Nov. 5, 1935. C. W. PUNTON ET AL 2,019,928

RESPIRATOR

Filed Dec. 18, 1934 3 Sheets-Sheet 1

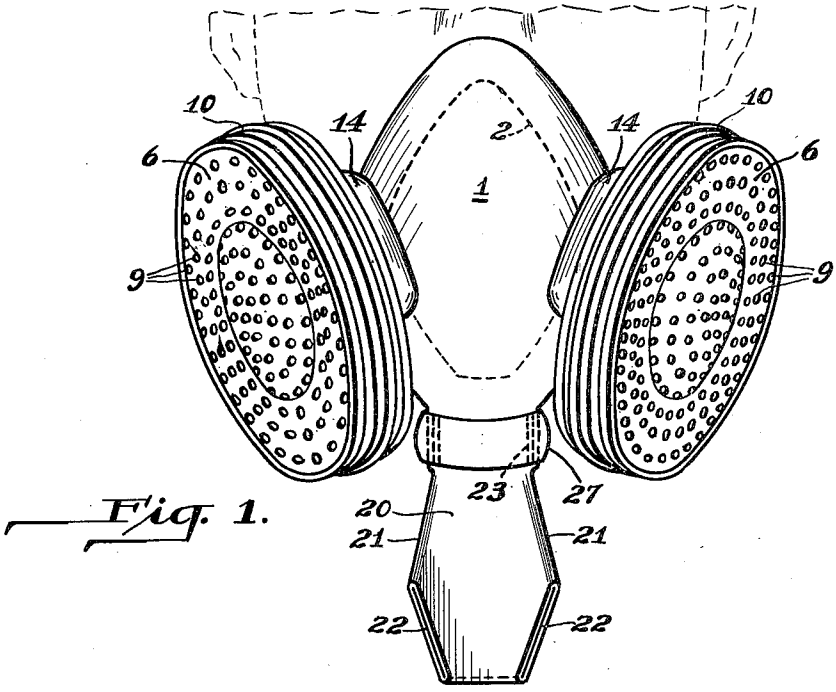


Fig. 1.

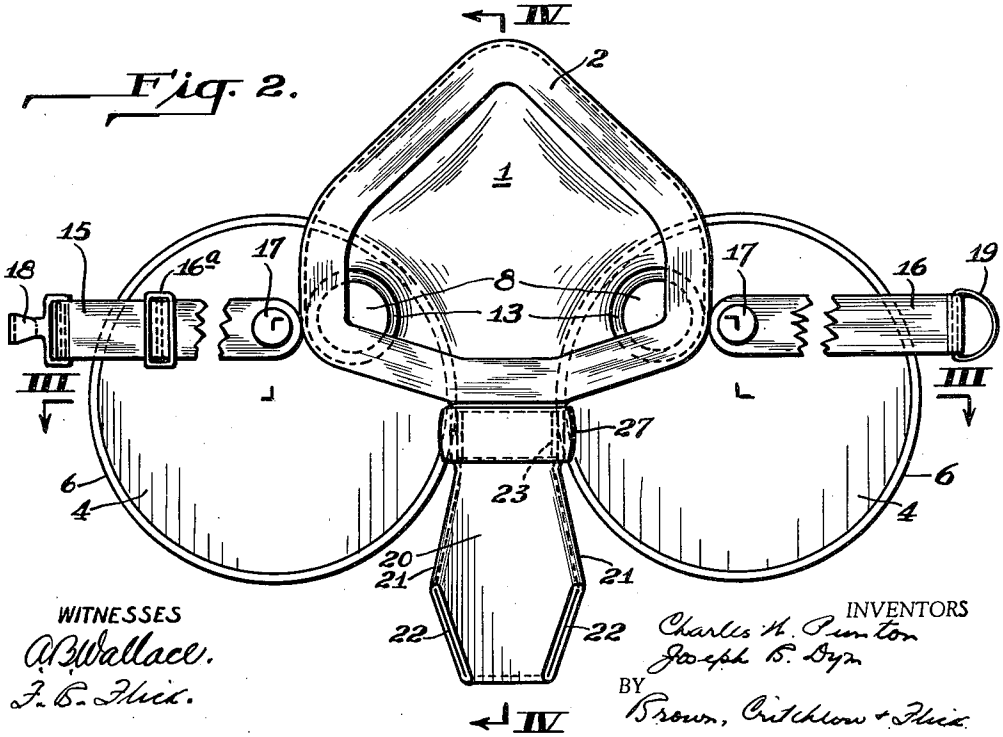


Fig. 2.

WITNESSES

A. B. Wallace.

F. B. Flick.

INVENTORS

Charles W. Punton

Joseph B. Dyn

BY

Brown, Critchlow & Flick

their ATTORNEYS.

Nov. 5, 1935. C. W. PUNTON ET AL 2,019,928

RESPIRATOR

Filed Dec. 18, 1934 3 Sheets-Sheet 2

Fig. 3.

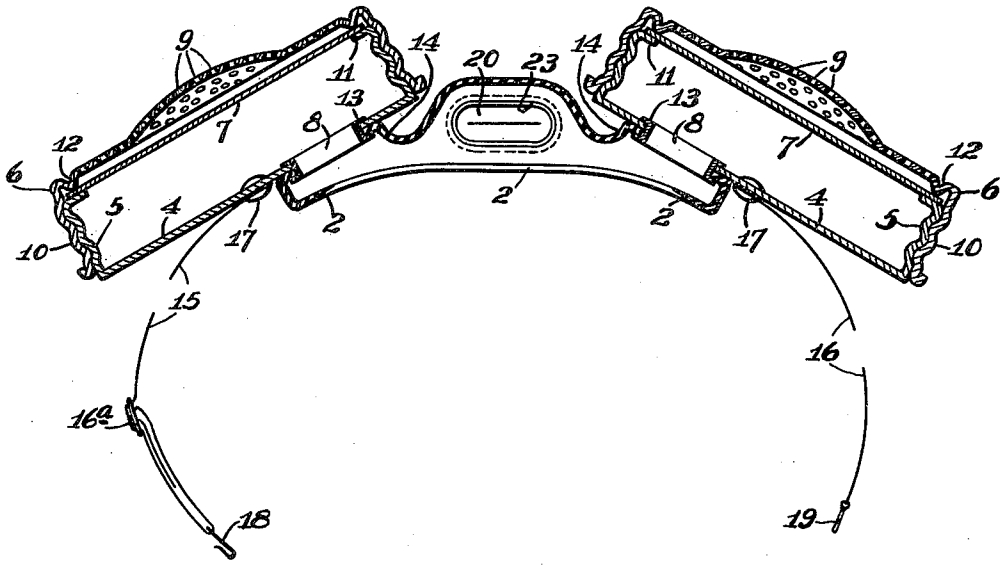
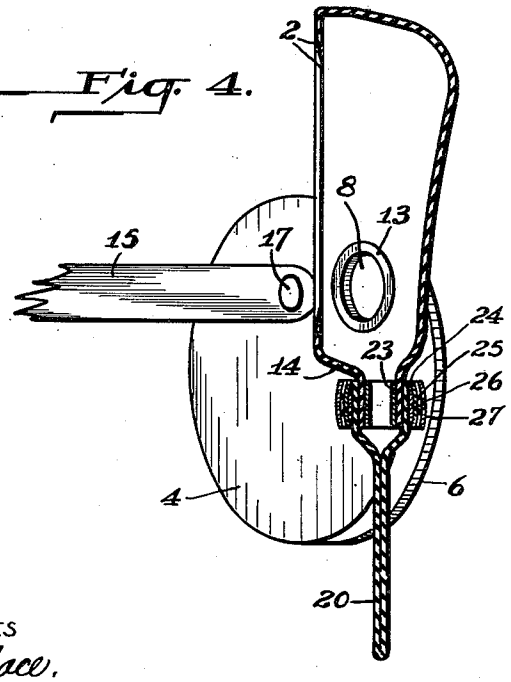


Fig. 4.



WITNESSES

A. B. Wallace.

F. B. Flick.

INVENTORS

Charles W. Punton

BY Joseph B. Dyer

Brown, Critchlow & Flick

ATTORNEYS.

Nov. 5, 1935. C. W. PUNTON ET AL 2,019,928

RESPIRATOR

Filed Dec. 18, 1934 3 Sheets-Sheet 3

FIG. 11

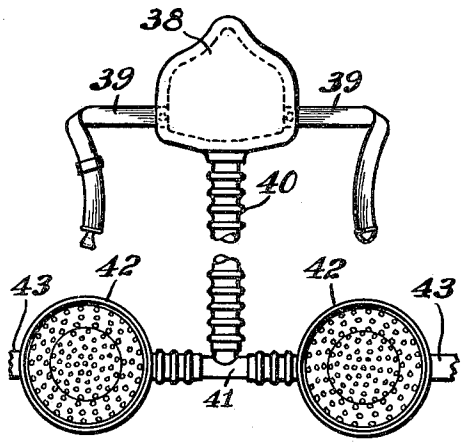


FIG. 6.

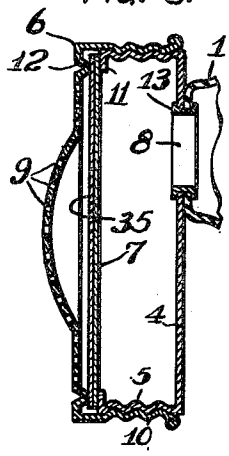


FIG. 5.

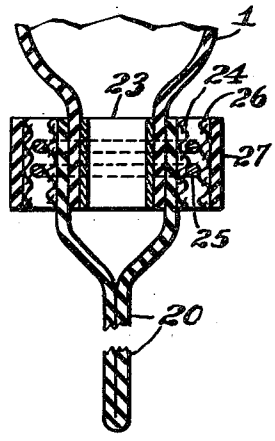


FIG. 10.

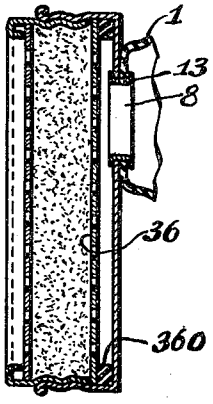


FIG. 7.

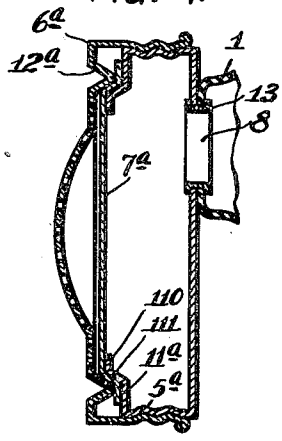


FIG. 8.

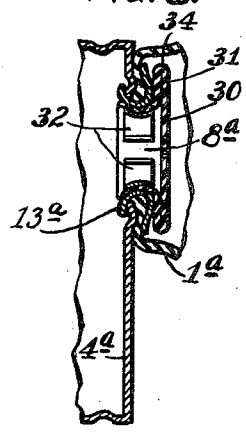
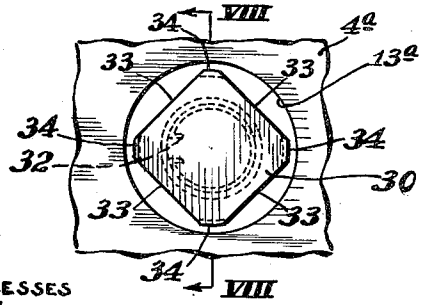


FIG. 9.



WITNESSES

A. B. Wallace.

F. B. Flick

INVENTORS

Charles W. Punton

Joseph B. Dyer

By Brown, Critchlow & Flick

Their attorneys.

Patented Nov. 5, 1935 2,019,928

UNITED STATES PATENT OFFICE

2,019,928

RESPIRATOR

Charles W. Punton and Joseph B. Dym, Pittsburgh, Pa., assignors to Mine Safety Appliances Company, Pittsburgh, Pa., a corporation of Pennsylvania

Application December 18, 1934, Serial No. 758,024

12 Claims. (Cl. 128—146)

This invention relates to respirators for removing solid material, such as dusts, smoke, and other solid particles, from air to purify it for breathing.

Various types of respirators have been proposed or used, but all of them have been subject to a variety of disadvantages. A major drawback of prior respirators has been the fact that they have had an unduly high breathing resistance, either initially or due to increase in use. High breathing resistance is undesirable not only because it reduces the wearer's physical efficiency, but also because it may cause him to work without a respirator with possible ill consequences to his health.

Some types of respirator suffer from the disadvantage that the user is unable readily to make himself understood vocally while wearing the respirator. In general the respirators known prior to this invention have been characterized by relatively great weight, which may cause tiring of the facial muscles of the user. The same result may follow also from the position of the filter unit, which in some prior respirators caused strains to be applied to portions of the wearer's face or head. These and other disadvantages known to those skilled in the art have militated against the various types of respirator available heretofore.

It is among the objects of this invention to provide a respirator for removing solid matter from air, which is efficient, adapted for the removal of extremely fine as well as relatively coarse particles, possesses an initially low breathing resistance, does not substantially increase in breathing resistance with use, is light in weight, can be made readily and inexpensively, and embodies other advantageous features as contrasted with the respirators known to the art.

The invention may be described with reference to the accompanying drawings, in which Fig. 1 is a front perspective view of the preferred embodiment of the invention; Fig. 2 a vertical elevation from the rear of the respirator shown in Fig. 1; Figs. 3 and 4 cross-sectional and vertical sectional views, respectively, taken on lines III—III and IV—IV of Fig. 2; Fig. 5 a portion of Fig. 4 enlarged and exaggerated somewhat to illustrate a detail of construction; Fig. 6 a sectional view through a modified form of filter unit; Fig. 7 a view similar to Fig. 6 showing a further modified embodiment; Fig. 8 a cross-section through the air-inlet portion of a face piece, taken on line VIII—VIII, Fig. 9, showing a modified embodiment intended to prevent moisture of respiration from reaching the filter; Fig. 9 a vertical elevation of the embodiment shown in Fig. 8; Fig. 10 a view like Figs. 6 and 7 illustrating the use of a canister with the respirator; and Fig. 11 a schematic view showing still another embodiment.

The most important feature in a respirator is that of comfort to the wearer, and the most important factor governing comfort is that of breathing resistance. It has been a characteristic of prior types of respirators for removing dust and other solid matter from air that even if the breathing resistance is not initially high it gradually increases as the respirator is used due to the increased resistance to passage of air through the filter element as it accumulates solid material taken from the air. This increase in breathing resistance not only is inimical to comfort, but also it may so greatly increase the breathing resistance as to reduce the physical efficiency of the wearer, as is well known, or it may render breathing so laborious that the wearer may discard his respirator with possible injurious consequences to his health.

We have discovered, and it is upon this that the invention is predicated in part, that this disadvantageous feature may be overcome by the use of a sheet-like filtering element, and by causing the filtering element to be vibrated in use so as to dislodge solid matter deposited on the element.

Most suitably, the element is supported in such manner that it is caused to move backward and forward, or flex, under the unbalanced pressures created in the respirator due to the acts of inhalation and exhalation in the breathing cycle.

In this manner there may be provided a filter element which possesses an initially low breathing resistance, and whose breathing resistance is maintained at a low value through the movements of the filter element in use. Thus, vibration, such as the backward and forward movements of the filter caused in the preferred embodiment by flexing created by the breathing of the wearer, tends to dislodge the solid matter from the filter, instead of permitting it to accumulate continuously therein and clog its pores. In this manner the pores are maintained open and the breathing resistance, while it may increase somewhat due to the inability to continuously dislodge all of the solid matter separated from the air, still is maintained at a satisfactorily low value.

The invention may be understood further with reference to the accompanying drawings. The embodiment shown in Figs. 1 to 4 comprises a face piece 1 adapted to cover the nose and mouth.

This may be generally of the shape and contour known in the art. Suitably it is made of flexible material, advantageously soft rubber, for adapting itself closely to the contour of the features of the wearer, so as to prevent leakage of air around the face piece, thus necessarily causing all of the air inhaled by the wearer to be drawn through the filtering element presently to be described.

Preferably, and in the embodiment shown, the face piece is provided with an inturned lip **2** which may decrease in thickness toward the edge, thus providing a feather edge, shown in section in Figs. 3 and 4, to insure sealing completely around the face piece. Not only does this inturned feather edge insure a good seal between the face piece and the face of the wearer, but it provides for obtaining that result with maximum comfort to the face of the wearer.

In accordance with the invention, air passed into the face piece is filtered through a sheet-like filter mounted to vibrate, or flex, under the action of the breathing cycle. This preferably is accomplished by supporting the filter around its edge in such manner as to prevent leakage of air around the edge and to leave the body of the filter element free to move backward and forward in the breathing cycle, as just described. The filter unit of the embodiment shown includes a cylindrical casing member comprising a base **4**, a side wall **5** upstanding from the base, and a cover **6** removably associated therewith. A circular sheet-like filter element **7** is supported around its edge between cover **6** and wall **5** of the casing, thus leaving the body of the filter free to flex, as seen in Fig. 3.

Base 4 of the casing is provided with a port **8** for conveying filtered air into the face piece, and cover **6** is provided with a plurality of openings **9** for ingress of unfiltered air to the filter.

The cover is, of course, associated with the casing in such manner as to prevent leakage of air past the filter, and to be readily removed for rapid and easy changing of the filter elements when that is desirable. Various means may be associated with the cover and casing for that purpose, but in the embodiment shown side wall **5** and cover **6** are provided with cooperating screw threads **10**.

A feature of the invention resides in the provision of particularly advantageous means of supporting filter **7** while positively sealing it against leakage of air around its edge. One means of doing this is shown in the embodiment of Figs. 1 to 4, in which the upper edge of casing wall **5** is turned inwardly to provide a continuous inwardly projecting flange **11** on which the edge of the filter element rests, as seen in Fig. 3. Cover **6** is provided adjacent its edge with an inwardly projecting rib **12** which overlies flange **11**. When cover **6** is screwed into place rib **12** is forced downwardly against filter element **7** thus exerting sufficient sealing pressure and supporting the filter for the flexing movement described.

Fig. 7 shows another construction applicable to positively holding the filter to seal it against leakage around its edge. In this form the upper end of the casing wall **5***a* is bent inwardly to form a flange **11***a*, the inner end of the flange being bent upwardly at an angle and then bent again to form another flange **110** parallel to flange **11***a* and connected to it by a sloping portion **111**. Cover **6***a* is likewise provided with a downstruck rib **12***a* whose inner wall lies parallel to portion **111**. In this manner the outer edge of filter **7***a* is forced against flange **11***a* and is gripped between rib **12***a* and wall **111**, thus being securely and positively sealed.

In the preferred embodiment shown in Figs. 1 to 4 face piece **1** is provided with two such filtering units disposed symmetrically one on each side of the face piece to be out of the line of vision of the wearer, as appears particularly from Fig. 1. This has a number of major advantages. It positions the filtering units well back on the face, thus giving good balance to the respirator and eliminating the downwardly acting strains which tend to be present in respirators having the filtering element disposed centrally of the face piece.

In addition to being out of the line of vision of the wearer, the units are also out of the direct line of exhaled breath. This is advantageous because it tends to minimize moistening of the filter by the moisture contained in the exhaled air, thus avoiding decrease in efficiency and increase in breathing resistance which may be caused by such moistening of the filter.

The units shown are connected to the face piece by ring members **13** crimped at one end around the edge of port **8** in container base **5** and on the opposite end around a similar opening formed in face piece **1**. Most suitably the face piece is molded to provide at this point an offset **14**, which has the advantage that it prevents collapsing of the face piece in the act of inhalation.

The respirator is provided, as usual, with head straps for holding it on the face of the wearer. As shown, head straps **15** and **16**, of elastic tape, are connected to container base **4** by rivets **17**. One of the straps, such as **15**, is provided with a hook **18** adapted to cooperate with an eye **19** carried by the other member, and one strap is provided with means **16***a* for adjusting its length.

The embodiment shown in Figs. 1 to 4 is also provided with a flutter valve **20** disposed at the bottom and centrally of the face piece. This flutter valve may take any of the customary forms, that shown being formed of rubber with its walls normally in contact as necessary in a flutter valve, and as shown in Fig. 4. The walls are connected at the edges in the upper portions, as seen at **21**, Figs. 1 and 2, and at the lower end are slitted to provide exhalation slots **22**. The mouth of the valve is slipped over the exhalation opening of the face piece, as seen in Figs. 4 and 5. In order to prevent collapse of the flutter valve there is inserted in the opening at the point of connection to the face piece, a rigid flattened tubular member **23**, such as metal, for example, held in place by wrapping a layer **24** of adhesive tape around the outside of the valve opposite member **23**, then binding with wire **25** about layer **24**, followed by an outer layer of tape **26**. A rubber band **27** may be disposed about the outside tape layer **26** to improve the appearance of the respirator.

This flutter valve operates in accordance with the usual principle. In the act of inhalation the reduced pressure causes its walls to collapse, sealing slots **22** and preventing ingress of air. On exhalation, however, the increased pressure causes slots **22** to open, thus permitting the air to be exhausted therethrough. The use of this flutter valve is advantageous because the resistance of the filter element is greater to exhalation than to inhalation, so that the act of exhalation is rendered easier.

The construction shown is also advantageous

because, due to the positioning of the flutter valve, it provides a saliva trap. The use of a flutter valve positioned in this manner also substantially reduces moistening of the filter member through the water vapor contained in the exhaled air, being positioned in the direct path of exhalation to encourage exhaustion through it.

In addition to the protection afforded by having air inlets 8 out of the line of respiration, and by the flutter valve 20, as just referred to, substantially complete protection of the filter against moisture of respiration may be had by the use of a flow controlling valve in the passage between the filter and the face piece, to permit ingress of air for respiration but to prevent outflow of respired air through or against the filter. A type of flutter valve suitable for this purpose is shown in Figs. 8 and 9, showing the valve applied to one of the filter units, although it will be understood that it is actually applied to both.

As in the preceding embodiment, filtered air passes into the face piece 1a through a port 8a in the bottom of casing 4a, the casing and face piece being connected by a ring 13a crimped as shown in Fig. 8. The valve 30 is formed from a sheet of flexible rubber by folding its edges under the body, as at 31, the extended edges being inserted in port 8a and engaged by a spring clip 32, to hold the valve in place. The valve is slit along edges 33 between the upper and lower layers, corners 34 being unslit. When the user of the respirator inhales, the reduced pressure in the respirator causes the slit edges 33 of valve 30 to part, permitting filtered air to enter the face piece, but the resiliency of the rubber and the positive pressure of exhalation cause the valve to close, thus preventing exhaled air from contacting the filter.

It will be observed from the drawings that the filter units are of such size as to accommodate filters of rather large area. This novel feature permits the use of filtering materials which if of small area might exhibit rather high breathing resistance, but owing to the great area exposed in our respirator the actual breathing resistance is low. This factor is further enhanced by the use of two such filter elements, or units. For instance, using filter casings four inches in diameter there will be exposed about 23 square inches of filter area, making it possible to use coarse soft filter paper as the filtering element.

While various sheet-like filtering elements capable of flexing in accordance with this invention may be used, we now prefer to use a porous cellulose material in sheet form and of such porosity as to satisfactorily remove particles of the size encountered in use. That is, for coarse dusts there may be used a cellulosic material sheet whose pores are coarser than those of a paper applied in a respirator for fine particles, such as those of smokes. Most suitably the filter element is formed from cellulose fiber sheet treated to provide pore openings of critical size as described and claimed, for example, in U. S. Patents No. 1,798,164 to Harry A. Kuhn and William A. Boyle, No. 1,814,190 to R. L. Sebastian and L. Finkelstein, and No. 1,818,155 to N. E. Oglesby and R. S. Brown. These filter materials have the advantage that they can be adapted to the removal of even the finest dusts, it being possible by the treatments described in the aforesaid patents to render the pore openings less than one micron in size, while at the same time providing filters that are efficient and of not unduly high breathing resistance.

Using such filters and applying the principle of providing filter units of large area, as indicated hereinabove, we have constructed respirators of the type shown in Figs. 1 to 4 having a breathing resistance not greater than about one-third inch of water at a flow rate of 85 liters of air per minute, which is unusually low for a respirator of such efficiency. Moreover, due to the flexing of the diaphragm under the acts of inhalation and exhalation, breathing resistance does not increase materially in the use of the respirator, even when applied to the removal of extremely fine solid matter from air.

In some instances it may be desirable to use a plurality of filtering elements. For instance, where relatively heavy and coarse dusts are encountered together with relatively fine dust, as in coal mines, it may be advantageous to use a filter adapted primarily to remove the heavier or coarser dust, followed by one adapted to remove the fine dust. We have found that for such purposes it is advantageous to form the filter of a layer of fibrous material 35, Fig. 6, such as felt, for initially removing the coarse particles. In back of the felt is placed a cellulose fiber filter sheet 7, preferably of the type described hereinabove, for removing the fine dust. The breathing resistance of the felt is, of course, low, and layer 7 is free to move under the stimulus of the pressures created in breathing, as described. The thickness of the felt layer will depend, of course, on its resistance to air flow and the size of the particles to be removed from the air.

The filter units described provide for very rapid and very easy replacement of the filters, and they are sealed against dust leakage. The construction described and shown may be made very light, the casing with its cover being made from light gauge metal, and the filter element constributing substantially no weight at all, which is a feature of novelty in respirators of this type.

A further advantage of the construction described is that it is capable of receiving a canister 36, Fig. 10, of materials adapted to remove toxic or injurious gases and vapors contained in air, to render the respirator capable of use as a gas mask. Such a canister is screwed into the casing, whereby it is readily and quickly inserted or replaced, and whereby the respirator is adapted quickly to either respirator or gas mask use. Leakage of air past the canister is prevented by a gasket 360 disposed between canister 36 and the bottom of the casing.

Although the invention has been described with reference to a respirator integrally embodying the filter units, it is possible also to obtain the benefits of the invention by constructing the respirators in other ways. One modification is shown in Fig. 11, in which there is provided a face piece 38 of the general type referred to hereinabove, having head bands 39 for holding it to the face. Projecting downwardly from the face piece is a hose 40 leading to a coupling member 41 adapted to lie on the chest of the wearer. Coupling member 41 is provided with a pair of filter units 42 embodying a filter element supported to flex under the movement created by the breathing cycle, such, for example, as the units described hereinabove. In order to maintain the filter unit satisfactorily on the chest of the wearer it may be provided with strap members 43 intended to encircle the chest.

It will be apparent that an advantage of the invention arises from the construction shown

and described, in which the filtering is accomplished by means of thin sheet-like filtering material. Due to this factor and the manner of disposition of the filtering element, the latter acts as a diaphragm, so to speak, for assisting in voice transmission, thus rendering it easy for the wearer to speak with other persons without unduly exerting himself.

According to the provisions of the patent statutes, we have explained the principle and mode of construction of our invention, and have illustrated and described what we now consider to be its best embodiment. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

1. In a respirator, a unit for removing solid matter from air, the unit comprising a casing, a sheet-like filter element of self-form-sustaining material adapted to remove solid matter from air passed therethrough mounted in said casing, said element being supported about its edge to prevent leakage of air therearound and with the body of the element unsupported and free to flex under the action of inhalation and exhalation, said casing being provided on opposite sides of the filter with openings for ingress of dust-laden air and egress of filtered air.

2. In a respirator, a unit for removing solid matter from air, the unit comprising a casing, a cover removably associated therewith, a sheet-like filter element adapted to remove solid matter from air passed therethrough, said element being supported about its edge between said casing and cover to prevent leakage of air therearound and with the body of the element unsupported and free to flex under the action of inhalation and exhalation, said cover being foraminous for ingress of dust-laden air to the filter, and said casing being provided with a port for egress of filtered air.

3. In a respirator, a round casing member, a perforated cover removably associated with said casing having a perforated body portion, a circular sheet of self-form-sustaining porous filter material of relatively large area disposed with its edge gripped between the top of the casing wall and the cover to cause all of the air to pass through the filter, and the body of the filter being free to flex under the action of inhalation and exhalation and serving as a speaking diaphragm to assist the wearer in conversing with other persons.

4. In a respirator, a round casing member provided with threads on its side wall, a perforated cover for the casing having a depending skirt provided with screw threads cooperating with those on said casing, a circular sheet of porous filter material of relatively large area disposed with its edge gripped between the top of the casing wall and the cover to cause all of the air to pass through the filter, and the body of the filter being free to flex under the action of inhalation and exhalation.

5. In a respirator according to claim 3, a layer of fibrous material of coarse pore size, such as felt, disposed adjacent said sheet of filter material.

6. In a respirator, a round casing member having a side wall provided with an inwardly extending flange around its top, a cover removably associated with the casing having a perforated body portion, a circular sheet of porous filter material disposed with its edge resting on said flange and gripped between the flange and the cover to cause all of the air to pass through the filter, and the body of the filter being free to flex under the action of inhalation and exhalation.

7. In a respirator, a round casing member having a side wall provided with screw threads and with a flange projecting inwardly about its upper end, a cover for the casing having a perforated body portion and having a depending skirt provided with screw threads cooperating with those on said casing, a rib projecting downwardly from the body of said cover and overlying said flange, a circular sheet of porous filter material disposed with its edge gripped between said flange and rib to cause all of the air to pass through the filter, and the body of the filter being free to flex under the action of inhalation and exhalation.

8. A respirator according to claim 6, and a layer of fibrous material of relatively coarse pore size supported with said filter sheet.

9. A respirator according to claim 7, and a layer of fibrous material of relatively coarse pore size supported with said filter sheet.

10. In a respirator, the combination of a face piece, a pair of filter units connected symmetrically one to each side of said face piece and each comprising a casing, a sheet-like filter element mounted in the casing with its body portion free to flex, a port in the casing rearwardly of said filter opening into said face piece for passing the filtered air to the face piece, inhalation and exhalation of the wearer causing said filter to flex and dislodge suspended matter deposited thereon.

11. In a respirator, the combination of a face piece, a pair of filter units connected symmetrically one to each side of said face piece and each comprising a casing having a side wall provided at its upper edge with an inwardly projecting flange, a perforated cover removably associated with said casing, a sheet-like filter element mounted with its edge gripped between said flange and cover and with its body portion free to flex, a port in the casing rearwardly of said filter opening into said face piece for passing the filtered air to the face piece, inhalation and exhalation of the wearer causing said filter to flex and dislodge suspended matter deposited thereon.

12. In a respirator, the combination of a face piece, a pair of filter units disposed symmetrically one on each side of said face piece and each comprising a casing having a side wall provided with screw threads and also provided adjacent its upper end with an inwardly projecting flange, a perforated cover having a skirt provided with screw threads cooperating with those on said casing and having a rib projecting downwardly and overlying said flange, a sheet-like filter element mounted with its edge gripped peripherally between said flange and rib and with its body portion free to flex, a port in the casing rearwardly of said filter, and a connection between said port and face piece for supporting the unit on the face piece and for passing the filtered air to the face piece, inhalation and exhalation of the wearer causing said filter to flex and dislodge suspended matter deposited thereon.

CHARLES W. PUNTON.
JOSEPH B. DYM.