United States Patent [19]

Agnew

[11] **3,804,086**

[45] **Apr. 16, 1974**

[54] **SURGICAL VACUUM APPAREL**

[76] Inventor: **Boyd F. Agnew,** 111 Via Lido Nord, Newport Beach, Calif. 92660

[22] Filed: **July 28, 1972**

[21] Appl. No.: **276,155**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 198,229, Nov. 12, 1971, which is a continuation-in-part of Ser. No. 47,414, June 18, 1970, Pat. No. 3,625,207.

[52] **U.S. Cl.** **128/146.2**

[51] **Int. Cl.** **A61m 1/00**

[58] **Field of Search** ..... 128/139, 146.2, 146.3, 128/146.4, 146.6, 146.7, 297, 142.5, 142.3, DIG. 26, 142.7, 141, 146, 140, 205; 21/53, 74; 15/344; 248/362; 2/1, 81, 82, 2.1 A, 2.1 R, DIG. 7; 132/9; 126/204; 4/160; 691/1

[56] **References Cited**

UNITED STATES PATENTS

3,529,594	9/1970	Charnley	128/139
2,773,262	12/1956	Brouha	2/81
2,573,414	10/1951	Dunn	128/142.5
3,029,303	5/1962	Severino	128/DIG. 26
3,608,091	9/1971	Olson	2/2.1 R
3,315,672	5/1967	Cunningham	128/139
2,922,417	1/1960	Bradley	128/141 R
2,460,269	2/1949	Appeldoorn	4/160
3,058,463	10/1962	Goodrich	128/139
2,657,396	11/1953	Klein	4/160

Primary Examiner—Richard A. Gaudet
Assistant Examiner—Henry J. Recla
Attorney, Agent, or Firm—Gausewitz, Carr & Rothenberg

[57] **ABSTRACT**

An air harness in the form of a belt and a pair of suspenders is made of flexible multi-apertured tubing. Ends of the tubing are coupled to a connector positioned behind the wearer and having a rearwardly projecting main vacuum duct that connects to a vacuum hose. The harness and connector are positioned entirely beneath the surgical gown and may be either separable or inseparable therefrom. Air is drawn into the gown and, together with particles shed from the wearer's body, is drawn into the harness tubing for disposal at a remote location. An oronasal vacuum aspirator worn under or formed as a part of a surgical mask is connected to the rearwardly extending vacuum duct. Particles of bacteria and moisture exhaled or shed from the wearer, both in the vicinity of his head and in the vicinity of his torso, are collected by the vacuum system for remote disposal.

10 Claims, 19 Drawing Figures

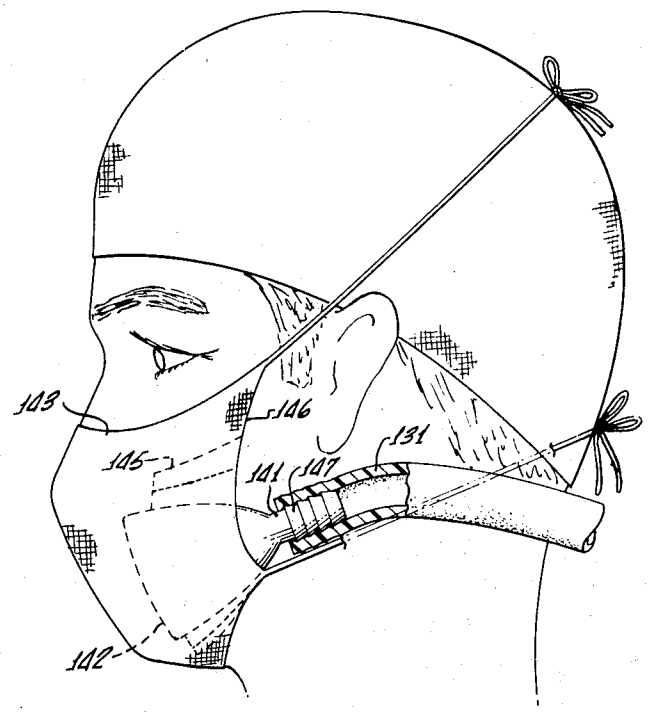


FIG. 1.

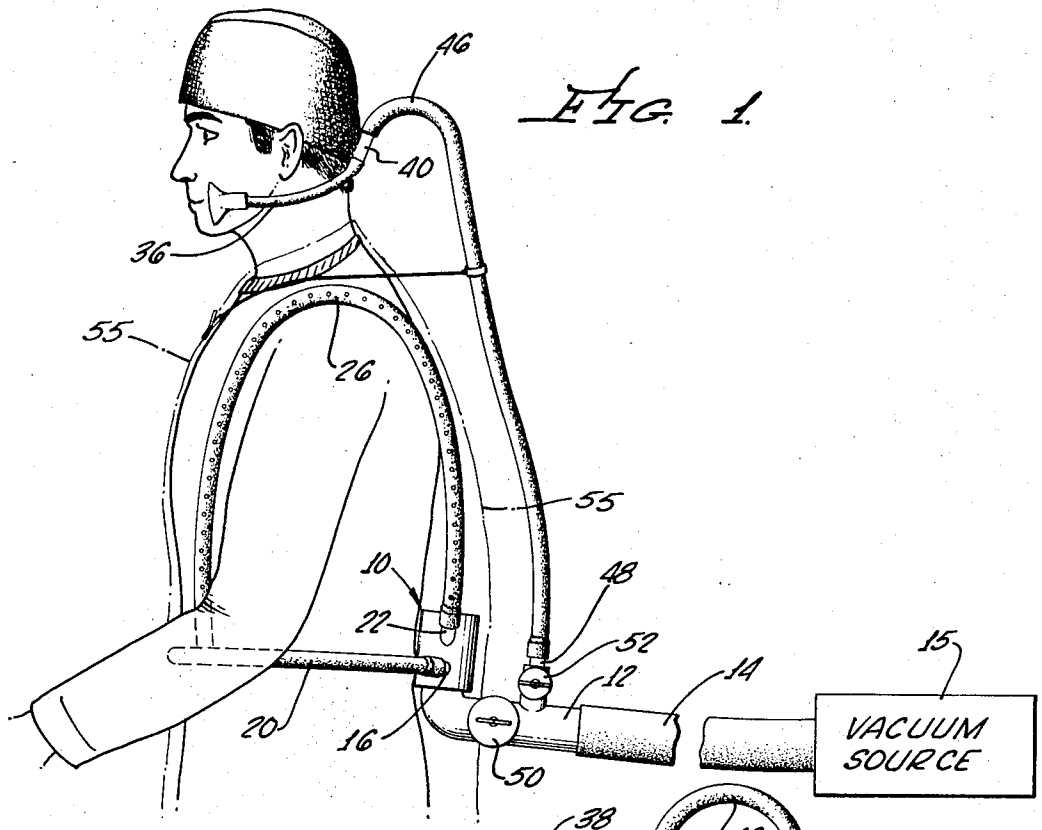
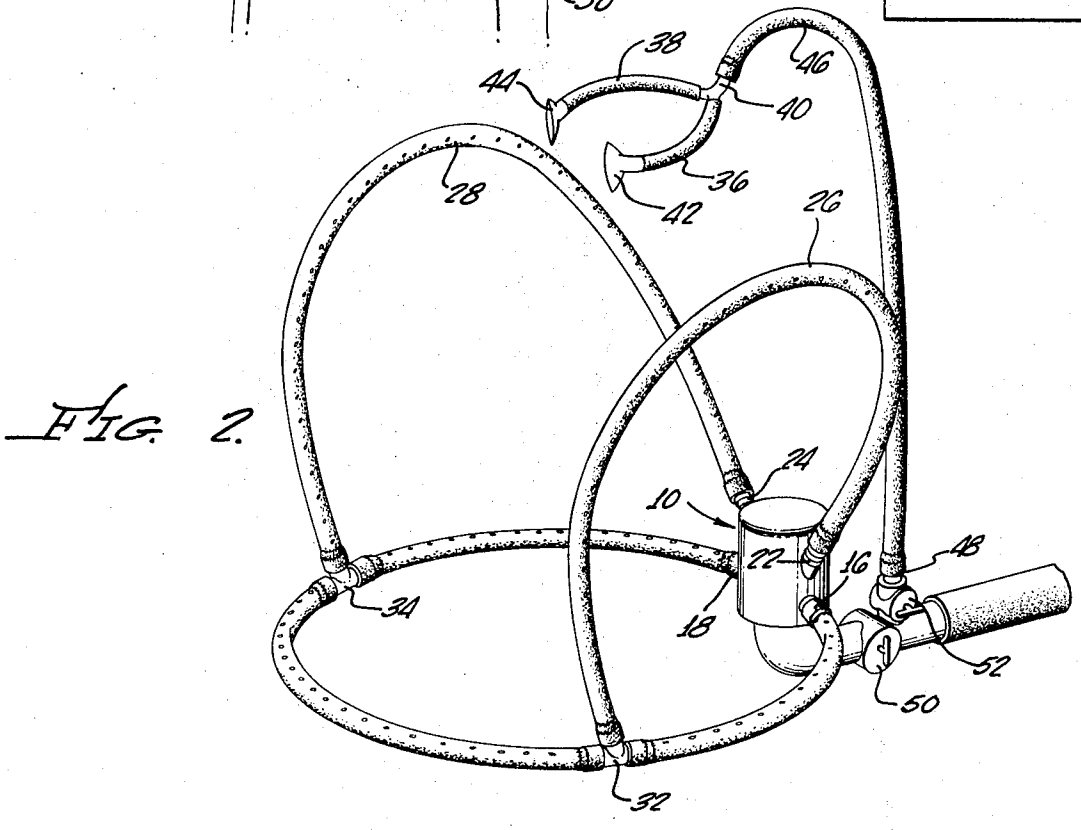

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VACUUM SOURCE
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FIG. 2.


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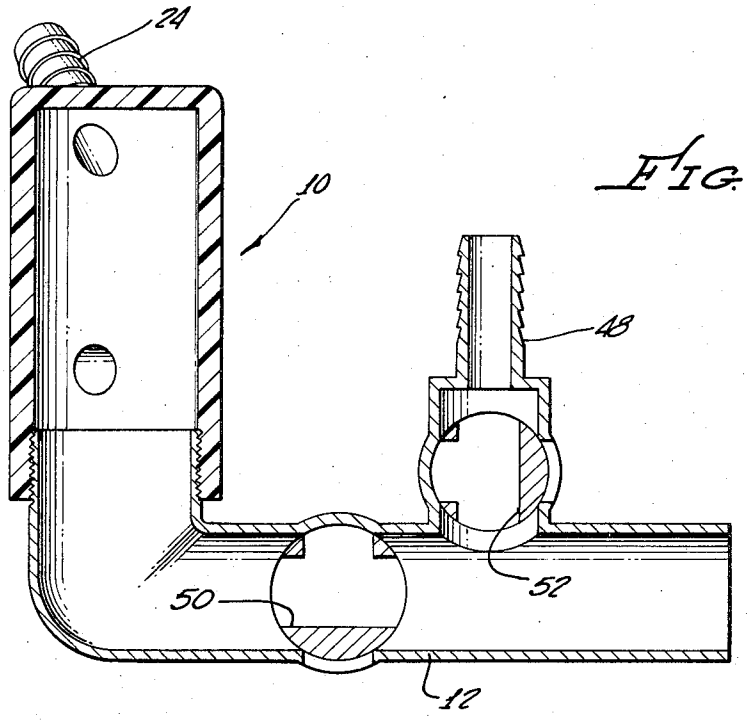


FIG. 3.

FIG. 4.

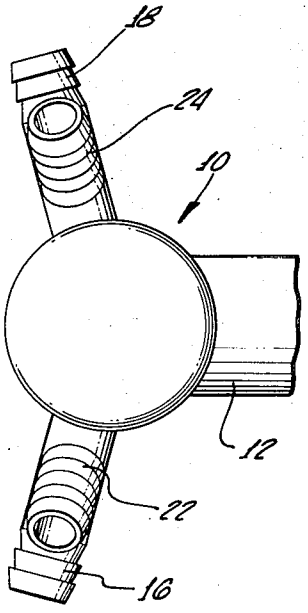


FIG. 5.

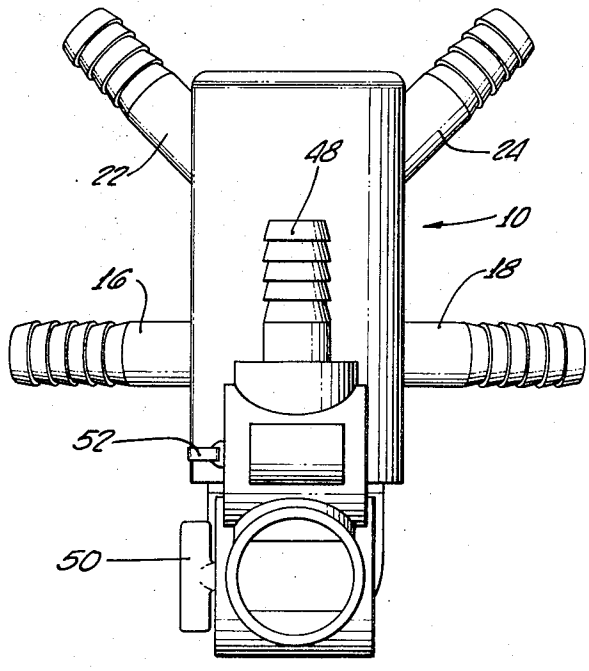


FIG. 6.

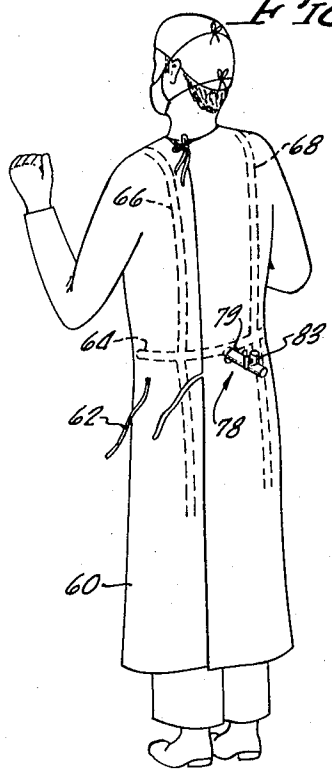
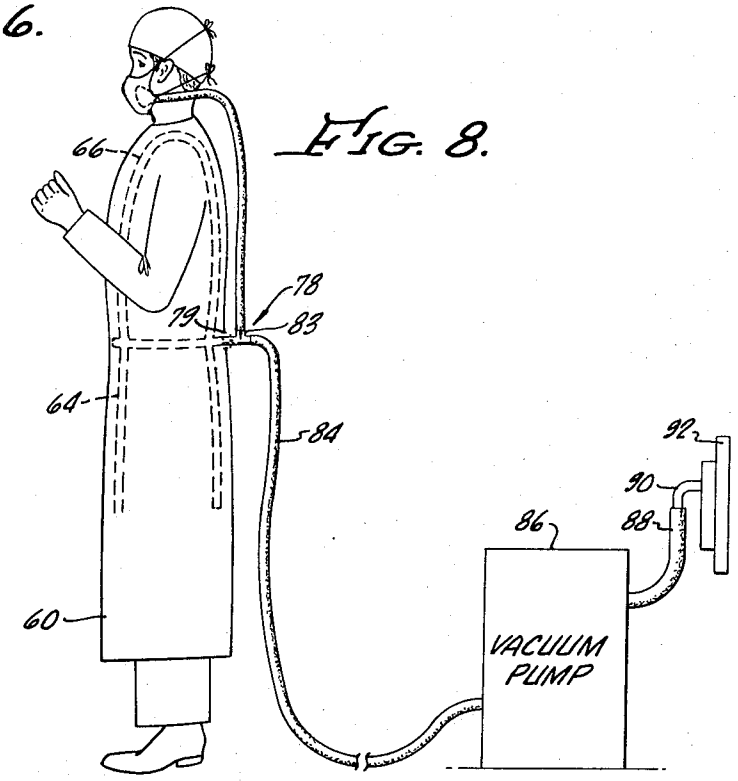


FIG. 8.



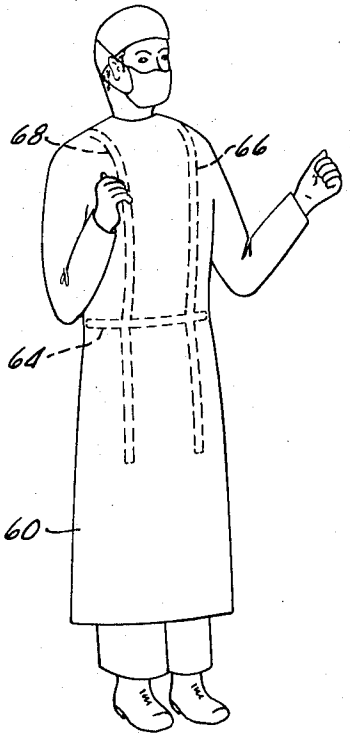


FIG. 7.

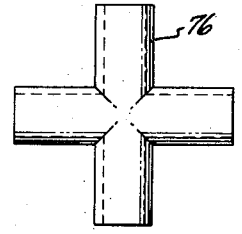


FIG. 9.

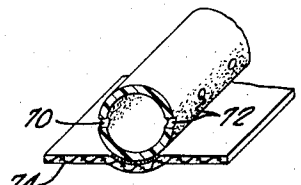


FIG. 11.

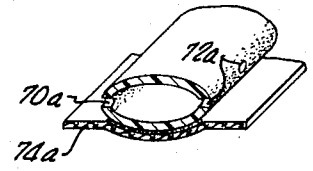


FIG. 11a.

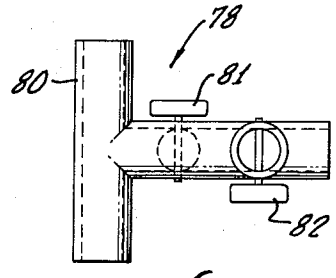


FIG. 10.

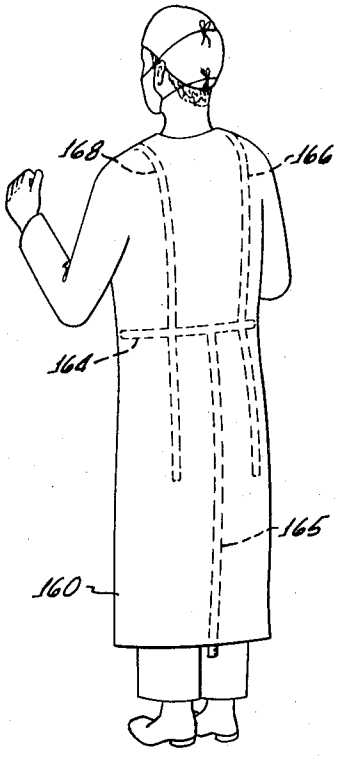


FIG. 12.

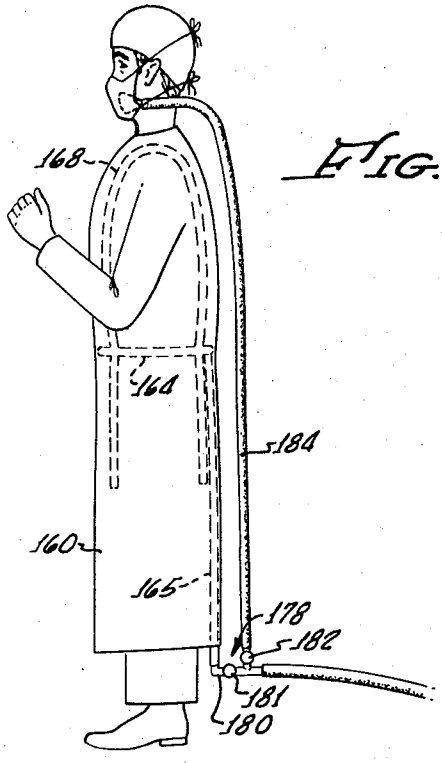


FIG. 13.

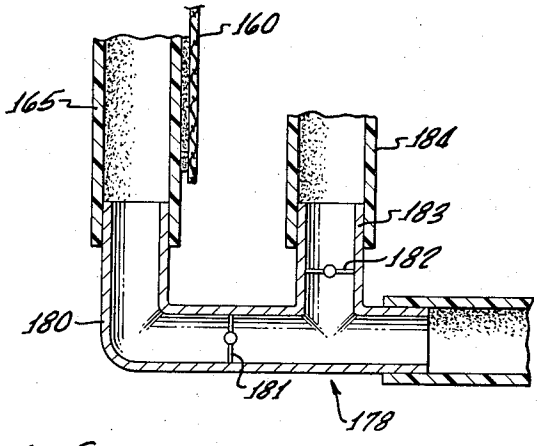


FIG. 14.

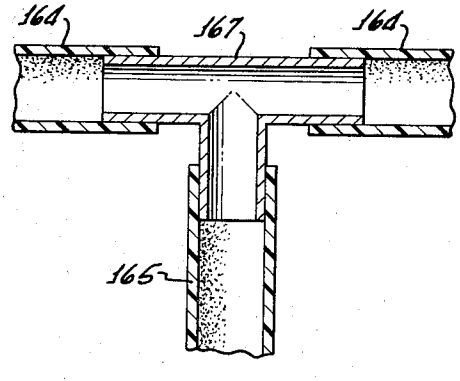


FIG. 15.

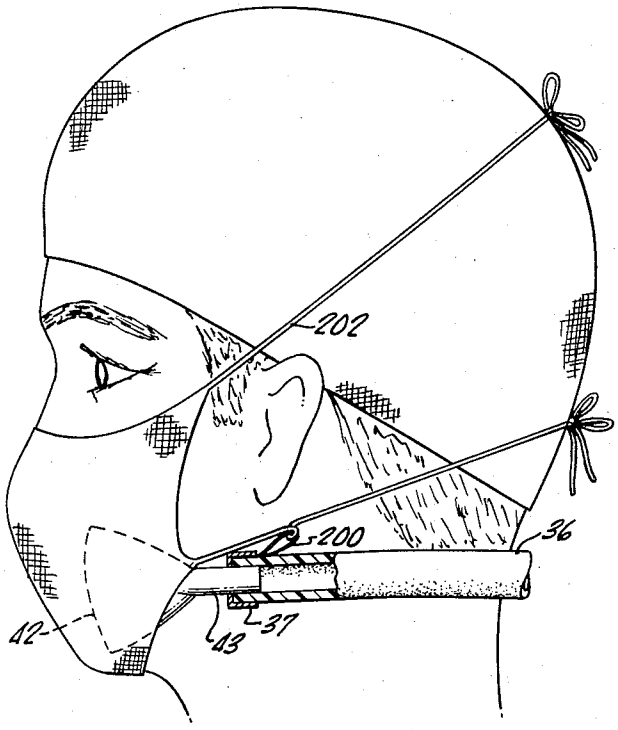


FIG. 16.

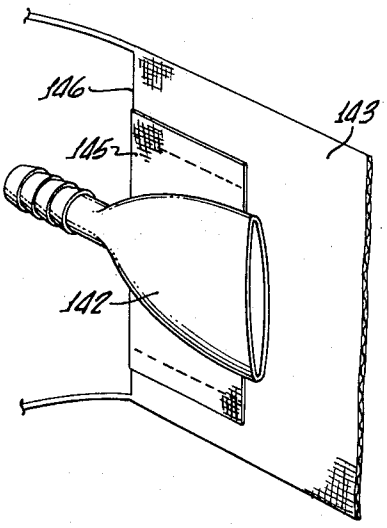


FIG. 18.

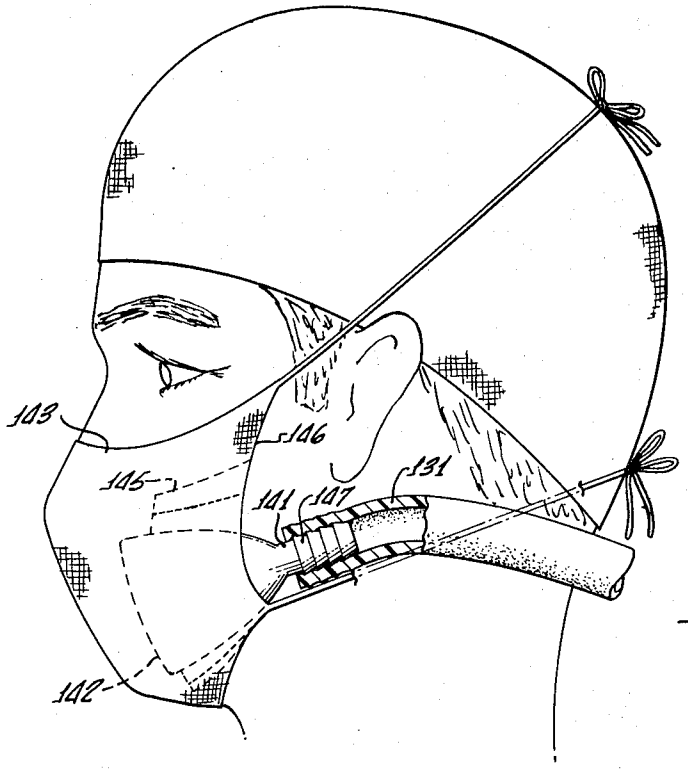


FIG. 17.

SURGICAL VACUUM APPAREL

REFERENCE TO PARENT APPLICATIONS

The present application is a continuation-in-part of my co-pending application for Vacuum Harness for Surgeons' Gowns, Ser. No. 198,229, filed Nov. 12, 1971, which is a continuation-in-part of application Ser. No. 47,414, filed June 18, 1970, now Pat. No. 3,625,207.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to protective clothing arranged to minimize contamination of ambient atmosphere by particles, bacteria or moisture shed or otherwise emanating from the body of the wearer.

2. Description of the Prior Art

The human body continually produces particulate matter. The rate at which particles are shed by the human body ranges from a low estimate of 10,000 particles per minute, up to a high estimate of 300,000 particles per minute. These particles include dead skin and body cells shed by the body in its process of continual regeneration of cells. Particles of hair and bacteria are shed as hair falls out and the bacteria are forced out of pores of the skin through body movement and in the process of hair growth. Lint is shed by the clothing. Droplet nuclei are expelled from the lungs and nasal passages. These nuclei are minute drops of vapor, some of which may contain infectious organisms. It is known that such nuclei constitute a major source of staphylococcus aureus in the atmosphere of operating rooms. When the droplet nuclei are expelled from the lungs, the moisture evaporates, leaving the staphylococcus bacteria floating in the air.

At a recent conference on infections, it was authoritatively stated that between 2 and 5 percent of persons hospitalized each year in the United States acquire infections during such stay. The probability that a non-immune patient will get certain kinds of infections is high. For example, the probability of picking up influenza, measles or chicken pox if the person is not immune is better than 50 percent, it has been said. For other types of infections, the range of the non-immune patients acquiring infections during a hospital stay may be anywhere from 10 to 50 percent.

It has been established that infections of surgical wounds may be caused by carriers of disease causing organisms that are present in an operating room. Specific carriers, including members of the surgical team, an orderly or nurse, present in the operating room, have been found to shed bacteria into the atmosphere of the operating room. Such bacteria are known to cause infections of surgical wounds. In addition to the threat posed by such carriers, all individuals in the operating room are known to harbor infectious organisms in their respiratory systems. Such organisms are collected by the various individuals during their work in various parts of the hospital. Hospital atmospheres in general contain a greater concentration of air borne micro-organisms due to the fact that sick persons constantly shed such organisms into the air. The hospital air conditioning system distributes these organisms throughout the hospital. Operating rooms have their own air conditioning systems, but organisms are brought into the operating rooms by surgeons and other hospital personnel who have been in other parts of the hospital and may have drawn contaminated air into their respiratory systems at that time.

The three or four members of the surgical team are in close proximity to the surgical wound and this very proximity makes the potential for infection of the wound by organisms shed by these members of the surgeon team quite high. Other members of the surgical team also contribute bacteria and dust-associated virus to the atmosphere surrounding the wound. However, such proximity of a person shedding the bacteria to the surgical wound is not necessary for contamination since it has been found that infections of surgical wounds may be due to bacteria shed from persons merely present in the operating room at positions remote from the patient.

Accordingly, it is highly desirable to minimize or eliminate the transfer of particles, organisms and the like to the atmosphere of the operating room.

One such method and apparatus for minimizing this source of infection is the use of a laminar flow system, such as that shown and described in my co-pending application for Clean Air System for Hospital Operating Rooms, Ser. No. 176,909, filed Sept. 1, 1971, and my earlier application for Clean Air System for Hospital Operating Rooms, Ser. No. 88,667, filed Nov. 12, 1970, now abandoned. With such a clean air system, the infection potential of persons in the operating room can be reduced to include only those members of the surgical team in the immediate proximity of the surgical wound. Other persons in the room downstream of the laminar flow of clean air, as provided in such an arrangement, are less of a threat because organisms shed by them will be carried away from the wound and removed from the room environment. Nevertheless, such system, although substantially reducing the potential for infection of the shed organisms, does not completely eliminate the problem. Further, in the absence of such a laminar flow system, all persons in the operating room must be considered potential sources of infection.

Oronasal aspirator systems have been used to withdraw air from the vicinity of the head of the wearer, thus minimizing the infection potential of exhalations of the surgical personnel. Such oronasal systems are shown and described in my Pat. No. 3,625,207 for Respiratory Mask and Ducting. However, such arrangement in no way handles the problem of particulate matter and organisms shed by the torso area of surgical personnel.

U.S. Pat. No. 3,529,594 to Charnley describes an article of protective clothing comprising a hooded gown that covers the surgical wearer from head to toe and is made of substantially impermeable material. This sleeved gown, having an integrally formed hood and a rigid, complex face mask, is provided with a suction system. Air withdrawn from this gown is replaced by air entering at the lower open end of the gown according to the theory of this patent. However, in the arrangement of Charnley, the upward flow of air, which must traverse the full length of the body from foot to head, may be seriously impeded by creation of a slightly negative pressure inside the gown to thereby cause the gown to cling to the body. Further, the gown being impermeable will prevent entrance of air for either cooling or breathing of the wearer and thus make use of the

gown difficult if not impossible unless and until a negative pressure source is connected and operating.

It is common for the surgical team to don the surgical clothing in a room separate from the operating room. With the arrangement of Charnley, the special protective clothing must either be worn only in the operating room, or the vacuum hose and vacuum source must be moved with the wearer between the several rooms. The wearer, having his head and torso completely encased in the protective clothing, is unable to properly communicate with other members of the surgical team without an intercommunication system. He is unable to breathe without an artificial source of air, and his vision is impaired by requiring him to look through a viewing plate in the mask. If another member of the team should accidently step on the air hose, or if his communication line is accidently disconnected or broken, he can neither breathe nor talk. Within a few seconds after air is cut off from an arrangement such as the impermeable protective clothing of Charnley, the face mask will become fogged and vision impaired. With all these disadvantages, it is still necessary in this arrangement of Charnley to provide an entirely new surgical gown configuration and a complicated mask structure. This is a special garment particularly designed for a specific purpose. At present, operating rooms are supplied with the widely used disposable paper gowns, or sterilizable cloth gowns and masks. Thus, where special clothing is provided, large and expensive supplies of conventional protective clothing must be completely discarded.

In addition to minimizing potential contamination, it is desirable to provide the surgeon with an ample supply of fresh cool air, since many operations and surgical procedures require significant physical effort over extended periods of time. Cooling is desirable or required for both cloth and paper gowns. Cloth gowns have a number of disadvantages. Being too porous they allow escape of particles and bacteria shed by the body. They shed relatively large amounts of lint and washing and sterilization are costly. Air impervious and semi-impervious gown material is available and exhibits startling decrease in the shedding of lint. Such materials are relatively inexpensive and therefore readily disposable to eliminate costs of sterilization and other servicing. Nevertheless, because of the decreased permeability of this material, discomforts of use are greatly increased by retention of body heat. Body heat of the surgeon is increased because of the significant physical exertion and the emotional strain of the operation. Thus, in spite of the many advantages of impervious or semi-impervious disposable paper gown material, its use is limited. Without some means of overcoming the generated body heat within the semi-impervious or impervious gown any gain from the standpoint of protecting a patient from infection would be offset by a decrease in effectiveness if he becomes hot and uncomfortable to the point that he is unable to concentrate to a maximum degree on the task at hand. Various types of body cooling devices have been suggested for comfort and for protecting the wearer from a toxic or potentially dangerous surrounding atmosphere. These include a space suit for use in outer space, such as is shown in U.S. Pat. No. 3,487,765, to Lang, the air conditioned garment of D'Amato as shown in Pat. No. 3,468,299, and the ventilation arrangement of Brouha et al. shown in Pat. No. 2,773,262. The cooling devices of Lang, D'Amato and Brouha et al. and other similar cooling systems all provide arrangements for blowing air into a space between the wearer's body and his clothing. The garments are specifically designated to prevent the flow of air from the ambient environment to the wearer's body. The arrangements are complex, combersome, and in general, require large air flow rates. Nevertheless at best, such devices will merely cool the wearer, but can in no way minimize the problem of air borne infection due to organisms shed by the wearer. Quite to the contrary, such cooling and ventilating devices enhance the probability of this type of infection.

Accordingly, it is an object of the present invention to provide a system that will significantly decrease potential infection due to organisms shed by various personnel, increase the comfort of the wearer, and make maximum use of conventional and commonly available protective clothing, both pervious and impervious.

SUMMARY OF THE INVENTION

In carrying out principals of the present invention in accordance with a preferred embodiment thereof, there is provided a vacuum body harness beneath the conventional surgical gown. The harness includes perforated tubing extending between the gown and the torso and fluid coupled to a connector positioned behind the wearer within the gown. A main vacuum duct extends rearwardly of the wearer from the connector for connection to a negative pressure source. As an additional feature, the connector is adapted to provide a vacuum connection for an oronasal ducting system positioned under a porous face mask, whereby particles and organisms shed from the vicinity of the head and the vicinity of the body are all withdrawn and remotely disposed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** illustrates a vacuum system with an embodiment of the present invention in place upon a person wearing a surgical gown (shown in broken lines),

FIG. **2** is a perspective of the body harness tubing and connector of FIG. **1**, also showing the oronasal ducting attached thereto,

FIGS. **3**, **4** and **5** are detailed views of the connector of the body harness of FIGS. **1** and **2**,

FIGS. **6**, **7** and **8** illustrate a second embodiment of the invention in which vacuum tubing is formed as an inseparable part of the gown,

FIGS. **9** and **10** show details of tubing connections for the gown shown in FIGS. **6**, **7** and **8**,

FIGS. **11** and **11a** illustrates one manner of securing the tubing of FIGS. **6**, **7** and **8** to the gown,

FIGS. **12** and **13** illustrate a modification of the embodiment of FIGS. **6**, **7** and **8**,

FIG. **14** illustrates details of a main vacuum duct and connector employed in the arrangement of FIGS. **12** and **13**,

FIG. **15** shows details of a tubing connection for the embodiment of FIGS. **12** and **13**,

FIG. **16** shows a modified form of flexible porous face mask having vacuum ducting attached thereto by ties, and

FIGS. **17** and **18** show another form of modified mask having vacuum intake ports inseparably secured thereto.

DETAILED DESCRIPTION

As illustrated in FIGS. **1** and **2** a connector **10** is

firmly positioned and retained at the lower portion of the back of the wearer. The connector is provided with a rearwardly extending main vacuum duct **12** that is adapted to project approximately 12 inches rearwardly, from the back of the wearer, and has an end portion that is readily connected to and disconnected from a suction hose **14.** The suction hose which may be made in one or more sections as deemed necessary or desirable, is connected to a source of negative pressure such as a vacuum pump **15** that is conveniently located within or near the operating room. Such a negative pressure source may be a vacuum pump of the type described in my Pat. No. 3,625,207 for Respiratory Mask and Ducting, or the source employed may be any other suitable vacuum connection arranged above the work area.

Extending from opposite sides of the lower portion of the connector **10** are a pair of tubular coupling stubs **16, 18,** to which are attached the opposite ends of a waist-encircling flexible tube **20.** In effect the waist encircling tube comprises first and second hoses that extend in opposite directions from stubs **16, 18** and are integrally connected with each other at the front of the waist. A pair of shoulder coupling stubs **22, 24** extend generally upwardly and diverge outwardly from an upper portion of the connector and are respectively connected to flexible shoulder tubes **26, 28** that extend in the manner of a pair of suspenders upwardly along the back of the wearer over the respective shoulders and thence downwardly over the chest where they terminate substantially at the forward portion of the waist-encircling tube **20.** Conveniently the lower ends of the shoulder tubes are connected to the waist-encircling tube by a pair of T-shaped connecting conduits **32, 34** that provide both a physical connection of the shoulder tubes to the waist-encircling tube and fluid communication between the waist and shoulder tubes.

Although a physical connection between the lower ends of the shoulder tubes and the front portion of the waist-encircling tube is desired in order to assist in support of the waist tube, and further, to assist in positioning and support of the connector at the lower back of the wearer, it is not necessary that the shoulder tubes be fluid coupled to the waist tube. Thus the lower ends of the front of each of the shoulder tubes may be completely closed.

All of the tubes are multi-apertures, that is, they are formed with a series of mutually spaced perforations. Preferably the apertures may be arranged in diametrically opposed pairs, positioned so as to extend along axes substantially parallel to that portion of the wearer's body adjacent the tube section in which the particular aperture is formed. Thus with the body of the wearer pressing against one side of the tube and the porous gown against the diametrically opposed side of the tube, the several apertures will be positioned so as to be spaced a maximum distance from both the gown and the body.

Preferably the connector and the coupling stubs extending therefrom for connection to the waist and shoulder tubes are formed of a substantially rigid or at least self-sustaining resilient plastic that may be pressed comfortably against the small of the back of the wearer. The waist-encircling and shoulder tubes are formed of a lightweight flexible plastic tubing that has sufficient strength to retain its shape under the relatively light pressure of its own weight and the weight of the surgical gown. If deemed necessary or desirable, suitable shape-retaining stiffeners, such as internal or external helical elements, may be provided within or upon the waist-encircling tube and the shoulder tubes in order to prevent these from collapsing and impeding flow of air therethrough.

As previously stated, the rearwardly extending main vacuum duct extends to the rear about 12 inches for connection to the suction hose **14** of the negative pressure system **15.** This rearward extension is made with sufficient resilience and strength so that it will retain its position and orientation with respect to the main connector body but will, if struck against some obstacle or some other person of the surgical team, flex sufficiently so as to avoid any severe dislocation or shock due to the contact.

The described body harness may be used alone, if desired without any additional equipment such as the oronasal vacuum ducting system described below. Nevertheless, in order to supplement the contamination prevention of the described body harness, it is specifically designed and arranged to be used in conjunction with an oronasal vacuum ducting system of the type claimed and described in my patent for Respiratory Mask and Ducting. The contents of this patent are incorporated herein by this reference, as though fully set forth. As shown in the drawings, the oronasal vacuum ducting system of the patent, or a functionally equivalent vacuum ducting system, includes a pair of hose sections **36, 38** that diverge from a primary hose leg **40** and a primary suction hose loop **46** extending upwardly to the rear of the head as illustrated in FIG. **1.** Suitable ties affixed to the primary suction hose loop **46** extend over the shoulders of the wearer's gown for attachment by clamps such as alligator clips to the chest portion of the gown. Thus the oronasal vacuum ducting system and its suction hose **46** are supported by both the wearer's head and the connection of the ties to the gown.

The suction hose of the oronasal vacuum system extends downwardly along the back of the wearer for connection to an upwardly projecting coupling stub **48** that is formed in the rearwardly extending main vacuum duct **12.** For maximum breathing and bodily comfort and to provide for optimum operation of the combined torso and head vacuum systems, the two are made independently adjustable in flow rate. Thus, a first valve **50** is provided for control of air flow from the connector. Preferably valve **50** is located in the main vacuum duct between the body of connector **10** and the coupling stub **48** that connects to the oronasal ducting system. A second and independent valve **52** is provided to control air flow from the coupling stub **48** and from the oronasal vacuum system. Thus, the two systems, the body harness and the oronasal vacuum ducting system may have the air flow therethrough separately and relatively independently controlled. As shown particularly in FIG. **3** each of the valves **50** and **52** may be at least in partial communication with the exterior of the ducting in certain positions, so that air is drawn substantially entirely through the harness (for valve **50**) or the oronasal system (for valve **52**) in one valve position and as the valve is progressively moved, an increasing proportion of air is drawn directly from the exterior, thereby to progressively bypass the ducting controlled by the particular valve. With such an arrangement, flow of air through the body harness, for example, may be reduced by operation of valve **50**

without significantly changing air flow through the oronasal system, and vice versa.

In use of the apparatus described herein, the surgeon or other person of the operating team, dons the vacuum body harness over his bare body or underclothing. If deemed necessary or desirable the waist-encircling tube may be formed in two sections separated at the front of the waist of the wearer in order to facilitate putting the body harness on and off the body. In such two-section arrangement the ends of the separated sections are sealed and provided with suitable tying arrangement, such as a conventional strap and buckle, (not shown) to enable the two ends to be secured to each other with a suitable degree of tension at the wearer's waist. Similarly, the suspender-like shoulder tubes may also be made adjustable by providing adjustable connecting means between the lower ends of the shoulder tubes and the waist-encircling tubes. Thus the harness is either initially made, or adjustable to provide a relatively snug fit around the wearer's waist and shoulders whereby the harness tubes exert tensile forces on the several coupling stubs that extend from the connector. These forces will provide upward and forward forces on the connector so as to firmly and tightly retain the connector in position snugly against the lower portion of the back of the wearer. The vertical extent of the connector **10** also cooperates with the several coupling stubs and their connections to the harness tubing to maintain the proper orientation of the connector, acting against the downwardly tilting pull of the main duct **12.** If deemed necessary or desirable, the cross-section of connector **10** (shown to be substantially circular) may be flattened so that the horizontal cross-section will be laterally elongated and will more closely conform to and fit against the back of the wearer. The harness tubes not only provide the properly positioned and widely distributed pattern of suction points emcompassing the major portion of the torso of the wearer, but also act to retain the position and orientation of the connector at the back of the wearer with the main vacuum duct projecting from the wearer's body a distance sufficient to prevent fouling of the suction hose **14** that is connected thereto. With the main vacuum duct extending rearwardly as described, the suction hose **14** that is attached thereto, whether it hangs from a negative pressure system mounted in the ceiling or simply falls to the floor behind the wearer, will be clear of the wearer's body. There is, therefore, a minimum of interference with normal movement. The wearer may freely walk about the operating table or may bend his head and body as needed.

Continuing with the description of application of the harness to the body, after donning the body harness, the oronasal vacuum attachment is placed over the surgeon's head with its suction hose **46** disconnected from the main vacuum duct **12.** The latter, of course, is not yet connected with the suction hose **14** of the negative pressure system since such pressure system may be in a room other than that in which the clothing is donned. The common face mask, (not shown) generally made of disposable paper of sterilizable cloth, is then put on in the normal manner over the oronasal ducting system. Now the conventional disposable paper or sterilizable cloth surgical gown **55** is put on over the head of the wearer and over the body harness tubing. The gown is worn so that the suction hose **46** that connects the primary leg **40** of the oronasal ducting system to the main vacuum duct **12** lies outside of the gown. The alligator clips on the ties of the oronasal ducting system suction hose **46** are then entrained over the shoulders of the wearer, outside of the gown, and attached to the front of the gown so as to provide support for the suction hose **46.**

The main vacuum duct **12** extends through an opening (not shown) in the back of the surgical gown that is provided for this purpose. Accordingly all of the body harness and the connector excepting only portions of the rearwardly extending main vacuum duct, the coupling stub **48** and both valves **50** and **52,** are covered by the surgical gown as shown in FIG. **1.** The suction hose **46** of the oronasal ducting system may then be connected to the coupling stub **48** of the main vacuum duct.

Now the wearer is fully clothed with both mask and gown and with both of the independently adjustable vacuum systems securely emplaced. Nevertheless, since suction hose **14** has not yet been connected to duct **12,** the wearer is free to move about, may freely breathe through the porous face mask and has the same amount of cooling and comfort that is available from the conventional porous surgical gown.

After the wearer, clothed as indicated above, but completely independent of the negative pressure system, enters the operating room, another member of the surgical team will connect the negative pressure source via its vacuum hose **14** to the rearwardly extending main vacuum duct **12.** This provides the negative pressure to both the body harness and the oronasal ducting system. The valves are then adjusted to provide adequate and comfortable air flow without unduly cooling the wearer's body. As the vacuum is applied from the negative pressure source, air is withdrawn via the hose and oronasal ducting system. Air is drawn in toward the wearer's face through the porous surgical mask. The mouth and the face area surrounding the mouth are cooled by this incoming air. Exhalations of the wearer are vacuumed away and exhausted for remote disposal via the connection at the lower portion of the wearer's back. This action reduces the threat of infection by droplet nuclei or by particles of skin, lint, hair, etc., which may contain infectious organisms from the head area of the wearer.

Concomitantly with application of suction to the oronasal vacuum ducting system, suction is applied to the perforated tubular body harness. Ambient air is drawn through the permeable surgical gown throughout substantially the entire torso area of the wearer. The space between the wearer's body and the gown is thus established at a slightly negative pressure with regard to the ambient atmosphere whereby particles and bacteria shed by the body in and about the torso area are subjected to the slightly decreased pressure and withdrawn from such area through the tubing apertures that are distributed over the wearer's torso. Areas of the body that produce particularly high rates of shedding of bacteria have been found to be the back of the neck, the armpits, the stomach and the groin. Bacteria shed from these areas of the surgeon's body during an operation would heretofore find their way through the pores of the gown and become air borne. In addition, such bacteria shed by the surgeon's body may be directly transferred to tools or gloves used by the surgeon and which may come in contact with his gown. The body harness described herein will collect such bacteria as are shed

from these body areas and eliminate or substantially minimize their passage through the pores of the surgical gown. The air and contaminants contained therein are evacuated from beneath the gown, exhausted at the lower portion of the wearer's back, drawn into the vacuum pumping system and then remotely disposed so as to avoid mixing with the air in the room.

Not only is the danger of contamination due to particles shed from the head and body significantly decreased but a significant cooling effect is achieved. Ambient air at a temperature considerably less than the wearer's body temperature is continually drawn through the gown over substantially the entire torso area of the wearer. At the same time, air heated by the wearer's body is withdrawn through the body harness tubing. An additional cooling effect is due to the fact that the air drawn through the gown expands to some extent as its pressure decreases in the slightly negative pressure area between the gown and the wearer's body. As is well known, temperature decreases as the air expands.

Large flow rates are not necessary in the above-described arrangement. For contamination purposes, only relatively low rates of flow are required. To achieve adequate cooling, because of the negative pressure maintained over substantially the entire torso area and the very short flow path between outside air and the tubing apertures, only a relatively low flow rate is again required. It has been found that a flow rate of approximately 4 to 6 cubic feet per minute from the connector of the body harness and, in addition, a flow rate of the same magnitude from the oronasal vacuum ducting system achieves satisfactory results.

Illustrated in FIGS. **6, 7** and **8** is a modified vacuum decontamination and cooling arrangement that makes possible the use of impervious or semi-impervious gown material without compromise of the comfort of the wearer. The arrangement shown in this embodiment includes a gown **60** made of a disposable impervious or semi-impervious material having ties **61** and **62** secured thereto for snugly securing the gown about the wearer's body. In the embodiment of FIGS. **6** and **7**, instead of forming a separate self-contained vacuum body harness, a body harness of vacuum ducting is formed as part of and inseparable from the gown. Thus the vacuum harness includes a waist encircling tubing section **64.** Shoulder tubing sections **66, 68** of the harness extend from points at the rear of the gown below the waist section **64,** at a point approximately at the knees of the wearer, upwardly over the respective shoulders then downwardly beyond the waist section to a point at or about the wearer's knees. The lower tubing sections enhance cooling of the lower body and enhance collection of emanations from this area.

In the present embodiment, the tubing need not be semi-rigid or self-sustaining as previously described. However, just as in the tubing of the previously described embodiment, all of the tube sections are multi-apertures, that is, formed with a series of mutually spaced perforations. As illustrated in FIG. **11,** each tubing section has laterally positioned apertures **70, 72** mutually spaced along substantially the entire length of tubing.

The tubing sections are all formed in and inseparable from the inside of the gown **60.** Various means of bonding or attaching the tubes to the gown are available and may be employed. Preferably, as shown in FIG. **11,** a thin flexible strip or tape **74,** formed of a resin impregnated cloth, is welded to the plastic tubing as by a suitable adhesive or heat sealing for example. The tape is coextensive with the tubing and is bonded thereto substantially throughout its length. Tape **74** is then secured to the inner side of the gown, as by adhesive or by sewing, either continuously for the entire length of the tape **74,** or at mutually spaced portions along the length of the tape and tubing. Thus, the tubing of the body harness is formed as an integral part of the gown and is entirely positioned and supported by the gown itself when the latter is worn.

Although the described harness may be formed as part of a conventional gown that opens and closes by means of overlapping flaps at its rear, the gown still must be put on over the head unless the waist tubing section is made separable, with a detachable connection, as at an edge of the gown. Alternatively, the gown may be made in a generally tubular form, to be donned only over the head, with the harness built in as described.

An alternate flattened cross-section tubing is shown in FIG. **11***a* having apertures **70***a*, **72***a* and bonded to strip **74***a*.

The waist section **64** and shoulder sections **66, 68** are preferably connectioned to each other by four-way fittings **76** as illustrated in FIG. **9.**

As shown in FIG. **10,** a main vacuum duct **78** includes a T-shaped connector **80** having opposite coupling sections respectively connected to adjoining ends of the waist encircling section **64.** In a manner similar to the embodiment of FIGS. **1** and **2,** the rearwardly main vacuum duct **78** extends through an aperture **79** formed in the gown **60** and extends rearwardly of the gown for about 12 inches for connection with a suction hose **84** (FIG. **8**) of a negative pressure system, such as the illustrated vacuum pump **86.** As previously described, the main vacuum duct **78** is provided with a stub **83** for connection to oronasal ducting and also carries a pair of valves **81, 82** for separately and independently controlling air flow in a manner previously described.

In use of the embodiment illustrated in FIGS. **6, 7** and **8,** the gown with the integral vacuum ducting is put on over the head of the wearer. That is, the surgeon dons the gown by putting his head through the nect opening and his arms into the armholes, thus placing the gown and the vacuum ducting formed therein in position on and about his body. With the main vacuum duct extending through the gown aperture, the gown is tied firmly in place and detachable connection of vacuum hose **84** (FIG. **8**) to main vacuum duct **78** is made. The hose **84** is connected to any suitable source of negative pressure such as, for example, the low pressure side of the blowers shown in my above identified co-pending application for Clean Air System for Hospital Operating Rooms. Alternatively, the vacuum hose **84** may be connected to a portable self-contained vacuum motor and pump assembly **86,** which is suitable positioned at a convenient location within the operating room. The assembly **86** is then connected as by exhaust hose **88** to an effluent connection **90** that is suitably coupled to and covers a portion of an existing exhaust grill **92** of a standard air conditioning system. If the gown is made of impervious or semi-impervious material, air is entirely or partly drawn into the gown from the bottom and through the opening at the neck.

It will be readily appreciated that with the main vacuum duct **78** positioned at the small of the back of the wearer, it may be convenient to locate the vacuum motor and pump in the ceiling of the operating room and provide a plurality of connecting hoses depending from such ceiling mounted vacuum source at mutually spaced locations for connection to the vacuum harness gowns of a number of operating personnel.

If the exhaust hose **84** is most conveniently connected to a negative pressure source at or near the floor of the room, the gown with its inseparable vacuum ducting may be modified as shown in FIGS. **12** and **13.** As shown in this embodiment, gown **160** is formed of a disposable air impervious or semi-impervious material having a vacuum ducting formed therein and inseparable therefrom. The vacuum ducting comprises perforated tubing sections **164, 166** and **168** mutually interconnected by fittings, such as fitting **76** of FIG. **9,** and positioned and bonded to the inside of the gown **160** just as described in connection with the arrangement of FIGS. **6, 7** and **8.** In the modification of FIGS. **12** and **13** however, a depending connecting tube section **165** is provided. Section **165** is bonded to the inside of the gown as are the other tubing sections and connected with the other tubing sections by means of a T fitting **167** as shown in FIG. **15.** Connecting tubing section **165** is provided to allow the main vacuum duct **178** and its connector **180** (FIG. **14**) to be positioned at the bottom of the gown near the floor. In the arrangement of FIGS. **12** and **13,** the main vacuum duct **178** includes a connector **180** that extends upwardly for reception in the lower end of connecting tubing **165.** Main vacuum duct **178** includes a pair of valves **181** and **182** and an oronasal ducting connection stub **183** adapted for connection to an oronasal ducting hose **184.** The latter is connected to anyone of the oronasal aspirators described herein.

With the arrangement illustrated in FIGS. **12** and **13,** the vacuum hose between the gown and a floor supported negative pressure source may conveniently lie upon and run along the floor and thus provides less interference with operating personnel.

An air permeable disposable face mask and oronasal ducting therefore of the type shown in my Pat. No. 3,625,207 may be employed with any one of the gown and harness embodiments described herein. The oronasal ducting will be connected to the main vacuum duct of the gown and body harness. In each embodiment, both the body harness ducting and oronasal vacuum ducting have rates of air flow therethrough separately and independently controllable by the described valves.

Certain improvements in the oronasal aspirator will now be described. In order to assure positioning of the intake ports **42** and **44** (see FIG. **2**), suitable tie loops **200** (FIG. **16**) are secured to the ducting for reception of the conventional mask ties **202** which accordingly, may be turned once or twice through the loops **200,** or otherwise secured thereto, and thence secured to the head of the wearer. In this fashion, the mask ties **202** perform the additional function of securely holding the oronasal ducting port **42** in position along the cheek of the wearer.

In a preferred construction of the oronasal ducting, the intake port **42** is formed with a rearwardly extending connecting neck portion **43** that is a snug locking fit with the end of a hose section **36** of the oronasal ducting Y. The hose **36** is stiffened with a metallic ferrule **37** pressed on the end thereof. Loop **200** is formed of a number of strands of thread or string of which the ends are secured by being tightly clamped between the hose section **36** and the connecting neck **43** of the port **42.**

An even more positive securement and positioning of the vacuum intake ports is provided in the modification shown in FIGS. **17** and **18.** Two ports, of which one is shown at **142,** are formed in and inseparable from the conventional air permeable disposable mask **143** which covers the nose and mouth below the eyes of the wearer. Although the vacuum ducts **142** may be secured to the inside surface of the mask by various means, it is preferred to secure these in the same manner as the vacuum body harness tubing sections are secured to the gown. Accordingly, a resin impregnated cloth **145** is fixed to the plastic port **142** as by adhesive or heat sealing or the like and the cloth **145** is then sewn or adhesively secured to the side of the mask near the rear edge **146** thereof.

The positioning of the cloth **145** and duct **142** upon the mask is such that the connecting neck **141** of the port **142** extends rearwardly beyond the rear edge of the mask for detachable connections with a hose section **136** that forms one of the branches of the Y of the oronasal ducting (see FIG. **2**). To facilitate a secure detachable connection, the connecting neck **141** is formed with a number of circumferential teeth **147.** It will be understood that where quickly detachable connections are desired for the tubing and fittings, circumferential teeth such as those illustrated at **147** are provided, whereas for more permanent connections, a tighter fit of hose and connection fittings is employed and a ferrule or the like will circumscribe the end of the tubing.

In the embodiment of the mask illustrated in FIGS. **17** and **18,** the mask, together with the vacuum intake ducts that are secured thereto, is readily disposable. The Y hosing and its connection to the main vacuum duct are retained and reused. Accordingly, where the oronasal ducting of FIGS. **17** and **18** is used in conjunction with the gown and inseparable harness of FIGS. **6** and **13,** both mask and gown (including their built-in vacuum tubing) are readily disposable so that they can be thrown away at the end of a period of use. This will avoid the the cost of collecting, cleaning, sterilizing, storing and returning these items to the surgeon for further use. Furthermore, with the ducting made integral with the mask or with the gown, the ducting is properly and firmly positioned when the mask or gown, respectively, is put on by the wearer. There is no need to perform additional securing or positioning operations with respect to the vacuum harness or the oronasal ducting after performing the usual steps in placing mask and gown. The slight difference in normal dressing procedure is that the gown with built-in ducting is put on over the head rather than wrapped around the body. Of course, after donning mask and gown, the ducting forming part of the surgeon's clothing must then be attached to the vacuum system. Nevertheless, the illustrated mask and gown are simple, inexpensive articles that may be readily employed in conventional fashion even without connection to a negative vacuum source if such is not readily available or if power should fail during the course of an operation.

Particularly where the vacuum intake duct is bonded to the inside surface of the disposable mask, the Y hosing of the oronasal ducting need not employ any stiffening wire to assist in forming this housing. The latter may be formed of a soft, quite flexible tubing which need have only enough strength or stiffness to withstand flattening in the presence of the relatively low vacuum that is drawn therethrough. Likewise, all of the tubing that is integral with and inseparable from the gowns shown in FIGS. **6** and **13** may be made of a thin flexible plastic material of about ¼ inch inside diameter having a sufficient strength or rigidity only in amounts sufficient to prevent collapse in the presence of the vacuum drawn therethrough. All of the inseparable tubing may be of circular flattened or other suitable cross-section. It may be extruded and then drilled or molded in the desired configuration together with its perforations.

Where a separate vacuum source or negative pressure source is employed, it will be manufactured to meet standard safety regulations, having an explosion-proof motor and explosion-proof pump, preferably mounted in a stainless steel cabinet on metal wheels that establish an adequate ground connection with the conductive floor of the operating room. The arrangement will also employ explosion-proof switches, flexible cable and connector units for supply of electrical power to the motor.

It has been found that a vacuum pump operating at an air flow of 30 cubic feet per minute is adequate to service four vacuum mask operators of the type shown in my Pat. No. 3,625,207. The 7½ cubic feet per minute that is drawn through each mask has been found to be adequate for this portion of the vacuum apparel. To accommodate the additional 5 to 10 cubic feet per minute required to be drawn through the vacuum harness of the gown, the vacuum pump will therefore supply a total of between 50 and 70 cubic feet per minute when connected to four operating team members, each provided with oronasal mask ducting and vacuum harness gown.

It will be readily appreciated that the above-described vacuum apparel provides an efficient, comfortable, flexible and economical arrangement for minimizing contamination due to shed particles and organisms and for concomitantly enhancing comfort and convenience of the wearer. These advantages are achieved by a simple ducting arrangement that uniquely combines its operation with operation of conventional and widely available porous masks and gowns of various porosities. The apparel may be used, whether or not the present vacuum system is functioning or employed. The described system provides a minimum impediment to the comfort and movement of the wearer, who will suffer no detriment or difficulty even if the system be disconnected or otherwise malfunction in the course of use.

The foregoing detailed description is to be clearly understood as given by way of illustration and example only, the spirit and scope of this invention being limited solely by the appended claims.

I claim:

1. In combination

a flexible surgical mask having a sheet of air permeable material adapted to be secured to and over the face of the wearer and having securing ties connected thereto, and

ducting formed in and constituting an inseparable part of said mask, said ducting comprising a pair of vacuum intake ports at the inside of said mask, each said port comprising

a flattened, hollow substantially triangular body having a connecting neck that extends rearwardly beyond a rear edge of said mask when the mask is positioned upon the head of the wearer, said body diverging outwardly from said connecting neck to form a relatively narrow elongated mouth, whereby when said mask is secured to the head of the wearer and said connecting neck is coupled to a source of negative pressure, air is drawn through the mask to facilitate breathing of the wearer and exhalations of the wearer are exhausted through the port to the source of negative pressure.

2. The apparatus of claim **1** wherein each said body is securely bonded to the inside of said mask with its neck protruding beyond the mask edge.

3. The apparatus of claim **2** including a Y-shaped connecting hose having a pair of branches adapted to be detachably connected to respective ones of said connecting necks.

4. The apparatus of claim **3** including a surgical gown and a vacuum harness therefore, said harness comprising sections of perforated tubing and means for securing said tubing sections to the inside of said gown, a main vacuum duct connected to said vccuum harness, and a connecting hose coupled between said main vacuum duct and said Y-shaped hose.

5. The apparatus of claim **4** including means for separately and individually adjusting air flow from said mask ports and from said vacuum harness.

6. The apparatus of claim **1** wherein each said body is securely bonded to the inside of said sheet of air permeable material.

7. The apparatus of claim **6** including a bifurcated connecting conduit having a pair of branches adapted to be detachably connected to respective ones of said connecting necks.

8. The combination of claim **7** including a surgical gown, and means connected with said connecting conduit for withdrawing air from within said gown.

9. In combination

a flexible surgical mask comprising a sheet of air permeable material adapted to be secured to and over the nose and mouth and below the eyes of a wearer and having securing ties fixed thereto,

a first vacuum intake duct secured to the inside of the mask at one side thereof and having a connecting neck extending rearwardly, and

a second vacuum intake duct secured to the inside of the mask at an opposite side thereof and having a connecting neck extending rearwardly,

each said duct having an intake port opening within the mask at points thereof adapted to be located at the corners of the mouth of the wearer,

said duct connecting necks including coupling means for detachable connection to a source of negative pressure, a surgical gown, and

means connected with said connecting neck coupling means and with said gown for exhausting air from said gown whereby when the mask and gown are secured to a wearer with the intake duct ports positioned between the mask and the wearer's cheeks, and when the duct connecting neck coupling

means are connected to a source of negative pressure, breathing of the wearer is facilitated by the supply of air drawn through the mask to the vacuum intake duct ports, and exhalations of the wearer are withdrawn through duct ports to said source of negative pressure.

10. The combination of claim **9** wherein each said duct includes a flattened hollow body, and wherein each said intake port includes an elongated mouth formed at the end of a respective one of said flattened hollow bodies.

* * * * *

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,804,086 Dated April 16, 1974

Inventor(s) Boyd F. Agnew

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the claims, claim 4, Column 14, line 29, change "vccuum" to --vacuum--; claim 9, Column 15, line 5, after "through" insert --the vacuum intake--.

Signed and sealed this 1st day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents