July 10, 1962 L. F. SHEPARD 3,042,926

PRESSURE SUIT FOR HIGH ALTITUDE FLYING

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Fig. 1.

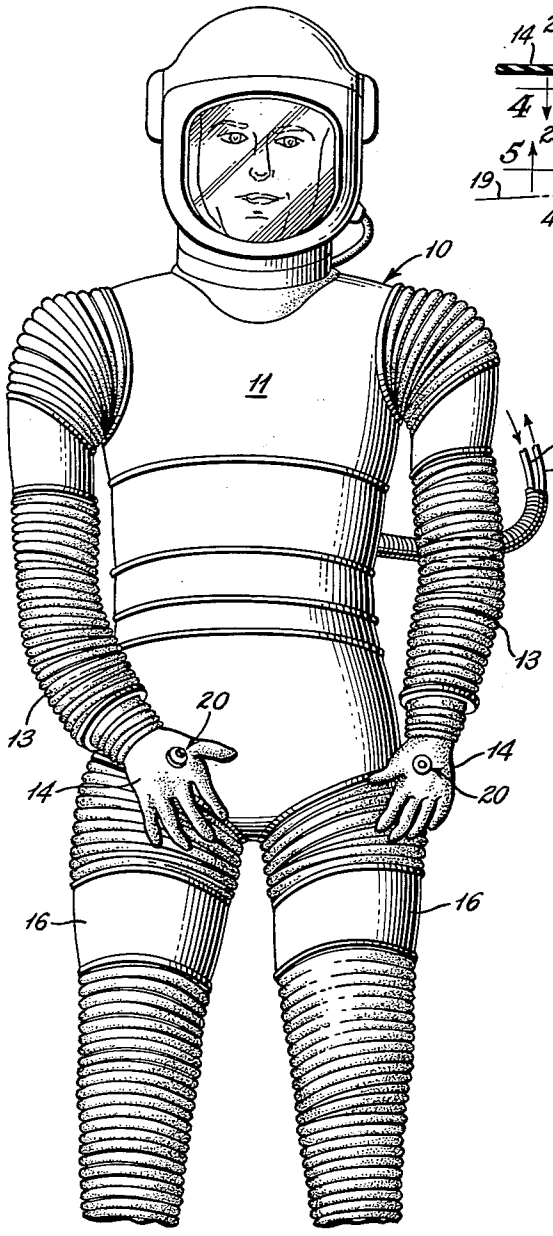


Fig. 2.

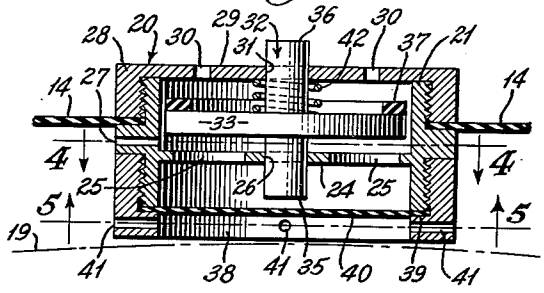
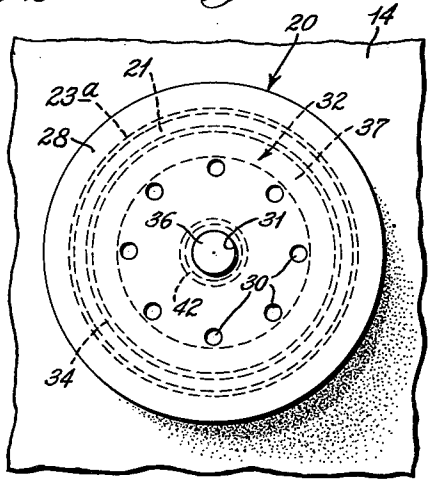


Fig. 3.



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Fig. 4.

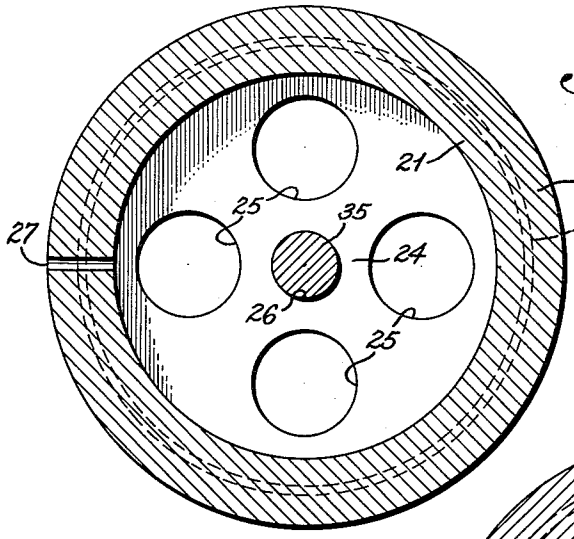
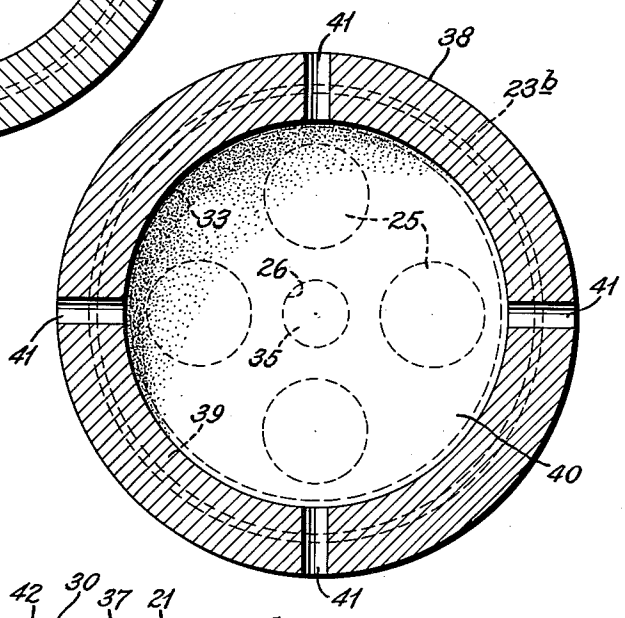


Fig. 5.



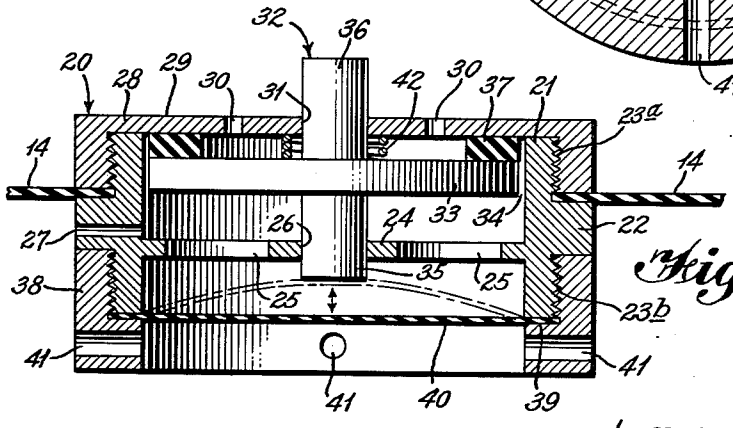


Fig. 6.

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PRESSURE SUIT FOR HIGH ALTITUDE FLYING

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8 Claims. (Cl. 2—2.1)

This invention relates to an improvement in pressure suits for high altitude flying. More particularly, the invention relates to a differential pressure valve positioned in the body of the flying suit to vent air from within to stimulate ventilation in substantially stagnant areas of the suit, which automatically closes when the pressure differential between the suit and its surroundings exceeds a fixed amount. The valve can be constructed so as to be manually operated to an open position after closing.

During high altitude flying, pressure suits are subject to high ambient temperatures. Under these conditions, remote areas of the suit, such as the fingers and feet, are subject to lack of ventilation, even when air distribution systems are used. Such stagnation of air at these points causes the wearer's skin temperature to rise, which produces sweating and extreme discomfort to the wearer and interferes with proper functioning of the hands and feet.

In accordance with the present invention, ventilation of a pressure flying suit is improved by providing a differential pressure valve device in the surface of the suit to permit controlled leakage of air from within when the pressure differential between the inside of the suit and outside thereof is within a prescribed range and to close automatically when the pressure differential is exceeded to retain the air in the suit. The valve device on closing can be manually operated, as desired, to an open position to allow leakage of air to resume from within the suit.

High altitude flying suits are ventilated by pumping a continuous supply of air through the suit. Even with the use of air distribution devices, difficulty is experienced in reaching stagnant areas. These areas can be ventilated by positioning the differential pressure valve in the surface of the suit, preferably in a region accessible to the hands to facilitate manual opening, so that constant leakage of air eliminates stagnation at these points. Allowing leakage to occur only within a fixed pressure differential between the inside of the suit and its surroundings adds a safety factor so that under emergency conditions, such as exposure to rarefied atmosphere, the exhaustion from the suit of air essential to body function is stopped.

One of the particular areas in which stagnation occurs is about the hands, and the differential pressure valve can be placed advantageously over the dorsal portion of the hand where the wearer can conveniently operate the valve by manipulation with the other hand but where it does not interfere with and is out of the way of the functioning of the hand and fingers.

The differential pressure valve can be in the form of an outer casing sealed in the wall of the suit so that a portion thereof extends into the suit. The casing internally can be provided with a piston chamber having a closed top portion with vent holes therein and a bottom cover in the form of a movable diaphragm. Communication between the suit and the atmosphere outside the suit can be made by orifice-like openings through the wall of the casing calculated to permit the escape of a measured amount of air from inside the suit into the chamber for a given pressure differential. In the chamber is positioned a pressure responsive movable piston having sufficient clearance between its peripheral edge and the wall of the chamber to permit passage of air

and being capable of sealing the chamber from the surrounding atmosphere when the piston is forced against the top portion of the chamber. The piston also has an extension which protrudes through the closed top portion of the cylinder and facilitates the unseating of the piston to reopen the valve.

When the valve is open, the air passing into the chamber through the orifice-like opening and escaping through the vents causes a pressure drop in the chamber so that the diaphragm is urged by the pressure in the suit into the chamber. When the pressure differential exceeds the fixed amount, the diaphragm is so urged into the chamber that it moves the piston into contact with the top of the chamber thereby sealing the chamber and stopping the flow of air through the vent hole. The pressure in the chamber at this point becomes equal to the pressure in the suit and the diaphragm returns to its relaxed position. If the wearer should desire further ventilation, depressing the extended portion of the piston permits the air to escape from the suit through the orifice and, when the pressure differential is below the fixed range, the valve remains in an open position.

In addition to the advantages of the present invention referred to above, other advantages are described below in connection with the specific embodiment shown in the drawings, it being understood that such embodiment is shown by way of illustration only, in which:

FIGURE 1 is a front view of a pressure suit for high altitude flying showing the pressure differential valves positioned over the dorsal portion of the hands;

FIGURE 2 is a cross-sectional view of the differential pressure valve in an open position showing the inlet air orifice to the piston chamber, the piston for sealing the valve, and the pressure-actuated diaphragm;

FIGURE 3 is a top plan view of the differential pressure valve positioned in the surface of the suit showing the holes for escape of air from within the suit;

FIGURE 4 is a cross-sectional view taken along the line 4—4 of FIGURE 2 showing the piston follower shaft and the pressure equalization hole in the chamber;

FIGURE 5 is a cross-sectional view taken along the line 5—5 of FIGURE 2 showing the vent holes for assuring full air pressure under the diaphragm; and

FIGURE 6 is a cross-sectional view of the valve shown in FIGURE 2 with the piston in a closed position and the position of the diaphragm, in outline, at the instant of closing of the valve.

In the drawings, FIGURE 1 shows a pressure suit **10** for high altitude flying to maintain the wearer under full required pressure. The suit **10** has a body portion **11** to which is secured a sealed helmet **12** covering the head of the wearer. Outward from the body portion **11** are arm extensions **13** so arranged as to allow for freedom of movement. To the outer extremity of each arm extension is secured a glove **14** connected by a locking ring **15**. Extending downwardly from body portion **11** are leg sections **16** which have attached at the lower ends thereof suitable shoes for covering the feet (not shown). The pressure in the suit is maintained by a pumping unit which continuously supplies air through an inlet tube **17** to the suit. Air from the suit is exhausted through an outlet tube **18**.

In the area of the glove **14** covering the dorsal portion of the hand **19** in the region of the interosseous area between the first and second metacarpal joints is positioned a differential pressure valve **20** which, below a fixed differential pressure between the interior of the suit and the outer surroundings, allows for a venting of air from within the suit to stimulate ventilation in the glove. Placing the valve in this area over the dorsal portion of the hand allows ease of manipulation by the fingers of one hand to set the valve in the other glove in an open

position when the differential pressure is exceeded and the valve is closed (see FIGURE 1).

The differential pressure valve **20** has a hollow cylindrical body **21** with a centrally positioned outwardly extending annular flange **22**. On the outer surface of the cylindrical body above and below flange **22** are threads **23***a* and **23***b*. Positioned horizontally across the interior of the hollow body **21** is a web **24** having spaced circular openings **25** symmetrically positioned with respect to the vertical axis of the body. The center of the web **24** defines a circular opening **26**. Through the annular flange **22** is an orifice **27** positioned slightly above the top surface of the web **24**.

Engaging threads **23***a* is a flanged cap **28** having a flat surface **29** in which are positioned a group of vent holes **30** symmetrically arranged with respect to the vertical axis of the body **21**. The central portion of flat surface **29** defines a circular opening **31** of the same size as opening **26**. Between the edge of the flange of cap **28** and the upper surface of the annular flange **22** is secured the marginal edge of the thickness of the material forming the pressure suit (see FIGURE 3).

Positioned in the hollow cylindrical body between the flanged cap **28** and the web **24** is a piston **32** having a flat cylindrical body **33** smaller in diameter than the internal diameter of the hollow cylindrical body **21** providing an annular space or opening **34**. Centrally located with respect to the vertical axis of the cylindrical body **21** and the piston **32** is a downwardly extending shaft **35** and an upwardly extending shaft **36** which extend through openings **26** and **31**, respectively, slidably operable therein. On the outer marginal edge of the top of cylindrical body **33** of the piston **32** is an annular gasket **37** securely mounted thereto for contacting the under surface of flange cap **28** to seal off the vent holes **30** from the interior of the suit.

Engaging threads **23***b* is an annular flange clamp **38** having an inner circular flange portion **39**. Clamp **38** is adapted to retain between the edge of flange portion and the bottom edge of the hollow cylindrical body a circular diaphragm **40** which, with flange cap **28**, defines the piston chamber. In the lower edge of the flange portion **39** are horizontal holes **41** arranged so as to assure that the air space between the surface of the hand **19** and the diaphragm **40** is always under the same pressure as the inside of the suit.

The differential pressure valve **20** is mounted in the surface of the suit by cutting a circular hole in the suit of sufficient diameter to allow the top portion of the hollow cylindrical body **21** to extend therethrough with the inner surface of the marginal edge of the hole resting against the top edge of annular flange **22**, and threading cap **30** over the top of the body until the bottom edge of the flange of the cap securely clamps the marginal edge of the material of the pressure suit to form an air-tight seal (see FIGURE 2).

Advantageously, the valve unit can be placed in any part of the suit where it is desired to increase the degree of ventilation, and preferably may be placed in remote areas, such as in the covering for the hands and feet where venting of air from within the suit will reduce air stagnation.

The differential pressure valve arrangement, when assembled in the suit as heretofore described, presents a diaphragm member which forms the bottom of an air escape chamber with a distributing plate thereabove which also acts as one of the guides for the piston. The only communication of the chamber with the outside of the suit is through orifice **27**. The top portion of the chamber represented by the flanged cap **28** is vented to pressure from outside the suit by means of vent holes **30**. The valve operates on the principle that the dynamic pressure drop across the orifice **27** when the suit is under a pressure greater than the pressure of the atmosphere surrounding the suit will cause the diaphragm to deflect upwardly into the piston chamber. The air passing through orifice **27** passes around the annular space **34** between the piston and wall of the chamber and escapes into the surrounding atmosphere to keep the stagnant area ventilated. When the pressure drop in the chamber exceeds a fixed amount (such as when there is a drop in the pressure of the surroundings), the diaphragm, due to the higher pressure inside the suit, is deflected sufficiently upward to push against the end of the downwardly extending shaft **35** forcing the piston **32** upward. When the piston has reached the top of its travel, the annular gasket engages the under surface of flange cap **28**, thereby closing the valve. Air passing through orifice at this point equalizes the pressure between the chamber and the suit causing the diaphragm to return to a relaxed position (see FIGURE 6).

During normal operation, the differential pressure between the pressure suit and its surroundings is a vent pressure of approximately 0.5 to 0.75 p.s.i.g. Under normal operation, the absolute pressure in the suit can be from 15.5 to 3.5 p.s.i.a., with the pressure outside the suit being less by the amount of differential pressure. Under these conditions, a measured amount of air is passed through the vent to the outside of the suit by maintaining the size of the orifice to a diameter of about .020 to .040 inch, thereby providing ventilation by air circulation. If the differential pressure rises above 0.75 p.s.i.g., the dynamic pressure drop across the orifice causes the diaphragm to deflect upward sufficiently to force the piston to seal the chamber.

Air may be vented from the suit by pressing the top of shaft **35** deflecting the piston from its sealed position and, in this case, if the pressure differential is below the fixed amount, the valve is reactivated to an open position.

Advantageously, a biasing means such as a spring **42** may be positioned between the top of the flanged cap and the piston **32** so as to assure that the forces of gravity do not cause the piston to seal the piston chamber.

Although the present invention has been described with particularity with reference to a preferred embodiment, it will be obvious to those skilled in the art, after understanding the invention, that various changes and modifications may be made therein without departing from the spirit and scope of the invention, and the appended claims should therefore be interpreted to cover such changes and modifications.

What is claimed is:

1. A ventilated pressure suit for high altitude flying which comprises a pressurized suit adapted to enclose the body; means for maintaining a substantially fixed pressure in said suit; a differential pressure valve positioned in the surface of said suit having a pressure differential chamber therein, said chamber defining an orifice for communicating the interior of said suit with said chamber and defining a valve opening for communicating the chamber with the surrounding atmosphere for releasing air from the suit below a fixed pressure differential; a valve closing piston operable in said chamber for closing said valve opening; an upwardly extended shaft centrally positioned on said piston protruding from said chamber above said valve opening; a downwardly extended shaft centrally positioned on said piston and depending in said chamber, said shafts adapted to maintain the piston centrally in the chamber during operation; and a pressure responsive diaphragm positioned below said depending shaft and forming the bottom of said chamber adapted to contact said depending shaft and urge said piston to close the valve when the pressure differential exceeds a fixed amount.

2. A pressure valve for ventilating a pressure suit during high altitude flying which comprises a valve body having a valve closing piston chamber therein; vent holes defined by said chamber for communicating the chamber with the surrounding atmosphere; an orifice defined by said chamber, said orifice communicating the interior of

said suit with said chamber for maintaining a constant flow of air from the suit to the surrounding atmosphere when the valve is in open position; valve closing piston means positioned in said chamber operable to seal said vent holes; and a pressure responsive diaphragm forming the bottom of said chamber adapted to urge said valve closing piston means into closed position when the pressure differential between the chamber and said suit exceeds a fixed amount, said pressure within the suit retaining the valve closing means in closed position.

3. The ventilated pressure suit of claim 1 in which said valve closing means has an extension thereon projecting outside said chamber into the surrounding atmosphere for manually inserting said piston to open position when the differential pressure is below a fixed amount.

4. A ventilated pressure suit for high-altitude flying which comprises a pressurized suit adapted to enclose the body, means for maintaining a substantially fixed pressure in said suit above the pressure of the surrounding atmosphere, a differential pressure valve positioned in said suit, said valve having means to urge and maintain it in open position below a fixed pressure differential, an orifice for maintaining a constant flow of air from said suit through the valve when in open position, and diaphragm means operable by the pressure within said suit to urge said valve to a closed position when the fixed differential pressure between the suit and the surrounding atmosphere is exceeded, said valve retained in closed position by the pressure within the suit.

5. The ventilated pressure suit of claim 4 in which means is provided to urge manually said valve out of closed position to bleed air above a fixed differential pressure and to return valve to open position below a fixed differential pressure.

6. The ventilated pressure suit of claim 4 in which means is provided for sealing said valve in said suit.

7. A ventilated pressure suit for high-altitude flying which comprises a pressurized suit adapted to enclose the body, means for maintaining a substantially fixed pressure in said suit above the pressure of the surrounding atmosphere, a differential pressure valve positioned in said suit, said valve having biasing means to maintain it in open position below a fixed pressure differential, an orifice for maintaining a constant flow of air from said suit through the valve when in open position, and means operable by the pressure within said suit to seat said valve when a fixed pressure differential between the suit and the surrounding atmosphere is exceeded, said valve retained in seated position by the pressure within the suit.

8. A ventilated pressure suit for high-altitude flying which comprises a pressurized suit adapted to enclose the body, means for maintaining a substantially fixed pressure in said suit above the pressure of the surrounding atmosphere, a differential pressure valve positioned in said suit, said valve having spring means to maintain it in open position below a fixed pressure differential, an orifice for maintaining a constant flow of air from said suit through the valve when in open position, and means operable by the pressure within said suit to seat said valve when a fixed pressure differential between the suit and the surrounding atmosphere is exceeded, said valve retained in seated position by the pressure within the suit.

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