceptable for silica mist environments.

Although the invention has been described with reference to these preferred embodiments, other embodiments can achieve the same results. Variations and modifications of the present invention will be obvious to those skilled in the art and it is intended to cover in the appended claims all such modifications and equivalents.

*See footnote in Example 1.

We claim:

1. A one-quarter facepiece type respirator (10) comprising:

a one-quarter facepiece (12) made of flexible material;

a pair of exhalation valves (20) with one exhalation valve being positioned in each opposed side of said facepiece (12) to allow air flow through each opposed side of said facepiece (12);

an inhalation valve (24) positioned in the front of said facepiece (12) to allow air flow through the front of said facepiece (12);

said facepiece (12) being designed so that it fits snugly to the contours of the wearer's face and only allows airflow through said valves (20; 24) when worn by a wearer;

a triangular shaped filter housing (22) defining a central aperture in communication with said inhalation valve (24) and being carried by said facepiece (12);

a triangular filter (14) in said filter housing (22); and

a filter cover (16) covering said filter housing (22).

2. The respirator as set forth in claim 1 wherein said filter housing (22) slopes in at the top and bottom toward the respirator facepiece (12) to reduce obstructions to the vision of the respirator wearer.

3. The respirator as set forth in claim 2 also comprising filter support pins (64) which provide free air space between the inhalation valve (24) and the filter (14).

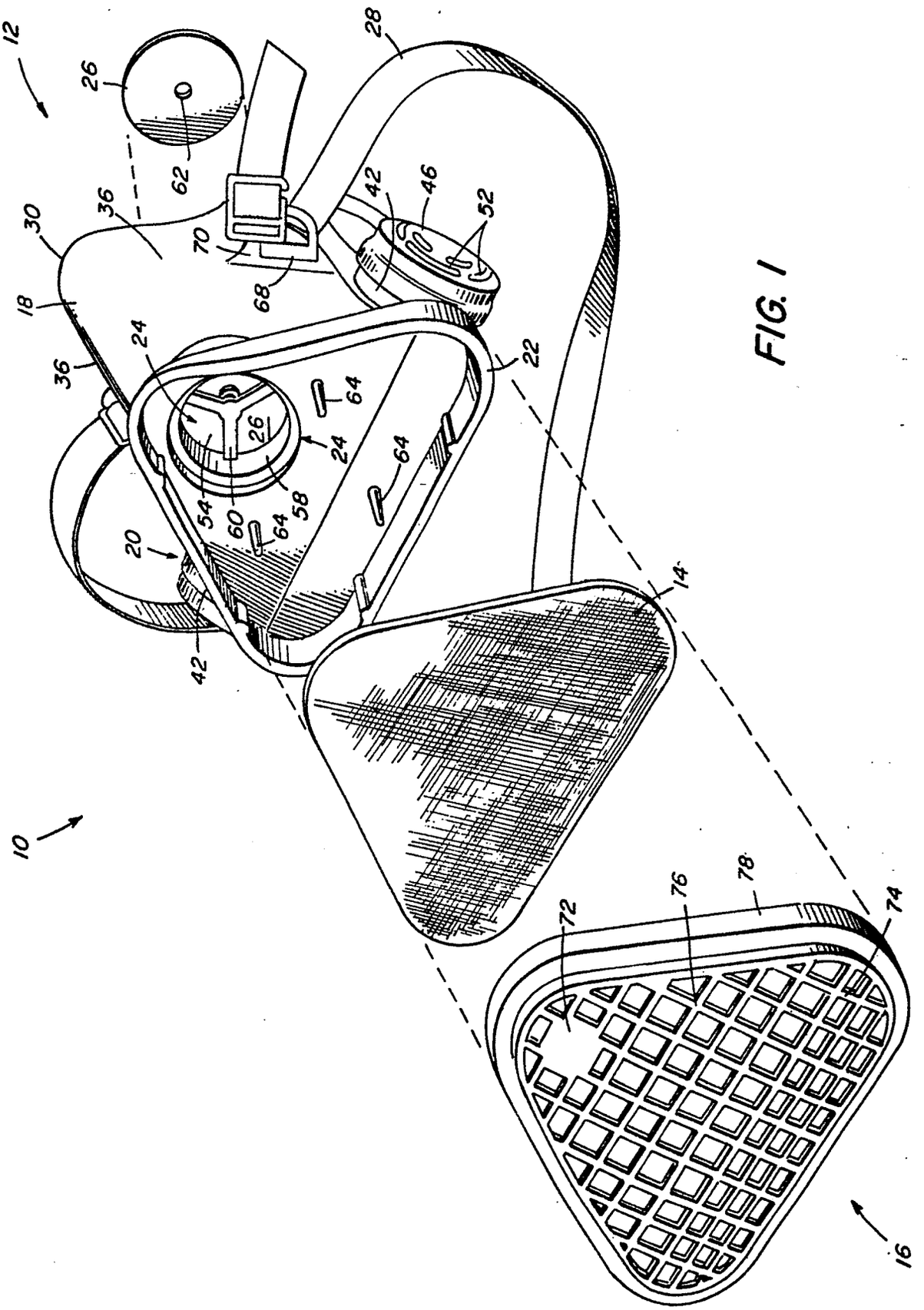
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FIG. 1

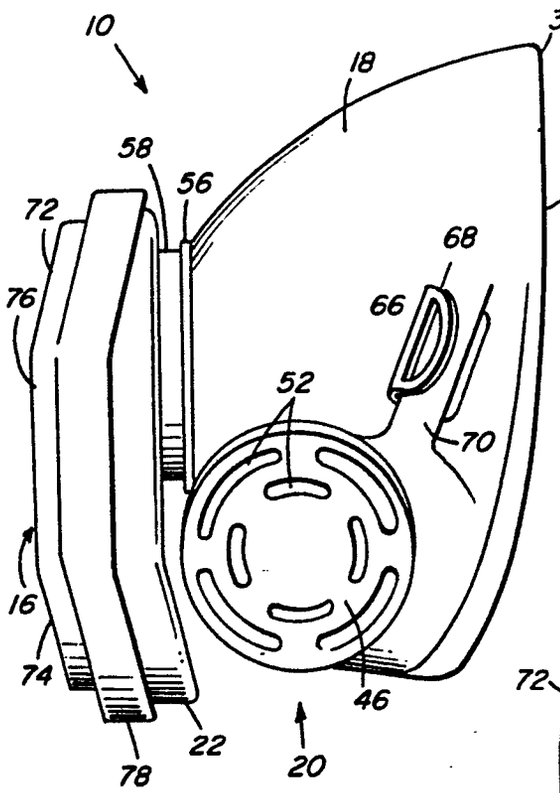

FIG. 2

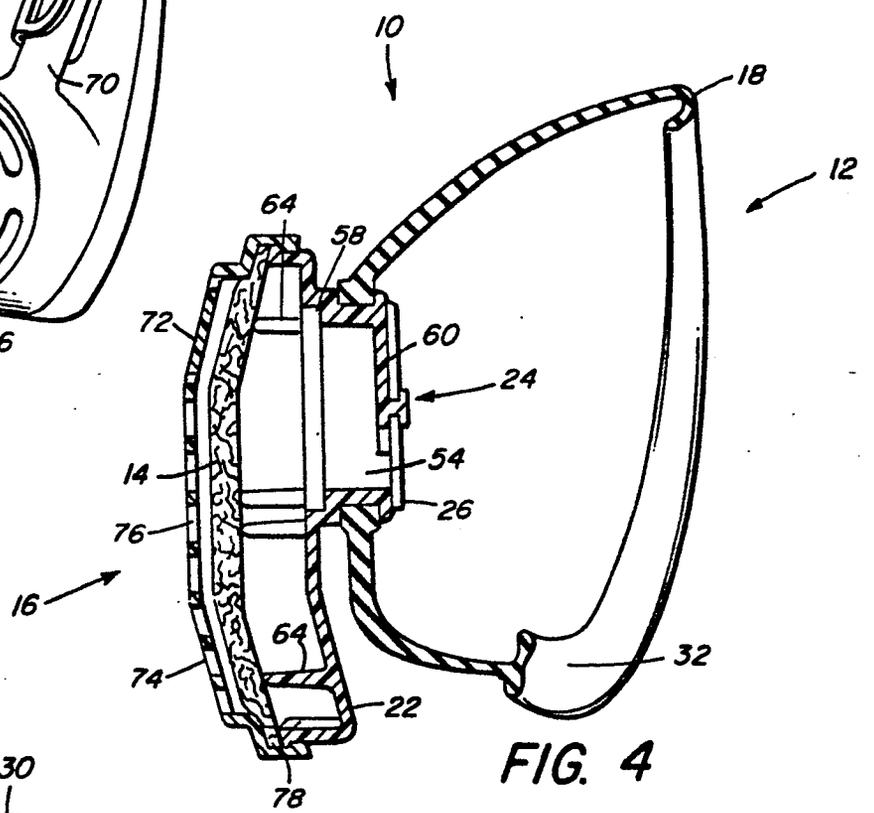

FIG. 4

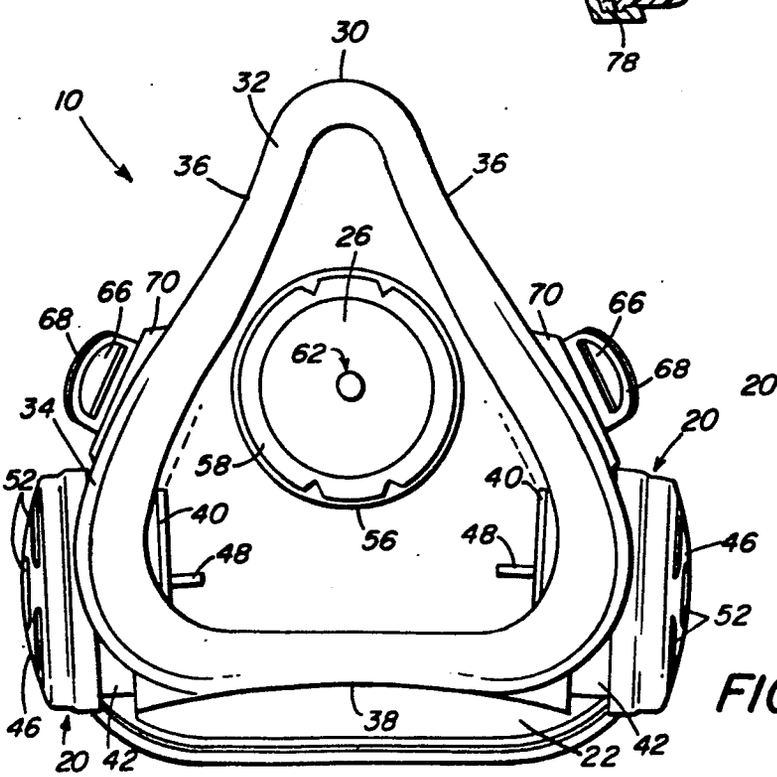

FIG. 3

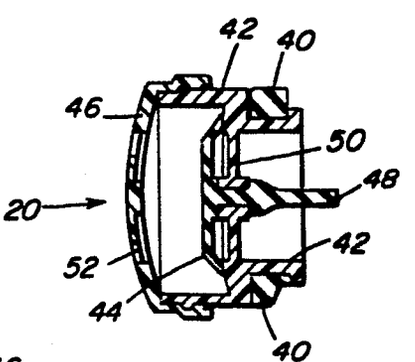

FIG. 5

0109514

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 83 10 9639

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
X	GB-A- 761 263 (MARTINDALE ELECTRIC CO. LTD.) * Entire document *	1	A 62 B 18/02
A	CH-A- 9 133 (DETOURBE) * Figures 1, 2 *	2	
A	US-A-3 014 479 (MATHESON) * Column 2, lines 42-45; column 3, lines 4-7; figure 2 *	3	
A	US-A-2 181 026 (SCHWARTZ) * Page 2, right-hand column, lines 9-11; figures 3, 4 *	3	
A	DE-A-2 329 668 (DRÄGERWERK AG) * Page 6 *	1	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	US-A-2 895 472 (MATHESON)		A 62 B 7/00 A 62 B 18/00
A	US-A-2 201 315 (LEHMBERG)		
A	DE-C- 144 267 (LOEB)		
D,A	US-A-2 823 671 (GARELICK)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	26-01-1984	KANAL P K

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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