United States Patent [19]

Marsh

[11] **3,774,522**

[45] **Nov. 27, 1973**

[54] **MODULAR CLEAN ROOM ENCLOSURE**

[75] Inventor: **Robert Claude Marsh,** Albuquerque, N. Mex.

[73] Assignee: **Bio-Dynamics, Inc.,** Castleton, Ind.

[22] Filed: **Mar. 10, 1972**

[21] Appl. No.: **233,453**

[52] **U.S. Cl.** ..... **98/33 R,** 98/115 SB

[51] **Int. Cl.** **F24f 9/00**

[58] **Field of Search** ..... 98/36, 33, 115 SB; 128/1 R, 1 B; 55/DIG. 29

[56] **References Cited**

UNITED STATES PATENTS

3,570,385	3/1971	Heisterkamp et al.	98/40 D
3,256,384	6/1966	Lindgren	55/DIG. 29
2,875,680	3/1959	Forshee	98/115 SB

OTHER PUBLICATIONS

The Farr DF/48 Clean Booth, Product Data Sheet, May 5, 1965.

Laminar Flow Clean Room Handbook; Boyd Agnew, Jan. 1966, pages 2, 20 & 40.

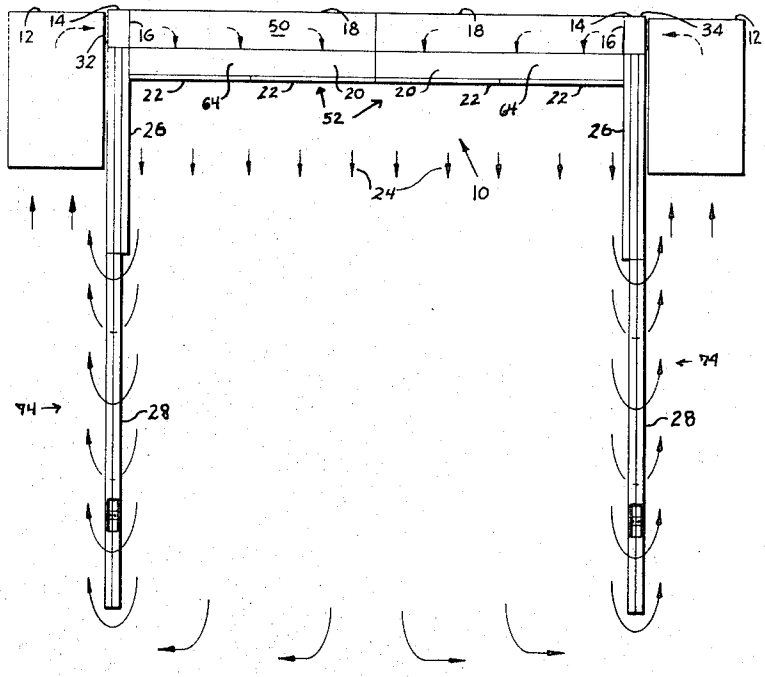
Primary Examiner—William E. Wayner

Attorney—Woodard, Weikart, Emhardt & Naughton

[57] **ABSTRACT**

A portable, modular room enclosure having an open end providing horizontal, contaminant-free tunnel type laminar flow for surgery or the like includes mobile means for generating an air flow demountably connected to said enclosure, air supply means in the unit in communication with the air flow generating means for receiving the air flow and converting it to a contaminant-free horizontal laminar flow within the enclosure toward the open end, first and second partitions forming side walls of the enclosure, wherein each partition is demountably connected at one end to said air supply means and at least one retractable side panel slidably mounted on a track connected to each partition wherein the track and panel are in parallel relation with the partition. By extending or retracting the side panels the length of each partition may be selectively changed to accommodate the needs of a surgery theater or the like.

1 Claim, 9 Drawing Figures



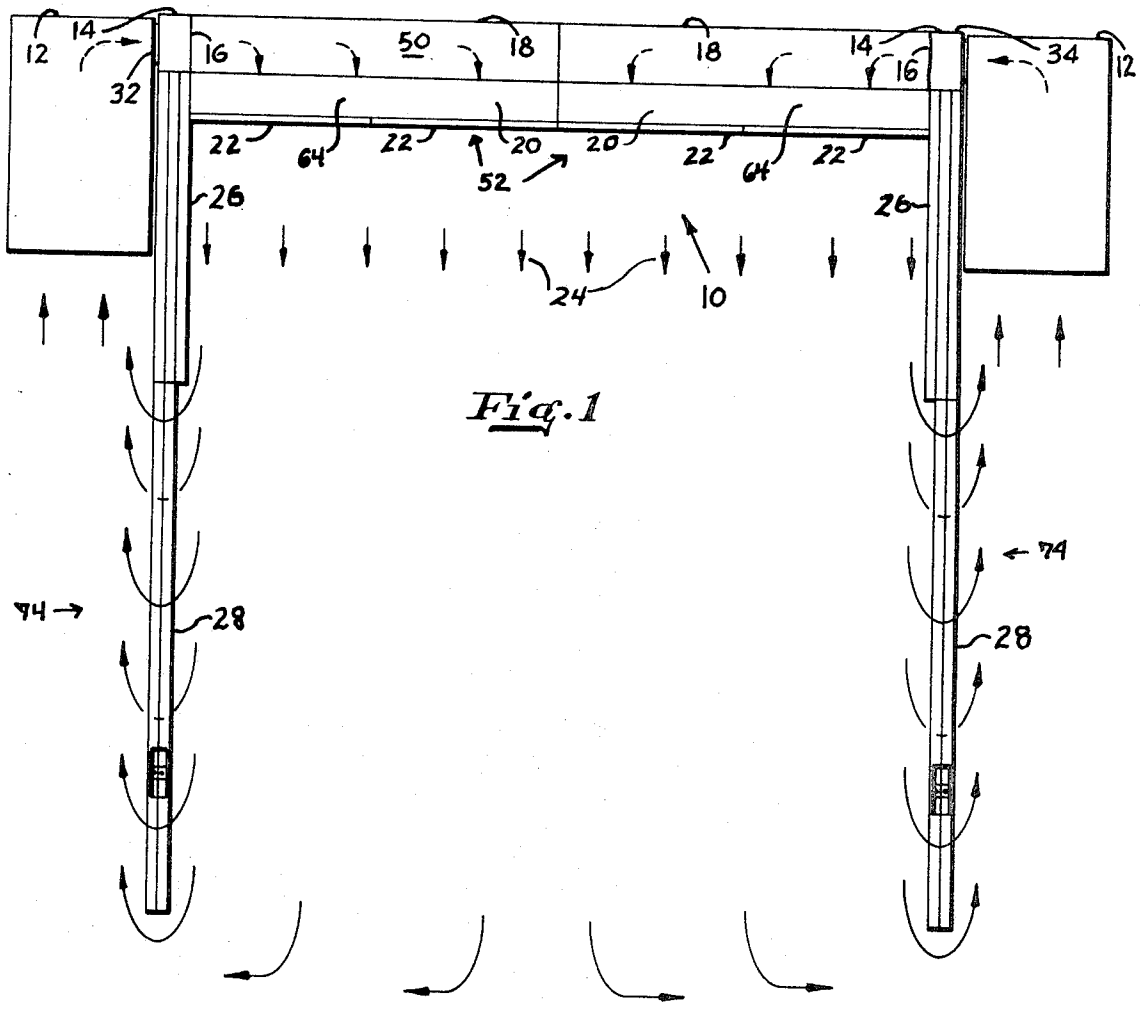

12
14
32
16
50
18
18
14
16
34
12
22
64
22
20
52
20
22
64
22
26
26
24
10
74
74
28
28

Fig. 1

Fig. 2

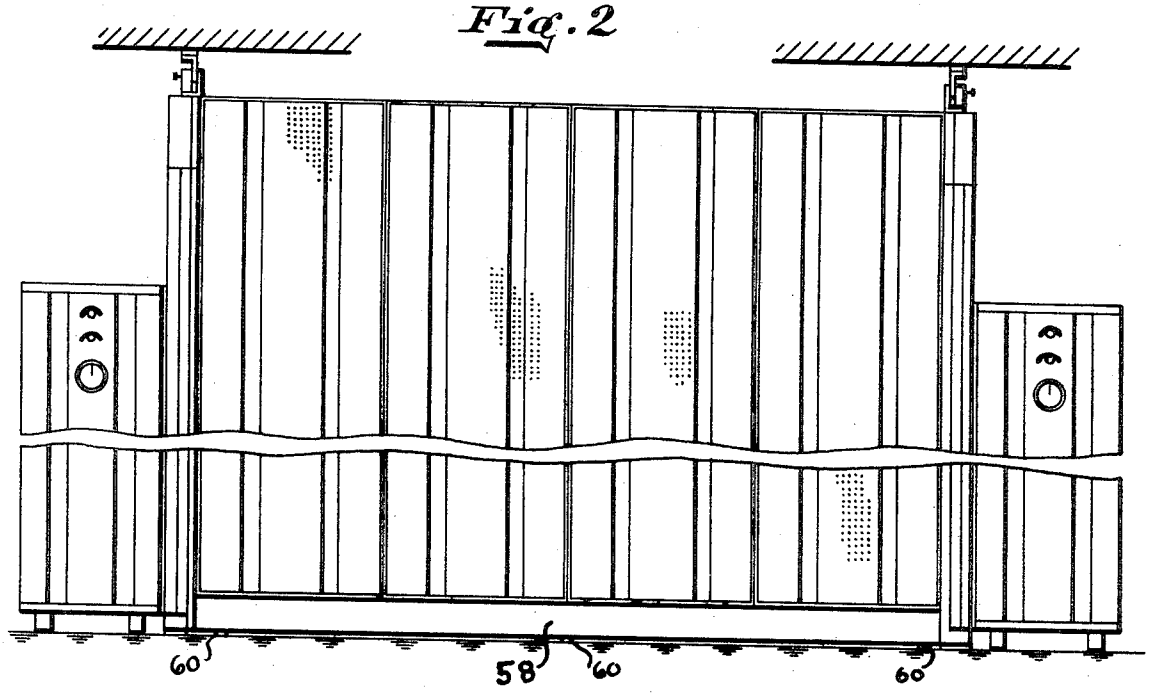

66
66
60
58
60
60

Fig. 3

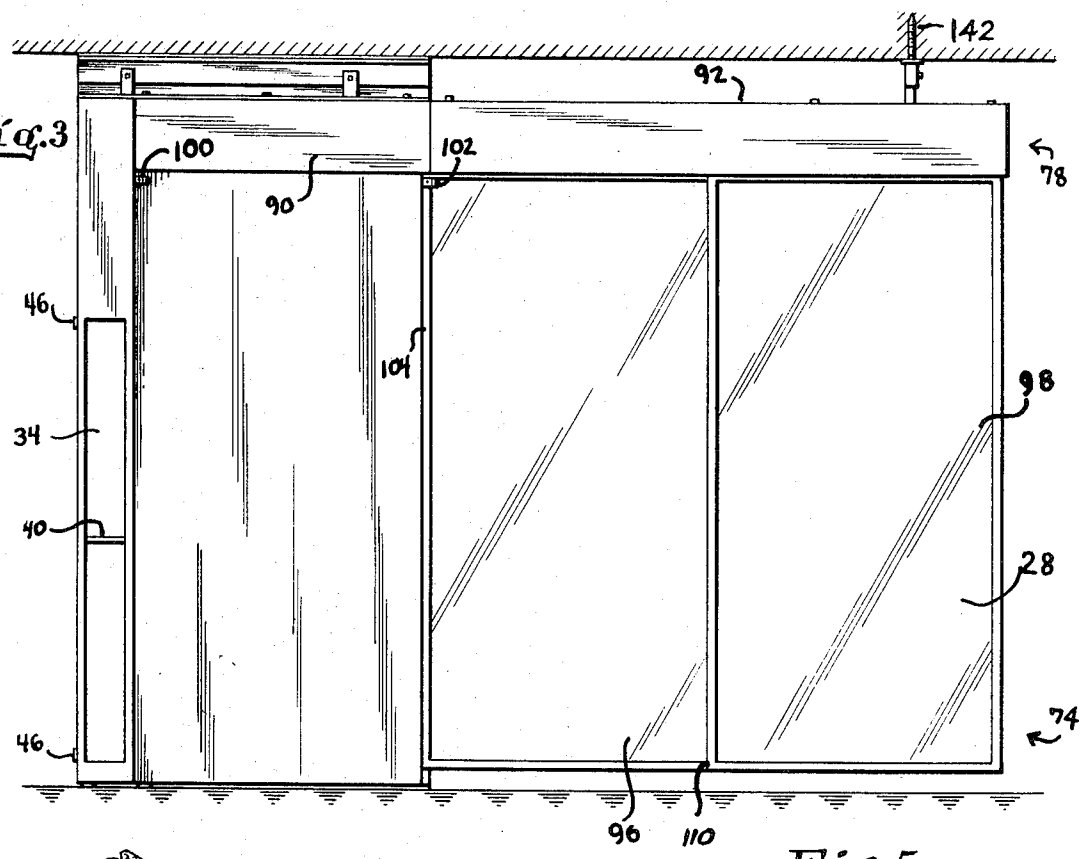


Fig. 4

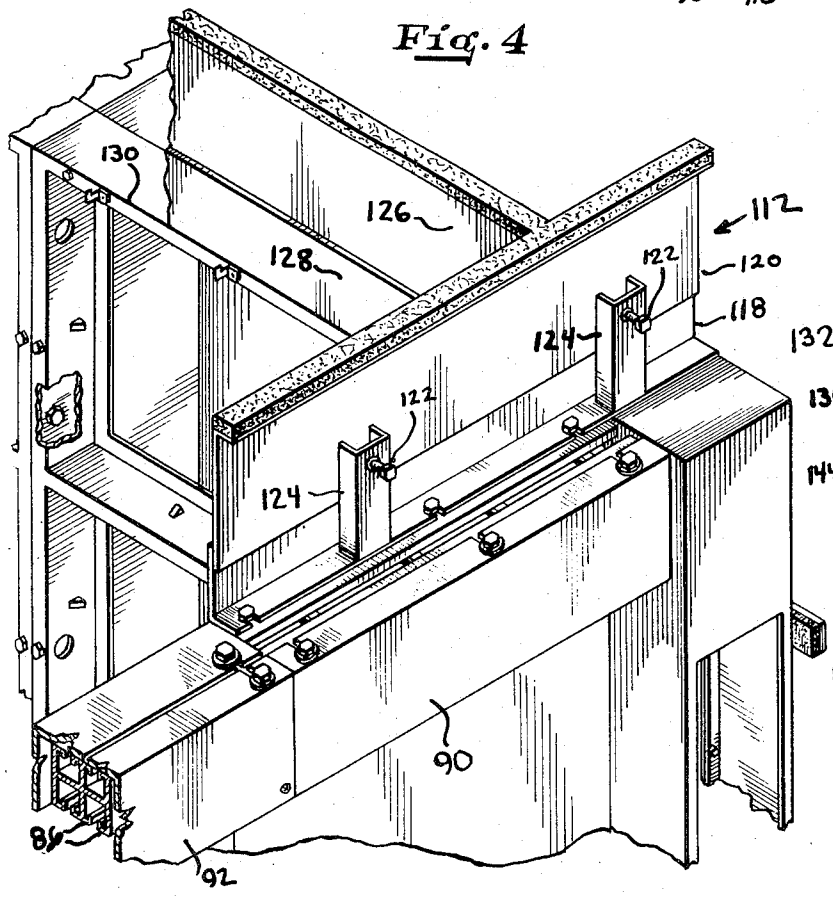


Fig. 5

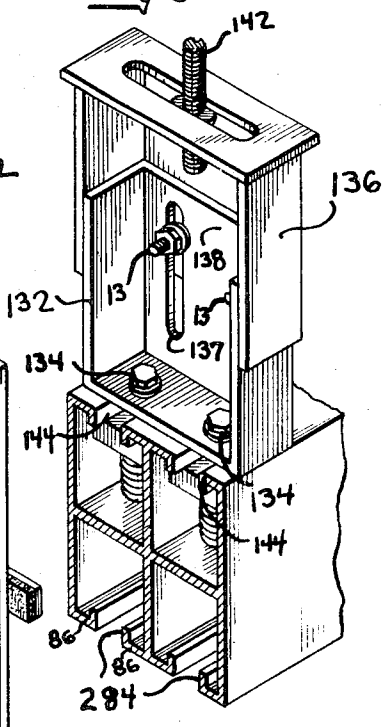


Fig. 6

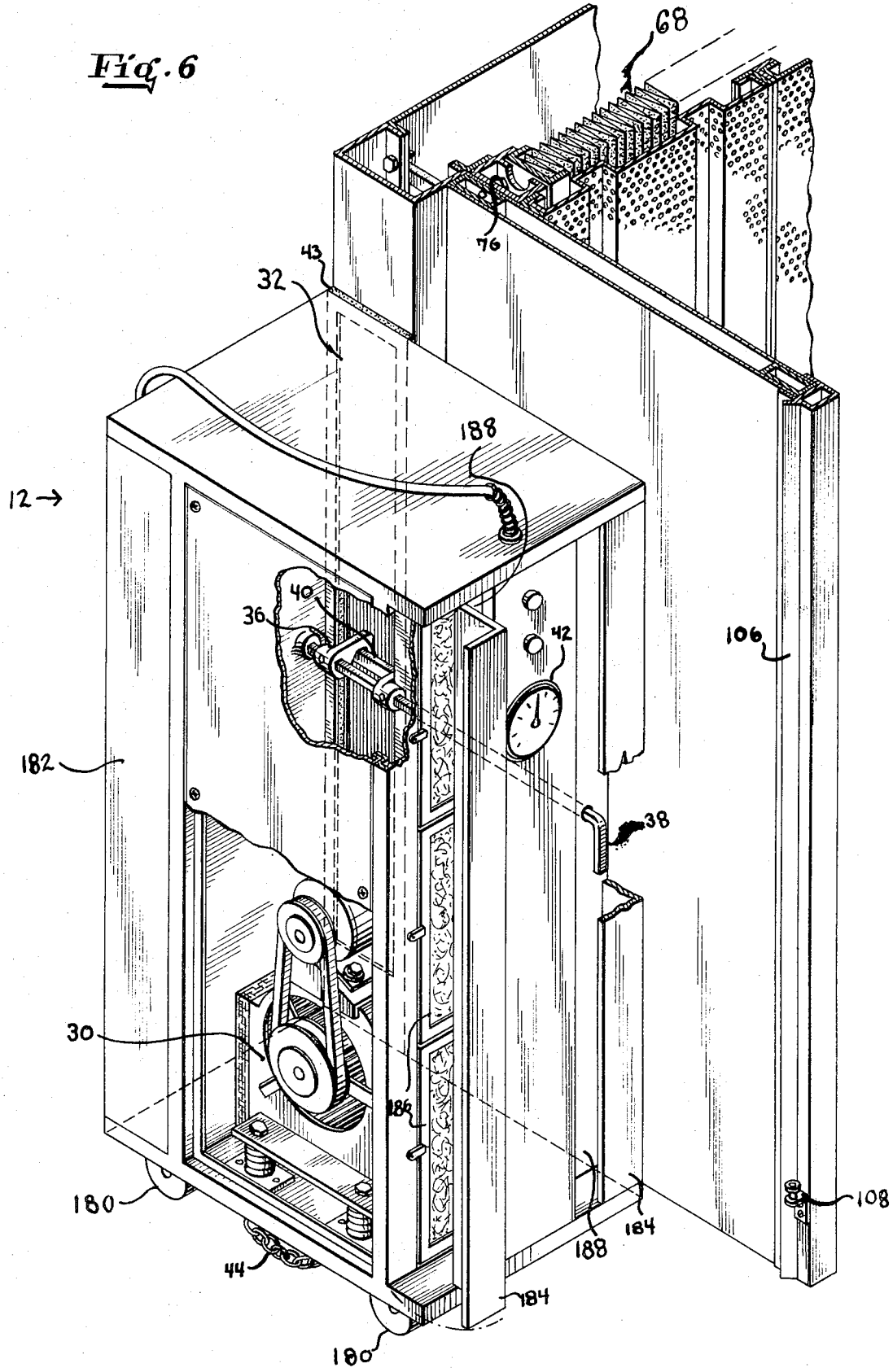

68
76
43
32
188
12
40
36
42
106
182
38
30
186
180
108
44
184
188
184
180

Fig. 7

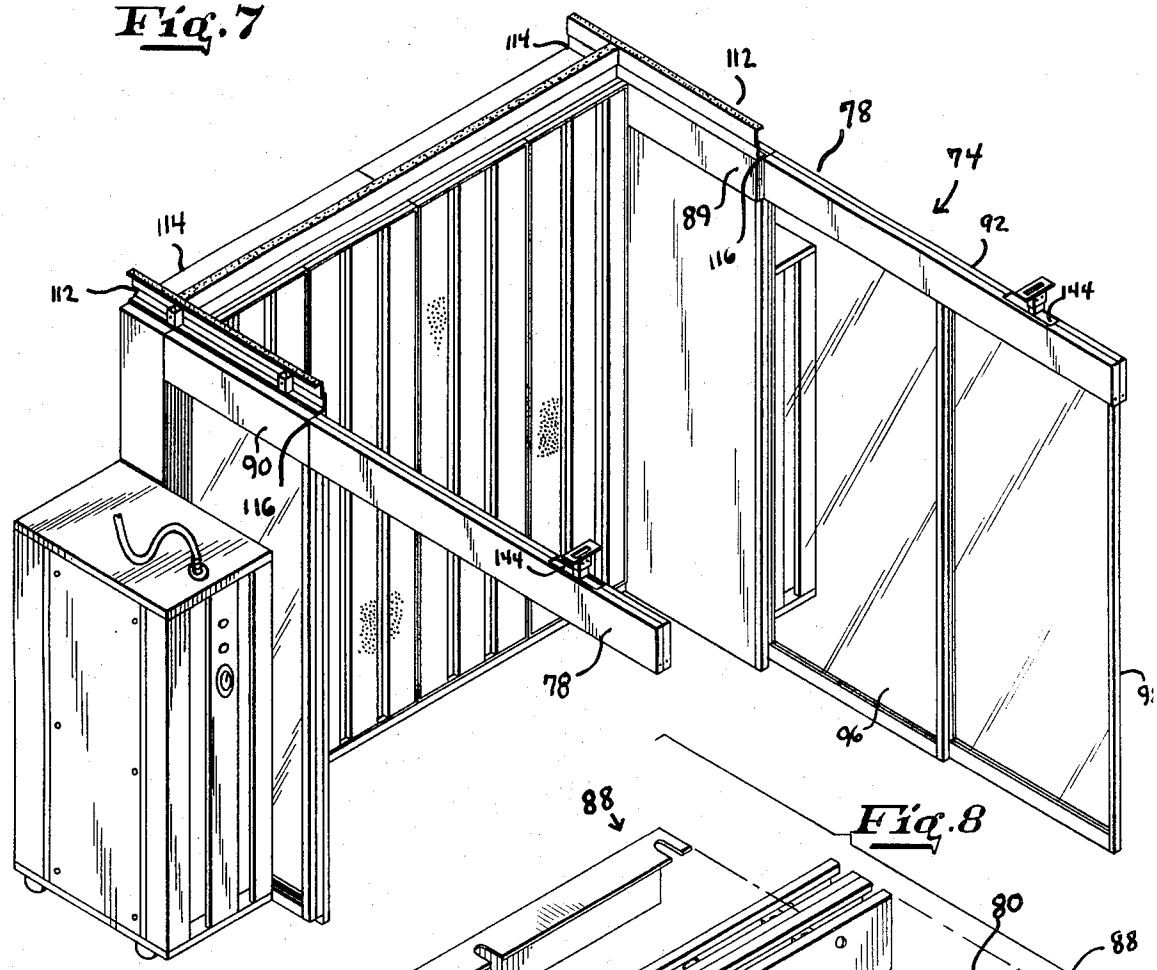


Fig. 8

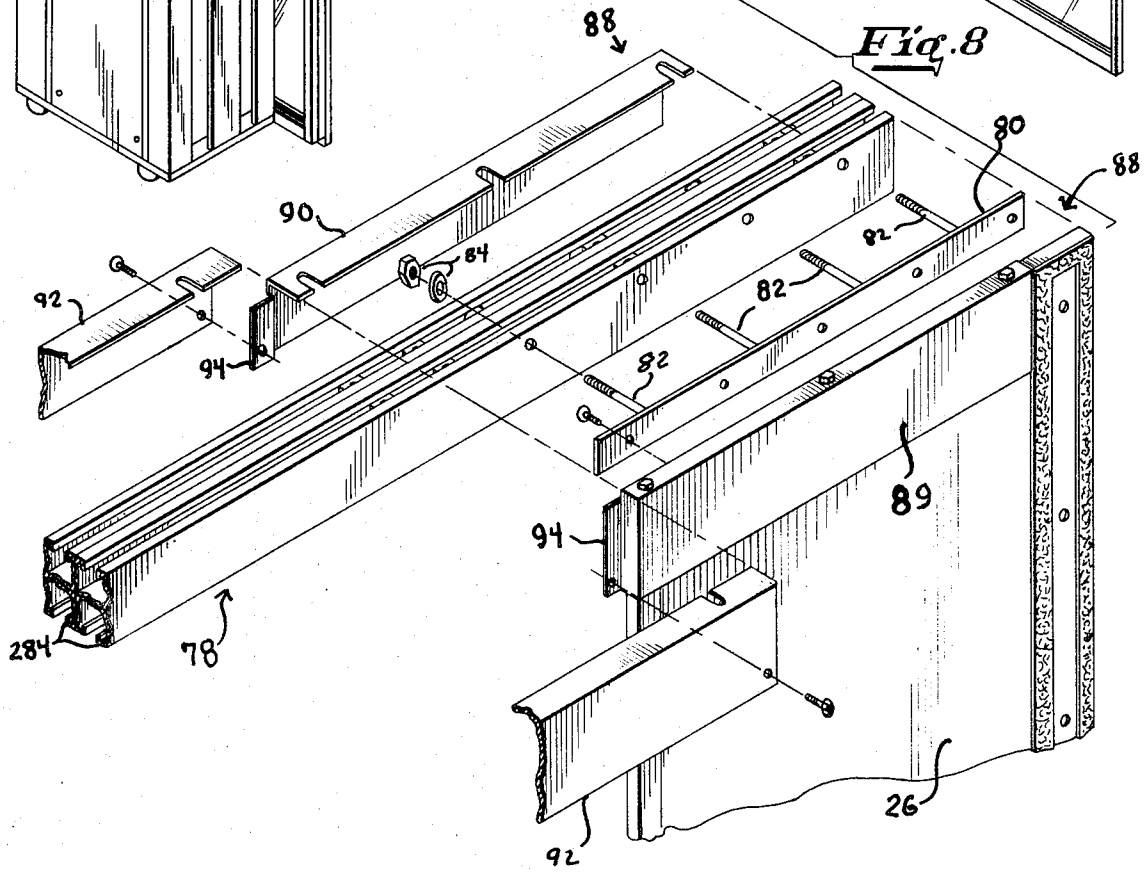
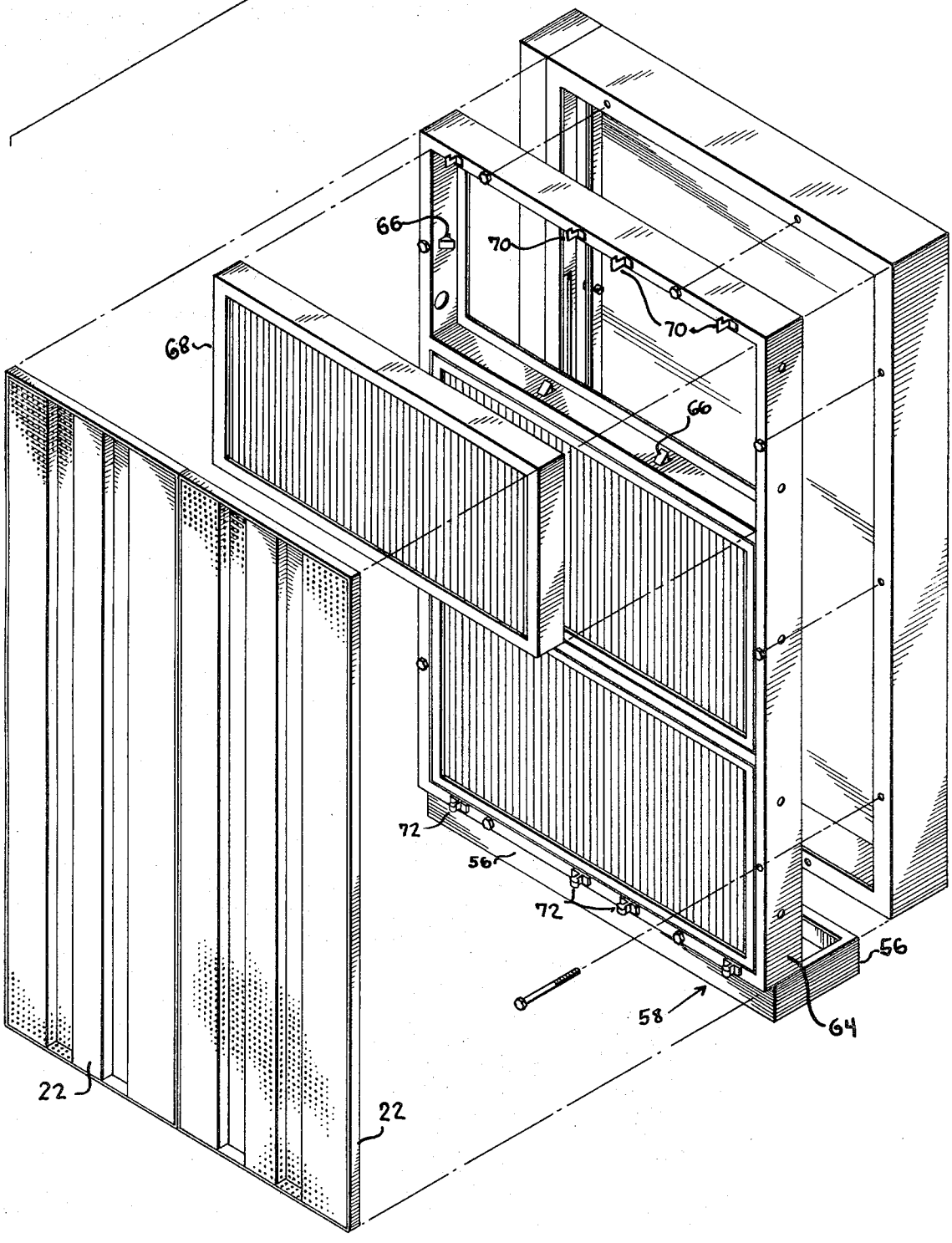


Fig. 9



MODULAR CLEAN ROOM ENCLOSURE

BACKGROUND OF THE INVENTION

The invention relates to a portable clean room and, in particular, to a surgery isolator as a movable, clean room enclosure providing a sterile, pathogen-free environment for surgical operations needing sepsis control.

Infection of surgical wounds and microbial complications in other hospital treatment areas still persist despite great advances in antiseptics during the past century. Additionally, modern implant and transplant surgery and such specialized treatment as chemotherapy often place fatal significance on hospital acquired sepsis. Airborne contamination control has always been recognized as vital in controling cross-infection within the hospital and is one of the first steps in the overall sanitation program. Recently the requirements for ultra-clean or sterile assembly environments in the nuclear or space exploration industries have lead to the development of "clean rooms" which can virtually eliminate the environment as a source of airborne infection.

Contemporary clean rooms are permanent structures generally entered through air lock or the like and, as such, are not compatible with hospital surgery problems. Operating theaters and surgery rooms require special equipment, such as X-ray equipment, gas fixtures and special operating lights. Therefore, a permanent clean room enclosure is not feasible for a hospital as the requirements for a clean room will not be needed for every operation. Accordingly there has developed a need for a portable enclosure for use with existing ceilings and fixtures in an operating theater which will provide a clean room environment for operations.

As employed in the present application the term clean room denotes a facility especially designed to create an atmosphere substantially free of particles. For this purpose a maximum particle concentration of 100 particles per cubic foot 0.5 microns and greater in size, is required. The term laminar flow clean room as employed in the application is directed to an enclosure or room formed by a bank of high efficiency particulate air filters on one entire wall wherein air is introduced to the enclosure through the filter at a rate of from about 70 to 110 feet per minute. Conventional high efficiency particulate air (HEPA) filters have a minimum efficiency of 99.97 percent for particles as small as 0.3 microns in size.

SUMMARY OF THE INVENTION

It is, therefore, a primary object of the invention to provide a portable, modular enclosure for use in operating theaters or the like which permits use of existing facilities and permits free access for operating personnel.

It is another object of the invention to provide a modular clean room enclosure having externally mounted support equipment to provide maximum available space within the enclosure.

It is an additional object of the invention to provide a modular clean room which is readily converted into a conventional operating theater, as desired.

It is yet another object of the invention to provide a modular clean room which is freely open to personnel without the need for air locks or the like.

It is a further object of the invention to provide a portable surgery isolator whose length may be varied within predetermined limits in order to adjust to the needs of different operations.

The above and other objects are met in a portable modular room enclosure having an open end providing horizontal, contaminant free, tunnel type laminar flow for surgery or the like which includes mobile means for generating an air flow demountably connected to the enclosure. Air supply means in the unit is in communication with the air flow generator and receives the air flow and converts it to a contaminant-free horizontal laminar flow toward the open end of the enclosure. First and second partitions form side walls of the enclosure. Each partition is demountably connected at one end to the air supply mechanism. At least one retractable side panel is provided which is slidably mounted on a track, wherein the track is connected to the partition. The track and panel are mounted in parallel relation to the partition for selectively extending the length of the position.

In one embodiment the modular enclosure includes a mounting base having adjustable leveling feet. First and second air plenums, each plenum having a side opening and a front opening are adjacently seated on the mounting base. First and second filter frame supports are bolted respectively to the first and second air plenums. Each frame support carries a plurality of individual framed high efficiency particulate air filters in snap locking engagement with the filter frame support. Each bank of HEPA filters is protected by a pair of punched screens latched onto the frame support.

An air tower is provided on each side of the air plenum. Each air tower is equipped with a prefilter and blower for generating an air flow into the plenum.

The sides of the portable clean room are formed by a pair of enclosure panels attached to the side of a filter frame unit and singly anchored to the ceiling. Each enclosure panel is provided with a pair of sliding glass door panels suspended from the floor. The glass door panels permit individual adjustment of the sides of the isolator module.

If necessary, adjustable ceiling filler panels are provided on each side enclosure wall and the filter frame support unit to prevent contaminated air from entering the isolator immediately forward of the HEPA filter bank.

Substantial significant advantages are obtained by the isolator. The isolator is readily set up in existing operating theaters making use of existing ceilings and permitting use of existing lighting facilities, X-ray facilities, outlets and fixtures. Ready access through the opened end of the isolator is available without disturbing the integrity of the clean room environment. All available space within the clean room enclosure is utilizable as the mechanical and electrical support equipment remains outside the enclosure. If a clean room is not needed the sliding glass sidewalls are retracted into the enclosure panel.

The adjustable ceiling filler panels permit the unit to be set up in rooms of varying heights within certain limits. Power cords, gas supply cords and monitoring circuit cords readily pass under the sliding doors. The transparent side panels permit a large audience to view the operating theater within the room without the danger of cross-contamination.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate a somewhat preferred embodiment of the invention in which:

FIG. 1 is a top plan view of the modular enclosure or isolator illustrating the laminar flow of air through the unit;

FIG. 2 is a front view of the unit from the open end of unit toward the filter bank;

FIG. 3 is a side view of the isolator with the corresponding air tower removed and diagrammatically illustrating the ceiling anchor for the side wall;

FIG. 4 is a fragmentary, perspective view of a corner of the isolator illustrating the adjustable filler panels;

FIG. 5 is an enlarged fragmentary view showing a ceiling hanger bracket;

FIG. 6 is a partial sectional view of an air tower of the unit adjacent the side panel of the unit with the retractable glass sliding panel removed;

FIG. 7 is a perspective view of the isolator with one pair of glass doors retracted to the side wall;

FIG. 8 is a fragmentary, exploded view illustrating the connections between the track assembly carrying the sliding glass doors and the side wall panel; and

FIG. 9 is an exploded view of a filter wall and air supply plenum of the unit.

DESCRIPTION OF PREFERRED EMBODIMENTS

As illustrated in FIG. 1 modular enclosure or isolator **10** has associated therewith a pair of air towers **12** for generating an air flow into the unit. Each air tower is mechanically connected to a plenum extension panel **14** to provide an air way into the unit. Air passing through the plenum extensions is received through the side openings **16** of air plenums **18.** Each said air plenum **18** opens into a bank **20** of high efficiency particulate air filters. Each bank is protected by a pair of abutting perforated screens **22.**

The wall of contaminant-free, laminar flow air represented by the solid line of arrows **24** in FIG. **1** is bounded and shaped by a pair of solid stationary partitions **26** connected to the sides of filter bank **20.** One pair of sliding glass door panels **28** is mounted to the exterior wall of each of the partitions **26.** The bottom of the sliding glass door panels is suspended above the floor to permit air and power lines and the like to extend under the door panel. Air also passes over the tops of the door panels as well as from the end of the isolator **10.** The aforesaid air passages are denoted by arrows in FIG. **1.** This ultra clean air gently sweeps across the enclosure area removing all airborne contaminants generated therein and also provides a positive barrier against particles from the surrounding environment.

As particularly illustrated in FIG. **6** air tower **12** is a self-contained mobile unit carried by a set of adjustable casters which provide a leveling adjustment to compensate for any possible uneven floor. Casters **180** are spaced at each corner of the air tower. Tower **12** is formed from a rectangular shell **182.** On the face of the shell are a pair of elongated hinged corner panels **184** which provide access for a set of three vertically mounted prefilters **186,** one set of prefilters to each panel. A pair of elongated slots **188** on the face of the air tower provides an intake for the prefilters.

A pair of stacked blowers **30** draw air into the air tower and exhaust the air into an elongated rectangular discharge orifice **32.** The blowers are shock mounted to reduce vibration.

Air is discharged from the air tower to discharge orifice **32** into a matched intake orifice **34** in plenum extension panel **14.** In order to provide a positive but detachable mechanical connection between air tower **12** and plenum extension panel **14** a rotatable mechanical latching knuckle **36** is provided adjacent discharge orifice **32.** The knuckle is operated by means of crank **38** located on the face of the air tower. Latch knuckle **36** cooperates with horizontal bar **40** which is spaced across plenum extension intake orifice **34.**

Air tower **12** also contains gauge **42** for measuring air flow velocity and indicates a malfunction should one or both blowers fail to operate properly. A ground chain loop **44** below air tower **12** provides a ground to the conductor floor of the operating theater. In order to provide a more positive and air tight seal between the air tower and plenum extension panel **14** a resilient, preferably Neoprene gasket **43** is provided about the periphery of discharge opening **32.** As illustrated in FIGS. **3** and **4** in order to properly align air towers **12** with plenum extension panels **14** there are provided a pair of docking stops **46** mounted at the top and bottom edges of intake orifice **34.** As seen in FIG. **4** the stops extend outwardly from the back edge of the extension panels **14** and engage the rear panels **48** of air towers **12.**

The isolator air supply and filter modules are shown in FIGS. **1, 2, 6, 7** and **9.** Air supply module **50** is formed from plenum extension panels **14** and plenums **18.** Filter module **52** is formed from filter bank **20** and protective screens **22.** Air supply module **50** and filter module **52** are seated on the walls **56** of mounting base **58.** Mounting base **58** is a rectangular frame containing six spaced apart leveling feet **60** as shown in FIG. **2.** After the base has been leveled it is preferred to employ a rubber or Neoprene gasket to seal the bottom of the mounting base to the floor. A pair of rectangular air plenums **18** are seated side to side along the length of mounting base **58.** Each plenum consists of a generally rectangular frame with a solid rear and open front face. There is provided a side opening **16** in each of the plenum frames to receive air passed from plenum extension panels **14** which is bolted on to the plenum. Air plenums **18** are each bolted to mounting base **58.**

Filter module **52** is formed from a pair of filter frame support units **64** bolted together side to side as illustrated in FIG. **9.** If necessary a silicone sealant is provided between the bottom of each filter frame support and the mounting base to provide an air tight seal therewith.

Each filter frame is divided into three compartments for retaining framed HEPA filters. For this purpose a spring loaded clamping mechanism **66** is provided for each compartment. When necessary each framed HEPA filter may be easily removed from the unit and replaced. Conventional framed HEPA filters **68** are provided for each filter frame compartment, wherein each filter is adapted to remove all particulate matter 0.3 microns and larger with an efficiency of 99.97 percent.

A pair of rectangular perforated screens **22** are latched to the front of each frame support **64.** The perforated screens protect the HEPA filters and also indicate damage to them. For present purposes it is preferred to employ perforated aluminum screens having

a 30 percent open area. A workable screen contains openings approximately 0.06 inch in diameter. The screen is preferably about 1/16 inch thick. As shown in FIG. 9 latches 70 are provided on the upper face of frame support 64 and cooperate with mounting hooks (not shown on the screen) to anchor the screen to the frame support. Further, a series of spaced apart tongues 72 are provided along the base of each frame support to cooperate with tongue receiving grooves to further anchor the screens.

The screens cooperate with the filter bank to provide a unidirectional laminar flow pattern directed toward the open end of the isolator and at preferred velocity of from 70 to 110 and particularly 90 feet per minute.

The modular side enclosure units 74 are illustrated in FIGS. 3–8. Each enclosure includes a solid aluminum partition 26 which is preferably caulked or sealed with a silicone sealant to the floor of the operating theater. As shown in FIG. 6 each partition is bolted 76 to a side edge of frame support 64. In order to carry glass door panels 28 each said partition is provided with a track assembly 78. FIG. 8 illustrates the mounting of track assembly 78 to partition 26. An elongated stud plate 80 is bolted or screwed to the outside upper wall of the partition.

Four elongated threaded bolts 82 project horizontally from stud plate 80. Each track assembly has a complimentary pair of pre-punched holes for capture by each said bolt. A nut and washer 84 are employed to anchor each bolt on the track assembly.

As illustrated in FIG. 5 track assembly 78 contains four extruded rectangular compartments. The parallelly aligned bottom compartments 284 are each provided with a pair of opposed channels 86 adapted to receive the rollers associated with a conventional sliding door assembly.

For aesthetic purposes it is preferred to employ a pair of closure plates 88 to cover the track assembly. As shown in FIG. 8 rear inside closure plate 89 is bolted to partition 26. Outer closure plate 90 is bolted to track assembly 78.

A second pair of closure plates 92 cover the assembly beyond the partitions. The ends of closure plates 92 are screwed or bolted to mating flanges 94 on closure plates 88.

As illustrated in FIGS. 1, 3, 6 and 7 a pair of conventional glass door panels 28 are hung on track assembly 78. Doors 28 are preferably suspended about 3 inches off the floor so that operating room power lines, gas lines and the like may pass safely thereunder. Each glass door panel assembly has a pair of parallelly aligned glass doors consisting of inner door 96 and outer door 98. A bumper 100 is provided to arrest the movement of inner door 96 adjacent plenum extension 14. Bumper 100 faces inner door 96 and is screwed to partition 26. A similar bumper 102 is screwed to the outer frame 104 of inner door 96 and serves to arrest the movement of outer door 98 as it is retracted.

As illustrated in FIG. 6 in order to arrest the movement of inner door 96 as it is moved from its position of rest adjacent panel 96 and moved towards a furthest extended position, an ENTERLOCK extrusion wing 106 is provided at the end of partitions 26. A mating wing is provided on the inside rear edge of inner door 96. Similarly, an extrusion wing is provided on the forward outer edge of inner door 96 which is adapted to mate with an extrusion wing on the inside rear edge of outer door 98. In order to provide a further positive arrest for the outward movement of the sliding doors a closure plate is screwed across the ends of the track assembly (not shown).

In order to prevent scraping of the doors during opening and retraction a partition mounted roller guide 108 is provided to ease movement between the inner door and partitions. Similarly, a roller guide is provided on the lower forward edge 110 at inner door 96 to prevent scraping between the inner and outer doors.

In order to provide an air tight seal between the ceiling of the operating room, the air supply module and the side partitions 26 filler panels are employed. Turning now to FIGS. 4 and 7 there is shown a pair of partition mounted side filler panels 112. Each side filler panel extends from the rear edge 114 of each plenum 18 to the forward edge 116 of each partition 26. Each filler panel 112 is formed from a lower L-shaped bracket bolted to the top of partition 26 and an upper inverted L-shaped bracket 120 which is frictionally mounted to lower bracket 118 by means of set screws 122. Upper bracket 120 is adapted to frictionally slide along the outer surface of lower bracket 118 until the upper bracket engages the ceiling. At this point set screws 122 are engaged. A pair of upright extrusions 124 provide mounting brackets for the set screws.

A Neoprene gasket is provided along the upper ledge of upper bracket 120 to provide an air tight seal with the ceiling.

In similar fashion an upper 126 and lower 128 filler panel is provided along the inner edge 130 of frame supports 64. A sealing gasket is provided along the upper ledge of the upper filler panel 126 of the blank-off.

In order to support the weight of the glass doors in the extended position it is preferred to employ a track assembly mounted hanger bolt, as illustrated in FIGS. 3 and 5. For this purpose a bottom hanger bracket is screwed into the top compartments of track assembly 78 by means of machine screws 134. An inverted U-shaped top hanger bracket 136 is slidably engaged along the rear wall 138 of lower bracket 132. For this purpose a pair of complimentary slots are provided in top and bottom hanger brackets 132, 136. A pair of screws 13 extend through the mating slots and the height of top hanger bracket 136 is adjusted by selectively tightening the nuts on the screws in the desired position.

The top of top hanger bracket 136 contains a slot elongated in direction perpendicular to the mating slots 137 in the respective hanger brackets. For mounting purposes a hanger bolt 142 is driven into the operating room ceiling and permitted to extend the preselected distance below the ceiling. The hanger bolt is captured by the slot in top hanger bracket 136 and is engaged thereunder by a nut.

To assemble the surgery isolator mounting base 58 is moved to a preselected portion section of the operating theater and, if necessary caulked or sealed to the floor. Depending on the length of the track assemblies a hanger bolt 142 is driven into the ceiling for capture by the respective hanger brackets. Air supply plenums 18 are bolted to the mounting brackets and plenum extensions 14 are bolted to the respective ends of plenum 18. With the air supply module 50 assembled, the filter module is then erected by bolting the frame support 64 to the air plenums 18. Next the partitions 26 are bolted

to the filter support **64.** The individual HEPA filters **68** are snapped into the respective filter support compartments and the perforated screens **22** are latched onto the front of the frame supports. The track assembly and sliding doors are then bolted to the respective side partitions. To support the track assembly lower hanger bolt bracket **132** is slid along an extruded track **144** on track assembly **18.** When the hanger bolt **142** is suitably aligned a pair of screws extending through the lower hanger bolt bracket are tightened locking the bracket onto the track assembly. The top hanger bracket is vertically adjusted until the hanger bolt extends through the slot in the top plate and then a nut is selectively tightened beneath the slot to capture the hanger bolt.

Next, the side and top mounted ceiling filler panels are vertically adjusted until they are in sealing engagement with the operating room ceiling. Silicone sealant is then applied to the juncture between the top of the frame support unit and mounting base. Next, air towers **12** are individually aligned with docking stops **46** on plenum extension **14.** After alignment crank **38** on each of the air towers is actuated and mechanical latch knuckle engages plenum bar **40** locking each respective air tower to the plenum extension.

In general it is preferable to employ strong, rigid but lightweight metals for the modular units. Aluminum is a preferred material. Preferably all components are desired to passed through a standard doorway. If desired an additional air intake may be employed on top of the air tower.

While the preferred embodiment of the invention has been illustrated hereinabove it will be obvious to those skilled in that art that various modifications can be made in materials, size and mounting arrangements within the spirit of the invention. The invention is not to be limited except as set forth in the following claims.

I claim:

1. A portable modular room enclosure having an open end providing horizontal contaminant-free tunnel type laminar flow for surgery or the like comprising:

a. mobile means for generating an air flow demountably connected to the said enclosure;

b. air supply means in said unit in communication with said air flow generating means for receiving said air flow and converting said flow to a contaminant free, horizontal laminar flow within said enclosure toward said open end;

c. first and second partitions forming side walls of said enclosure, each partition demountably connected at one end to said air supply means; and

d. at least one retractable side panel, slidably mounted on a track connected to each said partition, said track and panel in parallel relation with said partition for selectively extending the length of each said partition.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,774,522 Dated November 27, 1973

Inventor(s) Robert Claude Marsh

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

Column 2, line 20, "position" should read -- partition --. Column 7, line 8, "18" should read -- 78 --. Column 8, after line 28 insert the following claims:

2. The enclosure of claim 1 and further comprising at least one adjustable filler panel rigidly attached to a top portion of each of said partitions and extending to a ceiling.

3. The enclosure of claim 2 in which said mobile means for generating an air flow comprises:

a shell having intake and exhaust openings therein;

a prefilter mounted over each said intake opening; and

blower apparatus mounted within said shell to draw air into said shell and exhaust the air into said air supply means.

4. The enclosure of claim 3 in which said air supply means comprises:

a high efficiency particulate air filter apparatus mounted in a frame;

a plenum having an output opening coupled to said filter apparatus and having an input opening; and

a plenum extension panel having an output coupled to the input opening of said plenum and having an input coupled to the exhaust opening of said shell.

5. The enclosure of claim 4 in which said retractable side panel is slidably mounted on a track, said track and panel in parallel relation with said partition.

6. The enclosure of claim 5 and further comprising at least one adjustable filler panel rigidly attached to a top portion of each of said partitions and extending to a ceiling.

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,774,522 Dated November 27, 1973

Inventor(s) Robert Claude Marsh

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

On the cover sheet, "1 Claim" should read

-- 6 Claims --.

Signed and sealed this 20th day of August 1974.

(SEAL)
Attest:

McMCOY M. GIBSON, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
☆ U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.