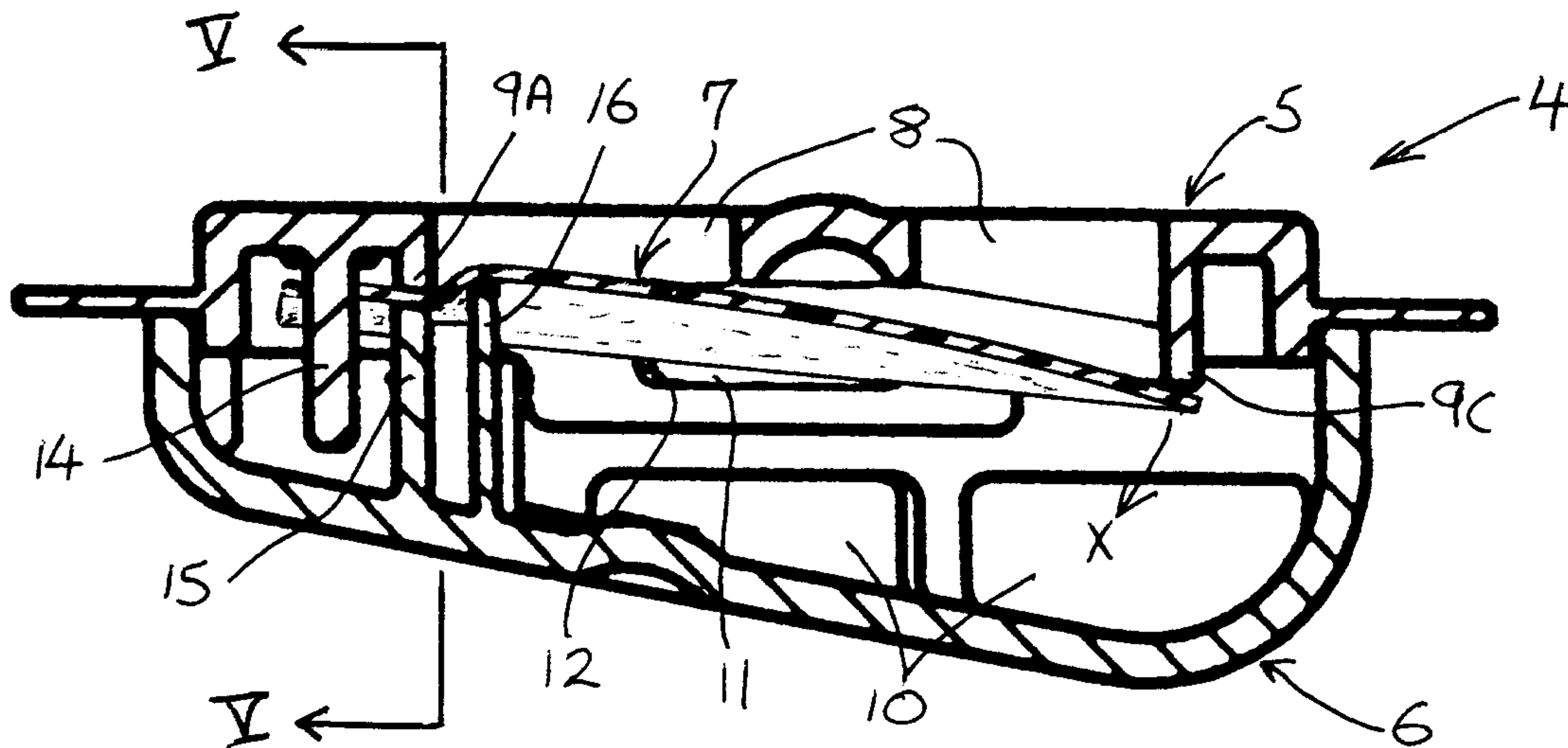




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(57) Abrégé/Abstract:

A uni-directional fluid valve particularly for use as an exhalation valve for a filter mask comprises a flexible flap attached at one end to a concave portion of a seat. The mounting of the flap imparts to it a transverse curvature, stiffening the flap sufficiently for it to remain seated in the absence of a pressure differential across it even when orientated with the seat above the flap.

ABSTRACT OF THE DISCLOSURE

A uni-directional fluid valve particularly for use as an exhalation valve for a filter mask comprises a flexible flap attached at one end to a concave portion of a seat. The mounting of the flap imparts to it a transverse curvature, stiffening the flap sufficiently for it to remain seated in the absence of a pressure differential across it even when orientated with the seat above the flap.

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TITLE OF THE INVENTIONUni-Directional Fluid Valve15 BACKGROUND OF THE INVENTION

The present invention relates to a uni-directional fluid valve which may in particular be used as an exhalation valve for a filter mask. By a "filter mask" we mean a device adapted to be worn over the nose and mouth of a user and made from or incorporating a filter material to remove one or more unwanted components from the inspired air. To improve the comfort and efficiency of such devices it is common to provide a uni-directional exhalation valve on the mask which opens under the pressure differential consequent upon exhalation of the user to allow for a relatively unrestricted flow of exhalate out of the mask, but which closes under other conditions. Examples of valved filter masks are shown in GB-2072516, DE-4029939, US-4414973, US-4630604, US-4838262, US-4873972, US-4934362, US-4958633, US-4974586, US-4981134 and US-5325892.

A common type of exhalation valve comprises a circular diaphragm of e.g. silicone rubber and a cooperating circular valve seat surrounding the orifice which passes the user's exhalate. The diaphragm is clamped at its centre and marginal portions flex away from the seat when the user exhales. In another known type the diaphragm is in the form of a flexible flap which is attached to a

26783-6

2

cooperating seat structure at one end, that is to say in cantilever fashion, and flexes away from the rest of the seat when the user exhales. In the design of an exhalation valve it is important to maximise the cross-sectional area of the open orifice to allow free flow of exhalate through the valve, and also to minimise the differential air pressure required to open the valve (i.e. the valve "cracking" pressure). Centrally clamped diaphragm valves require a greater force to open them than cantilevered flap type valves of equivalent size because their available "lever arm" is less. Furthermore, the structure of a cantilevered flap type valve, when open, generally presents less of an obstruction to flow than the centrally clamped circular diaphragm type valve, or in other words imposes a smaller pressure drop for a given orifice size. A potential problem which must be addressed in the design of a cantilevered flap valve, however, lies in ensuring that the flap will remain closed in all orientations of the structure while it is not subject to an exhalatory pressure differential. That is to say, while in order to minimise the opening pressure differential of the valve it is desirable to employ a highly flexible flap of minimal thickness, the very flexibility of the flap may mean that if the valve is inverted in use (i.e. orientated with the seat lying above the flap), the flap may droop down from the seat when the user is not exhaling. This is clearly undesirable as it may open a leakage path into the mask for the contaminants which it is intended to exclude.

US-5325892 discloses an exhalation valve with a cantilevered flap in which the valve seat has a seal ridge which is curved in the longitudinal direction of the flap, the curvature corresponding to a deformation curve exhibited by the flap when it bends under its own weight (with no pressure

26783-6

2a

differential). In other words the design of that valve recognises that the flap is unable to stay flat when the structure is inverted and

matches the configuration of the seat to the curvature of the flap under that condition.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a uni-directional fluid valve that comprises: (a) a flexible flap; and (b) a cooperating valve seat, the valve seat including a seal surface that surrounds an orifice, the flexible flap being attached to the valve seat in a cantilevered fashion such that the flap makes contact with the seal surface when the flap is closed and such that a free end of the flap lifts from the seal surface when fluid passes through the orifice in the permitted direction, the flexible flap having a transverse curvature to bias the flap to the seal surface in the absence of a pressure differential across the flap, under any orientation of the valve.

The invention also provides a filter face mask that comprises: (a) a mask body adapted to fit over a nose and a mouth of a wearer; and (b) an exhalation valve mounted to the mask body, the exhalation valve comprising a flexible flap and a valve seat, the flexible flap being mounted to the valve seat in cantilever fashion such that it has a longitudinal dimension, the cantilevered flap having a free end that rests upon the valve seat when closed, the flap exhibits a curvature in a direction transverse to the flap's longitudinal dimension, the transverse curvature biasing the cantilevered flap to assist in closing the valve in the absence of an opening pressure differential across the flap, under any orientation of the valve.

3a

The invention further provides a filter face mask that comprises: a) a mask body adapted to fit over a nose and mouth of a wearer; and b) an exhalation valve mounted to the mask body, the exhalation valve comprising a flexible flap, a valve seat, and a valve cover, the valve seat comprising one or more inlet ports, which one or more ports are surrounded by a seal surface, the valve cover comprising one or more outlet ports and being joined to the valve seat, the flexible flap having a stationary portion and a free portion and a peripheral edge that includes stationary and free segments, the stationary segment of the flap's peripheral edge being associated with the stationary portion of the flexible flap so as to remain stationary during an exhalation, and the free segment of the flap's peripheral edge being associated with the free portion of the flap so as to be movable during an exhalation, the flexible flap having a transverse curvature that is imparted to the flexible flap by the mounting of the flap at the stationary portion, the mounting of the flap at the stationary portion biasing the free portion of the flap towards the seal surface under neutral conditions while also allowing the free portion of the flap to be lifted from the seal surface during an exhalation.

The effect of the transverse curvature of the flap in a valve according to the invention is therefore to stiffen the flap sufficiently to resist any drooping away from the seat when there is no applied pressure differential, even in the inverted orientation of the structure. As soon as the flap is "cracked" by an appropriate pressure differential, however, the free end of the flap will rapidly flex away from the seat and this flexure will progress along the length of the flap to a position determined by the instantaneous rate of fluid flow. At least the root end of the flap, at its position of attachment to the seat, will retain its transverse curvature however, and this will apply a restorative force to the flexed flap, assisting to
10 reseal the flap when the permitted flow of fluid ceases. The stiffening effect of this transverse curvature is therefore to be distinguished from the longitudinal curvature of the flap in US-5325892.

The flap for a valve according to the invention may be manufactured to exhibit the requisite transverse curvature in its natural state, e.g. by means of injection moulding or thermoforming. In the preferred embodiment to be described hereinafter, however, the flap as manufactured is flat and its curvature is imparted in use by means of the shaping of the valve structure in which it is mounted.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be more particularly described, by way of example, with
20 reference to the accompanying schematic drawings, in which:-

Figure 1 is a perspective view of a filter mask incorporating a uni-directional valve in accordance with the invention as an exhalation valve;

Figure 2 is an "exploded" isometric view of the components of a preferred embodiment of the exhalation valve for the mask of Figure 1;

Figure 3 is an isometric view showing the interior of the upper housing member of Figure 2;

Figure 4 is a longitudinal section through the valve assembled from the components of Figure 2, on the line IV-IV of Figure 5, in the closed condition; and

Figure 5 is a section on the line V-V of Figure 4.

10 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Figure 1, the illustrated mask body 1 is made from one or more layers of flexible sheet filter material cut from a blank, folded and welded to form a cup-shaped structure to be worn over the nose and mouth of the user. It is in particular shaped in accordance with the invention in GB-2046102, to which reference is directed for a fuller description of the method of forming the mask from a flat blank. In use the peripheral edge of the mask body forms a seal against the wearer's face and it is held in place by elastic headbands 2 and a deformable wire nose clip 3 as well known in the art.

At a suitable location in the side wall of the mask 1 an aperture is formed in which an exhalation valve 4 is fitted, the structure of which is more clearly illustrated in Figures 2 to 5.

The illustrated valve 4 comprises two interfitting moulded plastics housing members 5 and 6, also referred to as a valve seat and a valve cover respectively, and an elastomeric flap 7 which in the assembled valve is trapped at one end between the housing members (i.e. between the seat 5 and the cover 6). The upper housing member 5 as viewed in Figure 2 is also seen from its opposite face in Figure 3. It has inlet ports 8 passing through it which on the downstream side are surrounded by a seal ridge 9A/9B/9C of generally trapezoidal plan-form. The lower housing member 6 as viewed in Figure 2 is of dished form with a series of outlet ports 10, and snaps onto the member 5 by means of a pair of integral lateral lugs 11 engaging in slots 12 formed in member 5. The flap 7 is of generally trapezoidal plan-form sized to fit over the seal ridge and is formed from a thin and highly flexible piece of elastomer, e.g. 0.5mm thick latex natural rubber having a Shore micro hardness of about 30.

The flap 7 is positioned in the valve by a notch 13 at one end embracing a block 14 on housing member 5, and when the housing members are snapped together that end of the flap becomes trapped between the adjacent portion 9A of the seal ridge and a profiled block 15 upstanding from housing member 6. That is to say it is mounted in the valve in cantilever fashion. In its natural state, if the flap 7 is

held horizontally at one end it will tend to bow longitudinally under the force of gravity, i.e. so that its opposite end droops down considerably from the plane of its fixed end. Both the block 15 and the facing portion 9A of seal ridge are, however, curved so

as to impart to the flap a transversely arched configuration in the assembled valve, as seen particularly in Figures 4 and 5. In the illustrated embodiment this arching is accentuated for the central part of the flap by means of a second profiled block 16 upstanding from the housing member 6 in front of and to a slightly greater height than the block 15, although this is not essential in all embodiments of the invention. The arching of the flap stiffens it sufficiently to prevent it drooping away from any part of the seal ridge under zero pressure differential conditions, whatever the orientation of the valve. The preferred orientation of the valve is in fact with the outlet ports 10 directed with a downward component, as indicated in Figure 1, so that the user's exhalate will not mist any associated eyewear, and if the user lowers his head the valve may become oriented with the flap 7 lying wholly below the housing member 5.

In use, therefore, the flap 7 seats upon the seal ridge to prevent the passage of any air into the mask through the valve 4 while the user is not exhaling. At the commencement of exhalation, as soon as a minimum "cracking" pressure differential is applied to the flap 7 from the interior of the mask the free end of the flap will lift away from the seal ridge in the sense of the arrow X in Figure 4, and flexure of the flap will progress rapidly along its length towards the fixed (root) end, to a position determined by the instantaneous rate of flow of exhalate out through ports 8 and 10. When exhalation ceases, the restorative effect of the arched mounting of the flap will cause the flap as a whole rapidly to reseal upon the seal ridge, to minimise the risk of any inward leakage of contaminant through the valve in the period between the end of exhalation and the commencement of inhalation. In particular, the flap 7 does not depend for its closure upon the subsequent application of an inhalatory pressure differential.

From Figure 3 it will be seen that while the portion 9A of the seal ridge at the root end of the flap has a concave curvature the remainder 9B/9C of the ridge has a flat surface. From Figures 3 and 4 it will also be seen that the portion 9C of the seal ridge at the free end of the flap rises further from the plane of the member 5 than does the root end portion 9A, and the two side portions 9B are straight but inclined as viewed in elevation. The combined effect of this configuration is that the transverse curvature of the flap 7 decreases towards its free end, which lies flat against seal ridge portion 9C, while a degree of longitudinal curvature is also imparted to the central section of the flap (but not to its side edges which lie flat against the ridge portions 9B). This has been found to enhance the stability of the flap in its closed condition while minimising the opening pressure differential for the particular embodiment illustrated. In other embodiments, however, there may be no longitudinal curvature of the flap and/or its transverse curvature may extend throughout its whole length, in the latter case the seal ridge portion 9C being modified to a concave form as indicated in broken line in Figure 3.

26783-6

8

CLAIMS:

1. A uni-directional fluid valve that comprises:
 - a) a flexible flap; and
 - b) a cooperating valve seat, the valve seat including a seal surface that surrounds an orifice, the flexible flap being attached to the valve seat in a cantilevered fashion such that the flap makes contact with the seal surface when the flap is closed and such that a free end of the flap lifts from the seal surface when fluid passes through the orifice in the permitted direction, the flexible flap having a transverse curvature to bias the flap to the seal surface in the absence of a pressure differential across the flap, under any orientation of the valve.
2. The valve of claim 1, wherein the flap exhibits the curvature in its natural state.
3. The valve of claim 1, wherein the curvature is imparted to the flap by virtue of its mounting to the valve seat.
4. The valve of claim 3, wherein the flap is trapped at a fixed portion of the flap between confronting surfaces of the valve seat and a valve cover.
5. The valve of claim 4, wherein the confronting surfaces are curved.
6. The valve of one of claims 1 to 5 wherein that part of the seal surface which the free end of the flap is adapted to contact is flat.
7. The valve of one of claims 1 to 6 wherein those parts of the seal surface which the side edges of the flap are adapted to contact are flat.

26783-6

9

8. The valve of any one of claims 1 to 7 wherein the mounting of the flap on the valve seat also imparts a longitudinal curvature to the central section of the flap.

9. A filter mask that has an exhalation valve, constructed in accordance with any one of claims 1 to 8 mounted to the mask.

10. A filter face mask that comprises:

a) a mask body adapted to fit over a nose and a mouth of a wearer; and

b) an exhalation valve mounted to the mask body, the exhalation valve comprising a flexible flap and a valve seat, the flexible flap being mounted to the valve seat in cantilever fashion such that it has a longitudinal dimension, the cantilevered flap having a free end that rests upon the valve seat when closed, the flap exhibits a curvature in a direction transverse to the flap's longitudinal dimension, the transverse curvature biasing the cantilevered flap to assist in closing the valve in the absence of an opening pressure differential across the flap, under any orientation of the valve.

11. The filter face mask of claim 10, wherein the flexible flap has a transverse curvature at the location where the cantilevered flap is mounted to the valve seat.

12. The filter face mask of claim 10 or 11, wherein the transverse curvature of the flap decreases in the longitudinal dimension toward a free end of the flap.

13. The filter face mask of any one of claims 10 or 11, wherein the transverse curvature is imparted to the flap by virtue of its mounting to the valve seat.

26783-6

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14. The filter face mask of claim 13, wherein the flexible flap is mounted to the valve seat by being pressed towards seat from a member disposed on a valve cover.

15. The filter face mask of any one of claims 10 to 14, wherein the exhalation valve is so located on the mask such that during normal head movements of a wearer, the free end of the flap is generally directed downward.

16. A filter face mask that comprises:

a) a mask body adapted to fit over a nose and mouth of a wearer; and

b) an exhalation valve mounted to the mask body, the exhalation valve comprising a flexible flap, a valve seat, and a valve cover, the valve seat comprising one or more inlet ports, which one or more ports are surrounded by a seal surface, the valve cover comprising one or more outlet ports and being joined to the valve seat, the flexible flap having a stationary portion and a free portion and a peripheral edge that includes stationary and free segments, the stationary segment of the flap's peripheral edge being associated with the stationary portion of the flexible flap so as to remain stationary during an exhalation, and the free segment of the flap's peripheral edge being associated with the free portion of the flap so as to be movable during an exhalation, the flexible flap having a transverse curvature that is imparted to the flexible flap by the mounting of the flap at the stationary portion, the mounting of the flap at the stationary portion biasing the free portion of the flap towards the seal surface under neutral conditions while also allowing the free portion of the flap to be lifted from the seal surface during an exhalation.

26783-6

11

17. The filter face mask of claim 16, wherein the mounting of the flexible flap causes at least a portion of the stationary portion of the flexible flap to reside beneath the seal surface of the valve seat when the valve is viewed from a side elevation.

18. The filter face mask of claim 17, wherein the flexible flap is mounted to the valve by being trapped between respective surfaces on the valve seat and the valve cover.

19. The filter face mask of claim 16, wherein the outlet ports are oriented on the valve cover relative to the flexing of the flap such that exhaled air from a wearer exits the exhalation valve with a downward component that directs the exhalate away from a wearer's eyes.

20. The filter face mask of claim 16, wherein the seal surface has multiple portions that include first and second side portions and a free end portion, the free segment of the peripheral edge of the flap having a flat configuration above the first and second side portions and the free end portions.

21. The filter face mask of claim 16, wherein the flap's transverse curvature decreases towards the free portion segment of the flap.

22. The filter face mask of claim 21, wherein the flexible flap lies flat against the seal surface that is disposed beneath the free portion of the flap.

23. The filter face mask of claim 16, wherein the valve seat and valve cover are inter-fitting plastic parts.

24. The filter face mask of claim 16, wherein stationary portion of the flap is configured for embracing a member on the valve seat.

26783-6

12

25. The valve of any one of claims 1 to 8 wherein the transverse curvature of the flap decreases in the longitudinal dimension towards a free end of the flap.

26. The filter face mask of claim 16, wherein the exhalation valve is positioned on the mask body and the flexible flap is positioned on the valve seat such that the free portion of the flap resides below the stationary portion when the mask is worn in its normal position over the nose and mouth of the wearer.

27. The filter face mask of claim 26, wherein the flexible flap has no more than one free portion and no more than one stationary portion.

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PATENT AGENTS

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Fig. 1.

