May 13, 1958 J. W. KECKLER ET AL 2,834,343

COMBINATION MASK AND SUIT REGULATORS

Filed March 30, 1955 5 Sheets-Sheet 1

Fig. 2

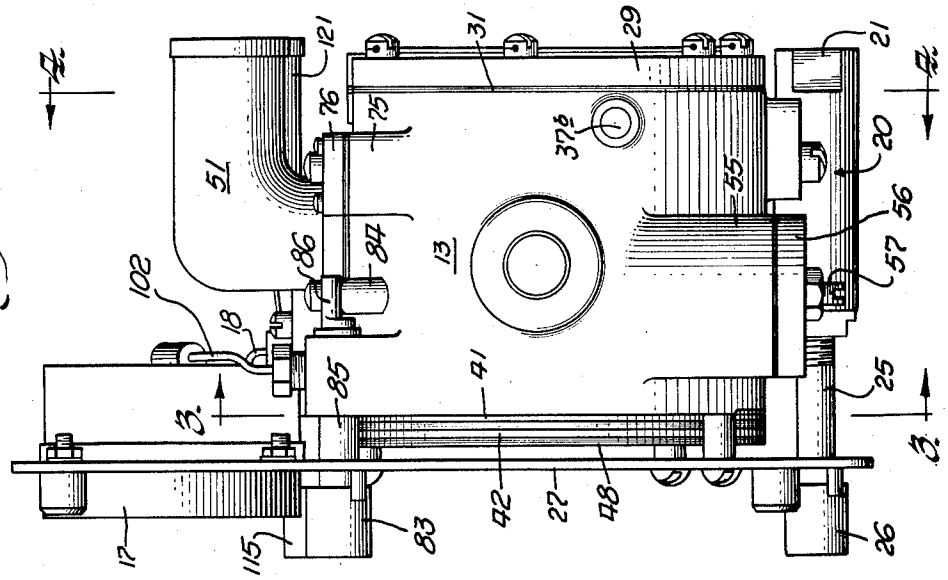
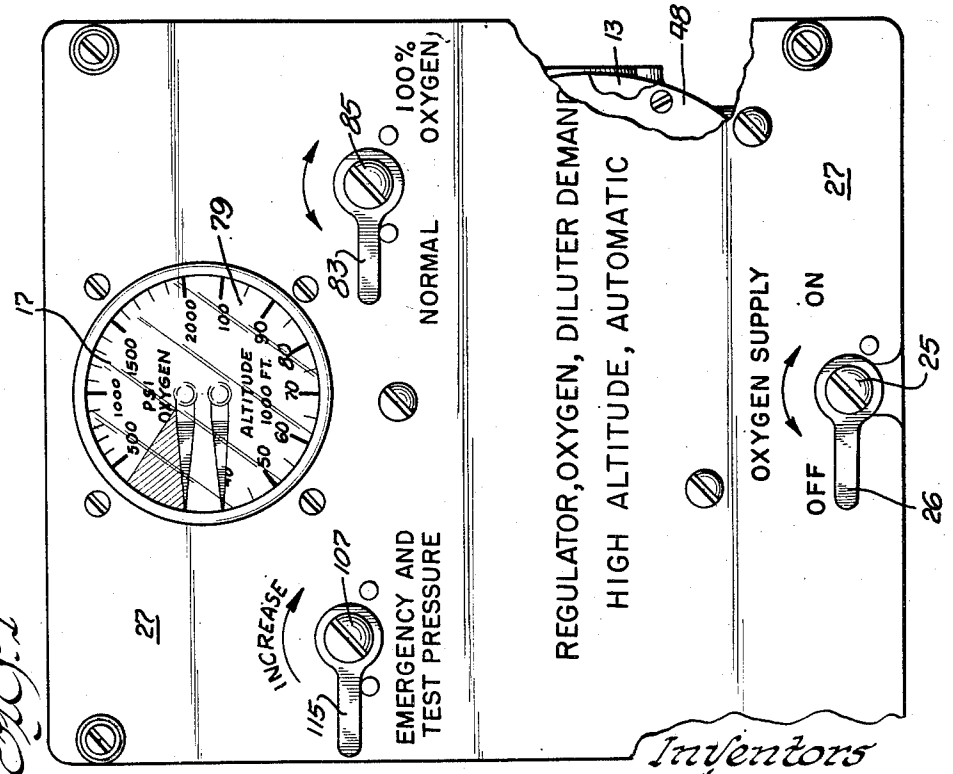


Fig. 1



Inventors
John W. Keckler
Walter O. Wilkening
By Bair, Freeman & Molinare
Attys.

May 13, 1958 J. W. KECKLER ET AL 2,834,343

COMBINATION MASK AND SUIT REGULATORS

Filed March 30, 1955 5 Sheets-Sheet 2

Fig. 4

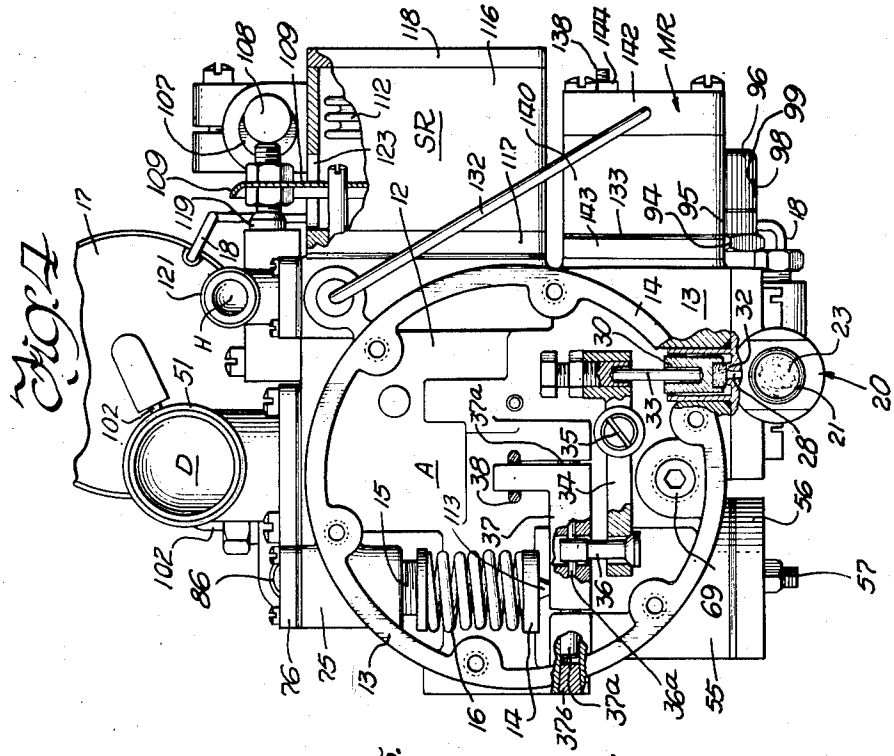
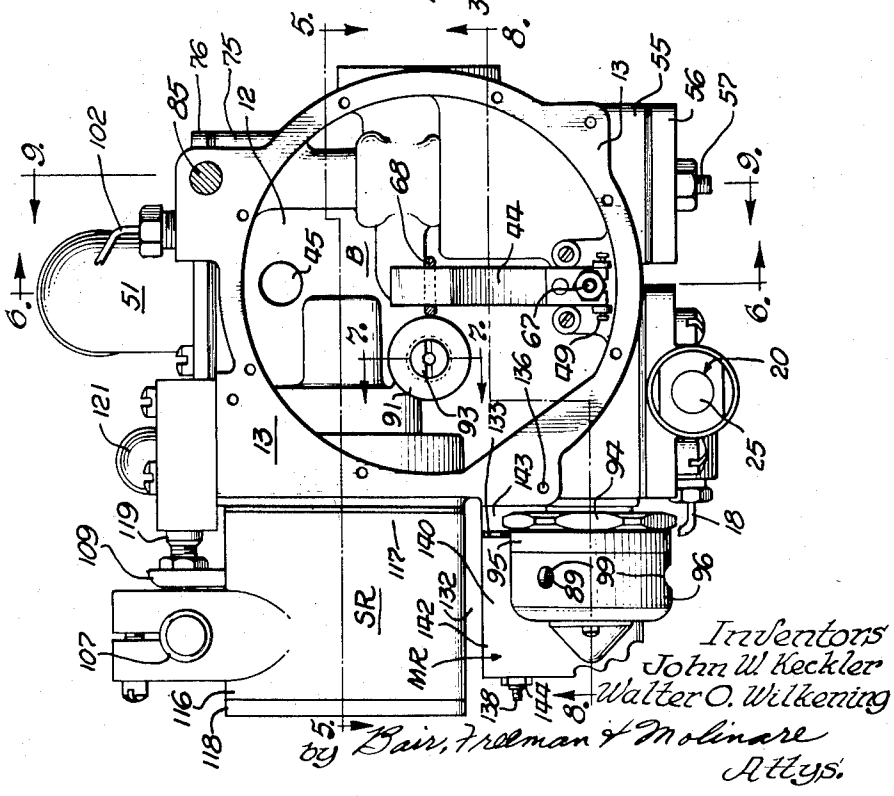


Fig. 3



Inventors
John W. Keckler
Walter O. Wilkening
by Bair, Freeman & Molinare
Attys.

May 13, 1958 J. W. KECKLER ET AL 2,834,343

COMBINATION MASK AND SUIT REGULATORS

Filed March 30, 1955 5 Sheets-Sheet 3

Fig. 5

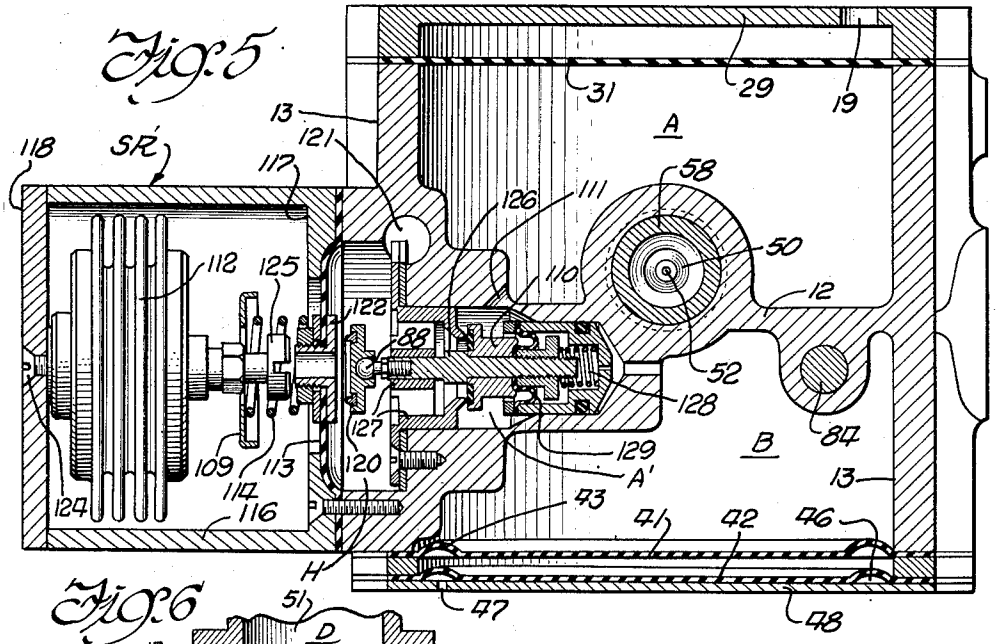


Fig. 6

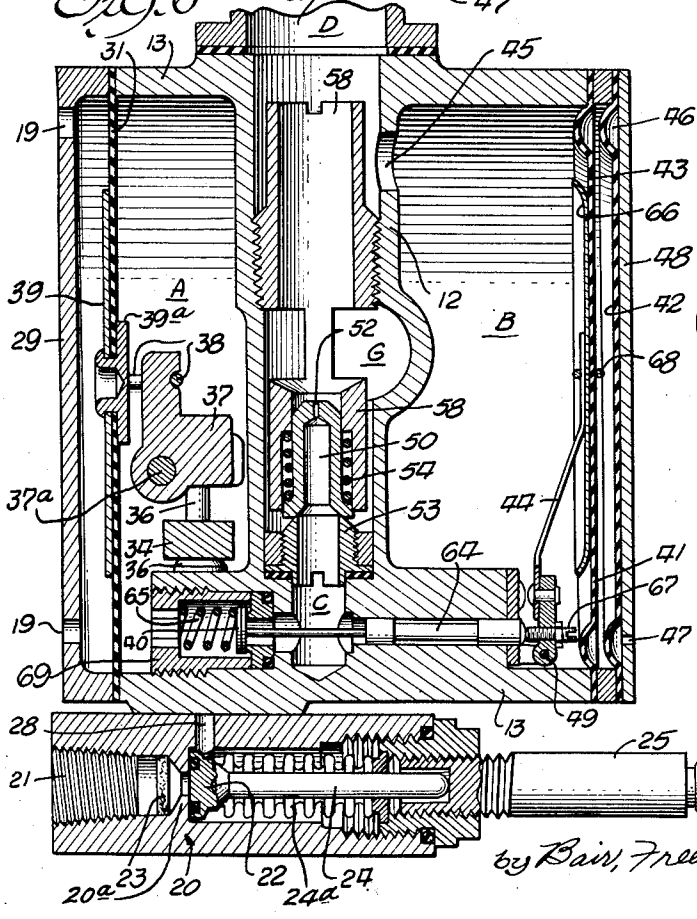
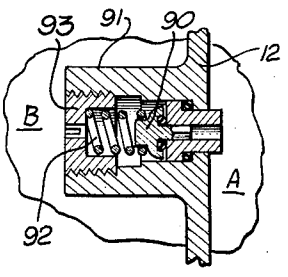


Fig. 7



Inventors
John W. Keckler
Walter O. Wilkening
by Bair, Freeman & Molinare
Attys.

May 13, 1958 J. W. KECKLER ET AL 2,834,343

COMBINATION MASK AND SUIT REGULATORS

Filed March 30, 1955 5 Sheets-Sheet 4

Fig. 8

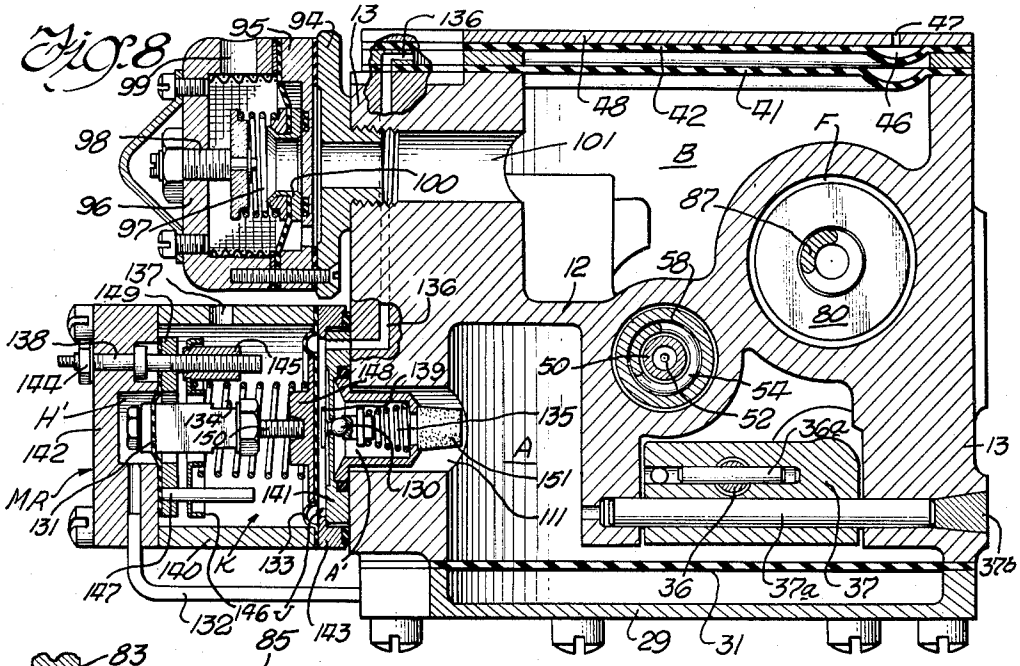
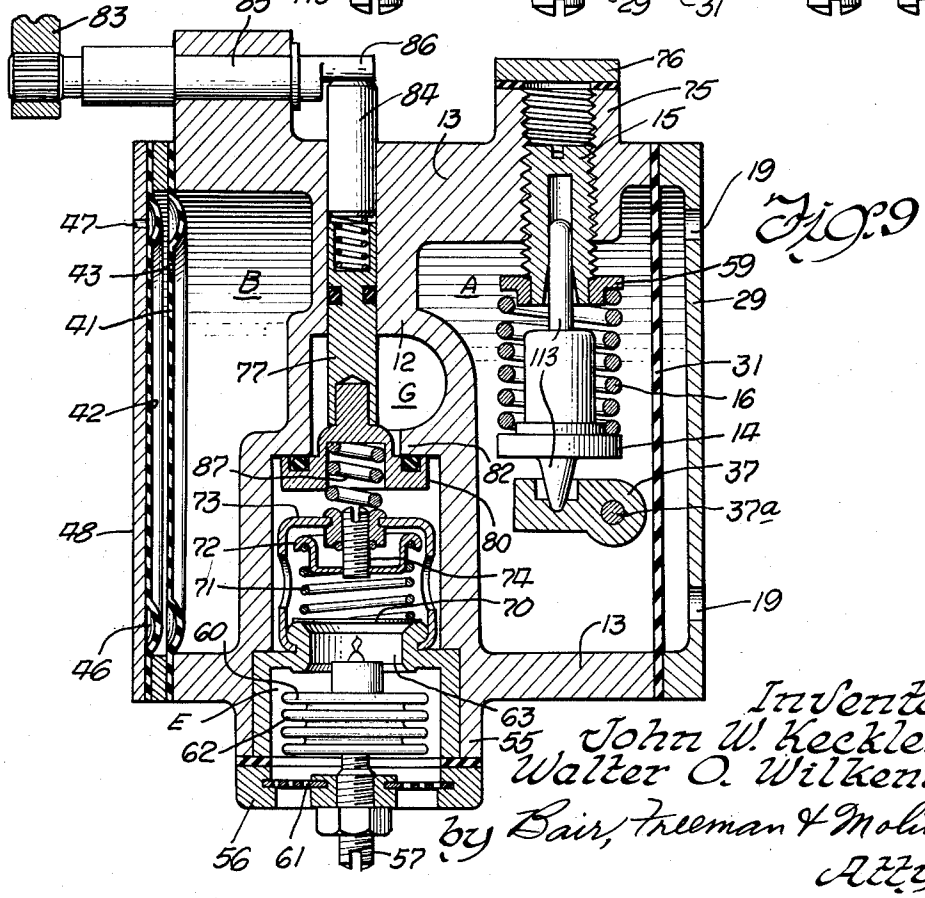


Fig. 9



Inventors
John W. Keckler
Walter O. Wilkening
by Bair, Freeman & Molinare
Attys.

May 13, 1958 J. W. KECKLER ET AL 2,834,343

COMBINATION MASK AND SUIT REGULATORS

Filed March 30, 1955 5 Sheets-Sheet 5

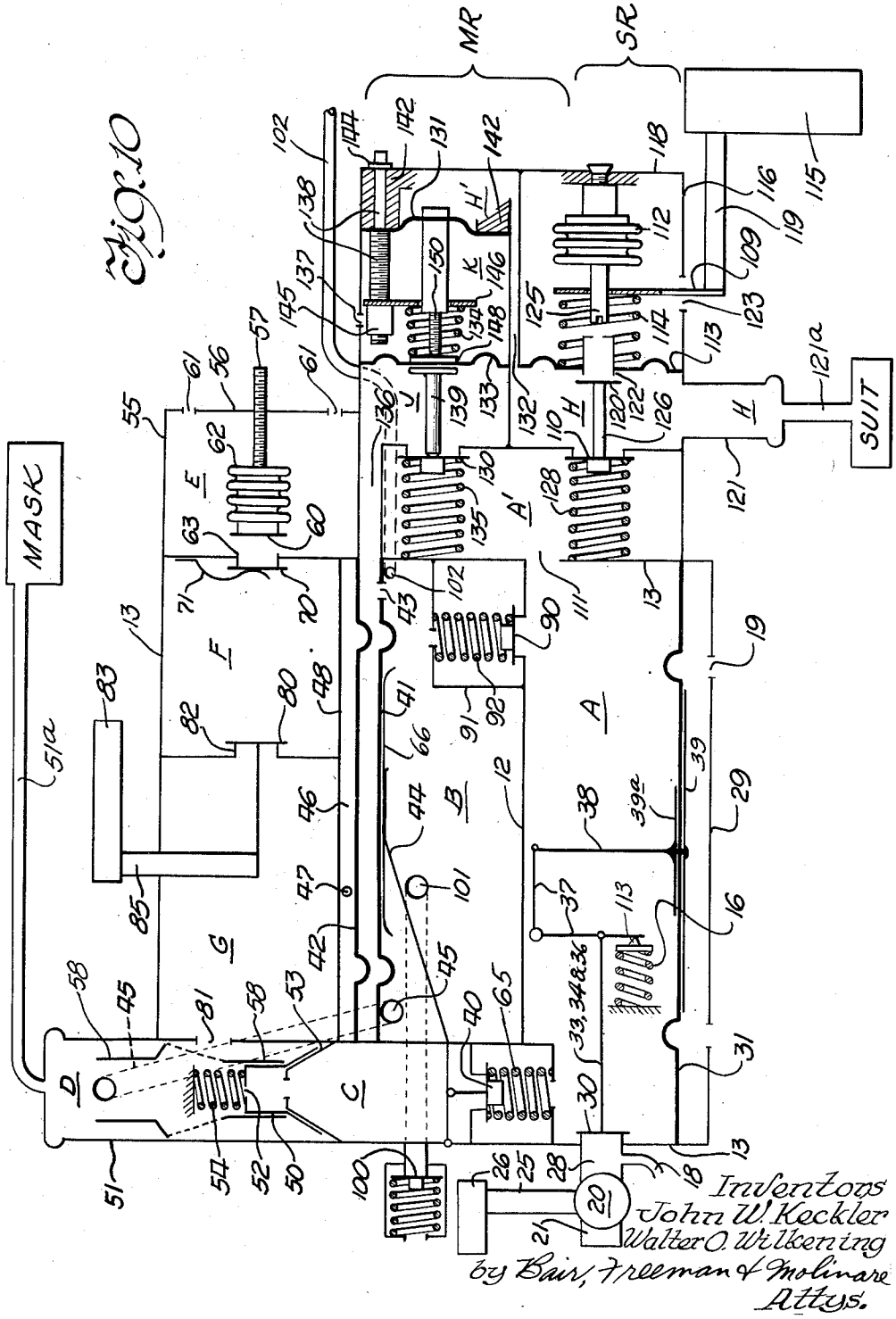


Fig. 10

United States Patent Office 2,834,343
Patented May 13, 1958

2,834,343

COMBINATION MASK AND SUIT REGULATORS

John W. Keckler and Walter O. Wilkening, Bryan, Ohio, assignors to The Aro Corporation, Bryan, Ohio, a corporation of Ohio

Application March 30, 1955, Serial No. 498,025

12 Claims. (Cl. 128—142)

Our present invention relates to combination mask and suit regulators for aviators to automatically pressurize, at unlimited altitudes, the suits and breathing masks they wear for protection when flying at high altitudes.

One object of our invention is to provide mask and suit regulators of comparatively simple, durable, and inexpensive construction which may be attached to, or may be built into, a diluter demand oxygen regulator so as to utilize certain pressures already present therein for pressurizing the suit and for providing pressure breathing for the mask section of the oxygen regulator.

Another object is to provide an automatic suit regulator that normally opens the suit to atmosphere at a suit exhaust valve thereof, but at a predetermined altitude closes it to atmosphere, thus providing a "ready pressure" in the suit, with further increases in altitude resulting in opening a suit valve to supply fluid under pressure such as oxygen from the first stage of the oxygen regulator to the suit for pressurizing it, thus providing a physiologically required pressure on the aviator's body.

Still another object is to provide the suit regulator in the form of a regulator that is responsive to the pressure in the suit as well as to altitude for proportioning the pressure in the suit in relation to altitude, thus keeping the required pressure substantially at the same absolute value at any altitude.

A further object is to provide a mask regulator having an automatic pressure breather demand valve for pressurizing the demand diaphragm of the oxygen regulator in response to increases in altitude, thereby providing oxygen under pressure at higher altitudes as required by the aviator to permit respiratory functions to continue at normal.

Still a further object is to provide the mask regulator responsive to altitude and utlizing pressure from the suit regulator as motive power to open a pressure breather demand valve of the mask regulator that pressurizes the demand diaphragm of the oxygen regulator.

An additional object is to provide the mask regulator with a pair of diaphragms, the space on one side of one of them being responsive to the suit pressure and the space between them being vented to atmosphere so that altitude variances will not change the effect of the pressure from the suit regulator on the valve of the mask regulator which thereby pressurizes the demand diaphragm in proportion to altitude.

Another additional object is to relate the diameters of the two diaphragms so that a pressure that is normally too high from the suit regulator to actuate the mask regulator valve can still be utilized by being modified by the effective areas of the two diaphragms.

With these and other objects in view our invention consists of the construction, arrangement and combination of the various parts of our mask and suit regulator, whereby the objects contemplated are attained as hereinafter more fully set forth, pointed out in our claims and illustrated in the accompanying drawings wherein:

Fig. 1 is a front elevation of our combination mask and suit regulator.

Fig. 2 is a side elevation thereof, showing the oxygen regulator in side elevation back of the panel.

Fig. 3 is a vertical sectional view on the line 3—3 of Fig. 2 showing in elevation, an assembly of oxygen regulator, suit regulator and mask regulator, the demand diaphragm being removed.

Fig. 4 is a similar vertical sectional view on the line 4—4 of Fig. 2, showing the first stage diaphragm removed, some portions being broken away and others shown in section to illustrate details of construction.

Fig. 5 is an enlarged horizontal sectional view on the line 5—5 of Fig. 3

Fig. 6 is an enlarged vertical sectional view on the line 6—6 of Fig. 3.

Fig. 7 is an enlarged vertical sectional view on the line 7—7 of Fig. 3.

Fig. 8 is an enlarged horizontal sectional view on the line 8—8 of Fig. 3.

Fig. 9 is an enlarged vertical sectional view on the line 9—9 of Fig. 3; and

Fig. 10 is a diagrammatic view showing all elements of the oxygen, mask, and suit regulators in their operating relation to each other.

Referring first to Fig. 10, our combination mask and suit regulators are shown diagrammatically in connection with a diluter demand regulator. All three regulators are assemblies of manual and automatic valves, together with associated parts. First the valves will be referred to generally at **20**, **30**, **40**, . . . **130**, then the associated parts as shown in Fig. 10 will be referred to, and finally details of construction as shown in Figs. 1 to 9 will be described.

The diluter demand regulator has a body **13** in which are a plurality of chambers designated A, B, C, D, E, F, and G. The chambers A and B are separated by a partition **12**. Our combination mask and suit regulators have a pair of chambers A′, J, H and K. The valves of the diluter demand regulator are as follows: an oxygen supply valve **20**, a pressure reducing valve **30**, a demand valve **40**, a Venturi valve **50**, a diluter altitude valve **60**, a diluter check valve **70**, a diluter control valve **80**, and two relief valves **90** and **100**. The valves of our combination mask and suit regulators are as follows: a suit valve **110**, a suit exhaust valve **120**, and a pressure breather demand valve **130**.

The valve **20** is manually opened or closed, depending upon whether oxygen is to be introduced to the chamber A or not, as desired by the user. The pressure reducer valve **30** is automatically operated under the control of a diaphragm **31**, subject on its exterior surface to atmospheric pressure, and on its interior surface to the pressure in the chamber A. The valve **30** regulates the flow of oxygen from the valve **20** into the chamber A to about 35 p. s. i. This is usually termed the "first stage pressure."

One wall of the chamber B is defined by a demand diaphragm **41**. Outside of this diaphragm **41** is a seal diaphragm **42**, sealing the space between the two diaphragms **41** and **42** from atmosphere in a chamber **46** except for a port **47** to atmosphere. The port **47** is in a cover plate **48** for the diaphragms **41** and **42**. A demand lever **44** is adapted to open the demand valve **40** when the pressure in the chamber B decreases in response to inhalations by the aviator in a mask outlet **51** thereby depressing the diaphragms **41** and **42**. The outlet **51** is usually connected by a flexible hose **51***a* to the face mask or helmet used in conjunction with the oxygen regulator and labeled "Mask" in Fig. 10. A port **45** connects the mask outlet **51** and its chamber D with the chamber B.

Interposed between the chambers C and D is the Venturi valve **50**, normally seated on a Venturi valve seat **53**, and provided with a small opening **52**.

The chamber E is vented to atmosphere at ports **61** and the chamber G is connected by a port **81** to the exterior of a Venturi sleeve or mixing tube **58**. The diluter altitude valve **60** is carried by an aneroid **62**, and is adapted to approach and seat on a valve seat **63**, as altitude increases. The diluter check valve **70** is normally closed by a light spring **71**, and is seated on the opposite end of the seat **63**.

The diluter control valve **80** may be manually seated and unseated relative to a seat **82** by a control handle **83**.

The relief valve **90** is interposed between chambers A and B, while the relief valve **100** has its discharge open to atmosphere and is connected by a port **101** to the chamber B.

Our suit regulator SR has a chamber A′ communicating with the chamber A of the diluter demand regulator by a port **111**. The suit valve **110** when open permits flow of oxygen under pressure from the chamber A′ into the chamber H of the suit regulator and from thence through the suit outlet **121** to the suit of the aviator for pressurizing it. The suit valve **110** is adapted to be controlled by an aneroid **112**, subject to atmosphere through a port **123**. Normally the aneroid **112** does not pressurize the suit, but an adjusting stem **125** thereof remains spaced from an exhaust valve seat **122** supported by a diaphragm **113** which is responsive on its right hand side to atmosphere through a port **123**, and on its left hand side to the pressure in the chamber H. A spring **114** is normally under no tension against the outer side of the diaphragm **113**, but tension can be applied and increased under the control of the operator by means of a control handle **115**, as will hereinafter appear.

Upon increasing altitude the aneroid **112** will expand and finally engage the stem **125** with the exhaust valve seat **122** to move it against the suit exhaust valve **120**, after which further movement effects opening of the suit valve **110** through a connecting stem **126**.

The mask regulator MR has a chamber H′ connected by a passageway **132** to the suit regulator chamber H. One side of the chamber H′ is defined by a diaphragm **131**. In the mask regulator there is a second chamber J, one side of which is defined by a diaphragm **133** of somewhat larger effective area than the diaphragm **131**. The chamber J is connected by a port **136** to the space between the diaphragms **41** and **42**. Suit pressure in the chamber H′ actuates the mask regulator MR.

A third chamber K in the mask regulator MR between the diaphragms **131** and **133** is open to atmosphere at a port **137**. A spring **134** contacts the diaphragm **133** and the load may be adjusted by an adjusting screw **138**. A thrust pin **139** is adapted to transmit motion of the diaphragm **133** to the pressure breather demand valve **130**.

Referring to Fig. 6, details of the valve **20** are shown. The oxygen inlet is shown at **21**. A valve plug **22** may be seated on a seat **20***a* formed by the valve body **20** through the action of a stem extension **25** on a stem **24** of the valve plug **22**. The stem **24** is sealed relative to the body **20** by a bellows **24***a*. The stem extension **25** is threaded as illustrated so as to either seat the valve plug **22** or permit it to be unseated by the incoming oxygen, depending on the position of a control handle **26** connected to the stem extension **25**. This handle is shown in Figs. 1 and 2, and may be moved either to the "off" or "on" positions shown on a panel **27**.

An oxygen pressure gauge **17** on the panel **27** communicates by means of a connecting tube **18** with the outlet side of the oxygen supply valve **20** to at all times indicate whether the valve is "on" or "off," and when "on" to indicate the pressure of the oxygen in the supply tank. In the housing with the oxygen pressure gauge **17** is a second pressure gauge **79** connected by a capillary tube **102** with the chamber B to indicate the pressure in terms of altitude.

A passageway **28** leads from the outlet side of the valve plug **22** to a valve seat **32** (see Figs. 4 and 6). The pressure reducing valve **30** is shown in Fig. 4, as a plug which is operatively connected by a pin **33** to a lever **34** pivoted at **35**. The lever **34** in turn is operatively connected by a link **36** and pivot pin **36***a* to a bell crank **37**, pivoted at **37***a*. A link **38** connects the bell crank to diaphragm plates **39** and **39***a* of the diaphragm **31**. The diaphragm is covered by a cover plate **29**, open to atmosphere at ports **19**.

The valve **30** is normally seated by a spring **16**, the tension of which may be adjusted by means of an adjusting screw **15** bearing against a spring thrust disc **59**. The spring seats against a flange **14** of a stem **113** (see Fig. 9). The screw **15** is threaded in a boss **75** of the housing **13** and sealed in by a cover plate **76**.

The parts above referred to as shown in Fig. 4 are in the chamber A, and are normally covered by the first stage diaphragm **31**, which in this figure has been removed. In Fig. 10 the parts **33**, **34**, and **36** are shown diagrammatically as a single element.

Referring to Figs. 3 and 6, the demand lever **44** is illustrated as pivoted at **49** and loosely connected by a U-shaped clip **68** to a diaphragm engaging plate **66** that engages against the demand diaphragm **41**. The lever carries a set screw **67** engaging the right hand end of a stem **64** in Fig. 6, the left hand end of which engages the valve disc **40** normally held seated by a spring **65** in a sleeve **69**. Upon reduction of pressure in the chamber B diaphragm **41** is drawn inwardly (toward the left) to open the demand valve **40** against the action of the spring **65** in proportion to the demand. In Fig. 3 the demand diaphragm **41** is removed to show details behind it.

Referring to Fig. 6 the Venturi valve **50** is shown as an injector nozzle. It is normally retained seated on a seat **53** by a spring **54**. The chamber C communicates with the interior of the injector nozzle **50** and the chamber G with the interior of the Venturi sleeve **58** which sleeve serves as a guide for the valve and injector nozzle **50** and as a seat for the spring **54**.

Referring to Fig. 9, a boss **55** extends downwardly from the regulator body **13** and the aneroid **62** of the diluter altitude valve **60** is contained therein. A cover plate **56** is provided for the boss **55** and carries a perforated plate **61** for communicating the aneroid to atmosphere. An adjusting screw **57** is carried by the cover **56** for adjusting the position of the aneroid so that it can close the valve **60** against the seat **63** at a desired altitude. The boss **55** provides the chamber E, illustrated diagrammatically in Fig. 10.

Further refering to Fig. 9, the diluter check valve **70** (a disc) is seated by the spring **71** on the top of the valve seat **63**, and the upper end of the spring is seated in a spring seat **72**. The seat **72** is carried by an adjusting screw **74** and the parts just referred to are enclosed in a perforated cage **73**, outside of which is the chamber F.

Referring to Figs. 1, 2, and 9, the diluter control valve **80** is normally seated by a spring **87** on a seat shoulder **82** formed in the partition **12**. A stem **77** extends upwardly from the valve **80** after passing through the chamber G, and a second stem **84** is adapted to engage its upper end, a spring **78** being interposed between the two to force the second stem upwardly. The control handle **83** is mounted on a rock shaft **85** having an eccentric cam **86** adapted to engage the upper end of the stem **84** and depress it and the stem **77** in one position of the handle. The position just referred to is the closed position shown in Figs. 9 and 10 and is the "100% Oxygen"

position. Normally, the valve **80** is open and the lever **85** is at the position indicated "Normal" as shown in Fig. 1, at which time air can enter through **61** and **70** to dilute the oxygen flowing into the chamber G.

The relief valve **90** as shown in Fig. 7 is mounted in the partition **12**, a boss **91** being provided therefor, and a spring **92** being provided to normally retain the valve seated. An adjusting plug **93** is threaded in the boss **91** for adjusting the setting of the relief valve which usually is in the neighborhood of 40 p. s. i. to relieve excess pressure from the chamber A to the chamber B in case of leakage of the pressure reducing valve **30**. Thus the oxygen is not wasted but can be used from the chamber B, unless it is more than needed, in which case it is relieved to atmosphere at the relief valve **100**.

Details of the relief valve **100** are shown in Fig. 8. It consists of a fitting **94** screwed into the port **101** that communicates with the chamber B, a seat plate **95** and a housing **96**, all three being bolted together as shown. A spring **97** normally seats the valve **100** and the seating pressure can be adjusted by an adjusting screw **98**. The housing **96** is vented to atmosphere at **99**. The maximum pressure in the chamber B is about 3 p. s. i., and the relief valve **100** is set to relieve pressure at about 3.3 p. s. i.

Describing now our combined mask and suit regulators, as applied to the diluter demand oxygen regulator thus far described, we will first describe the suit regulator, which is essentially the unit indicated by the bracket SR in Fig. 10, and extending to the right hand wall of the regulator housing **13** having the port **111** therein. For constructional details reference is made to Figs. 3, 4, and 5, and particularly Fig. 5. In these figures also the suit regulator is referred to generally by the reference character SR.

The suit regulator SR is contained in a housing **116**, Fig. 5 having a base plate **117** and a cover plate **118**. The base plate in turn is secured to and suitably gasketed relative to the regulator housing **13**. The aneroid **112** is contained in the housing **116**, which is open to atmosphere at **123** (see Figs. 4 and 10).

The connection between the handle **115** in Fig. 10 and the spring **114** is shown in Figs. 3, 4, and 5, as comprising a slide pin **119**, a sheet metal bracket **109** extending upwardly therefrom (toward the viewer of Fig. 5) and an eccentric cam **108** (Fig. 4) on a rock shaft **107** to which the handle **115** (Fig. 1) is secured. The aneroid **112** is supported on the cover plate **118** by a screw **124** and carries the adjustable stem **125**. The suit exhaust valve **120** is carried by a ball head **88** of the stem **126**. The stem is slidable in a combined seat and spider fitting **127**. The suit valve **110** is carried by the stem **126** and is sealed relative thereto and relative to the housing **13** by a diaphragm **129**. It is normally seated by a spring **128**. It will be noted that the effective diameters of the seats **120** and **127** are the same, which, together with the overall design of the suit regulator provides the valve **110** of balanced character so that it has maximum sensitivity to all pressure changes.

The mask regulator MR (see Figs. 3, 4 and 8) is contained in a housing **140**, bolted between a seat plate **141** and a cover plate **142**. The seat plate is surrounded by a ring **143** interposed between the regulator housing **13** and the edge of the diaphragm **133**, which in turn is interposed between the housing **140** and the ring **143**.

An adjusting screw **138** is rotatable in the cover plate **142**, and may be locked in position by a lock nut **144**. A sleeve **145** is threaded on the adjusting screw and carries a laterally extending sheet metal plate **146** that serves as a backing for the spring **134**. A pin **147** guides the plate **146** and prevents its turning with the adjusting screw **138**. The spring **134** is interposed between the plate **146** and a backing plate **148** for the diaphragm **133**. The diaphragm **131** is retained in position by a retainer plate **149** and an actuating stem **150** extends from it toward the backing plate **148**.

The pressure breather demand valve **130** is in the form of a ball as shown in Fig. 8, normally seated against a seat of the seat plate **141** by a spring **135** and a headed thrust pin **139** is located between it and the diaphragm **133**. The element **151** is a filter between the chambers A and A'. The port **111** from the chamber A to the chamber A' is illustrated in Fig. 5 as a hole drilled through the partition **12**.

Practical operation

Referring to Fig. 10, and first describing the operation of the diluter demand regulator, oxygen supplied to the inlet **21** at anywhere between 50 and 2000 p. s. i. may be admitted to the regulator by turning the oxygen supply lever **26** to the "on" position. Thereafter approximately 35 p. s. i. will be maintained automatically in the chamber A under control of the regulating diaphragm **31**.

Upon a demand for oxygen in the chamber D caused by inhalation of the aviator, the reduced pressure in this chamber will be transmitted through the demand port **45** to the chamber B and act on the demand diaphragm **41** therein. This diaphragm will be depressed against the closing action of the spring **65** on the demand valve **40**, thus permitting a flow of oxygen through the valve **40** and into the chamber C, then through the Venturi valve or nozzle **50** and the hole **52** therein. If the required flow is in excess of the capacity of the hole **52** plus the tension of the spring **54**, the nozzle **50** will be lifted from the seat **53** to permit additional flow.

At the same time, providing the diluter control valve **80** is open, atmospheric air will be drawn in through the ports **61** and the chambers E, F, and G, flowing through the port **81** and the Venturi sleeve **58** to the mask outlet **51**. Thus the oxygen is diluted with atmospheric air passing through the check valve **70**, which closes as soon as there is insufficient suction in the chamber F to overcome the tension of the spring **71**. Thus reverse flow of oxygen to atmosphere through the ports **61** is prevented.

When the control handle **83** is in the "100% Oxygen" position (see Fig. 1) the valve **80** is closed and no atmospheric air is mixed with the oxygen. When the altitude is great enough that the aneroid **62** is expanded until the diluter altitude valve **60** closes against the plate **63**, 100% oxygen is then being inhaled. The aneroid **62** being adjustable may be set at the desired closing altitude—usually about 34,000 feet. Between about 10,000 and 34,000 feet then the air will be progressively choked off as the valve **60** approaches the seat **63** so as to vary the ratio of air-to-oxygen in this range with 100% oxygen being effective only after closure of **60** against **63** at 34,000 feet.

Referring next to the suit regulator SR, its purpose is to pressure the flying suit of the aviator at unlimited altitudes. On increasing altitude the aneroid **112** expands until the stem **125** engages the exhaust valve seat **122** whereupon the aneroid moves the diaphragm-suspended seat until the seat engages the exhaust valve **120**. Thereupon there is created a "ready pressure" in the chamber H by reason of this chamber being closed to atmosphere, the suit and the chamber H then being a closed system.

Thereafter further expansion of the aneroid **112** opens the suit valve **110** against the action of the spring **128** with further increases in altitude, the aneroid exerting sufficient force to open the balanced suit valve in response to demand and this pressurizes the suit through the suit outlet **121** at a predetermined rate dependent upon the altitude affecting the aneroid **112** in opposition to the suit pressure in the chamber H on the reverse side of the diaphragm **113**.

Reversely as altitude decreases the suit regulator first reduces the pressure in the suit by closing the valve **110** and then opening the exhaust valve **120** to permit escape

of the suit pressure through the housing **116** at the port **123**. Upon reduction in altitude the pressure in the suit is again regulated in proportion thereto by reason of the balance of pressures in the chamber H and in the aneroid **112**. By suspending the seat **122** on the diaphragm **113** and connecting the valves **110** and **120** together by the stem **126**, we are always assured that both valves will never be open simultaneously and that upon movement in either direction by the stem **125** one will close before the other opens and vice versa with no possibility of an ntermediate position where the suit pressure could vary several pounds per square inch between the closing of one valve and the opening of the other. The suit pressure is thus always closely regulated in proportion to altitude changes.

In an emergency, or in order to test the action of pressurizing the suit, the handle **115** can be swung from the position shown in Fig. 1 to increase the tension of the spring **114** up to a point of maximum with the handle **115** rotated 180 degrees clockwise (indicated "Increase"), at which position the spring **114** is sufficiently compressed to have closed the exhaust valve **120** and opened the suit valve **110** to permit the aviator to determine that the pressure enters the suit properly. After test the handle **115** can be returned to the initial position for subsequent automatic operation in proportion to altitude, as already described. Since the setting of the aneroid **112** is adjustable at the adjusting screw **125** the altitude at which the exhaust valve closes and the suit valve **110** commences to open can be set. This is usually between 35,000 and 40,000 feet.

With respect to the operation of the mask regulator MR, the pressure breather demand valve **130** is supplied with oxygen under about 35 p. s. i. from the chamber A'. As the altitude increases and the suit regulator SR is activated, the pressure in chamber H^1 acts on the diaphragm **131** thereby transmitting a force to diaphragm **133** through the actuating stem **150** and in turn to the thrust pin **139** which opens valve **130**. Chamber K is vented to atmosphere through port **137**. The relative areas of diaphragms **133** and **131** are at a predetermined ratio such as 5 to 1 so that the regulated pressure in chamber J is one-fifth that in chamber H^1. In this way the mask regulator comes into action as a "pressure breather" only after the suit has been pressurized, atmospheric pressure acting on the diaphragm **133**. Since the pressure in H and H' would be too much if applied directly on the diaphragm **133**, the area of the diaphragm **131** is made less as above pointed out. Additional adjustment is had through the tension of the spring **134** by adjustment as desired of the adjusting screw **138**.

After the slack is taken up between the diaphragm **133** and the head of the thrust pin **139** the valve **130** is opened upon further increases in altitude as described above. This permits flow of the 35 p. s. i. of oxygen from chamber J through the passageway **136** to the space between the demand diaphragm **41** and the seal diaphragm **42**. Pressurizing this space adds a load to the demand diaphragm **41**, and therefore breathing is under pressure and additional oxygen is thereby delivered as a result of breathing under this pressure, as compared with ambient pressure from sea level up to 30,000 or 40,000 feet at which the aneroid **112** is set.

When altitude again reduces and the valve **130** closes, the pressure in the chamber J and in the space between the diaphragms **41** and **42** is gradually relieved through a leak port **43** of the demand diaphragm **41** into the chamber B where it can be utilized for inhalation.

From the foregoing specification it will be obvious that our combination mask and suit regulators pressurize both the flying suit and the breathing mask or helmet at unlimited altitudes. By utilizing the pressure that goes to the suit for pressurizing the diaphragm **131** of the mask regulator, the energy of the compressed oxygen is utilized to open the valve **130** proportionally under regulation of the diaphragm **133** as it responds to the pressure in chamber J. Figs. 1 to 9 illustrate one form of practical apparatus that can be used to secure the relationship of parts illustrated diagrammatically in Fig. 10 and which will operate in the intended manner for regulating the mask and suit pressures.

Various changes may be made in the structural details and certain relationships of the parts of our combination mask and suit regulator may be varied as well as the interarrangement of parts without departing from the real spirit and purpose of our invention. It is our intention therefore to cover by our claims any modified forms of structure or use of mechanical equivalents which may be reasonably included within their scope.

We claim as our invention:

1. In combination mask and suit regulators for a diluter demand oxygen regulator having a first-stage chamber and a demand diaphragm, a suit regulator comprising a housing having a suit regulator chamber communicating with a suit for pressurizing the suit, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for closing said exhaust valve seat against said exhaust valve disc upon increase in altitude to a predetermined degree and thereupon moving both discs for immediately opening said suit valve upon further increase above said degree, said diaphragm forming one wall of said suit regulator chamber and thereby responsive on one side thereof to the pressure therein and in the suit, and responsive on the other side thereof to atmosphere, spring means for acting on said diaphragm to bias said exhaust valve seat toward said exhaust valve disc, manually operable means to apply and increase the force of said spring means to close said exhaust valve and open said suit valve, a mask regulator comprising a housing having a first chamber communicating with said demand diaphragm to pressurize the same, a pressure breather valve seat between said first-stage chamber and said first chamber, said demand diaphragm having a leak opening therein from said first chamber to the demand diaphragm chamber, a first diaphragm responsive on one side to pressure from said first chamber, said diaphragm being responsive on the other side thereof to atmospheric pressure, a pressure breather valve disc normally seated on said pressure breather valve disc seat and operatively connected with said first diaphragm to be spaced thereby from said pressure breather valve seat upon response of said first diaphragm to predetermined differential of pressures between that in said first chamber and to atmospheric pressure, a second diaphragm responsive on one side to atmospheric pressure and on its other side to pressure from said suit regulator chamber, said second diaphragm opposing said first diaphragm to unseat said pressure breather valve disc from said pressure breather valve seat and to regulate the action thereof on said pressure breather valve disc proportional to altitude, and adjustable spring means acting on said first and second diaphragms and tending to open said pressure breather valve.

2. In combination mask and suit regulators for a diluter demand oxygen regulator having a first-stage chamber and a demand diaphragm, a suit regulator comprising a housing having a suit regulator chamber communicating with a suit for pressurizing the suit, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for closing said exhaust valve seat against said exhaust valve disc upon increase in altitude to a predetermined degree and thereupon moving both discs for immediately opening said

suit valve upon further increase above said degree, said diaphragm forming one wall of said suit regulator chamber and thereby responsive on one side thereof to the pressure therein and in the suit, and responsive on the other side thereof to atmosphere, a mask regulator comprising a housing having a first chamber communicating with said demand diaphragm to pressurize the same, a pressure breather valve seat between said first-stage chamber and said first chamber, said demand diaphragm having a leak opening therein from said first chamber to the demand diaphragm chamber, a first diaphragm responsive on one side to pressure from said first chamber, said diaphragm being responsive on the other side thereof to atmospheric pressure, and a second diaphragm responsive on one side to atmospheric pressure and on its other side to pressure from said suit regulator chamber, said second diaphragm opposing said first diaphragm to open said pressure breather valve and to regulate the action thereof proportional to altitude.

3. In mask and suit regulators of the character disclosed for a diluter demand oxygen regulator having a first-stage chamber and a demand diaphragm, a suit regulator comprising a housing having a suit regulator chamber for communication with a suit for pressurizing it, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for closing said exhaust valve seat against said exhaust valve disc upon increase in altitude to a predetermined degree and thereupon moving both discs for opening said suit valve upon increase above said degree, normally inoperable spring means operable to bias said exhaust valve closed and said suit valve open, manually controlled means to render said spring means operable, a mask regulator comprising a housing having a first chamber communicating with said demand diaphragm to pressurize the same, a pressure breather valve seat between said first-stage chamber and said first chamber, said demand diaphragm having a leak opening therein from said first chamber to the demand diaphragm chamber, means responsive on one side to pressure from said suit regulator chamber, said means being responsive on the other side thereof to atmospheric pressure, a pressure breather valve disc normally seated on said pressure breather valve disc seat and operatively connected with said first means to be spaced thereby from said pressure breather valve seat upon response of said first means to predetermined differential of pressures between that in said first chamber and atmospheric pressure, a second means responsive on one side to atmospheric pressure and on its other side to pressure from said suit regulator chamber, said first and second means unseating said pressure breather valve disc from said pressure breather valve seat and regulating the action thereof proportional to altitude, and adjustable spring means acting on said first and second means and tending to unseat said pressure breather valve disc from its seat.

4. In mask and suit regulators of the character disclosed for a diluter demand oxygen regulator having a first-stage chamber and a demand diaphragm, a suit regulator comprising a housing having a suit regulator chamber for communication with a suit for pressurizing it, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for closing said exhaust valve seat against said exhaust valve disc upon increase in altitude to a predetermined degree and thereupon moving both discs for opening said suit valve upon increase above said degree, a mask regulator comprising a housing having a first chamber communicating with said demand diaphragm to pressurize the same, a pressure breather valve seat between said first-stage chamber and said first chamber, said demand diaphragm having a leak opening therein from said first chamber to the demand diaphragm chamber, means responsive on one side to pressure from said suit regulator chamber, said means being responsive on the other side thereof to atmospheric pressure, and a second means responsive on one side to atmospheric pressure and on its other side to pressure from said suit regulator chamber, said first and second means unseating said pressure breather valve disc from said pressure breather valve seat and regulating the action thereof on said pressure breather valve disc proportional to altitude.

5. Combination mask and suit regulators for an oxygen regulator having a first-stage chamber and a demand diaphragm comprising a suit regulator having a housing provided with a suit regulator chamber therein communicating with a suit for pressurizing the same, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for seating said exhaust valve seat on said exhaust valve disc upon increase in altitude to a predetermined degree and for opening said suit valve disc relative to said suit valve seat upon further increase of altitude, said valves being responsive to the pressure in the suit in opposition to atmospheric pressure to regulate the pressure to the suit in proportion to altitude, spring means to act on said valves to bias the exhaust valve seated and the suit valve unseated, manually operable means to apply and increase the force of said spring means, a mask regulator comprising a housing having a first chamber communicating with the demand diaphragm to pressurize the same, a pressure breather valve seat between said first-stage chamber and said first chamber of said mask regulator, said demand diaphragm having a leak opening therein, a pressure breather valve disc, said mask regulator having a diaphragm responsive on one side to pressure from said suit regulator chamber for unseating said pressure breather valve disc relative to said pressure breather valve seat, said last diaphragm being responsive on the other side thereof to atmospheric pressure, and pressure-responsive means responding to the pressure in said first chamber of said mask regulator and differentially to atmosphere for regulating the action of said first diaphragm on said pressure breather valve disc proportional to altitude.

6. Combination mask and suit regulators for an oxygen regulator having a first-stage chamber and a demand diaphragm comprising a suit regulator having a housing provided with a suit regulator chamber therein communicating with a suit for pressurizing the same, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for closing said exhaust valve seat against said exhaust valve disc upon increase in altitude to a predetermined degree and for unseating said suit valve disc from said suit valve seat upon further increase of altitude, said valves being responsive to the pressure in the suit in opposition to atmospheric pressure to regulate the pressure to the suit in proportion to altitude, a mask regulator comprising a housing having a first chamber communicating with the demand diaphragm to pressurize the same, a pressure breather valve seat between said first-stage chamber and said first chamber of said mask regulator, said demand diaphragm having a leak opening therein, said mask regulator having a diaphragm responsive on one side to pressure from said suit regulator chamber, a pressure breather valve disc actu-

ated thereby, said last diaphragm being responsive on the other side thereof to atmospheric pressure, and pressure-responsive means responding to the pressure in said first chamber of said mask regulator and differentially to atmosphere for regulating the action of said first diaphragm on said pressure breather valve disc proportional to altitude.

7. Combination mask and suit regulators for an oxygen regulator having a first-stage chamber and a demand diaphragm comprising a suit regulator having a housing provided with a first chamber therein communicating with a suit for pressurizing the same, a suit valve seat between said first-stage chamber and said first chamber, an exhaust valve seat between said first chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for closing said exhaust valve seat against said exhaust valve disc upon increase in altitude to a predetermined degree and for unseating said suit valve disc from said suit valve seat upon increase in altitude above said degree, said valves being responsive to the pressure in the suit in opposition to atmospheric pressure to regulate the pressure to the suit in proportion to altitude, a mask regulator comprising a housing having a first chamber communicating with the demand diaphragm to pressurize the same, a pressure breather valve seat between said first-stage chamber and said first chamber of said mask regulator, said demand diaphragm having a leak opening therein to the demand chamber of said oxygen regulator, a diaphragm, a pressure breather valve disc actuated thereby, said diaphragm being responsive on one side to pressure from said first chamber of said suit regulator and on the other side thereof to atmospheric pressure, and pressure-responsive means responding to the pressure in said first chamber of said suit regulator and differentially to atmospheric pressure for regulating the action of said first diaphragm on said pressure breather valve disc proportional to altitude.

8. In a suit regulator for a diluter demand oxygen regulator having a first-stage chamber and a demand diaphragm, said suit regulator comprising a housing having a suit regulator chamber communicating with a suit for pressurizing it, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for closing said exhaust valve seat against said exhaust valve seat upon increase in altitude to a predetermined degree and for unseating said suit valve disc from said suit valve seat upon increase above said degree, a diaphragm forming one wall of said suit regulator chamber and thereby responsive on one side thereof to the pressure therein and in the suit and responsive on the other side thereof to atmosphere, said exhaust valve seat being carried by said diaphragm, spring means to act on said diaphragm to bias said exhaust valve seat toward said exhaust valve disc, and manually operable means to selectively render the force of said spring effective.

9. In a suit regulator for a diluter demand oxygen regulator having a first-stage chamber and a demand diaphragm, said suit regulator comprising a housing having a suit regulator chamber communicating with a suit for pressurizing it, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for seating said exhaust valve seat against said exhaust valve disc upon increase in altitude to a predetermined degree and for unseating said suit valve disc from said suit valve seat upon increase above said degree, and a diaphragm forming one wall of said suit regulator chamber and thereby responsive on one side thereof to the pressure therein and in the suit and responsive on the other side thereof to atmosphere.

10. In a suit regulator for a diluter demand oxygen regulator having a first-stage chamber and a demand diaphragm, said suit regulator comprising a housing having a suit regulator chamber communicating with a suit for pressurizing it, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for seating said exhaust valve seat against said exhaust valve disc upon increase in altitude to a predetermined degree and for unseating said suit valve disc from said suit valve seat upon increase above said degree, and a diaphragm forming one wall of said suit regulator chamber and thereby responsive on one side thereof to the pressure therein and in the suit and responsive on the other side thereof to atmosphere, a said exhaust valve seat being carried by said diaphragm.

11. In a regulator for use in connection with an oxygen regulator having a first-stage chamber and a demand diaphragm, said regulator comprising a housing having a suit regulator chamber communicating with a suit for pressurizing the same, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for seating said exhaust valve seat against said exhaust valve disc upon an increase in altitude to a predetermined degree and for unseating said suit valve disc from said suit valve seat upon increase above said degree, a diaphragm forming one wall of said suit regulator chamber and thereby responsive on one side thereof to the pressure therein and in the suit and responsive on the other side thereof to atmosphere, said exhaust valve seat being carried by said diaphragm, spring means to act on said diaphragm to bias said exhaust valve seat toward said exhaust valve disc, and manually operable means to apply and increase the force of said spring means to seat said exhaust valve seat and unseat said suit valve disc.

12. In a regulator for use in connection with an oxygen regulator having a first-stage chamber and a demand diaphragm, said regulator comprising a housing having a suit regulator chamber communicating with a suit for pressurizing the same, a suit valve seat between said first-stage chamber and said suit regulator chamber, an exhaust valve seat between said suit regulator chamber and atmosphere, a suit valve disc and an exhaust valve disc connected together for simultaneous movement, a diaphragm carrying said exhaust valve seat, altitude responsive means for seating said exhaust valve seat against said exhaust valve disc upon an increase in altitude to a predetermined degree and for unseating said suit valve disc from said suit valve seat upon increase above said degree, and a diaphragm forming one wall of said suit regulator chamber and thereby responsive on one side thereof to the pressure therein and in the suit and responsive on the other side thereof to atmosphere, said exhaust valve seat being carried by said diaphragm.

References Cited in the file of this patent

UNITED STATES PATENTS

2,390,233	Akerman et al.	Dec. 4, 1945
2,418,034	Kizaur	Mar. 25, 1947
2,619,959	Holmes	Dec. 2, 1952
2,703,572	Seeler	Mar. 8, 1955