June 13, 1961 L. JONES 2,988,085

BREATHING APPARATUS

Filed June 17, 1957 2 Sheets-Sheet 1

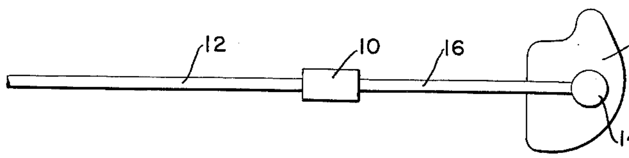

FIG. 1

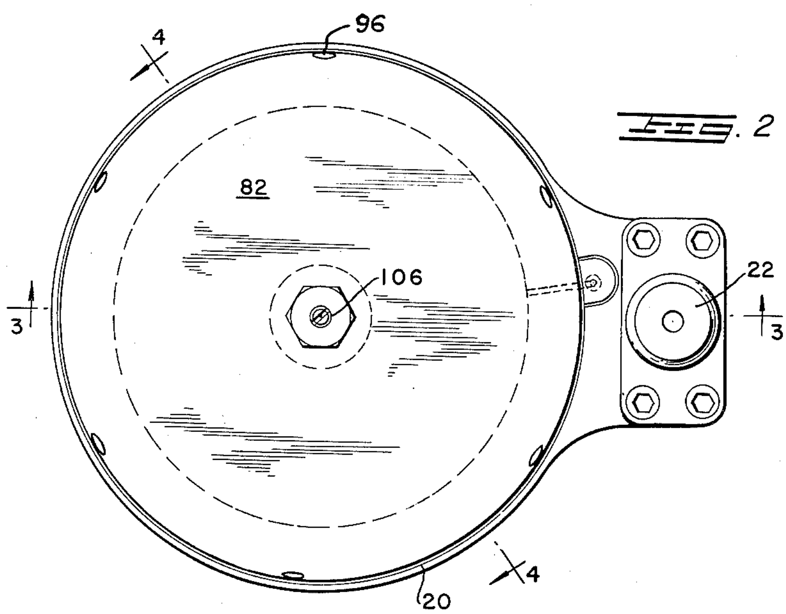

FIG. 2

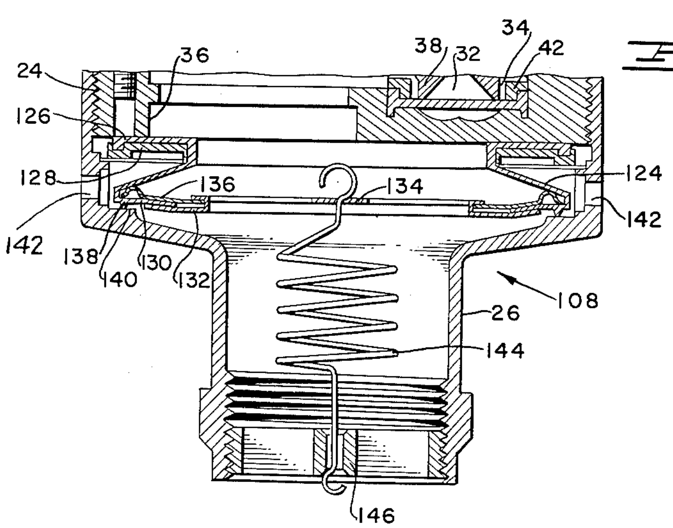

FIG. 5

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BREATHING APPARATUS

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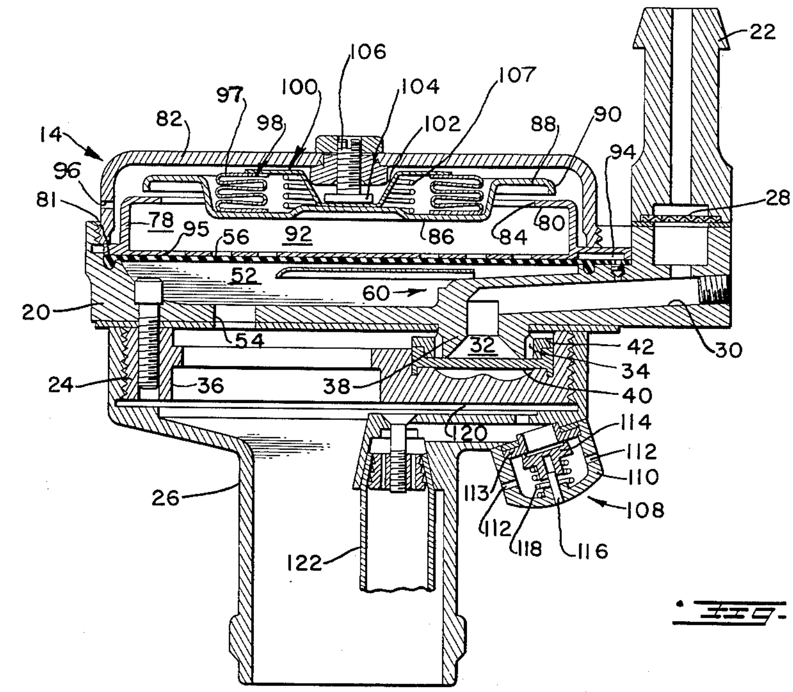

FIG. 3

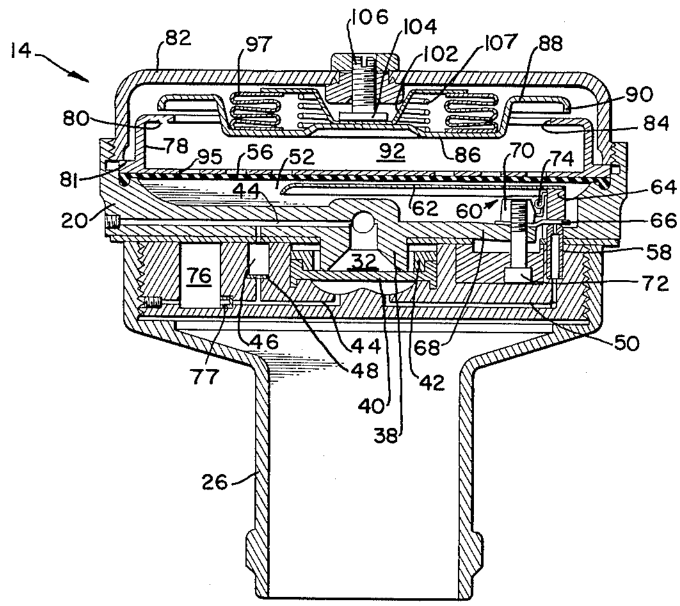

FIG. 4

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United States Patent Office

2,988,085

Patented June 13, 1961

2,988,085

BREATHING APPARATUS

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Filed June 17, 1957, Ser. No. 665,955
11 Claims. (Cl. 128—142)

This invention relates to breathing apparatus and more particularly to breathing apparatus for use in high altitude flight.

For high altitude flying where the atmospheric air is rarefied, it is desired to normally maintain a predetermined partial pressure of oxygen within the face mask or helmet to meet physiological requirements of the human body. It is, therefore, a principal object of this invention to incorporate in a breathing regulator a means which automatically varies the pressure within the mask or helmet with variations in altitude.

Another object of the invention is to subject the control diaphragm of a demand breathing regulator to the pressure of the oxygen source and to control the oxygen pressure on the control diaphragm in accordance with altitude.

Another object of the invention is produce an improved breathing regulator.

In the preferred embodiment of the invention, a demand regulator valve is connected between a suitable mask or helmet associated with the user of the apparatus and a source of oxygen under pressure. The regulator valve is operative to supply oxygen to the mask or helmet in response to inhalation by the user, and is provided with a means responsive to atmospheric pressure for maintaining a predetermined pressure of oxygen within the mask or helmet at low atmospheric pressure conditions such as when flying at high altitudes.

Other objects and advantages will become apparent from the following description taken in connection with the accompanying drawings wherein:

FIG. 1 is a schematic illustration of a breathing apparatus;

FIG. 2 is a plan view of a regulator valve embodying this invention;

FIG. 3 is a section taken along the line III—III of FIG. 2;

FIG. 4 is a section taken along the line IV—IV of FIG. 2; and

FIG. 5 is a sectional view showing a modification of a portion of the structure illustrated in FIG. 3.

Referring more particularly to FIG. 1, the breathing apparatus includes a pressure reducing valve **10** connected to a suitable source of oxygen under pressure (not shown) by a conduit **12**. The reducing valve **10** may be of any suitable form and serves to deliver oxygen at a workable pressure to a breathing regulator **14** by means of a conduit **16**. The regulator **14** is here shown as mounted on a face mask **18**.

Referring more particularly to FIGS. 2, 3, and 4, the regulator valve **14** comprises a casing **20** having a hollow tubular inlet fitting **22** extending upwardly from one side thereof. The casing **20** is also provided with an externally threaded lower portion **24**, on which hollow tubular outlet fitting **26** is threaded. The inlet fitting **22** is adapted for connection to the conduit **16** (FIG. 1), and the outlet fitting **26** is adapted for connection to the mask or helmet **18**.

The inlet fitting **22** has a suitable filter **28** mounted therein, and is connected by means of a passage **30** to a valve chamber **32** formed within the casing **20**. The valve chamber **32** communicates with the outlet fitting **26** by means of a plurality of ports **34** which communicate

with an opening **36** in the bottom wall of the casing portion **24**.

An annular valve seat **38** is formed on the casing **20** within the valve chamber **32** for cooperation with a flexible diaphragm valve member **40** for controlling fluid flow from the inlet passage **30** to the ports **34**. The valve member **40** is secured at its periphery to the wall of the casing **20** by means of an annular retaining member **42**.

A passage **44** extends through the casing **20** from the inlet passage **30** and opens into the valve chamber **32** on the lower side of the diaphragm valve member **40** to subject the lower side of the diaphragm valve member **40** to the inlet fluid pressure. The passage **44** is provided with a chamber **46** in which a fitting **48** having a metering orifice therein is positioned. With this arrangement, the upper side of the valve member **40** is subjected to the inlet fluid pressure within passage **30**, and the lower side of the valve member **40** is subjected to the inlet fluid pressure by means of passage **44**.

It will be apparent that the effective area of the valve member **40** exposed to inlet pressure at the lower side thereof is greater than the exposed area of the upper side. This difference in area subjected to inlet fluid pressure accordingly establishes a pressure differential on the valve member **40** which normally tends to hold the same in engagement with the seat **38**.

The valve member **40** is moved out of engagement with the seat **38** to permit flow of fluid to the ports **34** and outlet fitting **26** by venting the fluid pressure acting on the lower side thereof to reverse the pressure differential acting on the valve member **40**. To this end, a passage **50** formd in the casing **20**, extends from the valve chamber **32** at the under side of the diaphragm valve member **40** and opens into a chamber **52** formed in the casing **20** which communicates with the interior of the mask or helmet **18** by means of a port **54** opening into the outlet opening **36**.

A flexible diaphragm sensing element **56** is secured at its periphery to the upper end of the casing **20** to enclose the chamber **52** and to define the upper wall thereof. The position of the diaphragm sensing element **56** is influenced by the fluid pressure within the chamber **52**. Accordingly, since the chamber **52** is in communication with the mask or helmet **18**, a reduction in pressure will occur within the chamber **52** when the user of the apparatus inhales causing the diaphragm **56** to flex downward. This movement of the diaphragm **56** in response to inhalation by the user is used to control the venting of the fluid pressure acting on the under side of the valve member **40** to thus control opening of the valve member **40**.

A hollow fitting **58** has one end pressed within the end of the passage **50** and the other end thereof projecting within the chamber **52** to define a pilot valve seat. A pilot valve, indicated generally by the reference numeral **60**, is cooperative with the end of the fitting **58** to control fluid flow from the valve chamber **32** through the passage **50** to the chamber **52**. The pilot valve **60** comprises a rigid lever arm **62** having one end engaging the diaphragm **56** and the other end thereof fixed to a block **64** overlying the fitting **58**. One end of a strip **66** of sealing material is secured to the underside of the block **64** and the other end of the strip **66** is clamped to an extending and movable partition **68** of the casing **20** by means of a nut **70** tightened against the partition **68** by a screw **72** seated within the casing **20**. A spring **74** has one end attached to the block **64** and the other end thereof attached to the nut **70** for biasing the block **64** downwardly and the end of the lever arm **62** into engagement with the diaphragm **56**. During assembly, the screw **72** is tightened to cause downward deflection of the partition **68** until the strip **66** engages the end of the fitting **58**.

The spring **74** normally biases the block **64** and strip **66** into engagement with the end of the fitting **58**. However, should the diaphragm **56** be flexed downwardly by reduction in pressure within the chamber **52** as a result of inhalation, displacement of the lever arm **62** will occur, and the spring **74** will yield adjacent to the nut **70** against its bias and move the block **64** out of engagement with the fitting **58** to permit flow of fluid from the passage **50**. When the user exhales, the pressure in chamber **52** will increase to move the diaphragm **56** upwardly and close the pilot valve **60** to thus re-establish the pressure differential on the valve member **40** causing the same to engage its seat **38**.

It has been found that chattering or vibration of the diaphragm valve member **40** sometimes occurs due to the rapid pressure change in chamber **32** upon opening and closing of the pilot valve **60**. To provide for a more gradual pressure build-up or relief on the underside of the diaphragm valve member **40** during operation of the pilot valve **60**, a surge chamber **76** having a metering orifice **77** is provided in the casing **20** in communication with the passage **44**. It will be apparent that upon flow of fluid from the valve chamber **32** as a result of opening of the pilot valve **60**, the flow of fluid from the chamber **76** as determined by the metering orifice **77** will reduce the rate of pressure drop within the chamber **32**. Likewise, the rate of pressure build-up within the chamber **32** will be decreased by pressure build-up in the chamber **76** when the pilot valve **60** is closed.

When the regulator thus far described is used at high altitudes or under low atmospheric pressure conditions, it is desired to establish a predetermined pressure within the mask or helmet **18** independently of inhalation on the part of the user to provide pressure breathing. Accordingly, the regulator valve is provided with means for maintaining a predetermined pressure within the mask or helmet **18** in accordance with the surrounding atmospheric pressure. To this end, a cup-shaped member **78** having an upper inwardly extending flange **80** is clamped to the upper end of the casing **20** and to the periphery of the diaphragm **56** by means of a cover **82** threaded on the upper end of the casing **20** in engagement with a lower outwardly extending flange **81** of the member **78**. The flange **80** is provided with a central bore **84** in which a cup-shaped valve member **86** is positioned. The valve member **86** is provided with an outwardly extending flange **88** terminating in an annular downwardly bent lip **90** above the flange **80**.

The valve member **86**, member **78** and diaphragm **56** define a chamber **92** above the diaphragm **56** which communicates with the inlet passage **30** by means of a passage **94** formed in one side of the member **78**. The passage thus establishes a fluid pressure within chamber **92** which acts on the upper side of the diaphgarm **56** through a plurality of ports **95** in the bottom wall of the member **78**.

The valve member **86** is cooperative wtih the flange **80** to control the fluid pressure within the chamber **92**. When the valve member **86** is in the position shown in FIG. 3, the lip **90** is out of engagement with the flange **80** and fluid pressure is vented from the chamber **92** to the atmosphere through a plurality of ports **96** in the cover **82**. However, if the valve member **86** is moved toward the diaphragm **56**, the lip **90** will be moved closer to the flange **80** to throttle the flow of fluid from the chamber **92** and increase the fluid pressure within chamber **92**.

An expansible bellows member **97** is provided for actuating the valve member **86** relative to the flange **80**. The bellows member **97** has one end sealed to the bottom wall of the valve member **86** and the other end thereof sealed to a flange **98** of a cup-shaped member **100**. The member **100** is provided with a central conical recess or indentation **102** which engages a flange **104** formed on one end of a screw **106** threaded through the cover **82** in axial alignment with the bellows member **97**. A spring **107** is mounted in compression between the valve member **86** and flange **98** within the bellows member **97** and serves to bias the bellows member **97** and valve member **86** downward.

The bellows member **97** is evacuated and will expand in response to a decreaase in atmospheric pressure to actuate the valve member **86** downward to move the lip **90** toward the flange **80**. Thus, the bellows member **97** will expand in response to an increase in altitude to move the lip **90** toward engagement with the flange **80** to increase the fluid pressure within chamber **92**.

A relief valve, indicated generally by reference numeral **108**, is positioned adjacent the tubular outlet fitting **26** to vent fluid pressure from the interior of the outlet fitting **26** when the fluid pressure exceeds a predetermined value. To this end, a hollow tubular casing **110** is secured to the side of the tubular outlet fitting **26** and is provided with a plurality of ports **112** extending through the wall thereof. A valve seating ring **113** is fixed within the tubular casing **110** and is adapted to be engaged by a valve member **114** which is slidably mounted on a guide stem **116** fixed to the end wall of the casing **110**. A spring **118** encircles the stem and is mounted in compression between the end wall of the casing **110** and the valve member **114** for biasing the valve member **114** into engagement with the seating ring **113**.

Fluid is conducted from the hollow interior of the fitting **26** to the underside of the valve member **114** by means of a drilled passageway **120**. The passage **120** also communicates with a hollow tube **122** which may be utilized to supply oxygen to a compensated exhaust valve (not shown) within the mask **18**.

It will be apparent that a pressure differential exists across the valve member **114** when the same engages the seat therefor since one side of the valve member **114** is subjected to the oxygen pressure within the outlet fitting **26** and the other side thereof is subjected to atmospheric pressure. As long as the pressure differential force on the valve member **114** is less than the bias of the spring **118**, the valve member **114** will engage the seat. If, however, due to an increase in the fluid pressure in the outlet fitting **26**, the pressure differential force becomes greater than the biasing force of the spring **118**, the valve member **114** will be moved out of engagement with the seat to vent the excessive fluid pressure in tube **122** to the atmosphere. This will allow the exhalation valve to relieve excess mask pressure.

In operation of the structure illustrated in FIGS. 2, 3, and 4, when the apparatus is used at low altitudes or at relatively normal atmospheric conditions, the bellows member **97** will be in a contracted condition and the valve member **86** will be in its uppermost position wherein the lip **90** is out of engagement with the flange **80**. In this position of the valve member **86**, fluid pressure is vented from the chamber **92** to the atmosphere, and the fluid pressure within chamber **92** will be minimum and approximately atmospheric.

When the user of the apparatus inhales, a reduction in fluid pressure within chamber **52** will occur and the diaphragm **56** will be deflected downward under the influence of the fluid pressure within chamber **92**. Such movement of the diaphragm **56** will cause opening of the pilot valve **60** as previously described to effect opening of the valve member **40**. When the valve member **40** is thus opened, oxygen will be supplied to the mask **18**.

Since the chamber **52** communicates with the interior of the mask **18** by means of the port **54**, exhalation on the part of the user will increase the fluid pressure within the chamber **52** to return the diaphragm **56** to its original position to close the pilot valve **60** and valve member **40**.

If a decrease in atmospheric pressure should occur, such as during an increase in altitude, the bellows member **97** will expand to move the valve member **86** downward. This movement of valve member **86** will accordingly position the lip 90 closer to the flange 80 to throttle the flow of fluid from the chamber 92 causing an increase in fluid pressure within the chamber 92.

The increased fluid pressure in chamber 92 will move the diaphragm 56 downward and open the pilot valve 60 to effect opening of the valve member 40 to cause oxygen flow to the mask 18. However, since the chamber 52 is in communication with the mask, the supply of oxygen to the mask when the user is not inhaling will increase the pressure in chamber 52 causing a pressure force to be exerted on the diaphragm 56 in opposition to the fluid pressure acting on the upper side of the diaphragm 56. This build-up in pressure within chamber 52 will continue until the pressure in chamber 52 equals the pressure in chamber 92 at which point the diaphragm 56 will have returned to its original position closing the pilot valve 60 and valve member 40.

It will be apparent that in operation in the above manner, the diaphragm 56 serves as a pressure regulator to maintain a fluid pressure within the mask 18 as determined by the position of the bellows member 97. Also, since inhalation on the part of the user is effective to open the pilot valve 60 by establishing a pressure differential on the diaphragm 56, it will be apparent that the sensitivity of the device to inhalation is constant irrespective of the atmospheric pressure condition sensed by the bellows member 97. This is due to the fact that the fluid pressure in chambers 52, 92 is always substantially the same. Accordingly, when the user inhales, the same pressure difference is established across the diaphragm 56 at high atmospheric pressure conditions as is established at low atmospheric pressure conditions. Thus, the device is operative to effect pressure breathing at low atmospheric pressure conditions without effecting the sensitivity of the device to inhalation and exhalation on the part of the user.

If it is desired to calibrate the response of the bellows member 97 to a particular atmospheric pressure condition, the screw 106 may be rotated to vary the axial position of the bellows member 97 and valve member 86 relative to the flange 80. Such positioning of the bellows member 97 will accordingly vary the pressure condition at which the lip 90 engages the flange 80.

If due to any condition, the pressure within the mask 18 becomes excessive, it will be apparent that relief valve 108 will open to vent the excessive fluid pressure in tube 122 to the atmosphere and allow the exhalation valve (not shown) to vent excess mask pressure.

Referring now to FIG. 5, the tubular outlet fitting 26 is shown as provided with another embodiment of the relief valve 108. More particularly, the bellows-type expansible element 124 is mounted within the fitting 26 and has one end 126 clamped to the bottom wall of the casing 20 by means of an annular clamp 128 which is engaged by a shoulder of the fitting 26. The other end 130 of the element 124 is secured to a peripheral flange 132 of a movable spider 134 by means of a locking ring 136.

An annular valve member 138 is formed on the end of the element 124 and is adapted to engage an annular shoulder 140 formed on the wall of the outlet fitting 26 to control communication between the interior of the fitting 26 and a plurality of ports 142 extending through the wall of the fitting 26.

A spring 144 is mounted in tension between the center of the spider 134 and the center of a second spider 146 threaded within the end of the fitting 26. With this arrangement, the spring 144 serves to bias the element 124 to cause expansion of the same and engagement of the valve member 138 with the shoulder 140 to prevent communication between the interior of the fitting 26 and the ports 142. If, however, the fluid pressure within the interior of the fitting 26 should exceed a predetermined value, the element 124 will contract under the influence of the fluid pressure to move the valve member 138 out of engagement with the shoulder 140 to vent the excessive fluid pressure to the atmosphere through the ports 142.

It will be apparent that the pressure at which the valve member 138 moves out of engagement with the shoulder 140 is readily adjusted by rotating the spider 146 to vary the axial position thereof and the tension of the spring 144.

While several embodiments of the invention have been herein shown and described, it will be apparent to those skilled in the art that many changes may be made in the construction and arrangement of parts without departing from the scope of the invention as defined in the appended claims.

I claim:

1. In a regulator valve for controlling the flow of fluid from a source of fluid under pressure, the combination comprising a casing having an inlet passage and an outlet passage for fluid intersected by a valve seat, a differential pressure actuated valve member movable relative to said seat for controlling the flow through said passages, passageway means establishing communication between said inlet passage and each side of said valve member whereby each side of said valve member is subjected to inlet pressure, pilot valve means in said casing for controlling the operation of said valve member and including a pilot valve element movable from one position to another to relieve the pressure acting on one side of said valve member for causing actuation of said valve member relative to said seat, a flexible diaphragm sensitive to a pressure condition on one side thereof for actuating said element between said positions upon a change in said condition, means communicating with said inlet passage for subjecting the other side of said diaphragm to the fluid pressure in said inlet passage to actuate said element independently of a change in said pressure condition, and means carried by said casing and being operative in response to atmospheric pressure variations for varying the pressure acting on the other side of said diaphragm.

2. In a breathing apparatus for supplying fluid under pressure to a breathing mask or the like, the combination comprising a casing having an inlet passage and an outlet passage intersected by a valve seat, a differential pressure actuated valve member having oppositely disposed pressure responsive sides and being cooperable with said seat for controlling the flow of fluid through said passages, communicating means between each of said oppositely disposed sides and said inlet passage, said oppositely disposed sides having different effective areas whereby said valve member normally engages said valve seat, pilot valve means in said casing to control the operation of said valve member and including a pilot valve element movable from one position to another to relieve the pressure acting on one side of said valve member to cause movement of said valve member, a flexible diaphragm in said casing defining a chamber on each side thereof with said casing, one of said chambers communicating with said inlet passage and the other of said chambers communicating with the mask, said diaphragm being movable in response to a decrease in pressure in said other chamber caused by inhalation and movable in response to a change in fluid pressure in said one chamber, an operative connection between said diaphragm and said pilot valve element for actuating said pilot valve to open said differential pressure operated valve member upon movement of said diaphragm, means for venting fluid pressure from said one chamber to vary the pressure therein, and an expansible element operatively connected to said venting means for actuating the same to increase the pressure in said one chamber in response to a decrease in atmospheric pressure to effect opening of said differential pressure actuated valve member to establish a predetermined pressure within the mask.

3. In a breathing apparatus as claimed in claim 2

wherein said venting means comprises an annular member clamping said diaphragm to said housing having an annular flange on the end thereof, and a cup-shaped valve member having a flange overlying said flange of said annular member and cooperative therewith, said expansible element engaging the bottom wall of said cup-shaped member.

4. In a breathing apparatus as claimed in claim 3 wherein said expansible element comprises an expansible bellows member.

5. In a breathing apparatus as claimed in claim 4 wherein said bellows member has one end engaging said bottom wall and the other end thereof engaging an adjustable support fixed to said housing.

6. In a breathing apparatus for supplying fluid under pressure to a breathing mask or the like, the combination comprising a housing having an inlet passage and an outlet passage intersected by a valve seat, a differential pressure actuated valve member cooperable with said seat for controlling flow through said passages, said valve member having different pressure responsive areas, means establishing communication between said inlet passage and each of said areas whereby said valve member normally engages said valve seat, a flexible diaphragm in said housing defining a chamber on one side thereof in communication with said inlet passage and a chamber on the other side thereof in communication with one area of said valve member and the mask, said diaphragm being movable in response to a decrease in pressure in said other chamber caused by inhalation and movable in response to a change in fluid pressure in said one chamber, pilot valve means in said other chamber for controlling communication between said other chamber and said one area of said pressure actuated member including an actuating member engaging said diaphragm, said diaphragm being operative upon movement thereof to open said pilot valve means to vent fluid pressure from said one area of said pressure actuated valve member to open said pressure actuated valve member to supply fluid to the mask, valve means for venting the fluid from said one chamber to the atmosphere to vary the fluid pressure in said one chamber, and means responsive to variations in atmospheric pressure for closing the last said valve means in response to a decrease in atmospheric pressure to cause opening of said pilot valve means for establishing a predetermined fluid pressure within the mask.

7. In a breathing apparatus as claimed in claim 6 wherein means are provided for venting the fluid in said outlet passage to the atmosphere in response to a predetermined fluid pressure in said outlet passage.

8. In a relief valve, the combination comprising a casing having a passage therethrough for fluid, an expansible element positioned in said passage and having a central opening permitting flow through said passage, a valve element formed on one end of said expansible element, a vent passage in said casing, a shoulder on said casing adjacent said vent passage and positioned to be engaged by said valve element, and means for biasing said expansible element to cause said shoulder to be engaged by said valve element in opposition to the pressure force of the fluid within said passage.

9. In a relief valve, the combination comprising a casing having a passage therethrough for fluid, an expansible element positioned in said casing and having an opening for permitting fluid flow through said passage, venting means in said casing, an abutment member in said casing adjacent said venting means, a valve element formed on said expansible element and being movable into engagement with said abutment member to prevent fluid flow to said venting means, means operatively connected to said expansible element and having a predetermined biasing force urging said valve element into engagement with said abutment member in opposition to the pressure force of the fluid within said casing whereby the valve element will be moved out of engagement with said abutment member to permit fluid flow to said venting means when the pressure force of the fluid exceeds said predetermined biasing force, and means in said casing connected to said urging means and being operable to adjust said predetermined biasing force.

10. In a breathing apparatus for supplying fluid under pressure to a breathing mask or the like, the combination comprising a casing having an inlet passage and an outlet passage intersected by a valve seat, a differential pressure actuated valve member having oppositely disposed sides and cooperating with said seat for controlling the flow of fluid through said passages, means establishing communication between each of said sides and said inlet passage, one of said sides being subject to a greater force than the other whereby said valve member normally engages said valve seat, pilot valve means in said casing to control the operation of said valve member and including a pilot valve element movable from one position to another to relieve the pressure acting on said one side of said valve member to cause movement of said valve member, a flexible diaphragm in said casing and cooperating therewith to define a chamber, said chamber communicating with said inlet passage and said diaphragm being movable in response to a change in fluid pressure in said chamber, means forming an operative connection between said diaphragm and said pilot valve element for actuating said pilot valve to open said differential pressure operated valve member upon movement of said diaphragm, means for venting fluid pressure from said chamber to vary the pressure therein, and an expansible element operatively connected to said venting means for operating the same to increase the pressure in said chamber in response to a decrease in atmospheric pressure to effect opening of said differential pressure actuated valve member to establish a predetermined pressure within the mask.

11. In a regulator valve, the combination comprising a casing having an inlet passage and an outlet passage intersected by a valve seat, a differential pressure actuated valve member cooperable with said seat for controlling the flow of fluid through said passages, said valve member having oppositely disposed sides, means communicating with said inlet passage to subject each of said sides to inlet fluid pressure, one of said sides having a larger effective area than the other whereby said valve member normally engages said seat, pilot valve means in said casing to control the operation of said valve member and including a pilot valve element movable from one position to another to relieve the pressure acting on said one side of said valve member to cause movement of said valve member, a flexible diaphragm in said casing and cooperating with said casing to define a chamber on each side of said diaphragm, one of the chambers communicating with said inlet passage and the other of the chambers communicating with said outlet passage, said diaphragm being movable in response to a change in pressure in the one chamber and being movable in response to a change in pressure in the other chamber, an operative connection between said diaphragm and said pilot valve element for actuating said pilot valve to open said differential pressure operated valve member upon movement of said diaphragm, means for venting fluid pressure from the one chamber to vary the pressure therein, and an expansible element operable in response to variances of a predetermined condition and being operatively connected to said venting means for controlling the operation of the same to effect opening and closing of said differential pressure operated valve.

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