

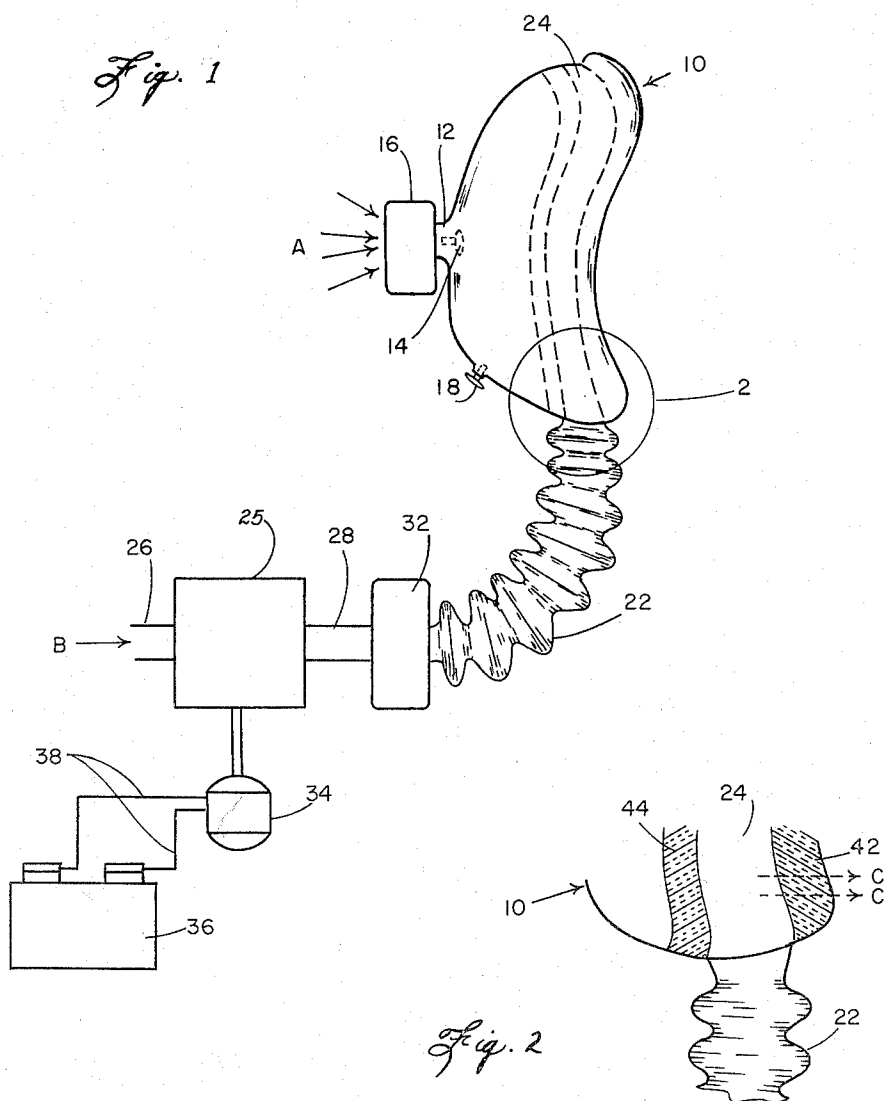
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L. SILVERMAN

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RESPIRATOR WITH POSITIVE AIR SEAL

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INVENTOR.
LESLIE SILVERMAN

BY

Richard G. Goodman
Attorney

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RESPIRATOR WITH POSITIVE AIR SEAL

Leslie Silverman, Dover, Mass., assignor to the United States of America as represented by the United States Atomic Energy Commission

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The present invention relates to respirators or gas masks with positive air sealing and more particularly to those devices with rim seals which can be pressurized.

Gas masks and respirators have long been used under certain environmental conditions to reduce the inhalation of toxic aerosols or gases. Both the gas mask and respirator are fitted to the wearer's face and a cartridge or filter is used which either removes the toxic substances from the aerosol or else neutralizes their effect. The individual wearing a mask which is not pressurized, referred to herein as a gas mask, provides the pressure differentials necessary during inhalation and exhalation to cause flow of air in through the filter and out through a check valve. In the air-supplied type of device, referred to herein as the respirator, the mask is provided with a clean compressed air supply such as from a pump and this relieves the wearer of the mask from the breathing effort which is required to draw through a filter.

Gas masks are the least expensive of the two types of devices as would be expected. However, due to the fact that breathing through a resistance produces a negative pressure in the mask, there is substantially more leakage into the mask, especially during the inhalation portion of the breathing cycle, as compared to the air-supplied pressurized respirator. Therefore, the gas mask is not as efficient in protecting the wearer from the presence of the toxic aerosols; and in environments of very toxic aerosols, it would not be possible for a mask of this type to be used. In addition, the gas mask, because of the effort required by the wearer to operate it, can be worn continuously only for a very limited period of time. The respirator, on the other hand, by providing a positive supply of air under pressure to the mask, relieves the wearer of the effort of providing the necessary pressure differentials so that this mask can be worn a longer period of time. However, there are certain substantial limitations connected with the use of respirators and these have mitigated against their being used as widely as the gas mask. First, the respirator is a much more expensive device than a gas mask. The air-line respirator requires a compressed air-line source of purified air with a long hose attachment, or this could be provided by a portable source consisting of a battery, an electric motor and an air pump to provide cleaned and filtered air under pressure into the face mask. Second, in a typical full face respirator, the pumping system must provide air at the high flow rate of approximately 120 to 180 liters per minute. This power requirement, due to present technical limitations in battery technology, restricts in a portable source the totally air-supplied respirator to relatively short periods of operation. In an air-line respirator, the long compressed air hose represents a formidable restriction on movement or a burden for the wearer of the mask to assume while carrying out his assigned duties.

A need has long been felt by many workers in this field to provide a safety device which combines the economic advantage, simplicity and convenience of the gas mask or filter respirator with the very important and substantial advantages of the leak-proof pressure seal provided by the air-line respirator. This need has been heightened recently by the increased use of more toxic materials and the higher toxic levels found in nuclear processes. To illustrate the latter situation, non-radioactive beryllium is considered to be 100 times more toxic than lead,

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whereas the radioactive nuclides Pu-239, Po-210 and Sr-90 are respectively considered five million, two billion, and three billion times more toxic on a weight basis. With increasing numbers of workers in the rapidly growing nuclear industries exposed to these materials, it is imperative that respiratory devices be improved to cope with these new, more dangerously toxic materials.

The present invention helps to meet this problem by combining to an extent not heretofore considered to be possible the principal advantages of both the above types of devices. Briefly described, the invention consists of a gas mask or half mask respirator provided with a peripheral plenum which is pressurized with sealing air. That is, the respirator is provided with a separate chamber extending throughout the periphery of the face mask, and this chamber is independently pressurized. The peripheral plenum is formed from a pair of multicellular membrane structure segments along the inner and outer walls of the plenum. The inner membrane segment is a flexible foam structure with closed cells while the outer segment is a porous foam material which is open-celled to permit air seepage or passage therethrough. When the mask is fitted to the face, the cellular structures contact the facial surface and seal in all locations where contact is made. Air which is supplied to the plenum will then pass out of the mask through the porous outer membrane at low velocity without disturbing the wearer, providing the sealing advantages of a fully pressurized respirator face mask. In the case of the inner membrane, at points where contact with the face is minimal or actually does not exist, air from the plenum will pass inwardly as filtered air relieving the wearer of some of the effort required to suck air into the mask through the filter.

By this invention, it is possible to minimize positive air requirements for the face mask while retaining the sealing effectiveness of the respirator thus making a compact portable pressurizing supply possible. At the same time, the inventive device provides a more economical protection device for filter type half masks by requiring a far smaller volume of air from the independent pressurized air supply.

It is, therefore, a first object of this invention to provide a protective respiratory device which is highly effective in preventing leakage therein of toxic aerosols.

It is another object of this invention to provide a positive seal type respirator or gas mask which requires far less pressurized air for its operation than previous devices of this type.

Still another object of this invention is the provision of a gas mask which requires less breathing effort by the wearer to operate than previous devices of this type.

Another object is to provide a respirator of simple and economic construction with positive sealing means capable of use over extended periods of time in toxic environments.

Other objects and advantages of this invention will hereinafter become more evident from the following description made with reference to the accompanying drawings in which:

FIG. 1 is a schematic diagram of a preferred embodiment of this invention; and

FIG. 2 is a detail of the mask shown in FIG. 1.

Referring to FIG. 1, there is shown in accordance with this invention a face mask 10 provided with an inlet pipe 12 controlled by a check valve 14 schematically illustrated and a cartridge 16 for filtering incoming air as is understood in the art. Mask 10 is also provided with an exhalation check valve 18 also schematically illustrated and corrugated flexible tubing 22, connected to the peripheral plenum designated 24 in FIG. 1. The details of plenum 24 will be described below in connection with FIG. 2. For supplying air under pressure to plenum 24 through tubing 22, there are provided, as the remainder of the

apparatus for the operation of mask 10, a blower or pump 25 with an inlet 26 and an outlet 28 leading to a filter cartridge 32 at the entrance to tubing 22. Electric motor 34 drives blower 25 and the former is energized by an appropriate electric dry cell 36 connected by electric lead lines 38. It is understood that the assembly of battery 36, motor 34, blower 25 and cartridge 32 form a compact unit which may be carried by the wearer of mask 10. When the wearer of mask 10 inhales, air enters into his face mask 10 through cartridge 16 as indicated by arrows A. The positive supply of air pressure to plenum 24 is delivered from blower 25 which brings in air as indicated by arrow B to provide sealing for mask 10, as will be explained further below.

Referring to FIG. 2 for a brief description of the details of plenum chamber 24 formed along the outer periphery of mask 10, it will be seen that this plenum 24 is formed by an outer cellular structure 42 and an inner cellular structure 44. Since the pressure within outer plenum 24 is higher than the pressure of the aerosol or atmosphere outside of the mask, and there is a uniform leakage of this pressurizing air outwardly, this will help to eliminate to a very great extent leakage into mask 10 of toxic aerosols surrounding the wearer. The outer cellular structure 42 consists of a foam material having open cells to permit as indicated by arrows C air supplied up through tubing 22 to pass outwardly through membrane structure 42 to the atmosphere. The purpose of the open-celled outer cellular structure 42 is to provide an egress for the air supply on a uniform basis. While this cell structure does not in itself contribute directly to sealing mask 10, it does provide a way in which the air pressure is relieved generally rather than through one specific opening, thereby avoiding jets or high velocity air currents which would tend to make the mask uncomfortable. A satisfactory material is open cell polyurethane, while other materials would be porous polyethylene, polyvinylchloride, and polypropylene.

The inner cellular material 44 is made from material having closed cells so that leakage into the interior of the mask will be limited to the contact surface between the face of the mask wearer and the contacting surface of membrane 44. The seepage at this surface is through points of poor fit and thus helps the sealing action of plenum 24 and also results in the mask being more comfortable in providing a cushioning effect to the wearer so that he can go for longer periods of time in wearing this mask before the discomfort reaches a point where it affects his efficiency and he must remove the mask. The air, of course, that passes into the inside of the mask from the plenum 24 is in small amounts to prevent full mask pressurization and already filtered so that there is no danger to the wearer. It will also be seen that the arrangement as herein provided makes absolute facial contact as in the case of the ordinary face mask totally unnecessary. It is further apparent that seepage of the sealing air into the face mask assists the wearer in his breathing since it reduces somewhat the amount of air which must be inhaled through cartridge 16. A satisfactory material for inner structure or membrane 44 is closed-cell polyvinyl. Thus, the dual foam barrier of non-ferrous porous surfaces provides a positive outward leakage protection as well as a much more comfortable structure for the wearer.

It will be noted that there is a substantial reduction in air volume which must be supplied to this mask as compared to the ordinary respirator. This results in a substantial reduction in the size of the air supply and filtration equipment necessary. This means that apparatus consisting of, for example, blower 25, motor 34 and battery 36 may be much smaller and lighter, thereby making the whole assembly more convenient for the wearer to carry about. If an outside source of compressed air is used a lighter more flexible hose would give greater mobility to the wearer.

To illustrate this advantage, in an inventive respirator

as just described, it has been found that the volume of air supplied to the rim is in the range of 15 to 20 liters of air per minute. This contrasts with a fully pressurized respirator having a positive seal maintained by some air escaping from the mask in which the air must be delivered at a flow rate of 120 to 180 liters per minute. Therefore, a tremendous saving in equipment size and related economic factors are effected by this invention, while the arrangement retains all of the sealing effectiveness of the fully pressurized mask devices. Further, due to the double cushioning effect and the distribution of the load on the wearer's face over an increased surface area, there is a far more comfortable respirator provided than fully pressurized devices. It should also be noted that the arrangement as herein described imposes no limitations in connection with the types of protection desired, as, for example, this device can still be used with cartridges for protection against gases, for filter type masks for protection against particles, or for combination units where protection is to provide against both contaminants.

It is, therefore, seen that there has been provided a unique and improved device for providing respiratory protection to a worker operating in an area containing a toxic gas or aerosol. The invention retains many of the simplicities in terms of weight and economics of the ordinary gas mask, yet incorporates many of the necessary and important advantages of the fully pressurized respirator. Also, the instant invention permits the use of masks at toxicity levels which heretofore have been considered to be impossible of attainment for simple face masks and which had been left for other more complicated and involved types of equipment. In addition, the invention provides for a respirator mask which is far more comfortable than masks heretofore in use, thereby permitting the use of such masks for more extended periods of time without extreme discomfort to the wearer.

While, of course, only a preferred embodiment of this invention has been described, it is understood that various modifications and alterations of this invention may be incorporated without deviating from the principles in this invention, and therefore the invention is to be considered to be limited only by the scope of the appended claims.

I claim:

1. A respirator comprising a mask in peripheral contact with the face of a wearer including
 - (a) first means for inhaling in and exhaling out of said mask in response to the breathing of said wearer,
 - (b) second means forming with said face along the periphery of said mask a sealing chamber, and
 - (c) third means for pressurizing said chamber with air to prevent outside leakage into said mask through the peripheral contact of said mask with said face,
 - (d) said second means including (1) a closed-cell porous material separating said sealing chamber from the interior of said mask to limit the flow of said air under pressure into said interior to relatively small amounts and (2) an open-cell porous material lining the outer periphery of said chamber to permit limited uniform flow outwardly of said air under pressure.
2. A respirator comprising a mask for contacting the face of the wearer including means forming a plenum along the periphery of the mask to form a breathing chamber, means responsive to inhalation of said wearer for permitting air to enter said breathing chamber including means for filtering the incoming air, means for exhausting air from said breathing chamber in response to exhalation of said wearer, and means for supplying filtered pressurized air to said plenum, said plenum formed by two spaced flexible raised structures having free edges extending about the periphery of the mask and adapted to be in contact with said wearer's face, one of said raised structures being spaced inwardly of the other and means in the outer structure to permit controlled leakage outwardly of said mask.

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3. A compact portable respirator comprising a face mask having a central breathing chamber and a plenum formed by a pair of spaced flexible ridges having free edges extending about the periphery of said mask with said free edges adapted to contact the face of the wearer, one of said ridges being spaced inwardly of the other and means in the outer ridge to permit controlled leakage of air uniformly outwardly around the periphery of said plenum, said mask having valve means including a filter for permitting air to enter directly into said breathing chamber in response to inhalation by said wearer, said mask having valve means to open and exhaust said chamber in response to exhalation by said wear, portable pump means carried by said wearer to pressurize said plenum with air, the last-named means including a port-

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able power supply means for said pump means to filter the pumped air.

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RICHARD A. GAUDET, *Primary Examiner.*