Feb. 4, 1958 P. E. MEIDENBAUER, JR 2,821,990

DEMAND VALVE

Filed Oct. 9, 1952

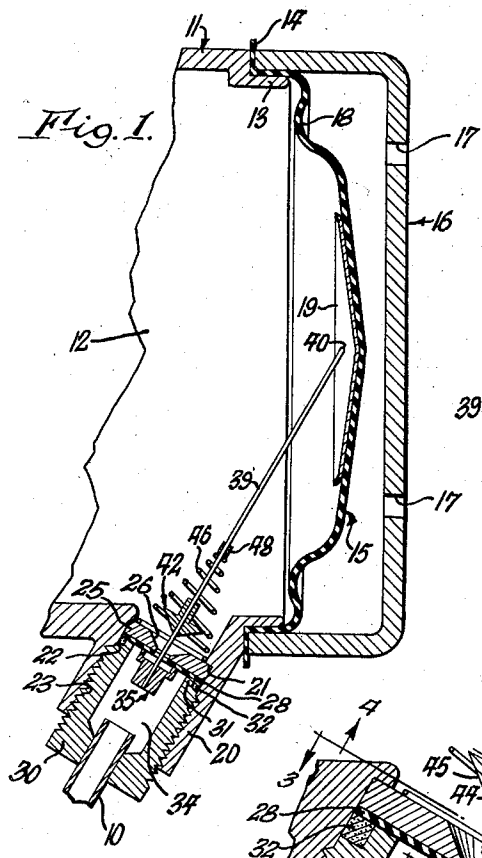

Fig. 1.

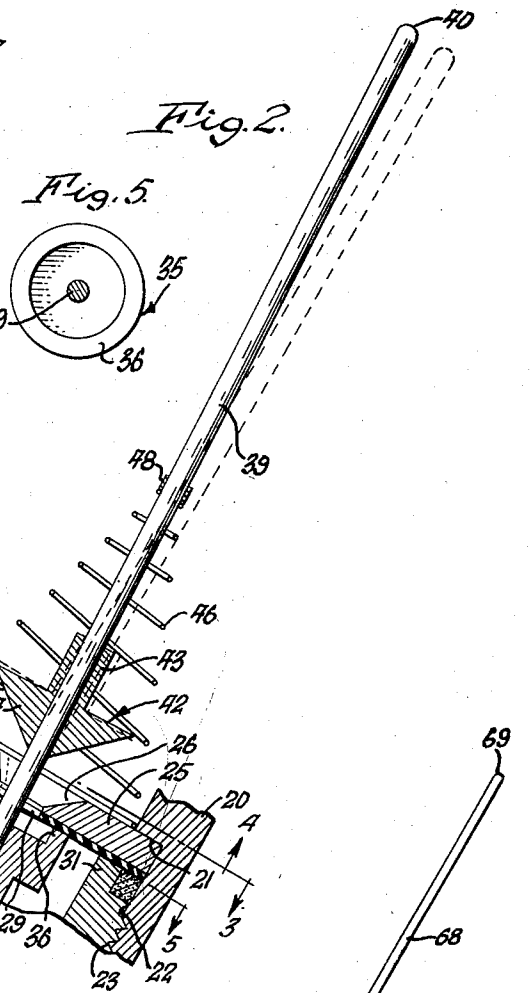

Fig. 2.



Fig. 5.

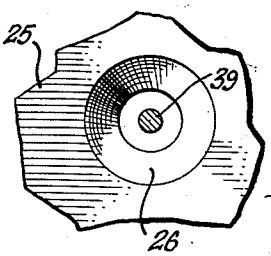

Fig. 3.

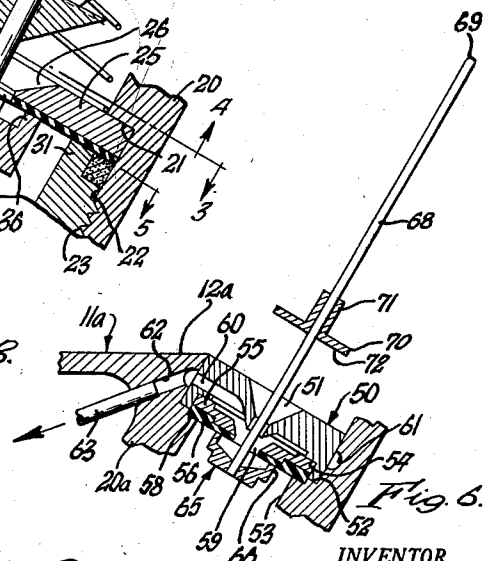

Fig. 6.

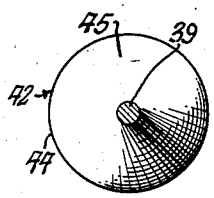

Fig. 4.

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2,821,990

Patented Feb. 4, 1958



2,821,990

# DEMAND VALVE

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Application October 9, 1952, Serial No. 313,866

8 Claims. (Cl. 137—64)

This invention relates to a demand valve such as used in a mask to supply oxygen or air in response to the reduced pressure in the mask caused by the inhalation of the wearer and which closes immediately following the inhalation so that the air or oxygen is supplied only as required. The use of the invention is not, however, confined to air or oxygen masks but may be used to control the supply of any gas in response to a demand for such gas as is evidenced by a reduced pressure on the outlet side of the valve.

One of the principal objects of the invention is to supply such a demand valve which is highly sensitive and is useful against high pressures of air or oxygen and operated by relatively slight pressure variations such as those caused by the inhalation of the wearer of a mask.

Another object is to provide such a demand valve which is partially self-energizing so that once opened it tends to keep itself open. By such characteristics a mask equipped with the demand valve is less tiring since while a certain amount of inhalation energy is required to open the demand valve, much less energy is required to hold the demand valve open so that little effort is required by the wearer of the mask for the greater part of each inhalation.

Another object is to provide such a demand valve which is very compact and can readily be installed in the mask to control a high pressure air or oxygen line leading to the mask. By carrying a high pressure line directly to the mask, it is unnecessary to use pressure reducing valves; a smaller and less clumsy line can be brought to the mask to facilitate its application, removal and use; there is a reduced pressure drop between the valve and the demand zone thereby to increase the sensitivity of the demand valve; and there is no danger of contamination of the air or oxygen supply through leakage since under high pressure the leakage would always be to the exterior to expel contaminants.

Another object is to provide such a demand valve which can be branched to provide a high pressure air or oxygen source for some special purpose, such as to supply a stream of dry air to prevent fogging of the goggles of the mask or to a flow indicator.

Another object is to provide such a demand valve which is partially self-energizing on closing so as to avoid the necessity for a closing spring or to permit of reducing the strength of such a spring. By eliminating or reducing the strength of such a closing spring less inhalation energy is required to open the demand valve since opening of the valve is not against a high spring loading.

Another object of the invention is to provide such a demand valve which is simple and reliable in construction and operation so as to always be operative without danger of leakage of the high pressure air or oxygen.

Another object is to provide such a demand valve which does not have critical tolerances or fits.

Other objects and advantages of the invention will be



apparent from the following description and drawings in which:

Fig. 1 is a fragmentary section through a part of a mask equipped with a demand valve embodying the present invention.

Fig. 2 is a similar view of the demand valve on an enlarged scale.

Figs. 3, 4 and 5 are sectional views taken on the correspondingly numbered lines on Fig. 2.

Fig. 6 is a view, on a reduced scale, similar to Fig. 2 and showing a modified form of the invention.

The demand valve of the present invention is shown as used in conjunction with supplying air or oxygen from a relatively high pressure supply line **10** to a mask having a tubular metal shell **11** the interior chamber **12** of which is in communication with the interior of the mask so that a reduced pressure in the chamber **12** results on each inhalation of the wearer of the mask. By relatively high pressure oxygen or air supply is meant pressure in the order of from, say, 5 to 100 pounds gage pressure. The tubular metal shell **11** is shown as having a rim **13** of reduced diameter over which is fitted the rim **14** of a flexible diaphragm **15**, such as one made of rubber. The rim **14** of the diaphragm can be held in contact with the reduced rim **13** of the tubular shell **11** by a cap **16**, or in any other suitable manner. This cap **16** is shown as press fitted over the rim of the rubber diaphragm and as having breather holes **17**. The rubber diaphragm is shown as having marginal annular corrugations **18** which tend to bias it to the position shown, and a metal plate **19** is shown as secured centrally to the side of the diaphragm facing the chamber **12**.

The tubular shell is shown as being formed to provide an angularly projecting cylindrical neck **20**, the axis of which is directed generally toward the center of the diaphragm **15**. This neck is bored to provide an outwardly facing annular shoulder **21** and a short smooth bore **22** and beyond this short smooth bore **22** is internally threaded, as indicated at **23**.

A metal valve seat disk **25** is fitted in the short smooth bore **22** against the annular shoulder **21**, this valve seat disk having a central opening **26**. Preferably this opening **26** is of conical form enlarging and with its axis directed toward the center of the diaphragm **15**.

The side of the valve seat disk **25** opposite the chamber **12** is preferably provided with a rubber facing or disk **28** and this rubber facing is provided with an opening **29** in register with the conical opening **26**. The rubber faced valve seat disk **25** is held in position by a screw plug or follower **30** screwed into the threads **23** and this screw plug having an annular end bead **31** bearing against the rubber facing **28** of the valve seat disk **25**. A ring seal **32** is preferably interposed between this bead **31** and the short smooth bore **22** to prevent leakage of gas along the threads of the screw plug or follower **30**. The high pressure inlet line **10** preferably extends axially through the screw plug or follower **30**. The high pressure air inlet line **10** is secured to extend through and discharge into the hollow interior chamber **34** of the screw plug **30**.

The valve head is in the form of a cup **35** with an axially extending rim **36** seated on the rubber facing **28** of the valve seat disk **25**. This valve head is also shown as having an axial extension **38** projecting away from the valve seat disk **25**. In this axial extension **38** is anchored one end of a valve stem or rod **39** which projects through the openings **29** and **26** of the rubber facing **28** and valve seat disk **25**, respectively, and has a rounded end **40** arranged in close proximity to the center of the metal disk **19** mounted on the diaphragm **15**.

Fast to this rod, within the chamber **12**, is arranged a baffle or vane member **42**. This baffle or vane member

is shown as having a tubular neck 43 press fitted around the rod 39 and also as having a circular conical enlargement 44, the conical face 45 of which opposes the conical opening 26 through the valve seat disk 25. The shape of the vane or baffle member 42 is not of particular importance but its size and spacing from the valve seat disk 25 must be such that the expanding regular cone of gas issuing from the conical opening 26 be of smaller cross sectional size than the enlarged part 44 of the vane at its point of impact against the vane and also that the cone of gas impinges against this circular enlarged part 44 with effective force.

In the form of the invention shown in Figs. 1–5, the demand valve is also shown as having a return spring 46 although such a return spring is not essential. This spring biases the valve toward its closed position and would only be essential if the effective force of the passing gas against the vane 42 were to exceed the effective force of this gas against the valve head 35. This spring is shown as being in the form of a spiral compression spring with its large end bearing against the valve seat disk 25 and with its small end bearing against a small collar 48 press fitted on the rod 39.

In the operation of the demand valve as above described, the high pressure of the gas supplied from the line 10 to the chamber within the screw plug 30 presses against the cup-shaped valve head 35 and holds its rim 36 firmly against the rubber facing 28 of the valve seat disk 25. Accordingly this valve head 35 is held perpendicular to the valve seat disk 35 and the valve stem or rod 39 is likewise held in a position perpendicular to this valve seat disk. In this position the rounding end 40 of this valve rod or stem is held in closely spaced relation to the center of the metal plate 19 on the diaphragm 15 on the side of this diaphragm facing the demand chamber 12.

When the user of the mask inhales, the pressure in the mask is reduced and accordingly the pressure in this demand chamber 12 is reduced. Accordingly the diaphragm is moved to the left as viewed in Fig. 1 to contact and move the free end 40 of the valve stem 39 laterally to the left. This tips the cup-shaped valve head 35 laterally and hence separates one side of the bead 36 of the valve head 35 from the rubber facing 28 and permits the high pressure gas to escape through the valve openings 29 and 26 into the demand chamber 12 in the form of an expanding regular cone of gas.

In so flowing into the demand chamber 12 in the form of an expanding regular cone, the high pressure gas strikes the baffle or vane 42. Since this vane is now tipped with reference to the axis of the valve orifices 29 and 26, and since the diameter of the enlarged part 44 of this vane is greater than the cross sectional size of the expanding cone of the gas at the point of impact therewith, the flow of the gas tends to tip this vane further and hence to drive the valve head 35 toward a further tipped and further opened position. Thus, the impact of the gas flow from the open valve is greater on the right hand side of the baffle or vane 42, as viewed in Fig. 2, than on the left hand side thereof and hence the kinetic force of the gas stream tends to tip the valve stem 39 further to the left and to open the valve head 35 further. Of course, this kinetic force of the gas stream against the vane or baffle 42 is not sufficient to take control of the demand valve away from the diaphragm 15 but it reduces the force of this diaphragm required to hold the valve open. Since the force of the diaphragm 15 is a function of the reduced pressure in the demand chamber 12, it is apparent that, once the valve is opened, less negative pressure is required in the demand chamber 12 to hold the valve open. Since this negative pressure, in an air or oxygen mask, is provided by the inhalation of the user, it will be seen that while a certain inhalation effort is required to open the demand valve, less inhalation effort is required to hold the valve open and to complete the inhalation. Accordingly it will be seen that the vane or baffle 42 renders the demand valve partially self-energizing following the initial opening to a degree which reduces the total inhalation effort. By actual experience this inhalation effort is reduced a very substantial degree.

After the inhalation is complete, the pressure in the demand chamber 12 rises, through the admission of high pressure gas past the demand valve, to the value of the pressure against the side of the diaphragm remote from the demand chamber. Accordingly this diaphragm, which is inherently so biased, moves to the right as viewed in Fig. 1 to its normal position. This moves its metal plate 19 out of contact with the free end 40 of the valve stem 39 and permits the valve parts to assume a closed position.

The closing of the valve, when its parts are so released, is essentially a function of the static pressure of the high pressure air in the chamber 34 against the convex side of the valve head 35. This static pressure exceeds the kinetic force of the gas stream striking the vane or baffle 42 and hence is effective in closing the valve. This closing force can be augmented by the return spring 46, but this spring is not essential to the operation of the demand valve, as is illustrated in the modification, Fig. 6.

In this modified form of the invention illustrated in Fig. 6, the demand valve is again shown as used in conjunction with supplying air or oxygen to a mask having a tubular metal shell 11*a* the interior chamber 12*a* of which is in communication with the interior of the mask so that a reduced pressure in the chamber 12*a* results on each inhalation of the wearer of the mask. The showing of the diaphragm is not repeated in Fig. 6 but the tubular shell 11*a* is again shown as being formed to provide an angularly projecting cylindrical neck 20*a* to which the gas is supplied under pressure in the same manner as with the form of the invention shown in Figs. 1–5.

As with the form of the invention shown in Figs. 1–5 a metal valve seat disk 50 is provided with a coaxial conical through opening 51 the axis of which is toward the center of the control diaphragm 15 (not shown). This valve disk is, however, shown as press fitted from the demand chamber 12*a* side against an annular shoulder or seat 52 in the bore or chamber 53 to which the gas under pressure is supplied. On the side of the metal valve seat disk 50 facing the bore 53 it is provided with a shallow central cylindrical recess 54 in which is fitted a secondary valve seat disk 55. This secondary valve seat disk has a rubber facing or disk 56 which is held against a secondary annular shoulder or seat 58 in the bore or chamber 53.

This secondary valve seat disk 55 and its rubber facing 56 have a through opening 59 which registers with the through opening 51 of the main valve seat disk 50 and which is also in communication with a passage 60 leading radially to the periphery of the main valve seat disk 50. In register with this passage 60 the bore 53 can be provided with an annular groove 61 which connects, through a passage 62, with an outlet tube or line 63. This tube 63 can lead to a flow indicator (not shown) or the gas flowing therethrough can be used for some other special purpose, such as to discharge against the goggles of the mask (also not shown) to prevent their fogging.

As with the form of the invention shown in Figs. 1–5, the valve head is in the form of a cup 65 with an axially extending rim 66 seated on the rubber facing 56 of the secondary valve seat disk 55. In the valve head 65 is anchored a valve stem or rod 68 which projects through the openings 59 and 51 and has its rounded head 69 arranged in close proximity to the center of the metal disk 19 mounted on the diaphragm 15.

Fast to this rod, within the chamber 12*a*, is arranged a baffle or vane member 70. This baffle or vane member 70 is shown as having a tubular neck 71 press fitted around the rod 68. The effective surface 72 of the

vane or baffle 70, that is, the face opposing the valve seat disks 50 and 55, is flat and arranged perpendicularly to the valve stem or rod 68 in contradistinction to the conical face 45 of the form of the invention shown in Figs. 1–5. However, the diameter of this vane must be greater than the cross sectional size of the expanding cone of gas at the point of impact therewith.

It will be seen that the operation of the form of the invention is essentially the same as with the form of the invention shown in Figs. 1–5. That is, when the valve stem 68 is tipped to tip and unseat the valve head 65 on the rubber disk 56, the expanding cone of gas escaping past the open valve head 65 strikes the baffle or vane 70 at such angle, due to the size of said vane and the tilt of this vane or baffle with the valve stem, as to tend to hold the valve open and thereby make the valve partially self-energizing in holding the valve open. Similarly the valve is partially self-energizing on closing due to the static pressure of the gas being controlled against the valve head 65 and which tends to urge this valve head toward its closed position. This pressure is normally sufficient to obviate the use of a valve return spring as with the spring 46 in the form of the invention shown in Figs. 1–5.

A particular distinguishing feature of the form of the invention shown in Fig. 6 is the conduit 60, 62 and 63 leading from the valve in advance of the restriction or orifice formed by the small end of the conical opening 51. Due to the pressure drop across this orifice, the air delivered to this conduit is at a higher pressure than that which obtains in the demand chamber 12*a*. Accordingly the high pressure air in this conduit can be used to operate a flow indicator, to clear fog from goggles or for any other purpose where a stream of high pressure air, under control of the demand valve, is useful.

From the foregoing it will be seen that the present invention provides a simple, reliable and sensitive demand valve which requires less effort to open and close due to its partial self-energizing characteristics on both opening and closing and which is also compact to permit of its being incorporated directly in a mask. It will also be seen that the valve can readily be designed to provide an auxiliary stream of high pressure air for any useful purpose.

I claim:

1. A demand valve of the character described for controlling the flow of gas from a pressurized source, comprising a body having an orifice surrounded by an axially facing valve seat and from which orifice said gas issues in the form of an expanding regular cone on the side of said body opposite said valve seat, a valve head engaging said valve seat and tiltable to permit gas to flow through said valve, a valve stem fast at one end to said valve head and projecting through said orifice in the direction of said expanding cone of gas, means arranged to tilt said valve stem to tilt said valve head and open said valve, and a vane on said valve stem and arranged in the path of the gase escaping past the open valve said vane being of larger cross sectional size than the cross sectional size of said expanding cone of gas at the point of impact therebetween so that the impact of said escaping gas tends to maintain said valve stem in its tilted position.

2. A demand valve of the character described for controlling the flow of gas from a pressurized source, comprising a body having an orifice surrounded by an axially facing valve seat and from which orifice said gas issues in the form of an expanding regular cone on the side of said body opposite said valve seat, a valve head engaging said valve seat and tiltable to permit gas to flow through said valve, a valve stem fast at one end to said valve head and projecting through said orifice in the direction of said expanding cone of gas, means arranged to tilt said valve stem to tilt said valve head and open said valve, and a round baffle member surrounding and fast to said valve stem and arranged in the path of the gas escaping past the open valve said vane being of larger cross sectional size than the cross sectional size of said expanding cone of gas at the point of impact therebetween so that the impact of said escaping gas tends to maintain said valve stem in its tilted position.

3. A demand valve of the character described for controlling the flow of gas from a pressurized source, comprising a body having an orifice surrounded by an axially facing valve seat and from which orifice said gas issues in the form of an expanding regular cone on the side of said body opposite said valve seat, a rubber facing on said valve seat, a cup-shaped valve head having a rim engaging said rubber facing around said orifice and tiltable to permit gas to flow through said valve, a valve stem fast at one end to said valve head and projecting through said orifice in the direction of said expanding cone of gas, means arranged to tilt said valve stem to tilt said valve head and open said valve, and a vane fast to said valve stem and arranged in the path of the expanding cone of gas escaping past the open valve said vane being of larger cross sectional size than the cross sectional size of said expanding cone of gas at the point of impact therebetween so that the impact of said escaping gas tends to maintain said valve stem in its tilted position.

4. A demand valve of the character described for controlling the flow of gas from a pressurized source, comprising a body having a conical valve orifice enlarging toward the outlet side of the orifice and from which orifice said gas issues in the form of an expanding regular cone, an axially facing valve seat surrounding said orifice on the inlet side of said orifice, means arranged to supply gas under pressure at the inlet side of said orifice, a cup-shaped valve head having a rim engaging said valve seat around said orifice and tiltable to permit gas to flow through said orifice, a valve stem fast at one end to said valve head and projecting through said orifice in the direction of said expanding cone of gas, means arranged at the outlet side of said orifice to tilt said valve stem to tilt said valve head and open said valve, and a vane fast to said valve stem on the outlet side of said orifice and arranged in the path of the gas escaping through said orifice said vane being of larger cross sectional size than the cross sectional size of said expanding cone of gas at the point of impact therebetween so that the impact of said gas escaping through said orifice tends to maintain said valve stem in its tilted position.

5. A demand valve of the character described for controlling the flow of gas from a pressurized source, comprising a body having an opening provided with an annular seat, a valve seat disk fitting against said seat, a rubber facing on the side of said valve seat disk opposite the side thereof engaging said annular seat, said valve seat disk and rubber facing being provided with a central orifice extending therethrough and from which orifice said gas issues in the form of an expanding regular cone on the side of said body opposite said rubber facing, said orifice through said valve seat disk being of conical form and enlarging away from said rubber facing, means arranged to supply gas under pressure from said pressurized source against said rubber facing, a cup-shaped valve head having a rim engaging said rubber facing around said orifice and tiltable to permit gas to flow through said orifice, a valve stem fast at one end to said valve head and projecting through said orifice in the direction of said expanding cone of gas, means on the side of said orifice opposite said rubber facing and arranged to tilt said valve head and open said valve, and a vane fast to said valve stem and arranged in the path of the gas escaping through said orifice, said vane being of larger cross sectional size than the cross sectional size of said expanding cone of gas at the point of impact therebetween so that the impact of said escaping gas tends to maintain said valve stem in its tilted position.

6. A demand valve of the character described, comprising a valve body having an opening, a pair of members

arranged across and blocking said opening and providing a space therebetween, an orifice through each of said members and communicating with said space, an axially facing valve seat on the side of one of said members remote from said space, means arranged to supply gas under pressure against said valve seat, a valve head engaging said valve seat around the orifice therethrough and tiltable to permit a main stream of gas to escape through said orifices, and a conduit leading from said space to provide an auxiliary stream of high pressure gas each time said valve is opened.

7. A demand valve as set forth in claim 6 wherein said main stream of gas issues from said orifices in the form of an expanding regular cone, wherein a valve stem is fast at one end to said valve head and projects through said orifices, wherein a vane is fast to said valve stem on the side of said members remote from said valve seat and is arranged in the path of said expanding cone of gas, said vane being of larger cross sectional size than the cross sectional size of said expanding cone of gas at the point of impact therebetween so that the impact of the gas escaping through said orifices tends to maintain said valve stem in its tilted position.

8. A demand valve as set forth in claim 6 wherein said



main stream of gas issues from said orifices in the form of an expanding regular cone, wherein a valve stem is fast at one end to said valve head and projects through said orifices, wherein said members are in the form of disks, wherein said valve seat is in the form of a rubber facing on the corresponding disk, and wherein a vane is fast to said valve stem on the side of said disks remote from said rubber facing and is arranged in the path of said expanding cone of gas, said vane being of larger cross sectional size than the cross sectional size of said expanding cone of gas at the point of impact therebetween so that the impact of the gas escaping through said orifices tends to maintain said valve stem in its tilted position.

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