United States Patent

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[54] **MODULAR PANEL SYSTEM FOR CLEAN ROOM**
1 Claim, 5 Drawing Figs.

[52] **U.S. Cl.** **98/32,**
98/40, 55/484, 240/47
[51] **Int. Cl.** **F24f 3/16**
[50] **Field of Search** 98/40
(DL), 40 (D), 33, 32; 240/47; 55/484

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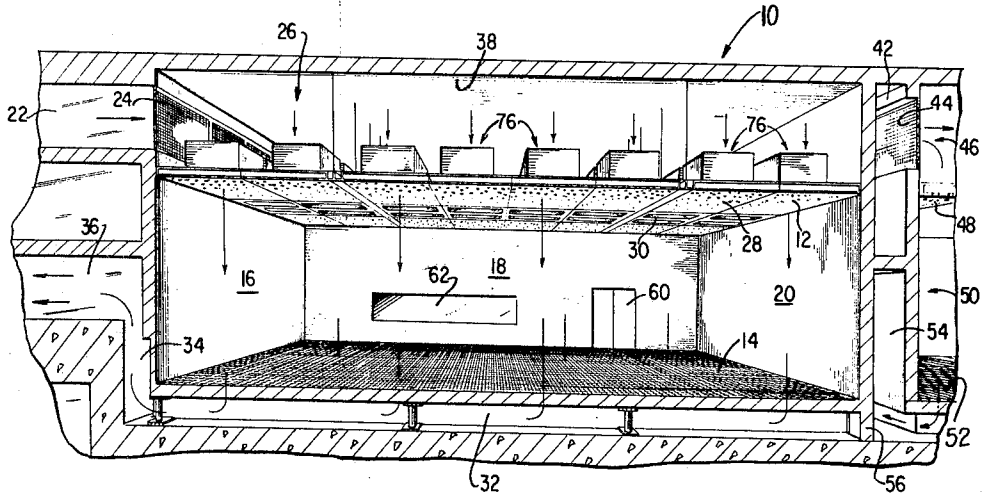
ABSTRACT: The disclosure is directed to a clean room design which has a uniform vertical laminar air flow pattern and which will provide a Federal Standard No. 209A, Class 100, environment in sterile gowning areas, around high-speed parenteral drug-filling apparatus, and in like environments. The disclosure is also directed to modular lighting panel designs for use in such a room. A basic modular panel is made up of a frame supporting a perforated panel on the outlet side and an absolute filter on the inlet side. A transition piece connects the filter to the frame, the perforated panel having a substantially larger area than the filter. The modular lighting panels utilize foraminous lenses so selected and located with relation to each lighting unit as to pass substantially the same volume of air per unit time as other modular panels used in the room.



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2 Sheets-Sheet 1

FIG. 1

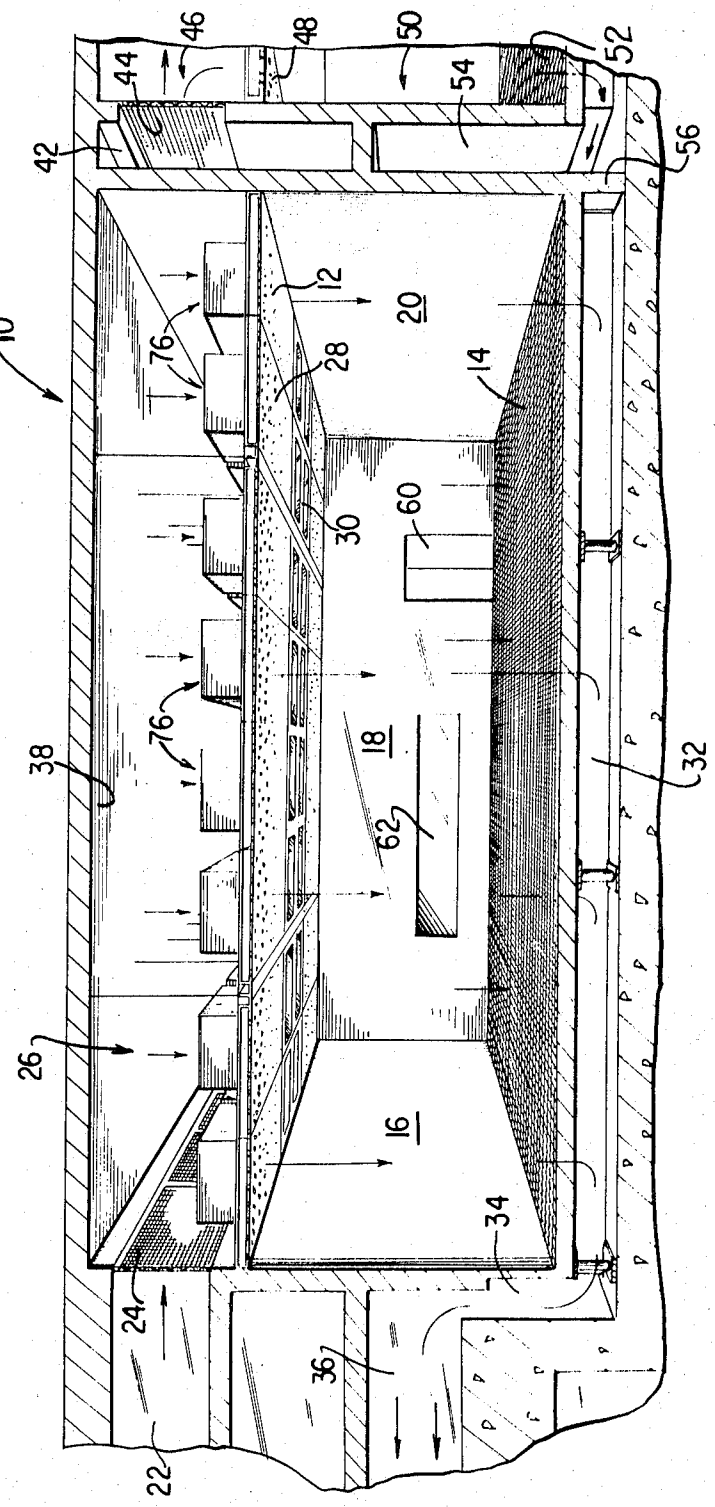

FIG. 2

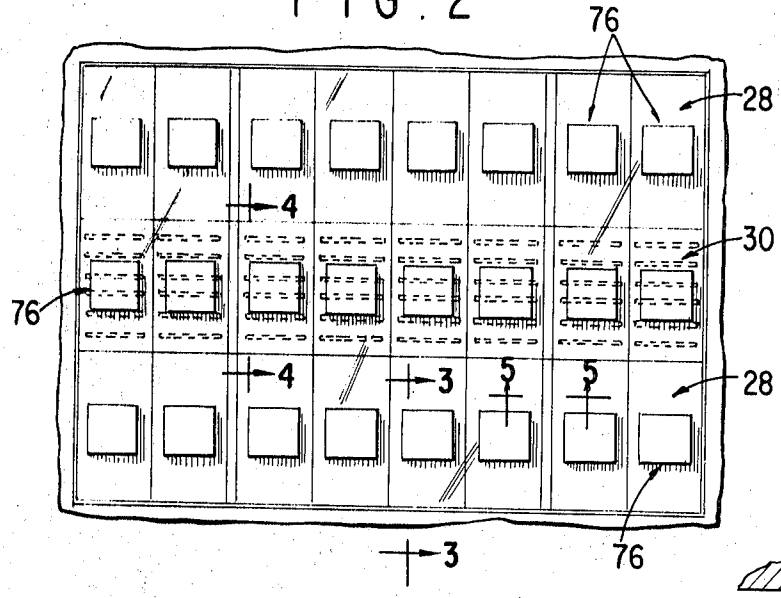

FIG. 5

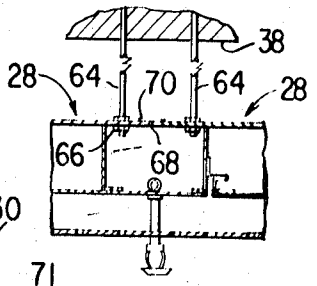

FIG. 4

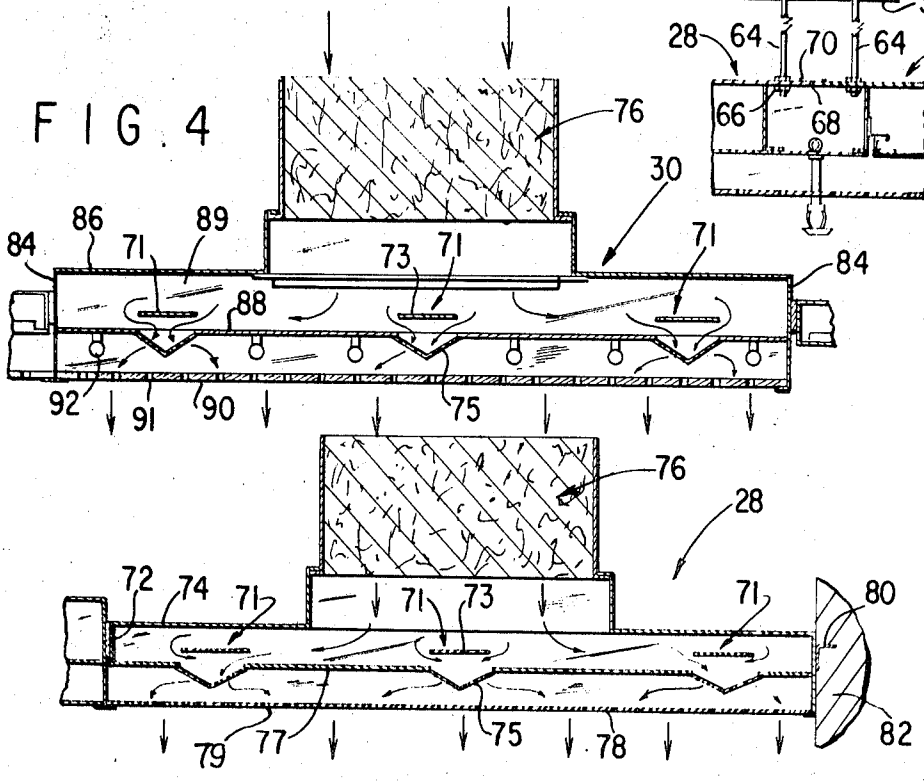

FIG. 3

MODULAR PANEL SYSTEM FOR CLEAN ROOM

This invention is directed to environment control apparatus for the exclusion of airborne dust and microorganisms. More particularly, the invention is directed to a novel clean room design and to novel air permeable modular panels for use in connection with such a room.

The packaging of highly sophisticated electronic components and the like and the packaging of certain drugs and medicine, particularly those for parenteral injection require an environment which is as nearly absolutely dust-free and absolutely microorganism-free as is possible. Clean room requirements are intended to provide an area in which activity may be performed in an atmosphere as free of airborne materials as possible by removing any particulate matter generated in the space as rapidly as possible. United States government Federal Standard 209A and Air Force TO 0 00-25-203 establish general standards for such procedures. The control of the particle size of foreign material has been effected by the use of "absolute filters" in the removal of the airborne dust particles.

An innovation of clean room design has been the rapid circulation of air under controlled temperatures and humidities in systems utilizing a vertical laminar flow. In laminar flow clean rooms large volumes of filtered air are distributed vertically from the ceiling and the entire volume is simultaneously removed through the floor. The volume of air which may have accumulated dust and dirt particles generated in the clean room is recirculated through adequate filter media before being recycled to the room. A limited amount of the recirculated air is removed from the system and a similar amount of fresh air is added to control temperature and humidity conditions as required. A typical clean room utilizes air flowing at the rate of about 100 feet per minute.

In early clean rooms, substantially the entire ceiling was made up of absolute filters. The filters were exposed to the room and were subject to mechanical damage, for instance, by tools used in cleaning.

The most recent clean room designs have largely eliminated the mechanical damage problem by making the ceiling from perforated metal, or high-impact plastic, panels. The absolute filters were located near to a fan or blower used for circulating the air, thus reducing the number of expensive absolute filters required.

Problems exist in the prior art. It is customary to place the blowers and filters in a room remote from the clean room, and a relatively long duct is needed in order to distribute air to a plenum chamber above the clean room panel. The large volume in the ductwork and plenum chambers provides space for microorganisms to grow and is difficult to reach for cleaning purposes.

Lighting fixtures used interrupted the uniformity of flow pattern across the room. The nonuniformity frequently caused eddies and increased the likelihood of recirculation of dust particles generated within the room. In tests it has been found that a 12-inch wide troffer light which was air-impermeable when placed between two air-permeable panels created considerable disturbance in the form of eddy currents for a distance of 4 to 5 feet below the ceiling and directly under the light fixture. One prior-art solution was to place lighting units only at the side of a room, but such placement results in inadequate lighting of larger rooms.

It is an object of the present invention to provide a clean room design which eliminates or substantially reduces the problems of the prior art.

It is a further object of the present invention to provide an improved modular panel design in which the absolute filter is protected from mechanical damage yet is readily accessible for replacement, and the duct length between the filter and the clean room is relatively small.

It is still another object of this invention to provide an improved modular panel design in which lighting units may be incorporated while maintaining the uniformity of the flow of air across the entire panel.

Other and further objects of the invention will be apparent to those skilled in the art from a reading of the description of the invention taken in conjunction with the drawings in which:

FIG. 1 is a perspective view of a clean room utilizing the features of the present invention;

FIG. 2 is a plan view of the modular panel layout forming the ceiling of the clean room of FIG. 1;

FIG. 3 is a sectional view of a basic modular panel utilizing the features of this invention and taken generally along lines 3–3 of FIG. 2;

FIG. 4 is a sectional view of a modification of the basic modular panel design incorporating lighting troughs and lenses and taken generally along lines 4–4 of FIG. 2; and

FIG. 5 is a sectional view of one embodiment of a method of suspension of the ceiling of the present invention taken generally along lines 5–5 of FIG. 2.

The objects of the present invention are achieved in a clean room 10 which has a ceiling 12, a floor 14 and walls 16, 18, 20. The fourth wall (not shown) may be a solid wall with no openings. Air from a remote fan (not shown) passes through duct 22 and through broad mesh screens 24 into a plenum chamber 26 bounded on the upper side by outer ceiling 38. The plenum chamber 26 is sized so that the entire volume of air above the ceiling 12 is at substantially the same pressure. The air flows through basic panels 28 and lighting panels 30 and flows in a vertical laminar flow pattern through the floor 14 into plenum 32 and duct 34 and returns to the suction of the fan through a duct 36.

Clean rooms may be placed adjacent to one another for economy in space and equipment utilization. The incoming air to the second room may enter through duct 42 and pass through screens 44 into plenum chamber 46 through ceiling 48 and laminarly through the clean room work volume 50, pass out through grating floor 52 and return to the fan through duct 54. The separate air streams are kept apart by partition 56.

As is shown in FIG. 1, an access door 60 and an observation winder 62 may be provided in the wall 18.

A typical layout plan of the modular panels is shown in FIG. 2. In the embodiment shown a plurality of basic modular panels 28 are located on each side of the ceiling and a plurality of modular lighting panels 30 are located across the middle of the ceiling. The panels may be suspended directly from the outer ceiling 38, as is shown in FIG 5, by a structural member 64, such as a stud bolt, and held in position by nuts 66. The joint 68 between adjacent panels may be sealed by a sealing member 70, such as masking tape.

As is shown in FIG. 3, the basic modular panel 28 is made up of a frame 72 and a housing 74 which supports an absolute filter 76. A foraminous member 78 is also connected to the frame. The frame 72 may be supported at one end by attachment to appropriate structural members 80, such as angles, mounted in a wall 82. The other sides may be supported from the ceiling, as described above, and connected to other modular panels, for instance by bolts and nuts. The airflow in the embodiment shown in FIG. 3 is downwardly through the filter 76, as indicated by the arrows, into the plenum chamber formed by the housing 74 and the foraminous member 78, and then downwardly through the foraminous member 78 into the room in substantially laminar flow. It has been found advantageous to provide flow control means in the panels. Dampers 71 having upper member 73 and lower member 75 and supported in member 77 may be mounted between the housing 74 and foraminous member 78. The dampers 71 are interposed in the path of air flow and may be regulated by well-known means, such as a worm gear.

A plurality of foramina 79 are defined in member 78. Typically member 78 is light gauge sheet metal, and the foramina are formed by stamping.

As may be seen in FIG. 4, a typical modular lighting panel 30 is made up of a frame 84, and a housing 86 that supports an absolute filter 76. A foraminous lens 90 is supported by the frame 84. Lighting units 92, are mounted within the plenum

chamber **89** formed by the housing **86** and the foraminous lens **90** or support member **88**. The support member may advantageously also support dampers **71** if desired. The lighting units **92** are mounted above the foraminous lens **90**. The foraminous lens is typically plastic, preferably translucent, such as polystyrene or methyl methacrylate, and the foramina **91** are typically formed in a molding process. The material for lens **90** is selected to be resistant to mechanical shock. The foramina are of suitable size and spacing to provide airflow characteristics substantially identical to the foraminous members **78**. Typically the airflow is about 100 cubic feet per minute per square foot of lens **90** at low head loss.

The airflow, as indicated by the arrows in FIG. **4**, is downwardly through the absolute filter **76** into the plenum chamber **89** formed between the housing **86** and the foraminous sheet **90**. The air fills the plenum **89** at a substantially constant pressure throughout and flows through the dampers **71**, when present, and the foraminous lens **90**. The air then flows in a vertical laminar flow through the clean room and is recycled as described above.

In a typical modular design, the basic module is about 36 inches by 5 or 6 feet long. The depth of the plenum chamber of a basic modular panel is typically 7⅝ inches. The absolute filters used are typically 24 inches by 24 inches square by 12 inches deep. The foraminous member has about 15 times the area of the filter.

It is to be understood that the ceiling layout shown is for exemplification only and that the actual arrangement of modular panels may be made in a number of patterns to meet particular conditions of environment. Also the modular panels may be used by making a physical duct connection from the supply fan in lieu of the pressure plenum.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

We claim:

1. An improved clean room meeting the requirements of Federal Standard Number 209A, class 100 for a sterile environment comprising:

A. An air-permeable ceiling further comprising:

1. A plurality of first modular panels having a frame, an absolute filter, a housing connecting said filter to said frame and a foraminous member connected to said frame and being substantially larger than said filter;
2. At least one second modular panel having a frame, an absolute filter, a housing connecting said filter to said frame, a foraminous lens connected to said frame opposite said housing, a support member connected to said frame and disposed between said housing and said lens, at least one lighting unit connected to said frame and disposed between said support member and said lens, said lens having an open area substantially equal to the open area of said foraminous member of said first modular panel;

B. An air-permeable floor;

C. A plurality of walls extending from said floor to said ceiling;

D. Means to supply air under pressure above said ceiling; and

E. Means to remove air from under said floor, whereby air flows from said ceiling to said floor in a substantially vertical laminar pattern that is substantially the same under both said first and said second panels.