

Jan. 14, 1941.

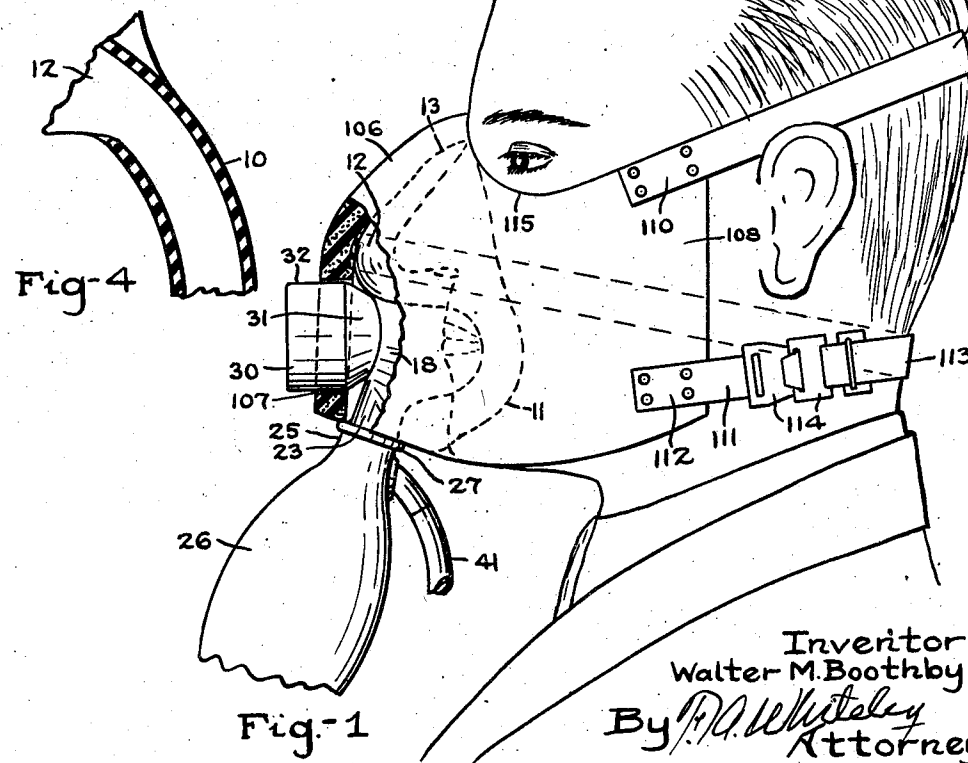
W. M. BOOTHBY

2,228,502

MEANS FOR BREATHING MIXTURES OF GASES AT LOW TEMPERATURES

Filed Dec. 14, 1939

5 Sheets-Sheet 1



Jan. 14, 1941.

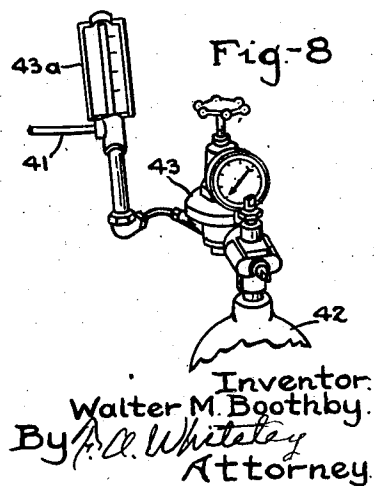
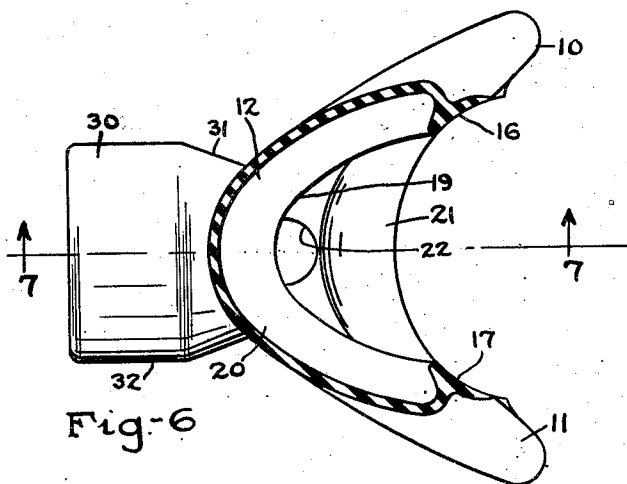
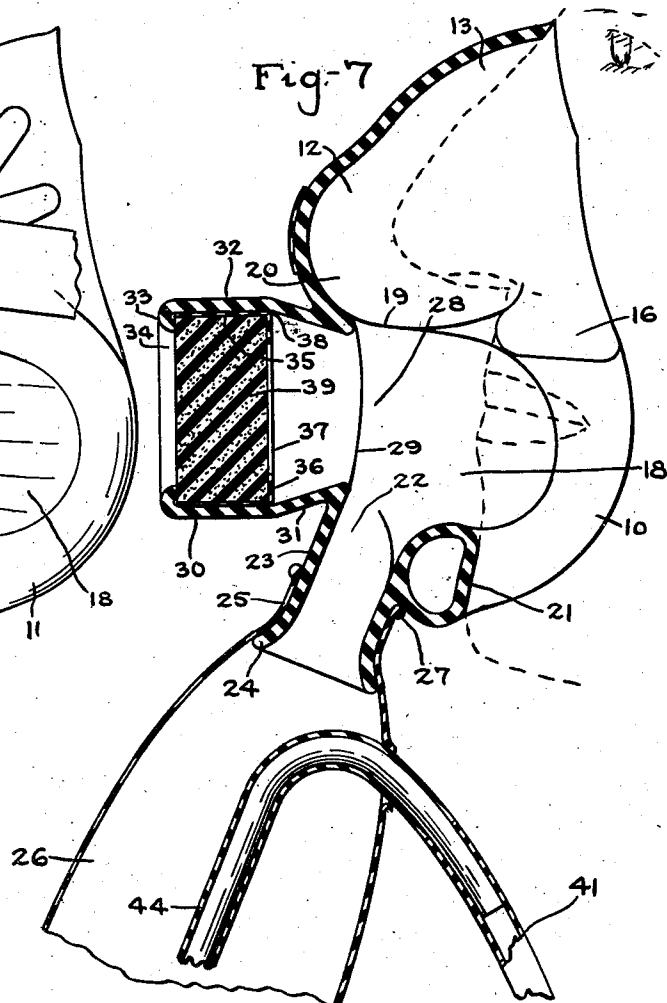
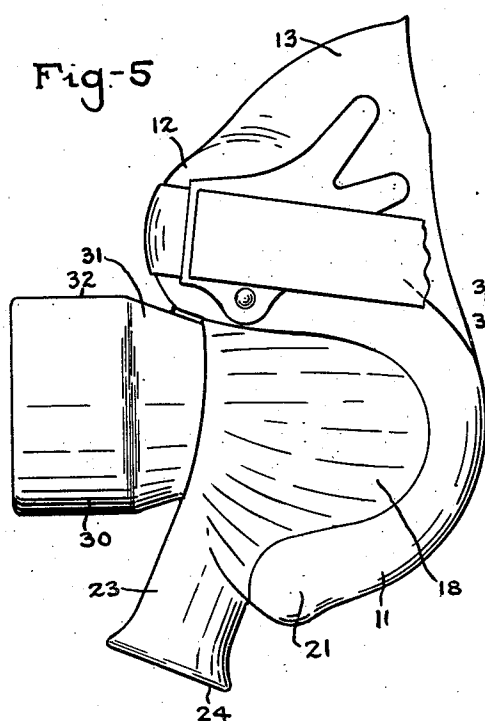
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MEANS FOR BREATHING MIXTURES OF GASES AT LOW TEMPERATURES

Filed Dec. 14, 1939

5 Sheets-Sheet 2



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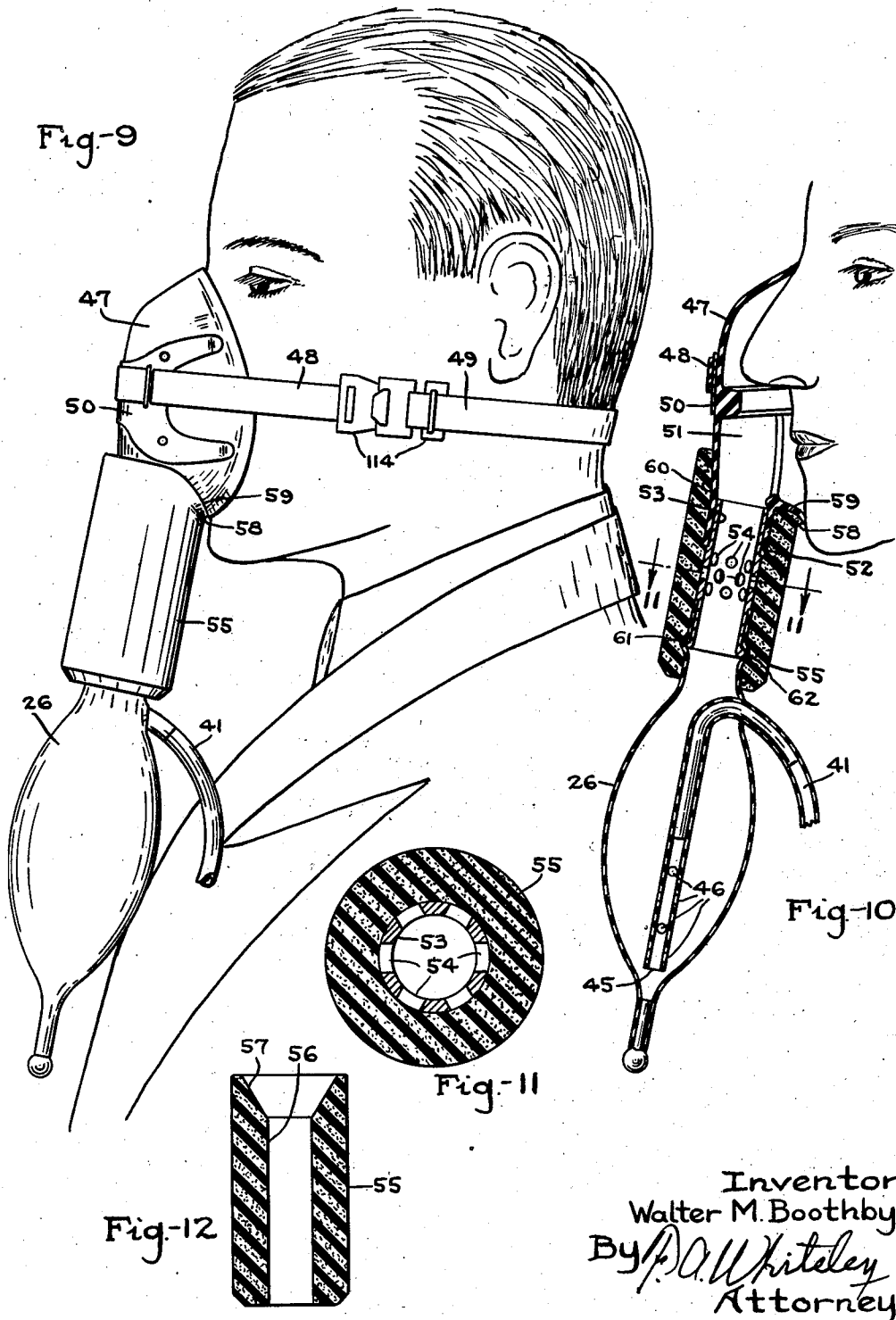
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MEANS FOR BREATHING MIXTURES OF GASES AT LOW TEMPERATURES

Filed Dec. 14, 1939

5 Sheets-Sheet 3



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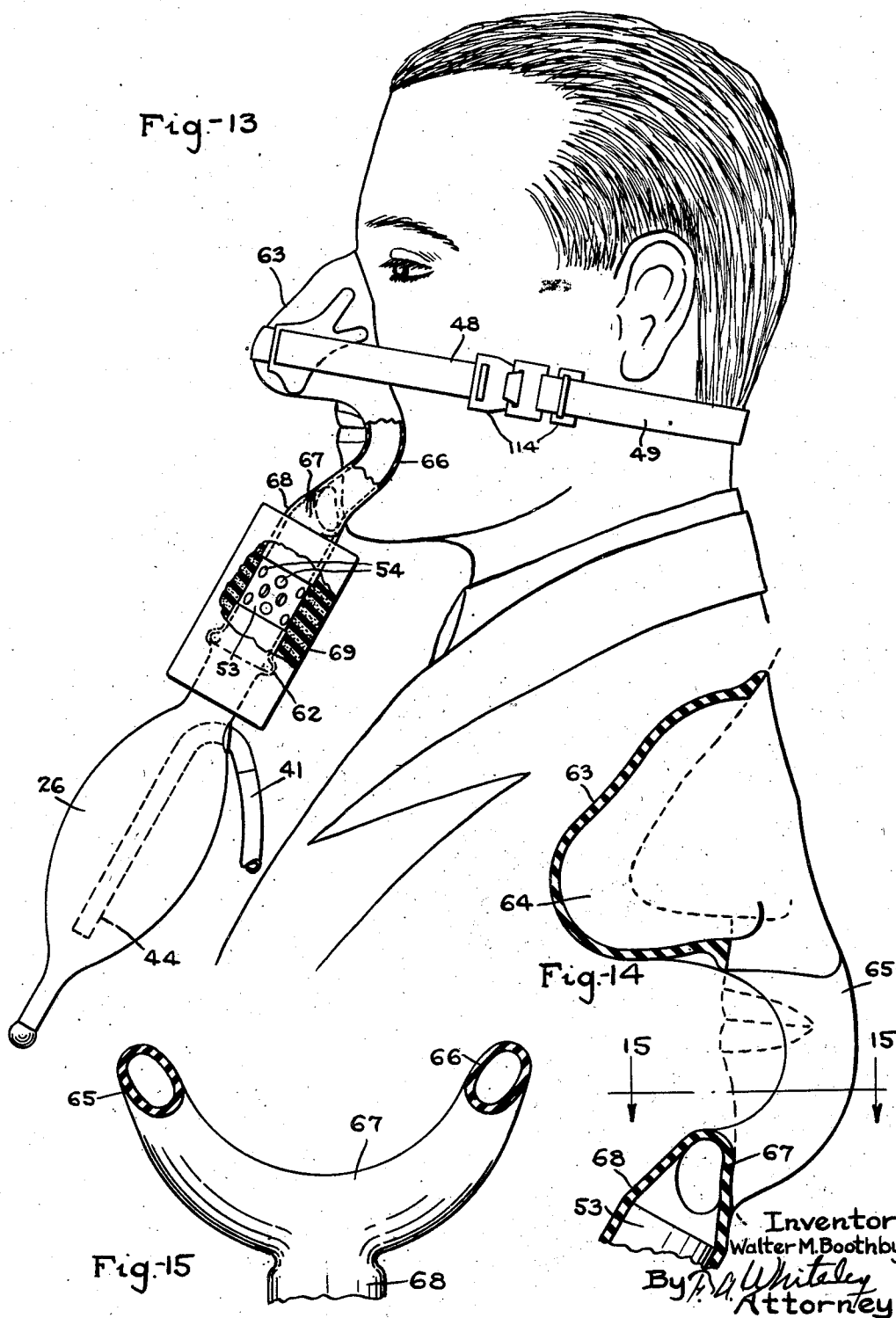
2,228,502

MEANS FOR BREATHING MIXTURES OF GASES AT LOW TEMPERATURES

Filed Dec. 14, 1939

5 Sheets-Sheet 4

Fig-13



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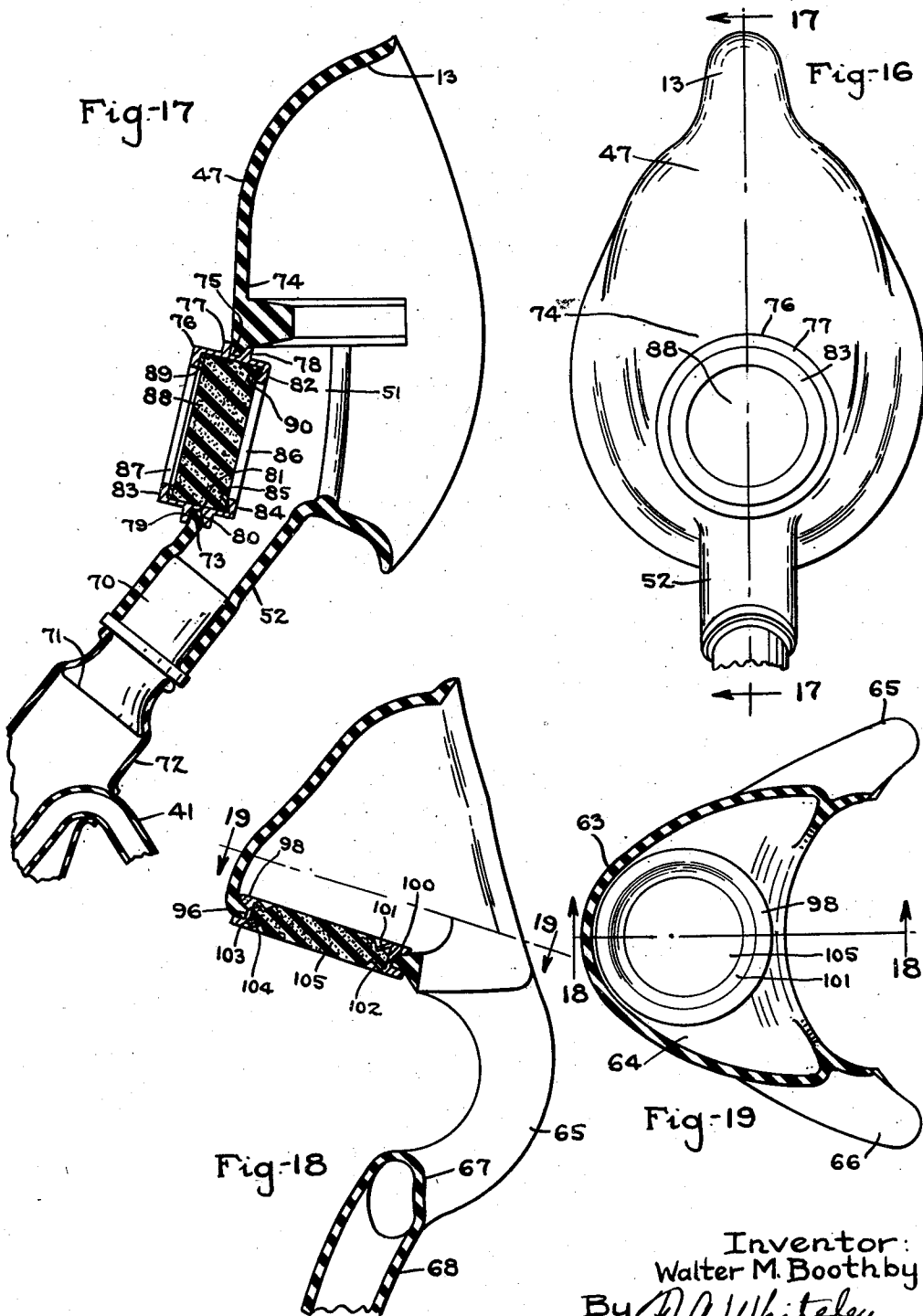
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MEANS FOR BREATHING MIXTURES OF GASES AT LOW TEMPERATURES

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,228,502

MEANS FOR BREATHING MIXTURES OF
GASES AT LOW TEMPERATURES

Walter M. Boothby, Rochester, Minn.

Application December 14, 1939, Serial No. 309,168

6 Claims. (Cl. 128—203)

My invention relates to means for breathing mixtures of gases at low temperatures and in predetermined proportions, and is adapted to be used in connection with a breathing mask and means for delivering to individuals a mixture of gases such as added oxygen mixed with air. My invention provides in effect valve mechanism of a restriction type for regulating the inlet of air on inhalation and the volume of the latter part of an exhalation which will be passed to atmosphere; and it will permit normal breathing of said mixtures under conditions of extremely low temperatures, and will prevent the freezing of moisture of exhalation which otherwise would cause the device to be put out of operation, and at the same time in any temperature effects automatic proportioning of the mixture of oxygen and air; that is by increasing the supply of oxygen to the breathing device the air drawn into it will automatically be regulated so that the proportion of oxygen in the mixture of gases actually going to the alveolar regions can be varied at will by merely varying the amount of oxygen, as shown by a flow gauge, going to the apparatus.

The invention is applicable both to the oronasal mask wherein both nose and mouth are covered, such as is shown in joint application of myself with Arthur H. Bulbulian and William R. Lovelace, Serial Number 287,087, filed July 28, 1939, or to nasal masks alone, such as shown in joint application of myself, Arthur H. Bulbulian and William R. Lovelace, Serial Number 287,086, also filed July 28, 1939.

In the structures of the above noted applications and in this application, there is a rebreathing bag the capacity of which is substantially less than the volume of a complete exhalation or an inhalation of a normal person in normal respiration. Means are there provided for delivering to this rebreathing bag a constant stream of oxygen the volume of which is controlled by well-known means including a regulator valve and a flow valve. It follows that the rebreathing bag will tend to be filling with oxygen at all times, and that the first part of an inhalation will draw into the lungs the contents of the rebreathing bag, after which external air with whatever oxygen is being delivered will be drawn into the lungs during the latter part of inhalation. And on exhalation the first part of the exhalation which is richest in oxygen and contains the least amount of carbon dioxide will flow into the rebreathing bag and the latter part of exhalation which contains a greater proportion of carbon

dioxide will go through the mask openings to atmosphere.

I have discovered that if, in place of the mechanically controlled inhalation and exhalation valves, I employ a suitably proportioned aperture or apertures for both exhalation and inhalation and arrange about or over said apertures a sufficient layer of some porous substance through which air going to or from atmosphere on exhalation or inhalation must pass, the slight resistance to breathing which is thus set up will, in conjunction with the flow of oxygen to the rebreathing bag, determine the proportion of oxygen in the mixture being breathed, so that the actual proportion of oxygen in the alveolar regions will be related in a predetermined manner to the amount of oxygen being delivered, as shown by the flow valve. At the same time the effect of the porous material through which the air passes on exhalation and inhalation, positioned as it is close to the mouth of the wearer, is to store heat, so breathing may be accomplished at low temperatures—minus 60° F. or even lower—and this stored heat will prevent freezing of condensed moisture of exhalation.

It is therefore a primary object of my invention to provide a passage to atmosphere from the mask having associated therewith a layer of porous material through which such inhalation and exhalation as may be required will be caused to pass.

I have discovered that an effective material for this purpose is a light and very fine mesh porous sponge rubber and it is an object of my invention to arrange between the breathing chamber of the mask and atmosphere a passage normally opening to atmosphere having therein or thereabout a layer of sponge rubber of sufficient thickness to retain heat sufficiently to prevent any freezing thereon and at the same time to permit free breathing on the part of the wearer, with only enough restriction to effect, in conjunction with the oxygen delivery control shown by the flow valve, proper proportioning of oxygen in the mixture.

For aviation purposes, particularly experimental or military aviation, where very high altitudes are frequently reached, it is essential that the aviator be able to send, as well as receive, radio signals. It is, therefore, an important object of my invention to arrange the aforesaid layer of porous material relative to the mouth of the aviator and the radio microphone so that the voice may be transmitted through the aforesaid porous material to the radio microphone and

effective transmission of radio signals may be effected.

It is a further object of my invention to provide means for securing the mask upon the face of the wearer for use in all forms of aviation such that at the same time it will certainly and definitely secure and maintain the same secured under all possible conditions of use, and will protect the face of the wearer from danger of freezing from excessive cold. This securing means will be particularly effective in that it will protect the points of contact between the margins of the mask and the face of the wearer, which points of contact at low temperatures are peculiarly subject to freezing.

The full objects and advantages of my invention will appear in connection with the detailed description thereof now to be given, and the novel features by which the indicated advantageous results are secured will be particularly pointed out in the claims, it being understood that the particular forms of the invention shown and described may be varied within the scope of the invention as recited in the claims.

In the drawings illustrating applications of my invention as recited in the claims:

Fig. 1 is a view of a preferred form of the invention as it appears upon the head of the wearer.

Fig. 2 is an inside view of the mask proper without the enveloping holding means.

Fig. 3 is a sectional view on line 3—3 of Fig. 2.

Fig. 4 is a fragmentary sectional view through one of the tubes at the side of the mask showing the manner of plugging the tube to prevent accumulations of moisture therein.

Fig. 5 is a side elevation view of the mask as shown in Fig. 2.

Fig. 6 is a sectional view taken on line 6—6 of Fig. 2 viewed in the direction of the arrows.

Fig. 7 is a sectional view taken on line 7—7 of Fig. 6 viewed in the direction of the arrows.

Fig. 8 is a diagrammatic showing of a source of oxygen supply and regulating valve and flow meter used in the connection thereto.

Fig. 9 is a view of a modified form of the invention as applied to the head of a wearer showing a modified form of the invention.

Fig. 10 is a view similar to Fig. 9 taken in longitudinal section through the mask and parts connected therewith.

Fig. 11 is a sectional view taken on line 11—11 of Fig. 10.

Fig. 12 is a sectional view taken through the cylinder of porous material protecting the passage to atmosphere.

Fig. 13 is a view similar to Fig. 9 with some parts in section showing the application of my invention to a nasal mask.

Fig. 14 is a central section through the mask proper.

Fig. 15 is a section on line 15—15 of Fig. 14.

Fig. 16 is a front view of a form of oronasal mask somewhat modified over that shown in Figs. 1 to 7.

Fig. 17 is a sectional view taken on line 17—17 of Fig. 16 viewed in the direction of the arrows.

Fig. 18 shows a form of device applicable to a nasal mask taken on line 18—18 of Fig. 19.

Fig. 19 is a sectional view taken on line 19—19 of Fig. 18.

Referring first to Figs. 1 to 7 inclusive, which is a particularly advantageous form of oronasal mask for aviation purposes, the mask proper comprises a pair of tubes 10 and 11 extending

into a nose-receiving extension 12 which, as shown best in Fig. 2, embodies a narrowed portion 13 adapted to receive the bridge of the nose and wing portions 16, 17 adapted to engage the cheeks of the wearer. A web 18 extends from the tubes 10, 11 across beneath the opening 19 into chamber 20 formed in the nose-receiving piece 12, the opening 19 being immediately beneath the nostrils when the device is worn, see Fig. 7. The tubes 10 and 11 unite in a transverse section 21 which is adapted to engage the chin of the wearer. Web 18, Fig. 3, is provided with an opening 22 which leads into the tubular extension 23, Figs. 5 and 7. The tubular extension will be of relatively solid and stiff rubber and is provided with an expanded rim 24 adapted to receive the neck 25 of a rebreathing bag 26. The neck 25 will preferably be additionally reinforced by a rim of rubber 27 and when said neck has been forced over the extension 24 of tube 23, it will be held in position thereon with the rebreathing bag very close to the breathing chamber 28 adjacent the mouth and nostrils of the wearer.

An opening 29 extends from chamber 28, see Figs. 4 and 7, into the turret-like extension 30 which is preferably formed with a conical portion 31 united directly with the web 18 and with a cylindrical portion 32 extending therefrom, and a turned over annular lip portion 33, leaving an opening 34 to atmosphere, as best shown in Figs. 3 and 7. Within the extension 30, as clearly shown in Figs. 3 and 7, is positioned an insulating stiffening ferrule 35 of material such as hard rubber or any heat-insulating composition, formed with an annular flange 36 which provides an opening 37 into the chamber formed by the conical portion 31 of turret 30. The ferrule 35 rests at 38 upon the outward inner limits of the conical portion 31 and the outer margins of ferrule 35 engage the intumed lip portion 33 of member 30. Within the ferrule 35 and held positioned between the flange 36 thereon and lip portion 33 is a cylindrical pad 39 of porous material, specifically of sponge rubber, which is thus held between the openings 37 from chamber 28 and the opening 34 to atmosphere.

The rebreathing bag 26 is supplied with oxygen from a delivery tube 41 going to an oxygen tank 42 from which delivery is made through a pressure reducing valve 43, and the volume of oxygen delivered is indicated by a flow meter 43a, all in a well known manner, see Figs. 8, 9 and 10. The tube 41 is normally extended within the rebreathing bag as at 44 to near the bottom thereof as at 45, Fig. 10, and may be provided with a series of apertures 46 for permitting the oxygen gas to flow into the rebreathing bag at various points along the tube extension 44. And since the rebreathing bag may be used in air of extremely low temperature, it is essential that it be composed of a type of rubber which will not freeze or stiffen at such low temperatures.

Air entering the breathing chamber on inhalation and exhalation gases going to atmosphere is thus caused to pass through this layer of sponge rubber of suitably proportioned thickness and fineness of mesh. The sponge rubber is of such a degree of fineness that air will not begin to pass through it in either direction until the flexible rubber rebreathing bag has been entirely emptied or entirely filled, which never would be true where openings go directly to atmosphere, and which makes possible the provi-

sion of maximum openings to atmosphere without the necessity of valve regulation for different elevations, which is required where openings go directly to atmosphere.

- 5 As shown in Figs. 9 and 10, an oronasal mask 47 is adapted to enclose the mouth and nose of the wearer, being held in position by adjustable strap members 48, 49, connected with the mask through a connector piece 50. This provides a
10 breathing chamber 51 enclosing the mouth and nose of the wearer, with a tubular extension 52 leading therefrom, in which is seated a cylindrical preferably non-metallic connector piece 53 to which the rebreathing bag 26 is attached.
15 The connector piece 53 is provided with a multiplicity of apertures 54, as clearly shown in Figs. 10 and 11, which may be of any desired number and shape, but preferably are circular and are distributed in a band entirely around the con-
20 nector piece 53.

Surrounding the connector piece 53 is a cylinder 55 of porous material which will permit passage of air from and to atmosphere through it upon inhalation and exhalation of the wearer.
25 I have discovered that the material best suited for this cylinder, as is true of pad 39 in the form of the invention above described, is a form of light and very fine mesh porous sponge rubber. From numerous experimental tests I have dis-
30 covered that sponge rubber will permit passage of air through it without seriously impeding or overloading the respiratory efforts, and at the same time has the property of retaining the heat brought to it by the exhalations, so that the en-
35 tire cylinder 55, or the pad 39, will become warmed to such an extent that its surface will always be at a temperature above freezing and hence frost cannot accumulate upon its surface even at such low temperatures as 60° below
40 zero F.

In the form of the invention as detailed in Fig. 7, the gases of inhalation and exhalation move directly through the pad 39 through open-
45 ings 34 and 37. In the form shown in detail in Fig. 10, the gases of inhalation and exhalation move through the openings 54 in connector piece 53 and thence in radially-expanding directions to the outside of the cylinder to atmosphere, or on inhalation in reverse manner.

50 The detailed form of the inclosing cylinder 55 is shown in Fig. 12, wherein a central cylindrical bore 56 is provided with an expanded conical part 57 which adapts the device to be seated at 58 against the lip 59 of the mask casing 47 and against the outer portion 60 of extension 52, thus firmly sealing the device in. At the same time the lower part of cylindrical bore 56 surrounds the expanded bead 61 at the bottom of the con-
55 nector piece 53, as indicated at 62, Fig. 10, and holds the cylinder 55 firmly in position thereon.

As shown in Figs. 13 to 15, a nasal mask provides a casing 63 which forms a breathing chamber 64 inclosing the nose of the wearer. Tubes 65 and 66, Fig. 15, pass from breathing chamber 64 about the mouth of the wearer, as clearly indicated in Figs. 13 and 14, to a central connecting tube 67 from which extends a tube 68 going to metallic connector piece 53 in exactly the same manner as heretofore described for the oronasal
70 mask 47. A cylinder of sponge rubber 69 surrounds the connector piece 53 and its apertures 54 in exactly the same manner as already described for the oronasal mask, except that the cylindrical member 69 does not have the conical expansion 57 from the central bore 56. Opera-

tively the constructions of Figs. 10 and 13 are identical except that the breathing chamber 51 of the oronasal mask structure includes the mouth and nose, whereas the breathing chamber 64 of the nasal mask structure includes only the
5 nose of the wearer, leaving the mouth free. However, the acts of exhalation and inhalation in breathing are carried on in the same manner, the gases in each case being constrained to pass through the envelope 69 of sponge rubber which
10 becomes heated from the heat of exhalation and prevents freezing even at excessively low temperatures.

As shown in Figs. 16 and 17 the oronasal mask 47 is shown with a modified form of connector piece 70 entering the tubular extension 52 which has an expanded portion 71 connecting directly with the neck 72 of the rebreathing bag 26. A circular opening 73 is formed through the casing of oronasal mask 74 so as to provide a circular
20 flange 75 about said opening. A circular metallic holder piece 76 is provided with spaced parallel annular flanges 77 and 78 with an intervening groove 79, Figs. 17 and 18, said groove preferably having one annular wall obliquely disposed, as
25 indicated at 80. The holder piece is thus adapted to receive the annular edge 81 surrounding the circular opening 73 into breathing chamber 51. The circular holder piece 76 is provided with inwardly turned annular flanges 82 and 83, a special flange 84 corresponding in position to flange
30 82 having an inwardly beveled face 85, Fig. 17. There is thus formed through the holder piece 76 a pair of circular openings 86 and 87. Within the annular channel of the holder piece 76
35 formed by flanges 83 and 84 of Fig. 17, is positioned a circular disc 88 of porous material, in practice, sponge rubber. In the form of Fig. 17, this disc of rubber may be slightly compressed by means of a washer 89 back of it which holds its
40 edges extended into the space behind the beveled faces 85, as indicated at 90 in Fig. 17.

As shown in Figs. 19 and 20, a circular opening 96 in the front wall of the nasal mask breathing chamber 64, comes substantially below the nostrils of the wearer. Obviously the circular edge
45 100 of the opening 96 may be caused to engage within the annular groove formed between flange members 77, 78 on the cylindrical holding member 76, thus permitting this form of holding
50 member and any form of sponge rubber pad carried thereby to be employed in connection with the nasal mask. As shown in Fig. 18, a special holder piece 98 is provided with annular flanges 101 and 102. These flanges are adapted to re-
55 ceive between them the edge of a button 105 of sponge rubber. The edges are then crimped in, as shown in Fig. 18, compacting the sponge rubber between them in the resulting annular V-shaped groove 103 so that there appears to be
60 an annular extension 104 of similar shape formed about the button or pad 105 of sponge rubber seated in the groove, as clearly shown in Fig. 18. This holds the pad 105 in position so that gases of exhalation and inhalation going from and
65 to the breathing chamber 64, other than those which go to and from the rebreathing bag 26, will be required to pass through the sponge rubber pad 105. This pad will preferably be of compacted sponge rubber considerably denser than
70 the pad 38, illustrated in Fig. 17, so that the smaller cross sectional diameter of the pad 105 will have something the same effect in accumulating heat from the breathing exhalations as is true of the pad 38, and also will affect the breath-
75

ing on inhalation and exhalation in about the same way.

It will be noted that in the forms of the device shown in Figs 1 to 7, and in Figs. 17 and 18, the pad of sponge rubber and the opening to it through the surrounding casing for holding the pad in position are directly in front of the mouth of the wearer. Also the circumferential area of opening through these holders, either the holder 30 of Fig. 3 or the button device 76 of Figs. 17 and 18, are proportioned to the size of a radio microphone. I have discovered that with a sponge rubber member so positioned, the speech of the operator will be freely transmitted through the sponge rubber to the radio microphone, thus enabling the aviator to wear the oronasal mask completely inclosing his mouth, and yet be able to freely use the microphone for radio transmission in the same manner as he would be able to do if his mouth were exposed, as for example, in the use of the nasal mask structure shown in Fig. 13. This is a highly important feature of my invention, as in very high flying, and particularly in military aviation, it would be impractical to use the nasal mask with the mouth exposed, for the reason that conditions might arise where the aviator would forget to breathe through the nose and breathe through the mouth, with the result that insufficient oxygen might cause distress or possible loss of consciousness.

Since the masks herein described are designed for aviation at high altitudes and in very low temperatures and also for military aviation, I have discovered that it is of importance to secure the mask, whichever form is employed, and its attached parts, to the face of the wearer in such manner that all possibility of displacement no matter what the contingencies of movement or shock might be, will be eliminated. It is also in a high degree desirable to protect the face of the wearer, particularly at the points where the margins of the mask engage the face, so as to prevent freezing of the face at low temperatures.

I have discovered that both of these valuable, even essential, features can be obtained by the means shown in Fig. 1, as applied to the form of oronasal mask disclosed in Figs. 1 to 7 inclusive. This means comprises a strip 106 of sponge rubber having at its front an opening 107 through which the turret extension 30 is adapted to protrude and which aids in holding the strip 106 in position. The strip is provided with portions 108 which overlie the cheeks of the wearer, as clearly shown in Fig. 1. An upper head-encircling strap 109 is secured at 110 to the outside of the cheek-overlying portions 108 and will be preferably of elastic material and of such size that it can be pulled down over the head to a position just over the ears where it will retain its position by natural elasticity and tend to pull the mask tightly against the face of the wearer. A second strap 111 will be secured at 112 to one cheek-overlying portion 108 toward the bottom thereof and a cooperating strap 113 will be adjustably united by fastener members 114 in the same manner as indicated in Figs. 9 and 13.

From the above it will be observed that the member 106 not only will hold the mask attached to the face of the wearer in such manner that no expected degree of movement or shock can displace it, but at the same time will cause all of the margins of the mask which contact the face of the wearer, notably those margins which

at 115 of Fig. 1 contact the upper part of the nose of the wearer, to be covered and protected, so freezing at these margins is prevented; when otherwise, because of the pressure at such points reducing circulation and the tendency for the hard rubber of the mask, if exposed, to become very cold in the low temperatures and withdraw heat from the parts its contacts, this would be very likely to happen.

The advantages of my invention will be apparent from the foregoing description, both in its use clinically and in its use at low temperatures in aviation. In respect to the first of these uses, the greatest difficulty has been experienced heretofore in the administration of gases mixed with air, either oxygen or other gases, in regulating the introduction of air relatively to the amount of added oxygen (or other gases) so that the proportions of oxygen and air in the alveolar regions of the lungs will be those desired. There has been further difficulty in obtaining anything like accurate indications of the true proportions of oxygen in the gas mixture in the alveolar regions. Adjustable mechanical air admission valves have not proved effective for that purpose, resulting in uncertainty as to the alveolar air mixture and to waste of oxygen or other gases added to the air.

It is therefore, of the highest advantage in the use of my invention that causing movement of gases to and from atmosphere to go through a layer of sponge rubber provides means for automatically adjusting the proportions of air introduced to the proportion of oxygen added, so that inspection of the flow gauge showing the volume of oxygen being delivered will correctly inform the operator of the proportion of oxygen, after admixture of air breathed with the oxygen, in the gas mixture in the alveolar passages. That is, where the flow meter indicates a proportion of 20% oxygen in the alveolar gas mixture, that percentage will be there. And when the volume of oxygen is increased so that the flow meter indicates a proportion of say 40% oxygen in the alveolar gas mixture, that percentage will be there. This is a discovery of the highest importance in the clinical use of gases added to air, specifically of oxygen added to air, and hence, is one of the highly important advantages of my invention.

My invention also has highly important advantages in its other use, for use with added oxygen at high altitudes and in low temperatures. As is well known the gases of exhalation, owing to their intimate contact with the moist surfaces within the lungs, are heavily charged with water vapor and may be substantially saturated, and this is at or near the temperature of the body. When such gases pass on exhalation into air at low temperature, the water vapor will necessarily be condensed out of exhaled air and tends to freeze immediately and to accumulate as frost or ice on surfaces adjacent the point of exhalation, which surfaces have a temperature at or below the freezing point. In inhalation devices for providing breathing of a mixture of gases such as oxygen and air, where necessarily orifices to atmosphere must be of limited area, it follows that accumulations of frost and ice might very quickly render the device wholly inoperative.

In all of the forms heretofore described, there is provided in conjunction with the opening from the apparatus to atmosphere, a sufficiently thick layer of porous material, specifically sponge rubber, through which the gases of exhalation and

inhalation must pass to and from atmosphere. Because the porous material is by its nature a heat insulator, and for that reason because it tends to accumulate heat and build up a maintained temperature within its body which carries to its surface exposed to atmosphere, the condensation of moisture at the surface of the sponge rubber protector never can reach the freezing point even when atmospheric air is being drawn through it. In other words, the protector layer of sponge rubber is a heat storing device as well as an insulator, and at all times when in normal operation, even at temperatures of 50° to 60° F. below zero, or lower temperatures, it will maintain a sufficient supply of heat to prevent the formation of frost or ice at its surface, thus always maintaining the necessary communication with atmosphere for such part of exhalation which must go to atmosphere and of inhalation which must come from atmosphere.

This is a great advantage over prior devices which have valve mechanism that has to be mechanically regulated as higher temperatures are reached. Not only does the formation of ice tend to close the apertures to atmosphere, but it will also render the valve mechanism inoperative by freezing it so it cannot be moved to adjust for air inlet and outlet at higher altitudes. With the sponge rubber pad or layer over the openings to atmosphere, not only does no freezing take place, but no adjustment of openings for varying altitudes is required.

Further advantages of my invention reside in the arrangement of this sponge rubber protector, or heat accumulator, in such manner related in position to the mouth of the wearer, and having the sponge rubber pad and the opening to atmosphere which it closes of such size and shape, that when wearing the oronasal mask with the nose and mouth completely inclosed the device none the less enables the aviator to transmit speech to the radio microphone without difficulty.

A further great advantage, when the mask is used at very low temperatures, is the provision of means for protecting the face of the wearer and particularly the face at points of contact with the oronasal mask structures, so as to insure against freezing the face, particularly at such points, said means also operating to securely hold the mask structure to the face of the wearer in such manner as to insure against displacement therefrom.

I claim:

1. In combination with a rebreathing bag and means for delivering oxygen thereto including a regulating valve and a flow meter, said rebreathing bag having a maximum volume less than the volume of a normal inhalation and exhalation whereby part of every inhalation and exhalation must go to atmosphere, an inhalation device comprising a casing forming a breathing chamber connected with said rebreathing bag, means forming an opening from the breathing chamber to atmosphere, and a layer of porous material such as sponge rubber between said opening through which air must pass to atmosphere on inhalation and exhalation.

2. An inhalation device for breathing mixtures

of gases, comprising a casing forming a breathing chamber, a rebreathing bag connected therewith of less than the volume of a normal inhalation or exhalation, whereby part of every inhalation and exhalation must go to atmosphere, means forming an opening close to the mouth of the wearer and leading from the breathing chamber to atmosphere, and a layer of porous material such as sponge rubber over said opening through which air must pass on inhalation and exhalation.

3. In an inhalation device, a mask and connected rebreathing bag having a maximum volume less than the volume of a normal inhalation and exhalation, means for delivering oxygen to the rebreathing bag, a flow meter, means forming an opening through the mask to atmosphere of predetermined suitable size, a layer of porous material such as sponge rubber over said opening through which air must pass to atmosphere on inhalation and exhalation, and means to control the volume of flow of oxygen to the rebreathing bag as shown by the flow meter, the cooperation of said oxygen delivery and passage to atmosphere through the sponge rubber operating to automatically regulate the proportion of oxygen in the alveolar passageways.

4. A mask for breathing mixtures of gases comprising a casing having its open side formed with a transversely and longitudinally curved top portion and an open side, the margins of said open side embodying tubular portions adapted to engage the cheeks and sub-labial portion of the chin of the wearer, said tubes being open to the breathing chamber formed by the casing, said casing formed to provide a nose-receiving chamber and a mouth chamber, a turret extending outwardly from the top portion of the casing and opening therethrough into the mouth chamber, and a removable pad of sponge rubber within the turret through which air of inhalation and exhalation must pass.

5. An inhalation device for breathing mixtures of gases, comprising a casing forming a breathing chamber, a rebreathing bag having a volume less than the volume of an exhalation or inhalation in normal breathing, connected therewith, an opening to atmosphere passing directly from said breathing chamber adjacent a breathing passage of the wearer, and a pad or button of sponge rubber within said opening through which air from inhalation and exhalation must pass.

6. A mask for breathing mixtures of gases, comprising a casing adapted to form a breathing chamber over the mouth and nose of the wearer, said breathing chamber formed with an opening therefrom to atmosphere, a layer of sponge rubber over said opening through which air must pass on inhalation and exhalation, and means for holding said mask on the face of the wearer and protecting the face at its points of contact with the margins of the mask, including a sheet of sponge rubber overlying the mask and the face at the face-connecting margins of the mask, with an opening in said sheet formed in conjunction with the opening in the mask to atmosphere.

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