United States Patent [19]

Wood

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[45] **Apr. 3, 1973**

[54] FILTERED AIR BREATHING ZONE

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[52] **U.S. Cl.** .....**55/97,** 21/74, 55/356, 55/385, 55/414, 55/467, 55/DIG. 29, 98/36, 128/1 R

[51] **Int. Cl.** **B01d 46/00**

[58] **Field of Search**.....55/97, 356, 385, 414, 467, 55/473, DIG. 29; 21/74; 62/261; 98/36; 128/1 R

[56] **References Cited**

UNITED STATES PATENTS

2,104,024	1/1938	Conboie	62/261 X
3,279,883	10/1966	Thompson et al.	21/74 X
3,511,162	5/1970	Truhan	98/36

Primary Examiner—Dennis E. Talbert, Jr.
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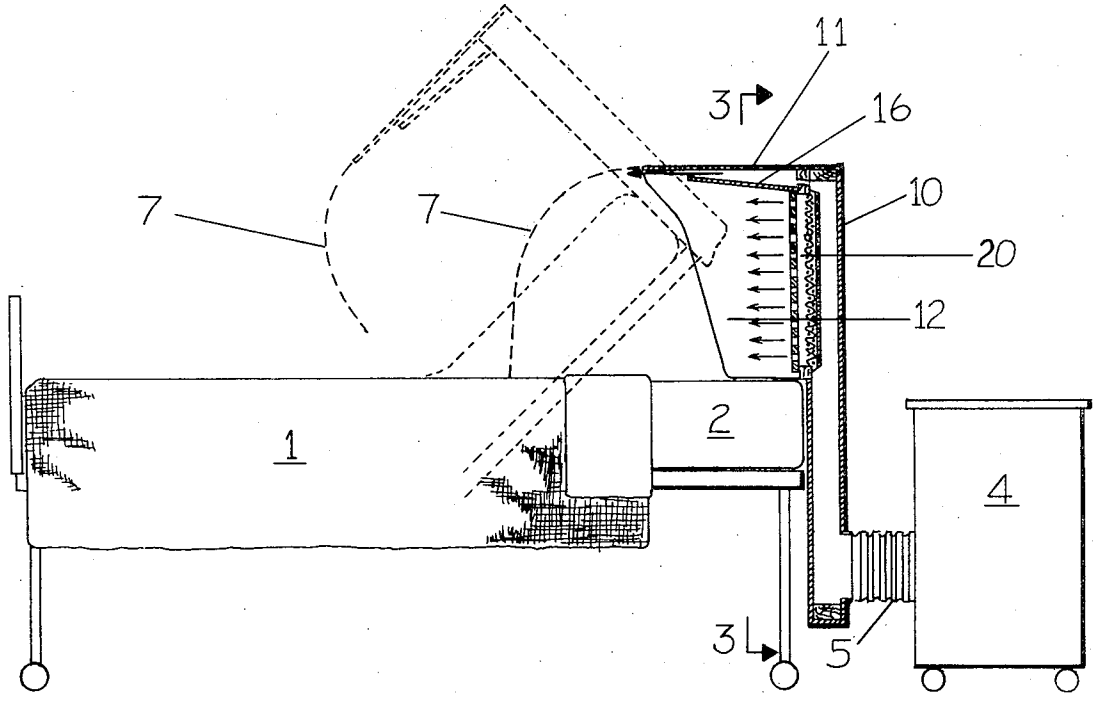
[57] **ABSTRACT**

A highly portable, localized filtered air breathing zone for a patient suffering from those respiratory diseases or who require protection from air borne contamination. The filtered air in which essentially all particulate matter has been removed provides a gaseous envelope in the breathing zone adjacent the top portion of the patient's bed. In another embodiment, the apparatus is arranged as to extend longitudinally of the bed and thus provide a patient zone extending transversely across the bed for essentially its entire length. The latter modification is to provide an essentially contamination free patient zone or breathing zone for intensive care units and for enclosures for small children requiring contamination free air. The patient zone is isolated from ambient air by means of three gas patterns, one formed at either vertical edge of the patient zone and one formed transversely across the top of the patient zone. These act as relatively high velocity air curtains and thus shield the center portion of the patient zone from the surrounding ambient air. A gas pervious diffusion wall is provided in the apparatus between the areas defined by the three high velocity gas patterns. This forms the center portion of the patient zone and provides a positive method for filling the breathing zone with contamination free filtered air. All of the air circulated is taken from a purified or filtered air source preferably derived by impelling ambient air through a high efficiency filter.

19 Claims, 5 Drawing Figures



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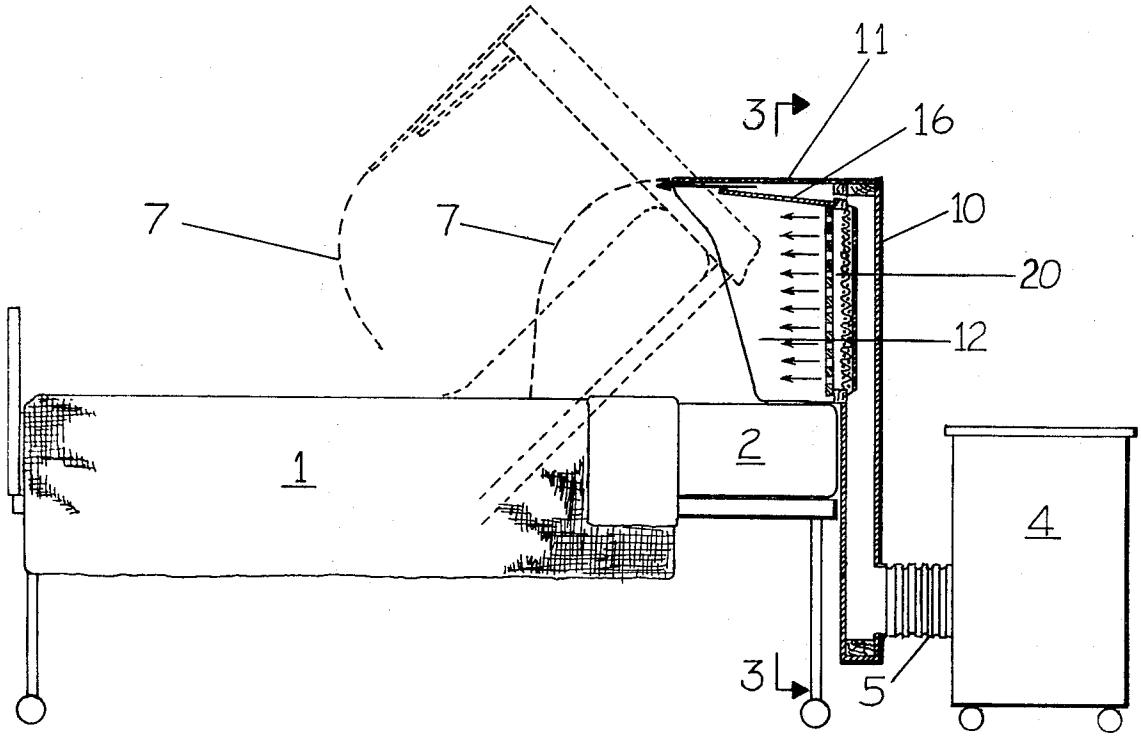

FIG-1

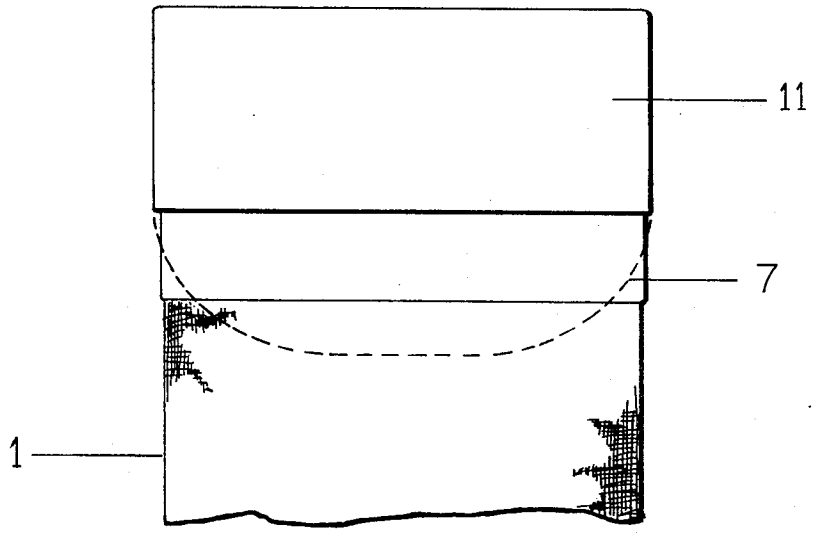

FIG-2

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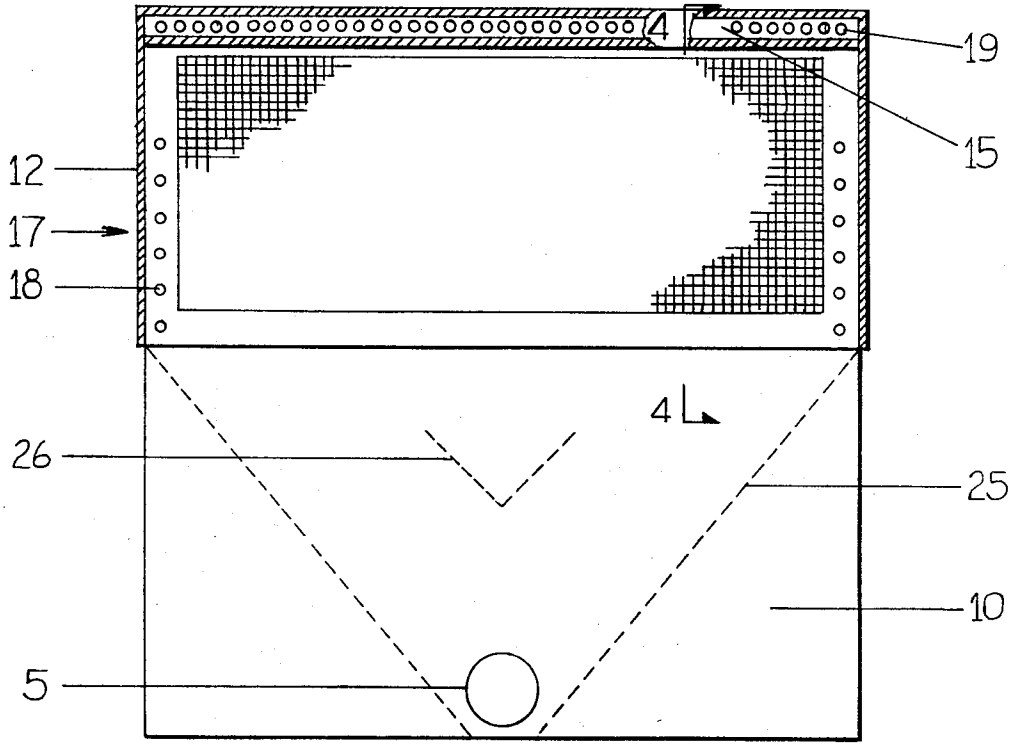

FIG-3

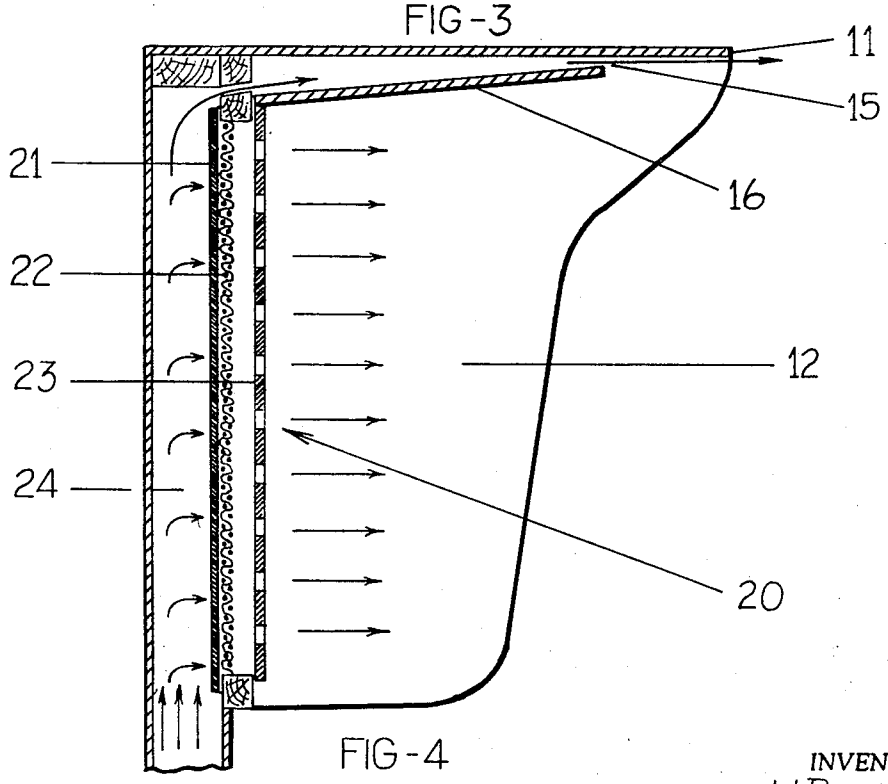

FIG-4

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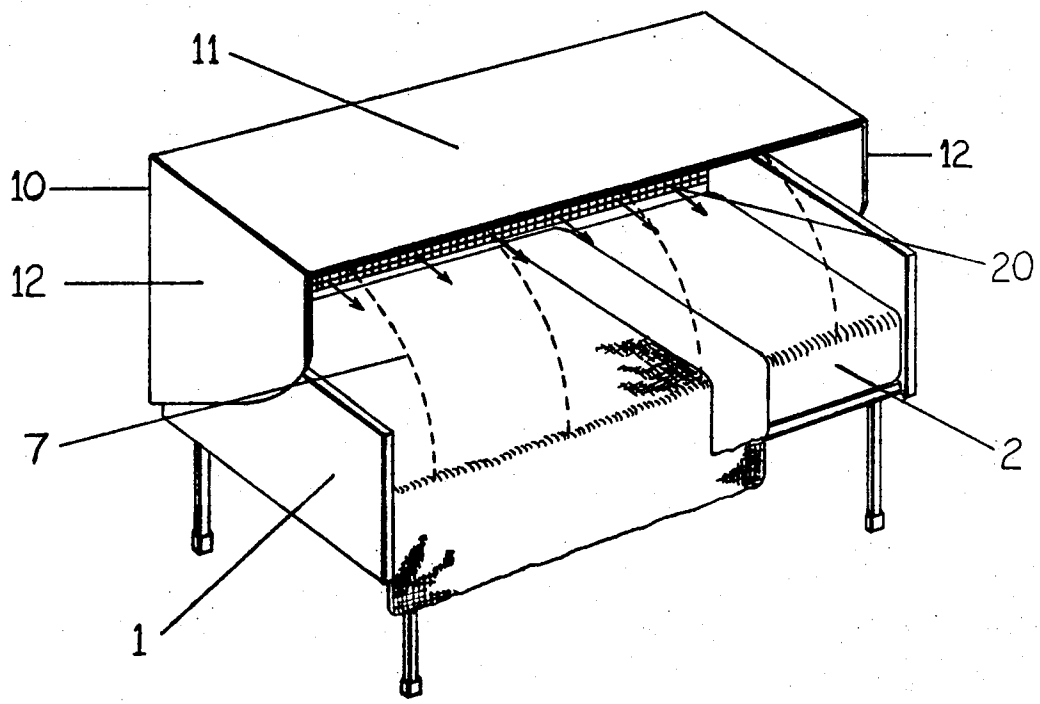

FIG-5

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FILTERED AIR BREATHING ZONE

BACKGROUND OF THE INVENTION

This invention relates to the provision of a gaseously formed curtain and is particularly applicable to the provision of an air curtain so located as to isolate air in a given space from the surrounding ambient air. More specifically the invention relates to an apparatus and method for controlling the environment in a localized zone and more particularly for effectively and economically isolating a patient zone or a breathing zone from the external environmental.

DESCRIPTION OF THE PRIOR ART

Patients in intensive care units whether suffering from respiratory infection, extensive burns or patients under going pre- or post-operative care for relatively severe or extensive operations are particularly subject to pathogenic micro organisms. Cross contamination, even in the most efficiently run hospitals has continued to exist despite improved aseptic techniques and antibiotics. It is known that if the air in the vicinity of a patient during pre- and post-operative periods is maintained virtually free from pathogenic organisms, the incidence of infection is only a fraction of that existing under normally controlled air conditions. Previously, patients have been isolated from the bacteria and virous laden air by the physical isolation of a specific part or even the whole of the patient within a plastic envelope or enclosure into which is pumped clean, contamination free air. However, patient morale is adversely affected by total confinement created by the severe claustrophobic environment of a plastic tent. Further, nursing care is complicated since direct physical treatment must be carried out through closed ports or air locks which demand considerable patience and training of hospital personnel.

To overcome these severe disadvantages, apparatus has been proposed which leaves one or more walls open and isolated from the external atmosphere by reason of an air curtain. Such apparatuses, are disclosed and claimed by Denny in U.S. Pat. No. 3,462,920, in 1969 and by Truhan in U.S. Pat. No. 3,511,162, in 1970. Both of these, however, are dependent upon a rather elaborate and expensive superstructure comprising a plenum chamber located parallel to the mattress of the patients bed and containing a series of ports or nozzles directed downwardly onto the patient with high velocity gas curtains on the peripheral edges of the plenum to isolate the filtered gaseous environment surrounding the patient from the bacteria ladened ambient air. Truhan additionally provides for recycling of the filtered air through a return duct **17** wherein the air forming the curtain and the patient zone is recycled to filtering media to be reused in isolating the patient zone.

The use of horizontal air flow in hospital applications requiring contamination free breathing areas has been accomplished in the past by installing a bank of filters either at the head or along the side of the bed and bathing the patient with filtered air flows of from 90 to 100 feet per minute. These installations have involved a complete wall fabricated of high efficiency particulate air filter (HEPA) modules. Each module might be 2 feet in width and up to 8 feet in height. The installations require an area of at least 3 to 4 feet behind the filter

module bank to service the filters. The cost of these units is extremely high and the rate of air flow can be a problem to some patients. The units are not portable.

SUMMARY OF THE INVENTION

The present invention provides a highly portable unit for protecting vulnerable patients from air borne bacteria and viral and other irritating solid particulate contamination. Further, the present invention provides a relatively inexpensive unit for protecting only the breathing zone of patients requiring protection from air borne contamination. The present invention provides a relatively inexpensive and portable unit for protecting a vulnerable patient either from bacteria, viral or particulate contamination so as to isolate the breathing zone of the patient from contaminated external atmosphere and yet provide easy access of the patient to nursing and medical personnel. In contrast to installations presently in use involving an entire bank of filter modules, a small compact HEPA filter, as for example, one 12 inches in height and 12 inches in depth can be used with a high rate of air flow through the filter. Thereafter the filtered air is diffused so as to flow at relatively low rates into the patient or breathing zone. By contrast with other developments the present invention does not direct the air curtain downwardly onto the patient but provides an air curtain having three borders of rather high velocity air which project in a generally horizontal direction to define the top and sides of the patient zone. The center portion of the patient zone is provided by a relatively low velocity air pattern obtained through a pervious gas diffusion wall. This in a preferred embodiment involves a velocity gradient across said gas pattern. The velocity is lowest at the center of the gas pattern and increases gradually toward the lateral edges of the breathing zone. While the unit is primarily adapted for use in providing a patient or breathing zone near the pillow or top area of the patient's mattress, and is designed for use by patients requiring protection from air borne particulate contamination, it is within the scope of this invention to utilize the apparatus so as to extend along the length of one side of the patient's bed so that the patient zone formed by the high velocity gas patterns extend horizontally across the patient's mattress for virtually the entire length of the bed. Thus, there is provided in this modification a patient zone comprising an envelope of purified air physically isolated from bacteria ladened and environmental air and encompassing essentially the entire area of the patient's mattress. Further it is within the scope of this invention to provide a unit adapted for a chair for use with ambulatory patients who require a contamination free breathing zone. Because of the novel and relatively low cost construction of the apparatus of this invention, an effective patient zone is provided, isolated from the external environment by use of relatively low velocity air. Thus the patient is not subject to drafts, noise is essentially eliminated and there is no claustrophobic effect. The patient is instantly accessible to medical and surgical care from the top side or front of the patient zone.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation with parts in section of the device of this invention in use with a bed and which il-

lustrates in dotted lines the patient breathing zone as well as portions of the invention when in tilted position.

FIG. 2 is a fragmentary plan view illustrating in dotted lines the outer boundary of the patient or breathing area.

FIG. 3 is a sectional view taken along lines 3—3 of FIG. 1 which illustrates the relation of the plenum chamber, the ports and gas pervious wall forming the front face of the plenum chamber.

FIG. 4 is a sectional view along lines 4—4 of FIG. 3 illustrating the structure of the various diffusion members of the gas per vious diffusion wall and illustrating the direction of air flow through the plenum chamber.

FIG. 5 is a view in perspective illustrating the apparatus of this invention extending longitudinally over a bed to protect the entire mattress area for use as an intensive care unit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1 a typical hospital bed 1, including a mattress 2 is shown in full lines. Behind the bed is a blower and filter package 4 and duct 5 which connects to the plenum headboard 10 to distribute air into the breathing or patient zone 7. It will noted in FIG. 1 that canopy 11 extends forwardly from the plenum headboard and side shield members 12 extend diagonally from the forward edge of canopy to the plenum headboard 10 at about mattress level. It is well known that hospital beds are pivoted so as to allow the patient to adjust the mattress to sitting, reclining or sleeping positions. This is shown in dotted lines in the FIG. 1 showing that the relationship of the headboard 10 and the canopy 11 relative to the top portion of the mattress remains constant even though the angular disposition of the mattress changes in well known manner. The fragmentary plan view illustrated in FIG. 2 illustrates the outer boundary of the patient zone 7 relative to the canopy 11.

Referring now to FIG. 1, air is pulled into the filter blower package 4 through air intake (not shown). Contained in the filter blower package 4 is a blower or gas impeller and a high efficiency filter. Such high efficiency particulate air (HEPA) filters are well known in the art and have been shown to remove 99.97 to 99.99 of all particles and bacteria, 0.3 microns in diameter and larger. Smaller particles are also removed by this type of filter but the amount of removal of these particles has not been established. Removal of smaller particles is not a matter for significant concern, however, since most bacteria range from 0.5 to 25 microns in diameter and very rarely exist in the air as single unattached cells but are usually attached to particles of dust and skin scales considerably larger than themselves. Typical diameters for particulate matter includes the following: tobacco smoke, 0.01 to 0.4 microns; bacteria and spores, 0.5 to 25 microns, pollens, 10 to 100 microns, insecticide dust, 0.5 to 10 microns, sneeze droplets, 10 to 400 microns, foundry dust, 1 to 1,000 microns. One of the organisms chiefly responsible for post-operative infection is the hemolytic *Staphylococcus aureus which is generally considered to be approximately* 0.8 microns in diameter. Thus by use of the HEPA filters essentially all of these irritating and pathogenic organisms are removed from the atmosphere. The purified air is impelled through duct 5 to the plenum headboard 10. It is directed by the V shape air directing vanes 25 and by the median air directing vane 26 to the upper portions of the plenum chamber 24. At the forward part of the canopy 11 is a horizontal port means 15 formed by the canopy 11 and the lower closure member 16 to form an elongated slit horizontally disposed relative to the mattress 2 and extending transversely across the mattress. High velocity air issuing from this horizontal port forms an air pattern which direction of flow is parallel to the top of the mattress 2 and which has its long axis directed transversely across the mattress. The side ports 17 are made up of a series of jet openings 18 which are vertically aligned along the side edges of the plenum chamber 24. Thus the air pattern formed by high velocity air issuing in horizontal direction along the length of the mattress 2 may be considered rectangular. In any event, when viewed in section relative to the direction of flow the longitudinal axis of the air pattern is vertical and forms the lateral edges of the patient breathing zone 7.

The pervious diffusion wall 20 (which is defined by the sideport means 17 and the horizontal port means 15) comprises a perforated diffusion cloth media 21 covering a supporting wire screen 22 and a perforated aluminum plate 23 containing about 43 percent openings. The gas pattern formed through the pervious diffusion wall varies from 10 FPM (feet per minute) in the center to 40 to 50 FPM along the vertical edge.

The variation in exit velocity from the pervious diffusion wall 20 is accomplished by gas directional vanes such as 25 and 26 and by the manipulation of nonporous blanking material over the diffusion media 21 to direct the air flow to vertical edges as required. The lowest velocity gases are in the pillow area and the higher velocity gases gradually increase as the pattern approaches the lateral edges adjacent to the side port means 17.

As previously mentioned, the primary purpose of this invention is for patients suffering from respiratory illness, such as asthma. Nevertheless, it is within the scope of this invention to arrange the plenum chamber 10 and the canopy 11 and the side shields 12 so that the unit extends longitudinally from head to foot of a patients bed so that the (filtered air) zone extends across the entire mattress.

Referring now to FIG. 3, it has been found that in order to maintain the integrity of the air curtains or air patterns that the velocity of the issuing from the side port means 17 and from the top horizontal port means 15 should be in the range of 100 to 200 feet per minute with a total of about 300 CFM of filtered air exhausting from all outlets in headboard 10.

Good results have been obtained by utilizing ¼ inch diameter jet openings 18 spaced 1 inch on center in side port 17 with the top 25 percent of the holes blocked off. Further, the jet openings 19, supplying horizontal slot 15 are one-fourth inch in diameter located one-half on centers with every third opening closed. Air velocity can also be regulated by increasing or decreasing fan speeds; opening or closing the jet openings 18 or 19 or by other techniques known to the art.

The effectiveness of the invention is well demonstrated by test data measuring the integrity of the

breathing zone **7** while operating in a normal contaminated area. The background of contaminates making up the ambient air surrounding the bed during the test consisted of the following particle counts per cubic of air sampled.

81,000	particles	0.5	microns or larger
18,000	"	1.0	"
800	"	2.0	"

These measurements were made using a Baush and Lomb Counter (40-1) with digital readout.

The test measurements of the contamination level surrounding the open end of the breathing zone **7** were taken by establishing an imaginary grid parallel to the pervious diffusion wall **20** and taking a reading every inch in the vertical and horizontal planes. The grid was first taken one inch from the outer most edge and gradually moved away from the face of diffusion wall **20**. It was determined that the high velocity jet action of the horizontal air pattern from part **15** prevented 0.5 micron and larger particles from entering the breathing zone **7** for almost the full height of the diffusion wall **20** as far as 20 inches downstream from plate **23** along the centerline of the bed. However, as the grid was moved away from the wall **20** particulate matter started to penetrate the vertical air patterns formed by side ports **17** on each side of the bed. The following measurements were taken in the grid plane 17 inches down from the wall **20**. (These figures were chosen since 17 inches provides a more than ample breathing zone for the patient.) All the readings were zero in a zone extending from 2 inches below the top edge of canopy **11** from the center of mattress to 3 inches from the side edge of the bed. All readings 4 inches from the edge of the bed, in an area extending vertically from canopy to 3 inches above the mattress, were zero except for 1 which read 100 particles of a size 0.5 microns and larger. At a height of 3 inches above the mattress particle counts for 0.5 microns diameter particles of 300 to 900 per cubic foot were obtained at the lateral border 8 inches from the edge of the bed. The particle count at mattress level is believed to result from particles shed from the sheet. It should be that the particle counts at 3 inches from the edge of the bed averaged 800 which is far below the ambient level of 81,000 particles per cubic foot.

The same procedure was followed testing for particles having diameters of 2 microns and larger and it was determined that **24** inches downstream from the perforated plate **23**, a zero count was found. This zone extended from 2 inches below the canopy to the top of the mattress with no reading at 1 inch above the mattress. The zone defined by the air patterns, produced by side port **17** and top port **15** are such that the entire center area of the patient breathing zone **7** is essentially completely free of particles of 0.5 micron diameter or above, at a distance of 17 inches from the headboard **10** and completely free of 2 micron and larger particles at a distance of 24 inches from the headboard **10**. Therefore, as previously indicated, essentially all pathogenic organisms will be shielded from a zone extending from 1 to 17 inches away from the headboard and basically all bacteria, pollen and spores will be shielded from the breathing zone, extending for a distance of from 1 to 24 inches, from the headboard **10**. In other words the contamination free zone for 0.5 micron diameter material is 7 inches shorter than the zone for 2 micron diameter material, but in any event is more than ample as a breathing zone for a patient. All of the experiments were run with a side shield **12** in place but without a closure member similar to closure member **16** to direct the air. It was found, however, that it was necessary to extend closure member **16** for 10 inches from the perforated plate **23** to be effective. The canopy **11** extended 14 inches forwardly of headboard **10** while, as previously indicated, the effective contamination free breathing area **7** extended forwardly from 17 to 24 inches.

It is clear, that by providing a canopy **11** with a forwardly extending horizontally disposed port **15** near the forward edge of the canopy and providing port means at the forward edge of the side shields **12** that the effective zone of the mattress could be extended so that when the unit is disposed longitudinally the entire mattress could be isolated from the surrounding environment. Of course, it is also possible to increase the velocity of gases extending from the port means to extend the breathing zone.

By utilization of the relatively low velocity of purified gases the unit runs quietly, drafts are essentially eliminated and the cost of the unit and operating expenses are relatively low.

Many modifications will occur to those skilled in the art from the detailed description here in above given and such modifications are meant to be exemplery in nature and non-limiting except so as to be commensurate in scope with the appended claims.

I claim:

1. Apparatus for providing a filtered gaseous envelope of air for isolating a patient zone from an ambient environmental gaseous medium which comprises: a filtering means, a passage means in communication with said filtering means and said patient zone and a motor driven gas impeller for impelling air through said filtering means and through said passage means;

A. the improvement which comprises:

1. a vertically disposed wall positioned adjacent to said patient zone, the front face of said wall defining a side of said patient zone;
2. a gas pattern forming means in communication with said passage means which comprises:
   a. a pair of spaced port means each being vertically disposed relative to said front face of said wall and each being located in alignment with one or the other of the lateral edges of said front face for providing streams of relatively high velocity air to form the lateral borders of said patient zone;
   b. a canopy extending forwardly over a portion of said patient zone and extending across the top of said wall;
   c. a horizontally disposed port means opening near the forward edge of said canopy for providing a stream of relatively high velocity air to form the upper border of said patient zone; and
   d. a low velocity pervious diffusion wall located within the area defined by said canopy and said vertically disposed port means for producing a stream of low velocity air to form

a zone embodying the center portion of said patient zone.

2. Apparatus, as defined in claim 1, in which said vertically disposed wall is the headboard for a patients bed.

3. Apparatus, as defined in claim 2, in which said headboard contains a plenum chamber in communication with said passage means and with said patient zone.

4. Apparatus, as defined in claim 1, the further combination with said passage means of:

A. a plenum chamber and

B. air directing vanes to direct the high velocity air to said port means and said low velocity air to said low velocity pervious diffusion wall.

5. Apparatus, as defined in claim 1, the further combination therewith of

A. plenum chamber and

B. air directing vanes to direct higher velocity air to the sides of said low velocity pervious wall and lower velocity air to the center of said low velocity pervious wall so as to form a zone of air of variable velocity said zone having a relatively low velocity in its center and a velocity which increases toward its sides.

6. Apparatus, as defined in claim 1, in which said spaced port means comprises a series of gas outlet openings arranged in vertical alignment.

7. Apparatus, as defined in claim 1, the further combination therewith of a pair of gas impervious side shields extending from the ends of said wall forwardly to cover a portion of the lateral edges of said patient zone.

8. Apparatus, as defined in claim 7, in which said port means comprises a nozzle formed by such shield.

9. Apparatus, as defined in claim 8, in which said nozzle is formed by said shield and by a cooperating vertically disposed closure member to form a vertically oriented elongated slit.

10. Apparatus, as defined in claim 1, in which said horizontally disposed port means comprises a nozzle formed by said canopy near its forward edge.

11. Apparatus, as defined in claim 10, in which said nozzle is formed by said canopy and by a cooperating lower closure member to form an elongated slit which extends across said patient zone.

12. Apparatus, as defined in claim 1, in which said pervious diffusion wall is a gas diffusion means.

13. Apparatus, as defined in claim 3, in which said pervious diffusion wall is in communication with said plenum chamber.

14. Apparatus, as defined in claim 13, in which said pervious diffusion wall includes a diffusing media stretched over said wall.

15. The process of providing a filtered gaseous envelope of air to isolate a patient zone from an environmental ambient gaseous medium, which comprises the steps of:

A. providing a source of filtered air;

B. forming a first and second relatively high velocity rectangular gas pattern by projecting filtered air so that the direction of flow of each of said gas patterns project horizontally to form the lateral borders of said patient zone;

1. each of said gas patterns when viewed in cross section relative to the direction of flow having a long major axis and a narrow minor axis in which said major axis is vertically disposed;

C. shielding a portion of the top of said patient zone with a forwardly projecting canopy means,

D. forming a third high velocity gas pattern of air near the forward edge of said canopy means by projecting filtered air forwardly of said canopy means so that its direction of flow is in a horizontal plane so as to form the top border of said patient zone,

1. said third gas pattern when viewed in cross section relative to the direction of flow having along major axis extending horizontally across said patient zone,

E. forming a fourth rectangular gas pattern of filtered air of relatively low velocity within the area defined by said first, second and third pattern, said fourth gas pattern when viewed in cross section relative to its direction of flow having a long major axis horizontally disposed and a relatively wide minor axis vertically disposed, said fourth gas pattern forming the breathing portion of said patient zone.

16. The process, as defined in claim 15, in which said source of air is provided by impelling ambient air through a high efficiency filtering means and thereafter impelling said filtered air to said patient zone.

17. The processes as defined in claim 16, the further step which includes:

A. impelling, said filtered air against air directing vanes so as to increase the velocity of the filtered air going to form the said first and second air pattern.

18. The process as defined in claim 16, the further step which comprises:

A. impelling said filtered air against air directing vanes so as to increase the velocity of filtered air going to form said third gas pattern.

19. The process as defined in claim 16, the further step which comprises:

A. impelling said filtered air against air directing vanes so as to increase the velocity of air toward the lateral edges of said fourth gas pattern so as to form a velocity gradient across said gas pattern, said velocity being lowest at the center of the gas pattern and increasing toward its lateral edges.

* * * * *