April 21, 1959

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2,882,895

OPEN-CYCLE BREATHING APPARATUS

Filed Sept. 26, 1956

4 Sheets-Sheet 1

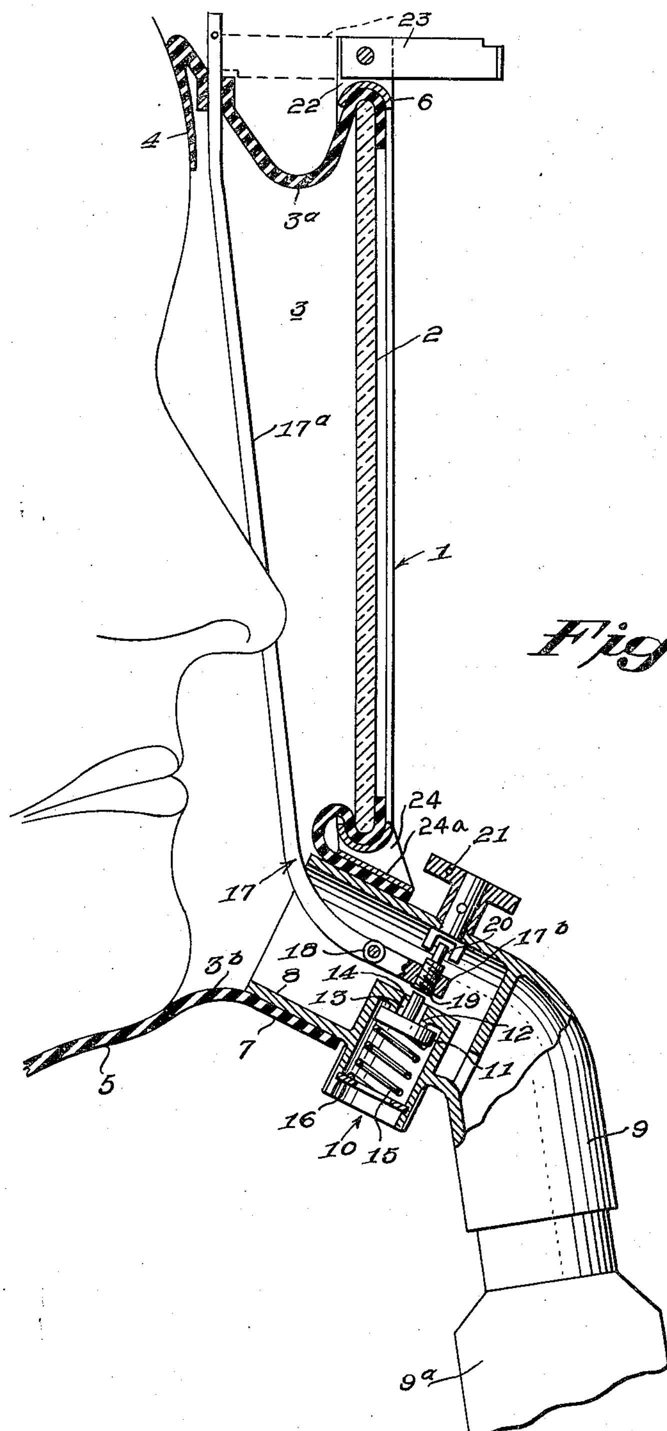


Fig.1.

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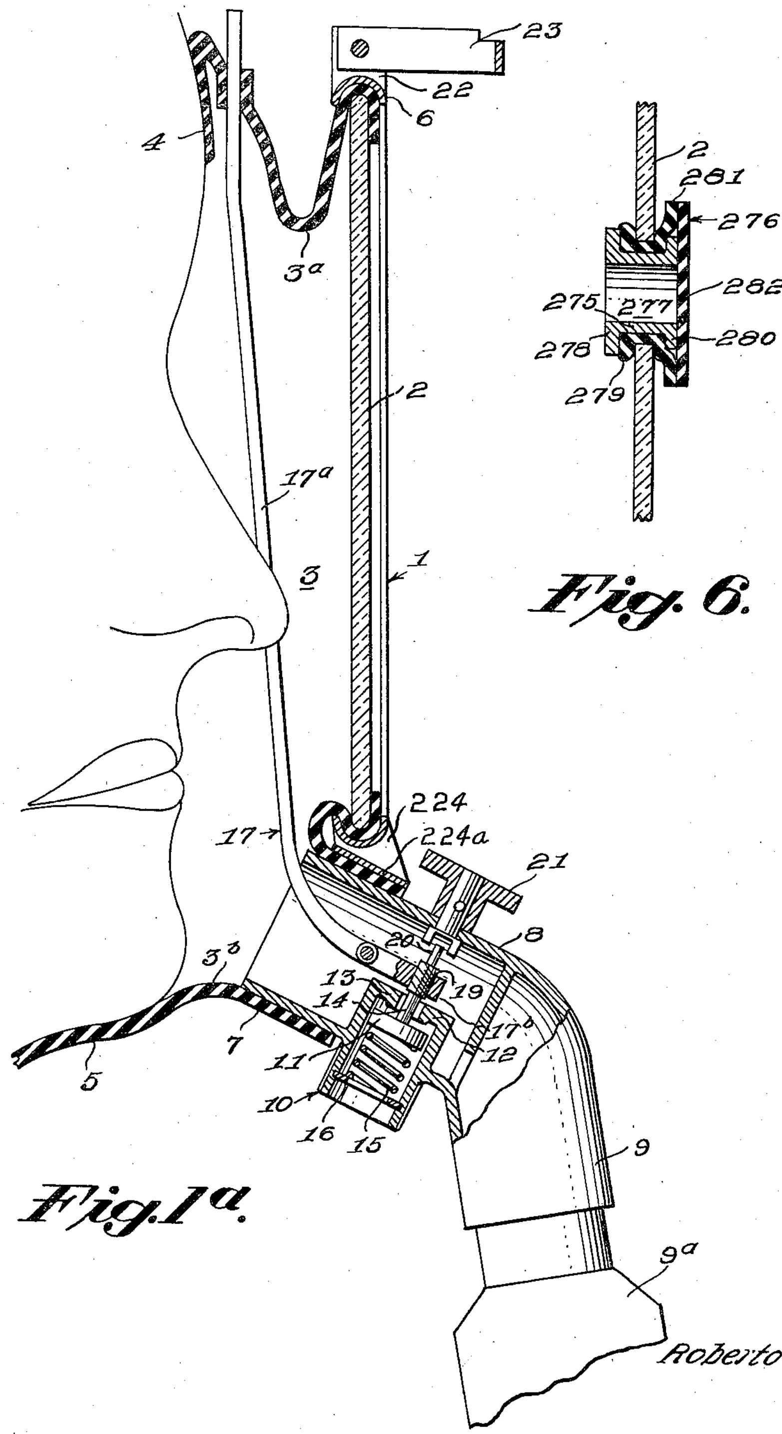


Fig. 1a.

Fig. 6.

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4 Sheets-Sheet 3

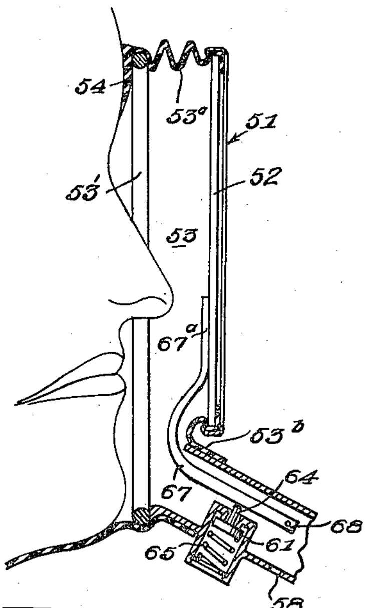


Fig. 2.

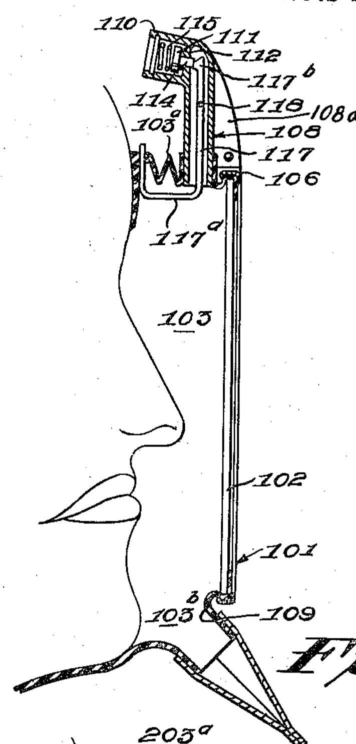


Fig. 3.

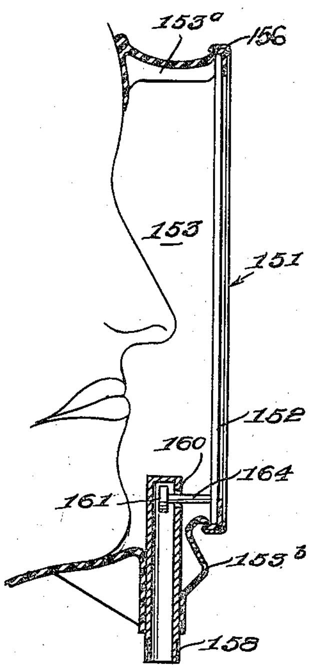


Fig. 4.

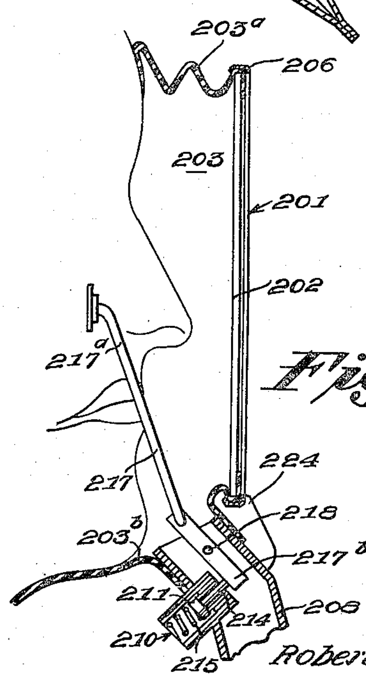


Fig. 5.

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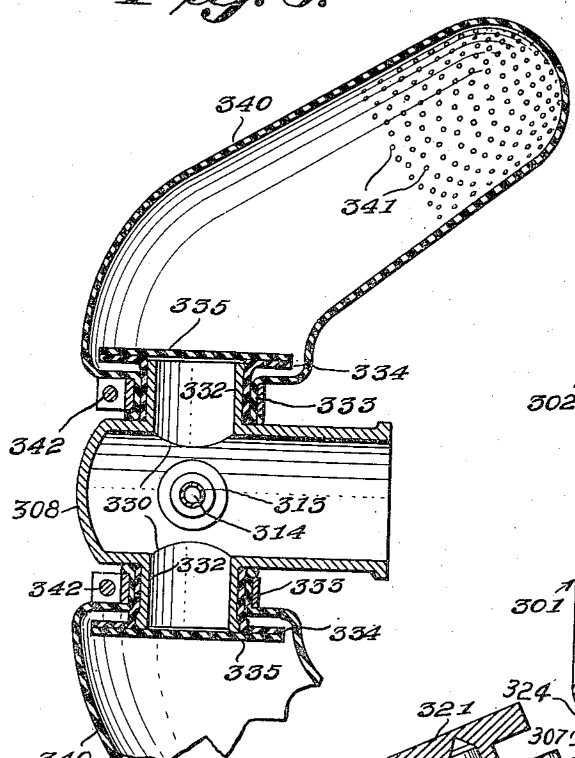


Fig. 8.

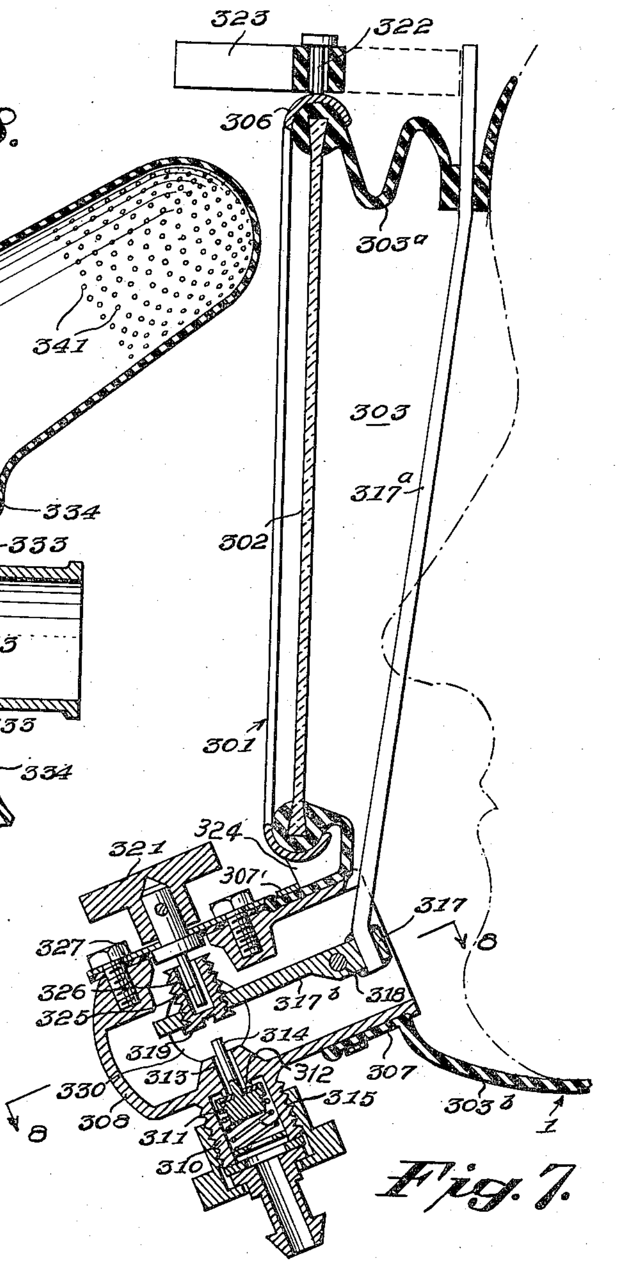


Fig. 7.

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United States Patent Office 2,882,895

Patented Apr. 21, 1959



2,882,895

# OPEN-CYCLE BREATHING APPARATUS

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Application September 26, 1956, Serial No. 612,238

Claims priority, application Italy October 1, 1955

17 Claims. (Cl. 128—141)

This invention relates to improved open-cycle breathing apparatus, and particularly to open-cycle breathing apparatus especially applicable to submarine use.

In such apparatus, it is the usual practice to employ a fluid-tight mask, a source of breathable air and an air inlet valve associated with the mask and operable, at the will of the wearer, by the wearer's tongue, teeth or lips. While such usual practice offers distinct advantages, the wearer often has difficulty in learning to operate the air inlet valve in proper timed relation to supply the necessary quantities of air.

Other breathing apparatuses are known, in which the air-supplying valve is a part of the mask, and is automatically opened and closed by the movements of the glass face piece of the mask to and from the user's face, in consequence of the pressure variations occurring, inside the mask itself with respect to the outside, at any inspiration and expiration of the user. In the breathing apparatuses of this type all the mask body attached to the periphery of the glass face piece is so made as to be easily and widely deformable, as for instance by being bellows-shaped, and the glass face piece may be hinged on a stationary frame of the mask by means of external hinges, so as to oscillate about an imaginary transverse axis extending across the plane of the glass itself.

The main disadvantage of this known form of mask is caused by the knuckled hinges by which the glass face piece is attached to the body of mask, since these hinges are liable to be blocked or damaged, and also because of the deleterious action of the sea water. Another disadvantage is due to the fact that the imaginary axis of oscillation of the glass face piece lies within the area of the glass itself, so that a portion of the latter oscillates outwardly, rather than inwardly, when the user inspires, and inwardly, rather than outwardly at his expiration; consequently, a satisfactorily wide oscillation of the glass, by virtue of the wearer's breathing, is precluded.

In order to eliminate the above described disadvantages, my invention comprises an easily and widely deformable portion of the mask body, which is attached to one portion of the periphery of the glass face piece, and is shaped like a bellows, with one or more undulations or the like. Also, a less deformable small portion of the mask body is attached to the glass periphery, at a point opposite the more deformable portion, so as to provide in said former portion an axis of oscillation of the glass face piece which lies outside the area of the face piece. Consequently, the prior art external knuckled hinges of the glass are eliminated, and an oscillating connection of the glass is obtained by means of the above described more and less flexible portions of the mask itself; the latter serving as a hinge, without any liability to blocks or jamming. Moreover, the fulcrum of oscillation of the glass face piece is not an intermediate transverse axis within the area of the glass, as in the known types, but is substantially a horizontal axis lying on, or outside of the periphery of the glass. Consequently, the



whole glass face piece moves as a unit in same direction to and from the user's face, and its oscillations may be obtained in an easier, safe and wider way, by virtue of the breathing of air by the user inside the mask.

According to a preferred form of embodiment of my invention, which provides a safer automatic control of the air-supplying valve, in comparison with the already known apparatuses, the air-supplying valve, instead of being mounted on a stationary part of the mask, is carried by a relatively less flexible portion of the mask which is rigidly connected to the glass face piece, and therefore movable as a unit with it. In this preferred realization, the air-supplying valve is controlled by a rigid arm, fixed near one end to a part which moves integrally with the glass, and is arranged to operate the valve, upon inhalation and exhalation of the user. The other end of the fixed arm bears directly against a portion of the user's face (for instance against his forehead or cheek), or else is attached to a stationary part of the mask, generally very near the user's face and preferably to his forehead.

From the foregoing, it will be understood that the principal object of my invention is accomplished by making one portion of the mask body, which is attached to the glass face piece, very flexible so as to be readily deformed in response to breathing pressure variations; and making the oppositely attached portion of said body less flexible, and so arranged as to serve as a hinge, about which the glass face piece oscillates as a unit, in the one direction during inhalation and in the opposite direction during exhalation of the wearer. By virtue of this construction, the axis of oscillation of the glass face piece lies wholly outside of the area of the glass face piece, but substantially in vertical alignment with the plane thereof, whereby the entire area of the glass is effective in creating a force, proportional to the differential pressure acting on the glass, which is utilized in operating the air supply valve; and also said force is applied with a greater leverage to the operation of said valve, because the aixs of oscillation of the glass face piece lies outside its area.

In employing such improved apparatus, difficulty is encountered when the apparatus is used in connection with "direct breathing" means, such as the "surface breathing" devices commonly used with submarine breathing apparatus to allow the wearer to breathe atmospheric air rather than air from the contained supply of the apparatus. In such case, the automatic air inlet valve actuating mechanism may operate during use of the "direct breathing" means, so causing a waste of the contained air supply. To overcome this disadvantage, the present invention provides a manually operable lock-out means for deactivating the automatic air inlet valve actuating mechanism during direct breathing of atmospheric air. Advantageously, such lock-out means is so constructed as to allow the wearer to bring the automatic valve actuating mechanism again into play, even though the lock-out means be in operative condition, simply by taking an exceptionally deep breath.

A further advantageous feature of the invention is the provision of means, associated with the automatic actuating mechanism for the air inlet valve, for adjusting the relative positions of the valve and its actuating mechanism to obtain the proper sensitivity of the automatic valve action and to compensate for affects on the mask of the particular shape and size of the wearer's head.

Another difficulty encountered in use of an apparatus of the type provided by the invention arises from the fact that, if the locations of the air inlet valve and the outlet valve for the mask are not properly related, there is a tendency for the automatic air inlet valve to operate properly when the user is in one position and to operate improperly when the wearer's position changes. Thus, for example, if the outlet valve is disposed at a point considerably removed from the plane of the face plate of the mask, and the air inlet valve actuating mechanism is set for proper automatic operation when the wearer is in a standing position with head upright, the inlet valve may remain open, not responding to the wearer's breathing, when the wearer changes his position so that his body is horizontal with head disposed downwardly. In such event, the air supply is rapidly and unnecessarily wasted. In this connection, I have discovered that automatic actuation of the air inlet valve will occur properly, responding to pressure changes within the mask as the wearer breathes, if the outlet valve is disposed substantially in the plane of the face plate of the mask at a point on the mask or immediately adjacent thereto. Advantageously, the outlet valvet is positioned at the center of the face plate. Alternatively, both the air inlet valve and the outlet valve are mounted on a single member attached to the mask at a position substantially on the vertical center line of the face plate and adjacent the periphery thereof. In both cases, the differential between the pressure within the mask and the pressure outside of the mask at the location of the outlet valve remains substantially constant regardless of changes in the wearer's position.

The invention also achieves uniform operation of the inlet and outlet valves regardless of whether the wearer is turned on his right side or his left side. This is accomplished by providing two outlet valves disposed adjacent the periphery of the face plate of the mask, the outlet valves being located one on each side of the center line of the face plate. In such case, the outlet valves are advantageously each provided with a flexible silencing and atomizing hood extending laterally outwardly and rearwardly, such hoods having perforations at their outer ends.

In order that the invention can be understood in detail, reference is had to the accompanying drawings, which form a part of this specification, and wherein:

Fig. 1 is a vertical sectional view of a mask and associated parts constructed in accordance with one embodiment of the invention;

Fig. 1*a* is a vertical sectional view of the apparatus of Fig. 1, showing the parts thereof in different operative position than in Fig. 1;

Figs. 2–5 are vertical sectional views, similar to Fig. 1, illustrating additional embodiments of the invention;

Fig. 6 is a fragmentary vertical sectional view illustrating outlet valve means applicable to the embodiments of the invention shown in Figs. 1–5;

Fig. 7 is a vertical sectional view illustrating an embodiment of the invention similar to that of Fig. 1 incorporating special outlet valve means comprising a pair of specially arranged check valves, and

Fig. 8 is a sectional view taken on line 8—8, Fig. 7.

Referring first to Fig. 1, it will be seen that the submarine breathing apparatus here shown comprises a mask, indicated generally at **1**, having a transparent face plate **2** of glass or other suitable material, the periphery of which is attached in water-tight relationship to the forward edge or rim of the main mask body **3**. The mask body **3**, fabricated from rubber or like sheet material, is generally annular in form and defines an air space between the wearer's face and the face plate. At its rear edge body **3** is provided with an inturned lip **4** adapted to lie in sealing relationship against the wearer's forehead and the side of the wearer's head, the lower portion of the rear edge of the mask being extended, without such lip, to lie flush against the undersurface of the wearer's chin and jowls, as seen at **5**, so that the mask is fitted in fluid-tight relationship to the wearer's head throughout the entire length of such rear edge. The mask is held in place by head straps or other conventional means, not shown, in the usual manner. The portion of the mask body between the rear edge and the face plate is in the general form of a bellows, in the sense that there is an excess of material in the mask body allowing movement of the forward edge of the mask body, and therefore of the face plate, toward and away from the wearer's face.



Plate **2** may be secured to the forward edge of the mask in any conventional manner. In this embodiment, the periphery of the face plate is rounded and the forward edge portion of the mask is clamped between such rounded periphery and an annular metal clamping ring **6** of generally semi-circular cross-section, as shown.

At its lower portion, at a point centered with respect to the vertical axis of the face plate and located adjacent the wearer's chin, the mask body **3** is provided with an open-ended, cylindrical, downwardly slanting extension **7**. Mounted within extension **7** and sealed thereto in fluid-tight relation, as by the use of a suitable sealing cement or other conventional means, is a downwardly inclined pipe **8** joining a forwardly disposed, downwardly extending tubular portion **9**. The tubular portion **9** is preferably provided with the usual lateral discharge valve and also serves as a collector for saliva and any water which has possibly infiltrated the mask. The tubular portion **9** terminates in a front valve **9*a***, preferably of the conventional "goat-beard" type. Integral with the lowest part of face plate clamping ring **6** is a rigid bracket **24**, having a curved portion **24*a*** which tightly embraces the outer surface of the upper part of tubular extension **7**, and thus serves to rigidly connect said extension and pipe **8** to face plate **6**.

At the bottom of the mask, the pipe **8** is provided with a downwardly extending tubular housing **10** adapted to be sealingly engaged by a conventional air supply conduit (not shown) to connect the mask to a source of contained air. The housing **10** extends inwardly of pipe **8**, as shown, to enclose a reciprocating valve member **11**. At its inward end, the housing **10** is provided with a transversely extending wall **12** having a centrally disposed aperture **13**. The valve member **10** is designed to seat in fluid-tight relationship against the wall **12** and is provided with an extension or pin **14** disposed in and of smaller diameter than the aperture **13** in wall **12**. Valve member **11** is normally held in engagement with wall **12**, so that the valve is normally closed, by means of a compression spring **15**, one end of the spring engaging the valve member **11** directly and the other end of the spring engaging a suitable annular stop member **16** mounted in an annular slot in the inner wall of tubular housing **10**.

To provide for automatic actuation of the valve member **11**, and thus automatic control of the air inlet to the mask, there is provided a substantially fixed and rigid arm **17** having one end disposed within pipe **8** and the other end extending through the wall of the main mask body **3** at a point adjacent the wearer's forehead, as shown. Thus, the upper end portion of the arm **17** is substantially fixed with respect to the wearer's head. At a point adjacent its lower end, the arm **17** is pivoted to pipe **8** by means of a pin **18** journalled at each end in the walls of the pipe **8**. Accordingly, the arm **17** includes a relatively long portion **17*a*** extending upwardly in front of the wearer's face, and bypassing the wearer's nose, as well as a relatively shorter portion **17*b*** extending downwardly and forwardly of pivot pin **18** within pipe **8**, so as to be disposed above the pin **14** on valve member **11**.

The tip of shorter portion **17*b*** of arm **17** is enlarged and provided with a threaded bore adjacent pin **14** of valve member **11**. Threadably engaged in this bore is a valve-actuating pin **19** aligned with pin **14** of the valve member **11**, the valve-actuating pin **19** being provided at its upper end with a flattened, laterally extending portion **20**. In order to manually adjust the position of the valve-actuating pin **19** relative to the pin **14** of valve member **11**, there is provided on the top of pipe **8** an adjusting knob **21** the shaft of which is journalled in the wall of pipe **8** and having, within pipe **8**, a bifurcated portion disposed astride the flattened portion **20** of valve-actuating pin 19. Thus, rotation of adjusting knob 21 in either direction will cause a corresponding rotation of valve actuating pin 19 and, since the valve actuating pin 19 is threadably engaged with the tip of the shorter portion 17*b* of the actuating arm, valve-actuating pin 19 will accordingly move toward or away from the valve member 11.

It will be noted that the upper end of longer portion 17*a* of the actuating arm extends above mask body 3. At a point forwardly aligned with such upper end of longer portion 17*a*, face plate clamping ring 6 is provided with a bracket 22 on which is pivotally mounted a lock lever or stop member 23. Thus, member 23 may be pivoted forwardly, to an inactive position, or rearwardly to a position, shown by dotted lines, in which it is in engagement with the projecting upper end of longer portion 17*a* of the actuating arm.

The upper portion 3*a* of mask body 3, located in front of the wearer's forehead, is of such configuration as to be readily and substantially deformed. Thus, upper portion 3*a* can, as illustrated, be provided with at least one undulation or fold, providing for a bellows-like action in this portion of the mask body. On the other hand, the lower portion 3*b* of the mask body comprises only a relatively small amount of flexible material capable of being deformed, a major proportion of such lower portion 3*b* being made rigid by its attachment to the pipe 8, the pipe 8 being fabricated from metal or other substantially rigid material.

In operation, when the wearer inhales the air contained within the mask, such inhalation causes the air pressure within the mask to decrease to a point substantially below the fluid pressure outside of the mask. This results in a movement of the face plate 2 toward the wearer's face, such movement being substantially greater at the top of the mask than at the lower portion of the mask, by virtue of the greater deformability of upper portion 3*a* of the mask body. Thus, the transparent face plate 2 is caused to pivot, with the upper portion thereof approaching the wearer's face, to the position seen in Fig. 1*a*. Such pivotal movement occurs substantially about pin 18 which is mounted in, the lower portion of arm 17. Since the upper end of the longer portion 17*a* of the arm is substantially fixed with respect to the wearer's forehead and pin 18, the arm 17 cannot follow such motion of the face plate 2. Accordingly, the forward portion of pipe 8 tends to move upwardly, during inhalation by the wearer, while the rearward portion of pipe 8 tends to move downwardly, such movement being centered approximately on pivot 18. Because of such movement, the inlet valve is moved upwardly until the end of pin 14 of valve member 11 is brought into engagement with the valve-actuating pin 19 carried at the tip of shorter portion 17*b* of the arm 17. As such movement continues, valve member 11 is held stationary, biasing spring 15 is compressed, and the inlet valve is accordingly opened, to the position seen in Fig. 1*a*, to allow fresh air to flow into the mask. When the user exhales, the pressure within the mask again becomes equal to the pressure outside the mask and the pivotal movement of face plate 2 is accordingly reversed. Thus, the top portion of the face plate moves outwardly, returning to the position shown in Fig. 1. In consequence of such outward movement, pipe 8 is caused to move in such manner that its forward portion is lowered and its rearward portion raised. Thus, pins 14 and 19 are brought out of engagement with each other and compression spring 15 is allowed to close its inlet valve.

In this manner, actuation of the inlet valve is completely automatic, responding to movement of face plate 2 which results from pressure variations caused by inhalation and exhalation by the wearer. Thus, the delivery of fresh air to the mask is accomplished in the normal ratio for the physiological need of air in accordance with the breathing of the wearer.

Manual adjustment of the inlet valve, accomplished by means of adjusting knob 21, serves two purposes. First, this adjusting means provides a way to effect in initial setting of the inlet valve-actuating mechanism which will be correct for the particular configuration of the face of the person wearing the mask. In this connection, it will be obvious that the initial position of the various parts of the mechanism will vary in accordance with the shape of the face and head of the particular person wearing the mask. The second purpose of the adjusting mechanism is to provide a means for varying the sensitivity of the automatic valve actuation.

It is desirable to provide the apparatus with some means, which may be constructed in any of the several known manners, allowing the wearer to directly breathe atmospheric air. Thus, in the case of a submarine breathing apparatus, any of the usual "surface breathing devices" may be employed. However, the use of such surface breathing device will, in the case of submarine service, cause automatically the constant opening of the air supply valve member 11. Since the surface breathing device places the interior of the mask in direct communication with the atmosphere, while the outside of the mask is subjected to the existing water pressure, face plate 2 will be displaced toward the wearer's face so long as surface breathing is maintained, the interior and exterior pressures not being equalized during any portion of the breathing cycle, and thus causing a waste of air supplied from the reserve. It is for this reason that the present invention includes stop member 23, whereby the movement of the face plate toward the wearer's face may be prevented. Thus, when the wearer is employing a surface breathing device or other means allowing the direct breathing of atmospheric air, stop member 23 is merely pivoted to the position shown in dotted lines in Fig. 1, locking the face plate 2 in the position shown and preventing automatic actuation of inlet valve member 11.

The illustrations in Figs. 2–5 for certain additional embodiments of the invention include a diagrammatic showing of only the parts inherently necessary for automatic control of the air supply valve in accordance with the invention. Thus, in Figs. 2–3, the mechanism for adjusting the valve-actuating means, corresponding to elements 20 and 21, Figs. 1 and 1*a*, and the stop means for locking the face plate in its forward position, and thus preventing automatic operation of the device, have not been shown. It will be obvious that such means may be employed in these embodiments in the same manner as in the embodiment of Figs. 1 and 1*a*.

Referring now specifically to Fig. 2, it will be seen that the apparatus again includes a mask generally indicated at 51, to the forward edge of which is secured in fluid-tight relationship a face plate 52. Adjacent the wearer's face, the mask is provided with a generally annular, rigid reinforcing element 53′ in contact with, and if desired, connected to, the main mask body 53. The re-enforcing element 53′ is disposed immediately forward of the wearer's face, the upper portion of element 53′ being in direct engagement with the lip 54 at the rearward edge of the mask body. Thus, the element 53′ is so disposed with respect to the mask body that, once the mask is applied to the face of the wearer, there will be substantially no movement of element 53′ with respect to the wearer's face.

Upper portion 53*a* of the main mask body 53 is again so constructed that the upper portion of the mask is subject to a substantial amount of deformation. Thus, upper portion 53*a* may be in the form of a bellows, comprising several folds, as shown. At the lower edge of face plate 52, the mask body includes a portion 53*b* of flexible mask material disposed between the face plate and the pipe 58, the pipe 58 being associated with the mask in the same manner as described with reference to Figs. 1 and 1*a*.

Inlet valve means similar to that described with reference to Figs. 1 and 1*a* is associated with pipe **58** and includes a reciprocating inlet valve member **61**, such valve member again having an upwardly extending pin **64**. To provide for automatic actuation of the valve in response to pressure variations caused by breathing of the wearer, there is provided a lever **67** having at its upper end a flat portion **67*a*** disposed in contact with the rear surface of face plate **52**. An intermediate portion of the lever curves around portion **53*b*** of the mask body, so that the lever enters pipe **58** and extends within the pipe in substantial alignment therewith. The lever **67** is pivoted to pipe **58** at its lowermost end by means of a pivot pin **68**, the ends of the pivot pin **68** being journalled in the wall of pipe **58** in any suitable manner. The lever **67** is so disposed as to extend in alignment with pin **64** of inlet valve member **61**.

When the wearer inhales the air within the mask, face plate **52** is displaced towards the wearer's face by reason of the pressure differential between the interior and exterior of the mask. Portion **53*b*** of the mask body is made somewhat stiffer than portion **53*a***. Thus, in moving toward the wearer's face, the face plate **52** is shifted in its entirety and also slightly pivoted, with the upper portion of the face plate moving more than the lower portion. Such movement forces the upper end **67*a*** of lever **67** rearwardly, so pivoting the lever downwardly against actuating pin **64** of inlet valve member **61**. Thus, when the wearer inhales, lever **67** is pivoted sufficiently to open inlet valve member **61**, against the bias of spring **65**, allowing a fresh supply of air to enter the mask. On the other hand, when the wearer exhales, pressure within the mask is increased until it equals the pressure outside of the mask, face plate **52** thus travelling to its forward position, as seen in Fig. 2, with the result that forces tending to pivot lever **67** downwardly are removed, so that biasing spring **65** returns inlet valve member **61** to its normal, closed position. In this connection, it will be recognized that, with lever **67** rigidly attached to pivot pin **68**, the lever can rest directly on pin **64** of valve member **61**, lateral displacement of the lever being prevented by the rigid connection between the lever and the pivot pin.

In this particular embodiment of the invention, it is possible to eliminate the adjusting means for the inlet valve, since provision of reinforcing element **53'** and arrangement of the actuating lever in such manner that it has no engagement with the user's face, or with parts lying directly thereagainst, make it unnecessary to adjust for variations caused by the particular configuration of the user's face.

Fig. 3 shows an embodiment of the invention constructed along the same general lines as that previously discussed with reference to Figs. 1 and 1*a*, but with an arrangement of the automatic valve mechanism at the top of the mask in such manner as to effect a remarkable shortening of the valve-actuating lever. In this embodiment, the invention includes a mask **101** to the forward edge of which is sealingly attached a transparent face plate **102**. The main mask body **103** is generally annular in form and fabricated of rubber or other flexible material, the upper portion thereof at **103*a*** being provided with several folds to allow for a bellow's like action. The lower portion **103*b*** of the mask body is of plain configuration, it being necessary only to provide a cylindrical extension **109** to which is attached a conventional "goat beard" type exhaust valve. In this embodiment, lower portion **103*b*** of the mask body is made very flexible, so that the lower portion of the face plate **102** may be easily moved toward the wearer's face.

At the top of the mask, there is provided an upwardly extending pipe **108**, the lower end of the pipe being received in a generally cylindrical extension of portion **103*a*** of the mask body **103** and the pipe being rigidly secured to face plate clamping ring **106**, as by a bracket **108*a***. At its upper end, pipe **108** is provided with an offset cylindrical extension **110** housing the movable valve element **111** and the biasing spring **115**. Biasing spring **115** urges valve member **111** to its normally closed position, in contact with wall **112** disposed between members **110** and **108**. Again, wall **112** is provided with an aperture through which extends a pin **114** carried by valve member **111**. An actuating fixed and rigid arm **117** is provided, having the general configuration of the letter J. The longer portion **117*a*** of arm **117** extends upwardly within pipe **108**, and is pivoted to pipe **108** by a pivot pin at **118**. Thus, arm **117** includes an upper, shorter portion **117*b*** and a lower substantially longer portion **117*a***. The substantially longer portion **117*a*** extends through and is securely fastened in the wall of the mask body **103**. It will be noted that this lower end of arm **117** is so disposed that there can be substantially no movement thereof relative to the wearer's forehead. The upper, shorter portion **117*b*** of the arm is disposed in alignment with actuating pin **114** of movable valve member **111**.

In operation of this embodiment of the invention, inhalation by the wearer exhausts the air from within the mask, so that the pressure within the mask is distinctly less than that outside of the mask. Face plate **102** is thus caused to move toward the face of the wearer, with the lower portion of the face plate travelling a greater distance than the upper portion. Since upper portion **103*a*** of the mask body is very flexible, face plate **102** and the rigidly attached pipe **108** are free to pivot as a unit, with the upper end of the pipe travelling outwardly and the lower portion of the face plate travelling toward the user's face. Such pivotal action occurs about pivot pin **118**. As a result of such movement, movable valve member **111** is forced against the upper, shorter portion **117*b*** of the rigid fixed arm **117**, so that the valve **111** is opened against the biasing force of spring **115**. The mask is thus placed in communication with the usual source of air. When the wearer exhales, the pressure within the mask is increased, causing face plate **102** to move outwardly. The pivotal motion just described is thus reversed, actuating pressure being removed from movable valve member **111**, so that spring **115** closes the valve and returns the mechanism to the initial position seen in Fig. 3.

Fig. 4 shows a very simple embodiment of the invention, the mask **151** again including a transparent face plate **152** secured in fluid-tight relation to the forward edge of flexible mask body **153**, as by means of an annular face plate clamping ring **156**. At the top of the mask, a rigid re-enforcing element **153*a*** is secured to the mask body so as to prevent any substantial movement of the top portion of the face plate **152** toward the face of the wearer. At the bottom of the mask, however, mask body **153** includes a very flexible portion **153*b***. Thus, the portion **153*b*** may include at least one fold of extra material, as illustrated, to provide increased flexibility in that portion of the mask body. The lower portion of the mask body is provided with a vertical, downwardly opening tubular extension within which is sealed a pipe **158**. The lower end of the pipe **158** is adapted for connection to an air supply conduit, the upper end of pipe **158** being closed. Immediately below its upper end, pipe **158** is provided with a forwardly directed bore and an internal boss **160** receiving an extension or pin **164** secured to movable valve member **161**. The pin **164** extends forwardly into direct contact with the rear face of transparent face plate **152**. Movable valve member **161** seats directly against the internal boss **160** provided on pipe **158**.

In this embodiment, when the wearer inhales, the resulting differential between the pressure within the mask and the exterior pressure causes face plate **152** to approach the face of the wearer. Because of re-enforcement **153*a***, such movement is limited to the lower portion of face plate **152**, so that the face plate is pivoted roughly about its upper edge. Movement of the lower portion of the face plate toward the wearer's face forces movable valve member **161** rearwardly, opening the valve and allowing fresh air to flow into the mask. When the wearer exhales, the pressure within the mask is increased until the face plate **152** is returned to the position shown. Such return movement causes movable valve member **161** to seat in its closed position.

In order to attain both rearward and forward movement of the valve member **161**, two alternatives can be employed. On the one hand, extension or pin **164** of the valve member can be secured to the face plate **152**, so that the movable valve member must necessarily travel with the face plate in either direction. On the other hand, the movable valve member may merely contact the face plate, not being secured thereto, and a biasing spring (not shown) may be provided between the inactive face of valve member **161** and the opposite wall of pipe **158**.

This embodiment of the invention may be provided with any conventional outlet valve, not shown.

Fig. 5 shows an embodiment of the invention similar to that previously described with reference to Figs. 1 and *1a*, except that the longer portion **217*a*** of a valve-actuating fixed and rigid arm **217** is disposed in direct contact with the cheek of the wearer, such contact being in the area of the cheek bone. Here, mask **201** again includes face plate **202** secured in fluid-tight relation to the forward edge of mask body **203**, as by means of a face plate clamping ring **206**. Upper portion **203*a*** of the mask body is again made very flexible, as by providing at least one extra fold of material to effect a bellows-like action. On the other hand, lower portion **203*b*** of the mask body is relatively stiffer, including a downwardly directed tubular extension sealingly embracing pipe **208**. Pipe **208** has a tubular extension **210** housing the inlet valve mechanism, including movable valve member **211** and biasing spring **215**. Movable valve member **211** has an extension or pin **214** directed inwardly of pipe **208**.

In this case, the valve actuating arm **217** includes a straight lower portion **217*b*** extending into pipe **208** and pivoted thereto by a pivot pin **218** journalled in the walls of the pipe. The arrangement is such that lower portion **217*b*** of the arm **217** overlies the upper end of pin **214** of valve member **211**. At its upper end, the straight portion **217*b*** of arm **217** is rigidly connected to the upwardly extending portion **217*a*** terminating at its upper end in a suitable contact pad to be disposed in contact with the cheek of the wearer.

In this embodiment, as in the embodiment shown in Fig. 1, pipe **208** is made rigid with face plate **202** by means of a bracket **224** interconnecting the pipe and the face plate clamping ring. Thus, while the flexible upper portion **203*a*** of the main mask body allows considerable movement of the upper portion of the face plate **202**, movement of the lower end of the face plate is limited to a pivoting action with pivot pin **218** acting as the center of such movement. Accordingly, when the wearer inhales, with the result that the pressure within the mask is reduced below that outside, face plate **202** is pivoted toward the wearer's face, approximately about pivot pin **218** as a center of movement. Such pivotal action forces pin **214** of valve member **211** upwardly into engagement with lower end of portion **217*b*** of arm **217**, so that the valve is forced open against the biasing action of spring **215**, and fresh air is supplied to the mask. When the user exhales, the pressure within the mask is again made equal with the outside pressure, causing the base plate to pivot outwardly. Such outward pivotal motion, being about pivot pin **218** as approximate center, carries pin **214** of valve member **211** out of contact with the actuating lever and allows spring **215** to close the valve. Upper portion **217*a*** of the valve-actuating arm **217** may consist of a single branch, engaging only one cheek of the user, or may be a dual-arm structure, with two branches disposed in the configuration of a **V**, so that the two branches each engage one of the user's cheeks.

In this embodiment of the invention, it is desirable to employ the manual valve-adjusting means described hereinbefore with reference to Figs. 1 and *1a*, and the same outlet valve mechanism mentioned with respect to those figures can be here employed.

Considering all of the embodiments shown in Figs. 1–5, it will be noted that a fulcrum of oscillation is provided for the face plate of the mask by making the mask body of a generally annular configuration, with certain portions of the mask body being relatively highly flexible, so as to provide for a considerable movement of the corresponding portion of the face plate, while other portions of the mask body are relatively less flexible, or even inflexible, so as to limit the movement of the face plate adjacent such less flexible or inflexible portions. By this procedure, the invention attains a movement of the face plate, in response to pressure variations within the mask, which is readily employable to obtain a positive actuation of the inlet valve mechanism.

I have found that there is a distinct and important relationship between automatic inlet valve actuating mechanisms of the type just described and the outlet valve which must be provided in such breathing apparatus. Heretofore, it has been the usual practice to provide an outlet valve positioned at some distance from the center of the face plate of the mask. When this is done, and automatic actuating means for the inlet valve is employed in accordance with the invention, difficulty may arise because an adjustment of the inlet valve actuating mechanism made when the wearer is in one position (such as standing with head upright in the water) will not be satisfactory when the wearer is in another position (such as with the body horizontal and the head disposed downwardly). Thus, when automatic valve-actuating mechanism described with reference to Figs. 1–5 is employed in a mask wherein the outlet valve is disposed at a substantial distance from the center of the face plate, the user may find that, if he first adjusts the outlet valve mechanism to give proper operation when he is in upright position, fresh air is then supplied to the mask continually when he is in diving position, so that there is a resultant important loss of breathable air. I have found that this disadvantage can be overcome by placing the air outlet valve as near as possible to the plane of the face plate of the mask and also as near as possible to the central portion of the face plate. When this is done, the sensitivity of the air inlet valve, adjusted for a given position of the wearer, remains substantially unaltered when the wearer changes positions. This result is reached because, with the outlet valve disposed either at the center of the movable face plate or immediately adjacent to said center and substantially in the plane thereof, the internal and external pressures at the outlet valve will be the same or substantially the same as the internal and external pressures at the face plate.

Considerable advantages are thus obtained, if, in the embodiments of the invention shown in Figs. 1–5, an outlet valve of the type disclosed in Fig. 6 is employed. Thus, the face plate **2**, of the apparatus of Figs. 1 and *1a*, for example, is provided with a circular opening **275**. Opening **275** is advantageously disposed in the center of the face plate, but may be located at any adjacent point on the face plate. Mounted in opening **275** is an outlet valve indicated generally at **276**. The outlet valve comprises a cylindrical metal member **277** having on its rear face an annular, outwardly directed flange or shoulder **278**. Member **277** is centrally disposed in opening **275** and the space between member **277** and the walls of opening **275** is completely filled by a tubular member **279** of rubber or the like. Thus, rubber or like material forms a fluid-tight seal between member **277** and the face plate **2**. At its forward end, member **277** is provided with a second outwardly directed annular shoulder **280**, and the forward end of **279** extends about shoulder **280** and flares outwardly to provide an annular lip **281**. The movable valve element of this structure consists of a disc of rubber or the like **282** having its outer edge portion cemented at circumferentially spaced points to the annular lip **281** just mentioned. Thus, when the pressure within the mask exceeds the outside pressure, flexible disc **282** will be bulged outwardly, away from the outer end of member **277**, so that air may escape between lip **281** and disc **282** in those areas where the disc is not cemented to the lip. However, when the pressure within the mask is less than the outer pressure, such pressure differential will hold the flexible disc **282** in fluid-tight seated position against lip **281** and the outer end of member **277**. In order to assure ease of assembly, member **277** may be fabricated in two parts adapted to be threaded together, or may be made from a relatively soft metal with inner shoulder **278** initially omitted, such shoulder being pressed to shape to complete the structure when all of the parts are assembled in the relation shown in Fig. 6.

Another particularly advantageous embodiment of the invention, incorporating outlet valves specially related to the automatically actuated air inlet valve, is disclosed in Figs. 7 and 8. Here, the mask **301** includes a face plate **302** secured to the forward edge of the mask body **303**, as by means of a face plate clamping ring **306**. The upper portion **303*a*** of the mask body is made very flexible, as by the provision of at least one extra fold of material. The lower portion **303*b*** of the mask body is relatively less flexible, being provided with a downwardly and outwardly inclined tubular extension **307** secured to a generally cylindrical valve mounting body **308**, as by a clamping ring **307′**. A metal bracket **324** rigidly connects clamping ring **306** to ring **307′**, so that any oscillating movement of face plate **302** causes a similar movement of tubular extension **307** and valve mounting body **308**. On its lower surface, body **308** is provided with a downwardly and rearwardly directed tubular projection **310** housing movable inlet valve member **311**, the valve member being biased toward its seat by spring **315**.

Movable valve element **311** is provided with an upwardly extending pin **314** which passes through an aperture **313** in the wall **312** forming the valve seat, pin **314** being smaller in diameter than aperture **313**. A valve-actuating fixed and rigid arm **317** comprises a lower portion **317*b*** disposed within body **308** and pivoted thereto by pivot pin **318**. The upper portion **317*a*** of the valve-actuating arm **317** is secured to lower portion **317*b*** and extends upwardly through the air space defined by body **303**, bypassing the wearer's nose, and terminating above upper portion **303*a*** of the mask body at a point immediately adjacent the wearer's forehead. Thus, the upper portion **317*a*** of the valve-actuating arm **317** extends through the valve body and is held in a position which is substantially fixed with respect to the wearer's forehead. At its outermost end, lower portion **317*b*** of the valve-actuating arm is provided with a threaded opening in which is disposed a screw **319** located immediately above the pin **314** of valve member **311**. Thus, when the wearer inhales, so that the pressure within the mask is decreased below the outside pressure, face plate **302** is forced toward the wearer's face, pivoting substantially about pin **318** as a center. Since movement of the valve-actuating arm **317** is substantially inhibited, such pivotal action of the face plate **302**, being imparted to member **308**, results in pin **314** being brought into contact with screw **319**. As the pivotal motion continues, the movable valve member **311** is forced open, against the biasing action of spring **315**. Accordingly, a fresh supply of air is communicated to the interior of the mask. When the wearer exhales, the pressure within the mask is restored to a value equal to the outside pressure and the face plate **302** is caused to return to its original position, as shown in Fig. 7. Such return pivotal motion withdraws pin **314** from contact with screw **319**, allowing spring **315** to close the inlet valve.

In order to adjust the inlet valve-actuating mechanism, there is provided an adjusting knob **321**, the shaft of which extends through plate **327** bolted to the upper portion of body **308**. The shaft of the adjusting knob includes a flattened end **325** extending into a recess **326** of corresponding shape in screw **319**. Thus, rotation of knob **321** is imparted to screw **319**, so that the position of the screw relative to the movable valve member will be changed in accordance with the direction and extent of rotation of the adjusting knob.

Body **308** is provided with a pair of side openings **330**, such openings communicating with lateral tubular extensions **332**, Fig. 8. Fitted on each such extension is a tubular rubber or like sleeve **333**, the outer end of such sleeve being flared outwardly to form a flat, annular lip **334**. A rubber or like flexible, circular disc **335**, forming the movable element of a check valve, has its outer edge portion cemented at spaced points to the annular lip just mentioned. Thus, when the pressure within the mask exceeds the outer pressure, fluid may escape because the check valve discs **335** are bulged outwardly, away from the ends of extensions **333** and away from those portions of lip **334** to which discs **335** are attached.

Associated with each of the outlet check valves is a silencing and atomizing hood **340**, formed of rubber or other elastic sheet material. Each hood is of generally tubular form, the outer end being closed and provided with a plurality of perforations **341** to allow the escape of fluid. The opposite end of each hood is open, such open end being secured in fluid-tight relation over the tubular elements **333** of the check valves, as by clamping rings **342**, as seen in Fig. 8. In addition to acting as silencing and atomizing devices, the flexible, preferably elastic hoods **340** provide means which may be used by the wearer in equalizing pressure in the Eustachian tubes with the outside pressure. To accomplish such equalization, it is necessary to cause a slight excess pressure in the cavity of the pharynx. With the present embodiment of the invention, this is done by grasping the two hoods **340** both in the same hand and collapsing their end portions so that the escape of air is prevented, and then blowing into the mask to build up an excess pressure therein. The hoods **340** being flexible and elastic, squeezing them by hand will generate enough pressure in the remaining areas of the hoods to maintain the two check valves in closed position.

Since the hoods **340** extend outwardly and rearwardly from points below the center of the face plate, the columns of air bubbles emanating from the two hoods will be located primarily at the sides of the face plate, so as not to obscure the wearer's view. In this connection, it is advantageous to provide the perforations only in the end portions of the hoods **340**.

In this embodiment of the invention, the outlet valves are provided in the same mounting in which the inlet valve is disposed, and such mounting is located at a point immediately below the center of the face plate. Thus, the aim of keeping the outlet valves as nearly as possible within the plane of the face plate and immediately adjacent thereto is achieved. It should also be noted that two outlet valves are employed, one on each side of the valve mounting and thus one on each side of the vertical center line of the face plate. In this manner, assurance is had that movements of the wearer in turning from side to side will not adversely affect the interrelated operation of the automatic inlet valve and the outlet valves. As has been stated, it is advantageous to keep the outlet valves as near as possible to the plane of the face plate and as near as possible to the central portion thereof. For this reason, I find it advantageous to employ the flat, check valve type outlet valve structures seen in Figs 6 and 8, rather than the conventional "goat beard" valves, since the latter type of valve construction is necessarily quite long and therefore must be spaced at a greater distance from the face plate of the mask.

In order that the embodiment of Figs. 7 and 8 may be employed with a surface breathing device, or with other means allowing the direct breathing of atmospheric air, without such use resulting in the continual opening of the inlet valve **311**, there is provided a lock lever or stop member **323** mounted at the top of face plate clamping ring **306**, as by means of a pivot pin **322**. Thus, the member **323** can be selectively positioned in an inactive position, as seen in Fig. 7, or in an active position in which it is in engagement with the upper portion **317a** of valve-actuating arm **317**, as shown by dotted lines in Fig. 7. In this latter position, the member **323** is effective to prevent, under normal conditions, movement of the face plate toward the face of the wearer, so precluding operation of the inlet valve in response to the wearer's breathing. However, it is advantageous to make member **323** of a material, such as rubber or a synthetic plastic, having some flexibility. Then, under normal usage, the member **323** precludes movement of the base plate toward the face of the wearer. However, when the user inhales to an unusual extent, member **323**, being flexible, will yield or bend under the pressure applied to the face plate, allowing the face plate to move then toward the face of the user, with the result that the air inlet valve will automatically open in the manner hereinbefore described. Thus, in member **323**, I have provided means capable of "locking out" the automatic inlet valve actuating mechanism so long as the wearer breathes in a normal fashion, such means being responsive to excessive heavy breathing to bring the automatic air inlet valve actuating mechanism again into operation. Such means assures that breathable air will be supplied to the mask at the will of the wearer, even though the lock lever may have accidentally or erroneously been moved to its active position.

I claim:

1. In an open cycle breathing apparatus, the combination of a mask adapted to be fitted in fluid-tight relation to the head of the wearer and including a body defining an air space between the wearer's face and a rigid face piece at the front of the mask, one portion of said body being more flexible than its opposite portion and thus more capable of being deformed in response to a reduction of pressure in said air space when the wearer inhales and of returning to its original position when pressure in said air space increases as the wearer exhales, whereby said face plate oscillates, in response to said changes in pressure, about a horizontal axis below and substantially in vertical alignment with said face; an air inlet valve communicating with said air space and mounted on said opposite less flexible portion of said body and is so arranged as to oscillate as a unit with said face plate, upon inhalation and exhalation of the wearer; and automatic valve-actuating mechanism operatively associated with said air inlet valve and including means operable to open said air inlet valve in response to said oscillation as the wearer inhales.

2. An apparatus constructed in accordance with claim 1 and including means for adjusting said automatic valve-actuating mechanism when said mask is in place on the wearer, said means having an adjusting member located on the outside of the mask.

3. In an open cycle breathing apparatus, the combination of a mask adapted to be fitted in fluid-tight relation to the head of the wearer and including a forwardly disposed, transparent face plate, said mask having a body defining an air space between the wearer's face and said face plate, one portion of said body being more flexible than its opposite portion and so arranged that the whole of said face plate oscillates as a unit toward the wearer's face in response to reduction of pressure in said air space as the wearer inhales and away from the wearer's face when pressure in said air space increases as the wearer exhales, an air inlet valve mounted on said mask and communicating with said air space, and automatic valve-actuating mechanism operatively associated with said air inlet valve and including means operable to open said air inlet valve in response to said oscillation of said face plate toward the wearer's face.

4. An apparatus constructed in accordance with claim 3 and wherein the body defining said air space is generally annular in form and of flexible material, at least one flexible portion thereof having a generally bellows-like configuration.

5. An apparatus constructed in accordance with claim 3 and wherein said air inlet valve is mounted on the mask so as to substantially follow the oscillation of said face plate as a unit as the wearer inhales and exhales, and said valve-actuating means includes an actuating member mounted on a portion of the mask which does not move with said face plate, said actutating member being aligned with said valve to open the same upon occurrence of a predetermined amount of said oscillation of the face plate toward the wearer's face.

6. In an open cycle breathing apparatus, the combination of a mask adapted to be fitted in fluid-tight relation to the head of the wearer and including a forwardly disposed transparent face plate, which is peripherially attached to said mask, said mask having a body defining an air space between the wearer's face and said face plate, a first portion of said body being more flexible than a second portion of said body aligned across said air space from said first portion, whereby reduction of pressure within said air space as the wearer inhales causes said face plate to pivot about an axis outside the area of said face plate toward the wearer's face while such movement of the face plate is reversed upon increase of pressure in said air space as the wearer exhales, an air inlet valve mounted on said mask in communication with said air space, and so arranged as to oscillate as a unit with said face piece; and automatic valve-actuating mechanism operatively associated with said air inlet valve and including means operated to open said valve in response to such pivotal movement of said face plate toward the wearer's face.

7. In an open-cycle breathing apparatus, the combination of a mask adapted to be fitted in fluid-tight relation to the head of the wearer, said mask including a forwardly disposed transparent face plate and a generally annular body defining an air space between the face of the wearer and said face plate, a tubular member connected to said body and communicating with said air space, a portion of said generally annular body across said air space from said tubular member being more flexible than the portion of said body adjacent said tubular member, whereby the face plate at said more flexible portion pivots toward the wearer's face in response to a reduction of pressure in said air space as the wearer inhales and returns when the pressure in said air space increases as the wearer exhales; the combination of said face plate, said tubular member and the portion of said generally annular body adjacent said tubular member being so constructed and arranged that such combination pivots substantially as a unit, about an axis outside the area of said face plate, during such pressure changes within said air space; an air inlet valve mounted in said tubular member and including a movable element exposed within said tubular member, and a valve-actuating member secured at one end to a point on said mask substantially fixed against movement, said actuating member extending into said tubular member and being disposed adjacent the movable element of said air inlet valve to contact and open said valve during such pivotal movement as the wearer inhales.

8. An apparatus constructed in accordance with claim 7 and wherein said tubular member is disposed at the bottom of the mask, adjacent the wearer's chin, the fixed end of said valve-actuating member is disposed at the top of the mask so as to be supported by the wearer's forehead, said valve-actuating member extends downwardly through said air space into said tubular member, and pivot means is

provided connecting said valve-actuating member to said tubular member.

9. In a mask for an open-cycle breathing apparatus the combination of a transparent face plate, a generally annular mask body connected to said face plate and defining an air space between the face plate and the wearer, a portion of said body being more flexible than its opposite portion to allow said face plate to pivot about an axis outside the area of said face plate, toward and away from the wearer's face in response to decrease and increase of pressure within said air space as the wearer inhales and exhales; air inlet valve means mounted on said mask and arranged to pivot as a unit with the face plate, said valve means including a movable member and communicating with said air space, and actuating means fixedly mounted on said mask and restrained against movement as said face plate pivots; said actuating means including a member disposed in the path of the movable member of said valve means and arranged to open said valve means when the face plate is pivoted toward the wearer's face during inhalation.

10. In an open cycle breathing apparatus, the combination of a mask adapted to be fitted in fluid-tight relation to the head of the wearer and including a body defining an air space between the wearer's face and the front of the mask, at least a portion of said body being flexible and capable of being deformed to allow movement of the front of the mask toward the face of the wearer in response to a reduction of pressure in said air space when the wearer inhales and to allow the front of the mask to return to its original position when pressure in said air space increases as the wearer exhales, an air inlet valve mounted on said mask and communicating with said air space, automatic valve-actuating mechanism operatively associated with said air inlet valve and including means operable to open said air inlet valve in response to pivotal movement of the front of the mask as a whole toward the wearer's face as the wearer inhales; and lockout means for deactivating said automatic valve-actuating mechanism comprising a member pivotally connected to the mask at the front thereof and adjustable from an inactive position to an active position in which said member contacts a fixed portion of the mask adjacent the wearer's head to prevent said movement of the front of the mask toward the wearer's face.

11. An apparatus constructed in accordance with claim 10 and wherein said pivotally connected member of said lock-out means is capable of being deformed under a predetermined pressure caused by an exceptionally deep inhalation of the wearer, to allow movement of the front of the mask, and operation of said automatic valve-actuating means as a result of such movement, though said member occupies its active position.

12. In an open cycle breathing apparatus, the combination of a mask adapted to be fitted in fluid-tight relation to the head of the wearer and including a forwardly disposed, transparent face plate peripherally attached to said mask, defining an air space between said face plate and the wearer's face; one portion of said mask being more flexible than an opposite portion and arranged to allow pivatol movement of said face plate as a unit, about an axis outside said face plate, toward the wearer's face in response to reduction of pressure in said air space as the wearer inhales and away from the wearer's face when pressure in said air space increases as the wearer exhales; an outlet valve communicating with said air space and mounted on said face plate, an air inlet valve mounted on the mask and communicating with said air space, and automatic valve actuating mechanism operatively associated with said air inlet valve and including means operable to open said air inlet valve in response to movement of said face plate toward the wearer's face.

13. In an open-cycle breathing apparatus, the combination of a mask adapted to be fitted in fluid-tight relation to the head of the wearer and including a body defining an air space between the wearer's face and the front of the mask, at least a portion of said body being flexible and arranged to oscillate about a relatively fixed pivot outside the area of said face plate, in response to a reduction of pressure in said air space when the wearer inhales and of returning to its original position when pressure in said space increases as the wearer exhales, a rigid tubular member attached to said flexible portion of the mask at a point at the bottom of the mask adjacent the wearer's chin, said tubular member communicating with said air space; an air inlet valve mounted in said tubular member to supply air to said air space, automatic valve-actuating mechanism operatively associated with said air inlet valve and including means operable to open said air inlet valve in response to said oscillation as the wearer inhales, and an outlet valve communicating with said air space and mounted on said tubular member adjacent said air inlet valve.



14. In an open-cycle breathing apparatus, the combination of a mask including a transparent face plate and a generally annular body defining an air space between said face plate and the wearer's face, said body having a flexible tubular portion inclosing an axis about which said face plate pivots toward and away from the wearer's face in response to decrease and increase of pressure within said air space as the wearer inhales and exhales, an air inlet valve, an outlet valve; a single rigid tubular member mounting said inlet valve and outlet valve, said tubular member being attached to said flexible portion, and being arranged to pivot as a unit with said face plate, and automatic valve-actuating mechanism operatively associated with said air inlet valve and including means operable to open said air inlet valve in response to pivotal movement of said face plate toward the wearer's face during inhalation.

15. In an open-cycle breathing apparatus, the combination of a mask adapted to be fitted in fluid-tight relation to the head of the wearer, said mask including a transparent, forwardly disposed face plate and a generally annular body defining an air space between said face plate and the wearer's face, a portion of said body at the top of the mask adjacent the wearer's forehead being flexible to allow the top portion of said face plate to move toward and away from the wearer's face in response to decrease and increase of pressure in said air space as the wearer inhales and exhales, said mask having a flexible tubular extension adjacent its bottom portion, a rigid, tubular member mounted in said tubular extension in communication with said air space, said rigid tubular member being disposed in substantial alignment with the vertical centerline of said face plate at a point adjacent the periphery of said face plate, an air inlet valve and outlet valve means each mounted on said rigid tubular member in communication with said air space, said rigid tubular member being so connected with said face plate as to pivot substantially as a unit with said face plate, about an axis outside said face plate and in substantial vertical alignment therewith, as the top portion of the face plate moves toward and away from the wearer's face, and automatic valve-actuating mechanism operatively associated with said air inlet valve and including means operable to open said air inlet valve in response to pivotal motion resulting from movement of the top of the face plate toward the wearer's face during inhalation.

16. An apparatus constructed in accordance with claim 15 and wherein said outlet valve means includes two check valves each disposed on a different side of said tubular member adjacent said inlet valve.

17. An apparatus constructed in accordance with claim 16, wherein each of said outlet check valves is provided with a flexible, generally laterally extending silencing and atomizing hood, each such hood being provided with perforations at its outer end.

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