

[54] **VERTICAL LAMINAR-FLOW CLEAN ROOM OF FLEXIBLE DESIGN**

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[51] Int. Cl.B01d 31/00

[58] Field of Search55/467, 470-473, 55/483, 484; 98/33, 115, 40 D

[56] **References Cited**

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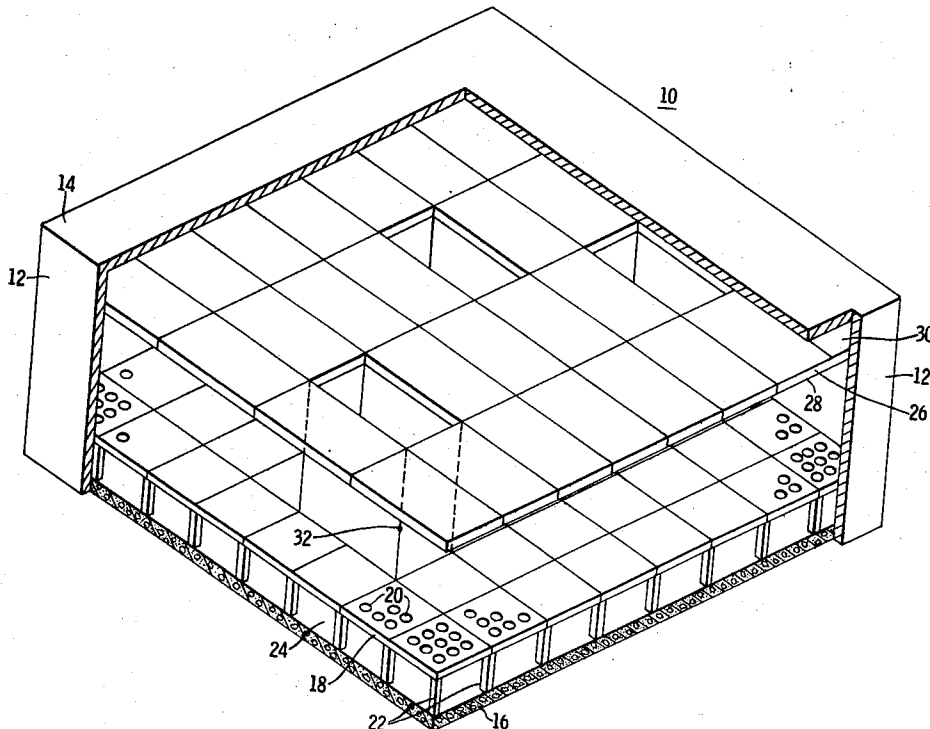
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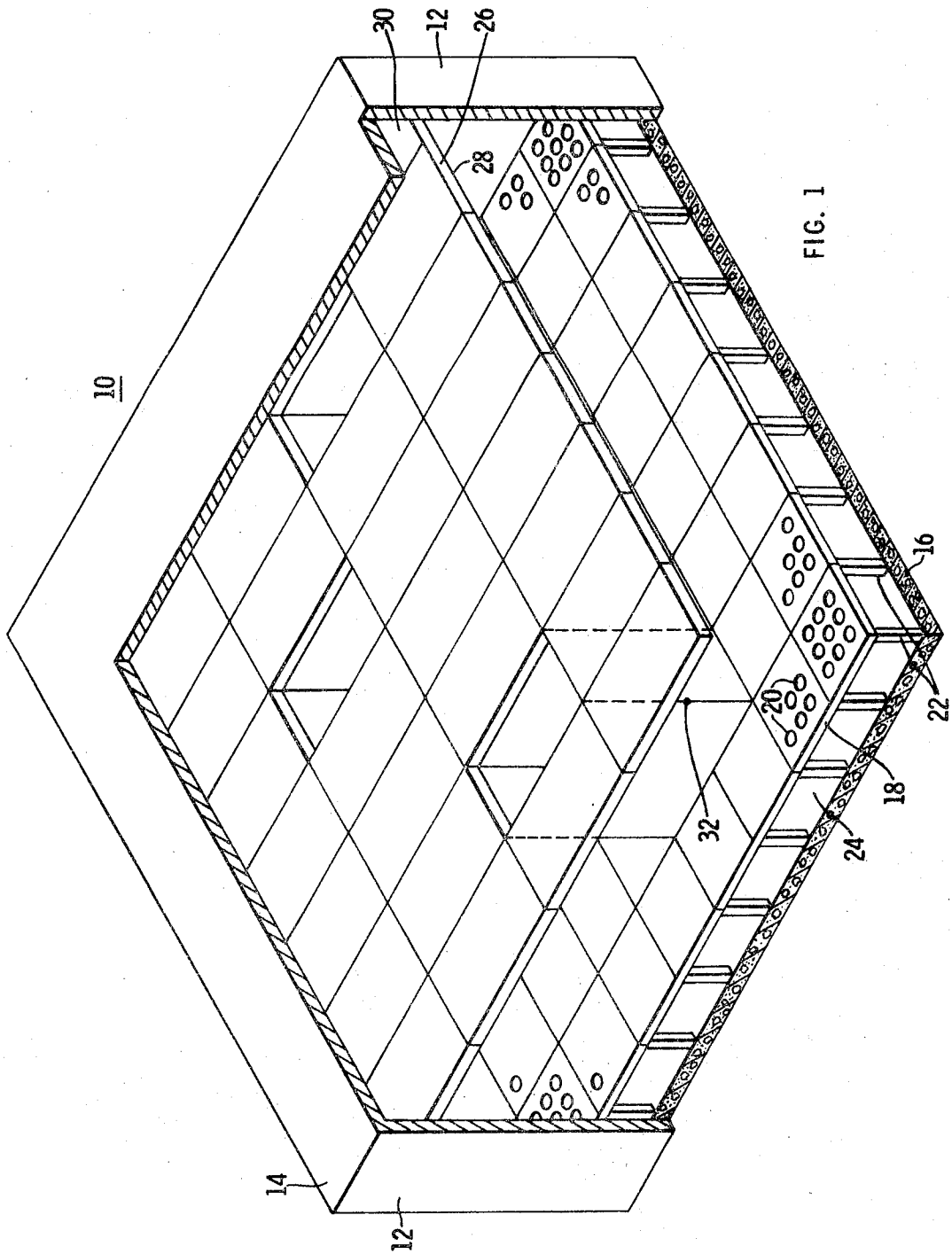
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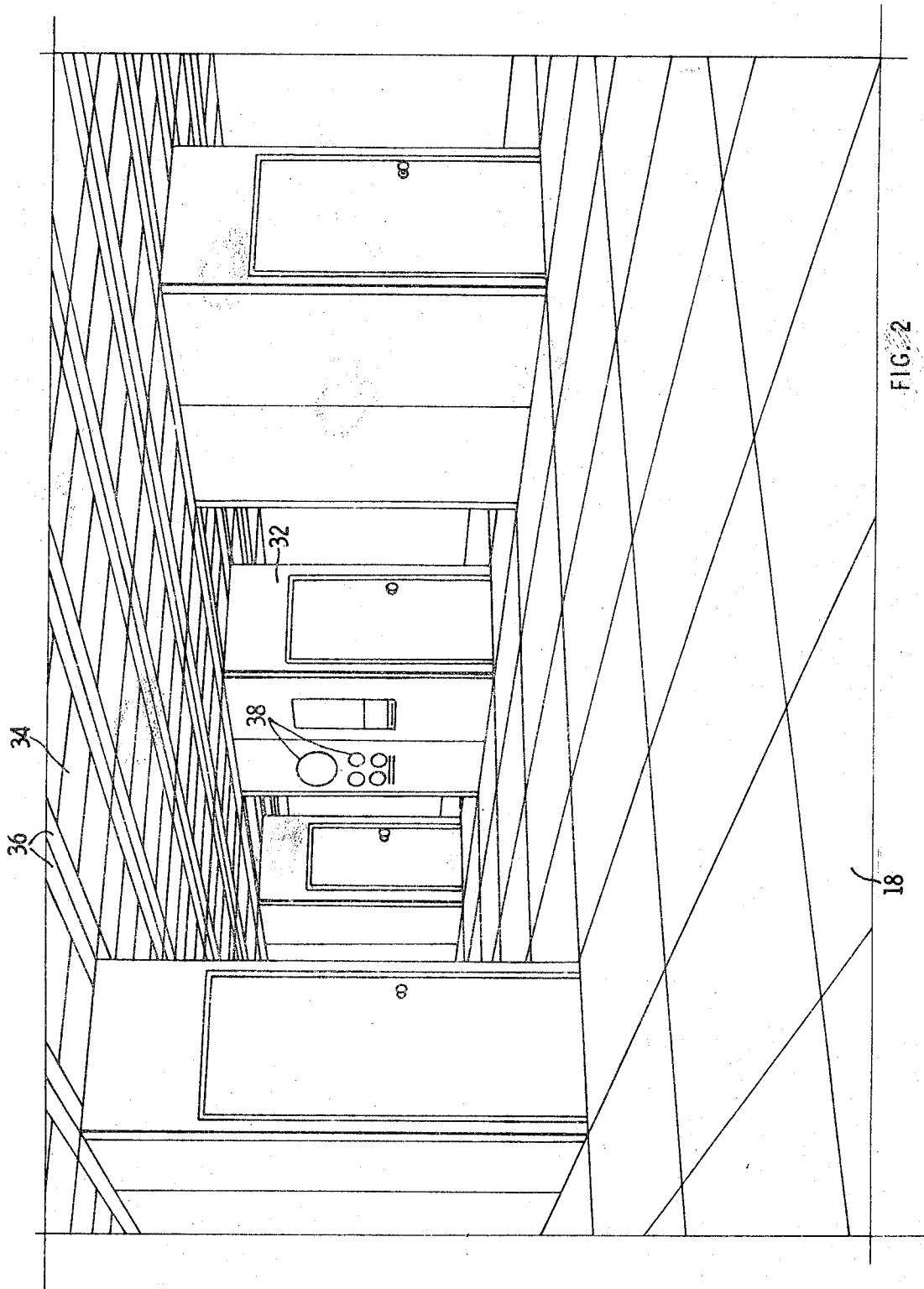
ABSTRACT

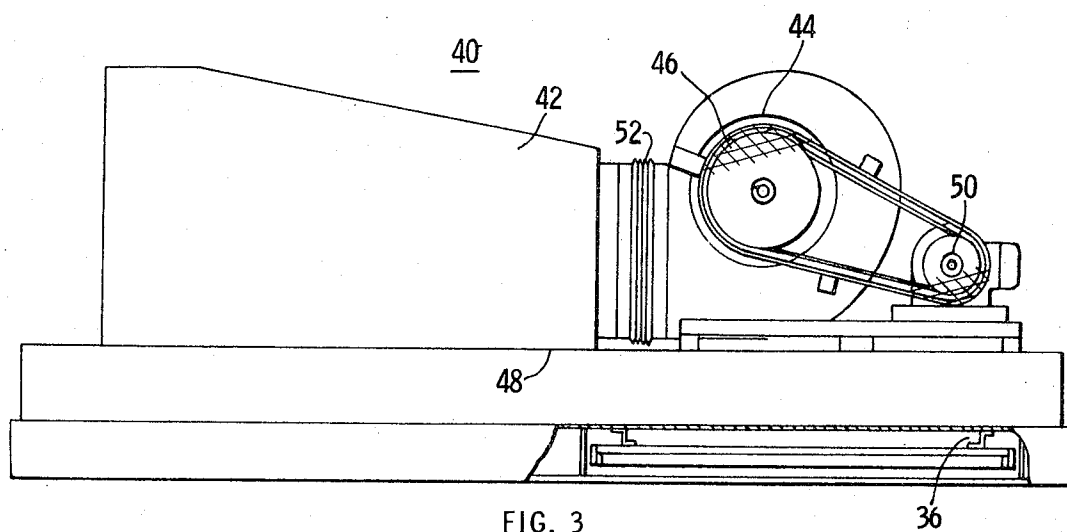
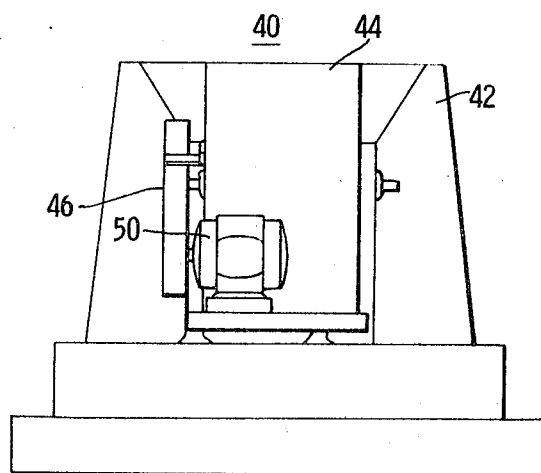
A vertical laminar-flow clean room is contained within a bounding enclosure which is substantially airtight. The clean room floor is raised and has apertures therein. The floor and the bottom of the bounding enclosure form an air-receiving plenum. A dropped ceiling is formed of an assembly of blower-hood-filter units, with the space directly above the dropped ceiling constituting an air-supply plenum. Air return plenums are contained entirely within the bounding enclosure and preferably incorporate prefilters and air-conditioning equipment, and the air return plenums connect the air-receiving plenum to the air-supply plenum. The blower-hood-filter units and air return plenums are all of a similar size, in order to facilitate a modular-type of construction and flexibility of design.

6 Claims, 9 Drawing Figures









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FIG. 5

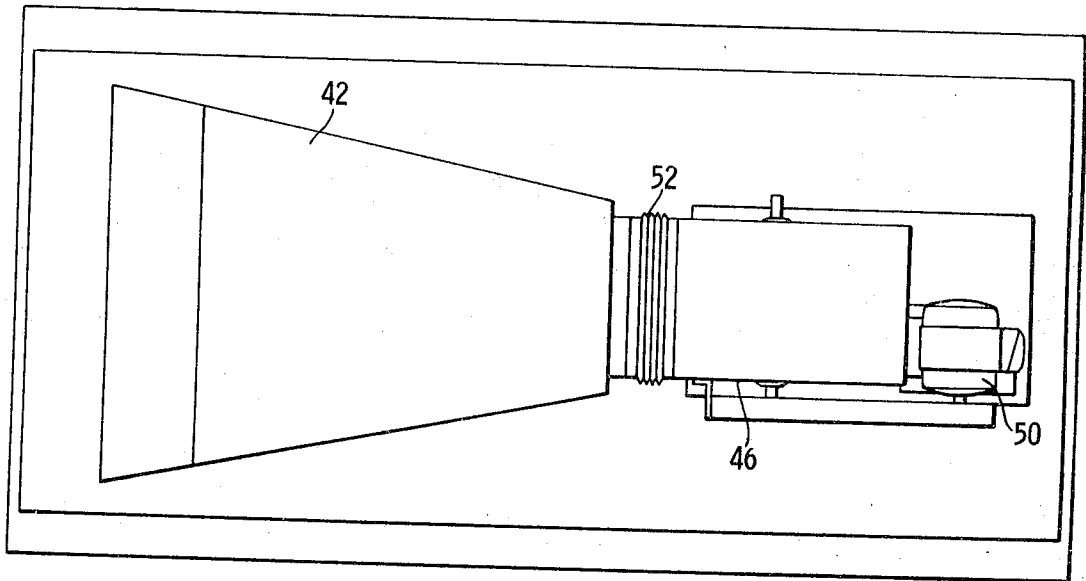
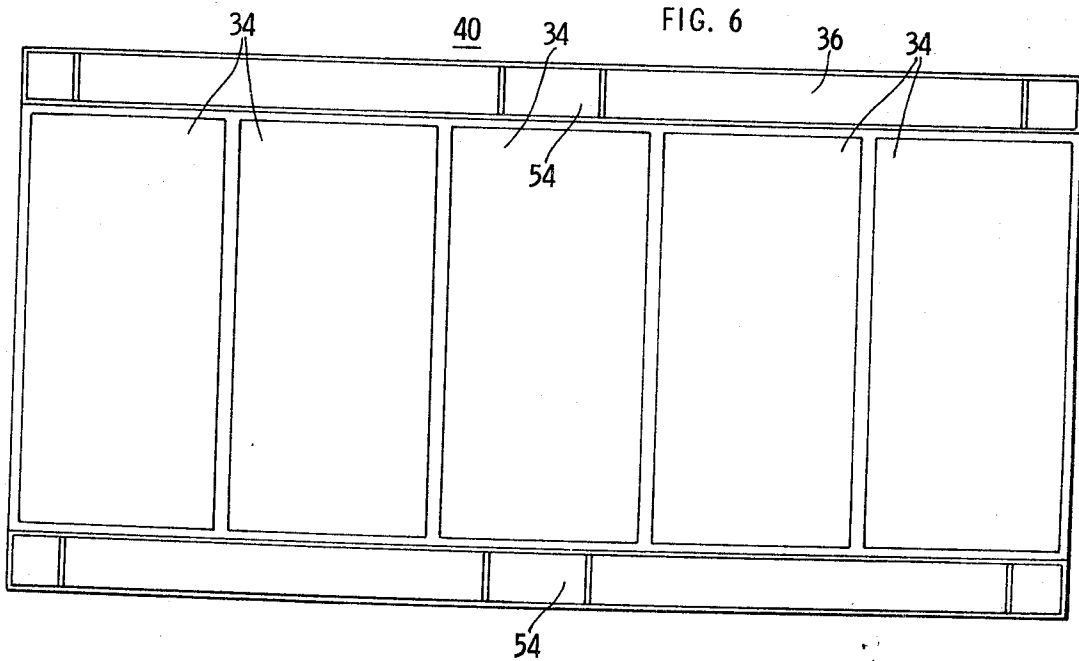


FIG. 6



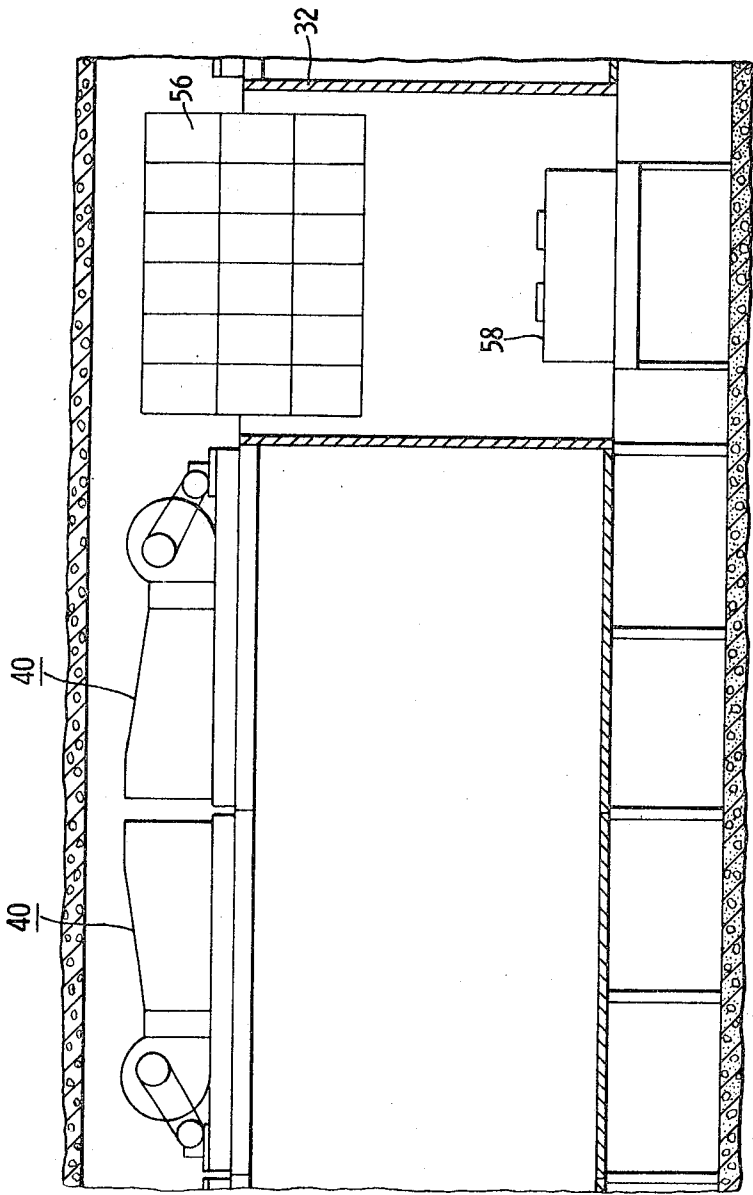


FIG. 7

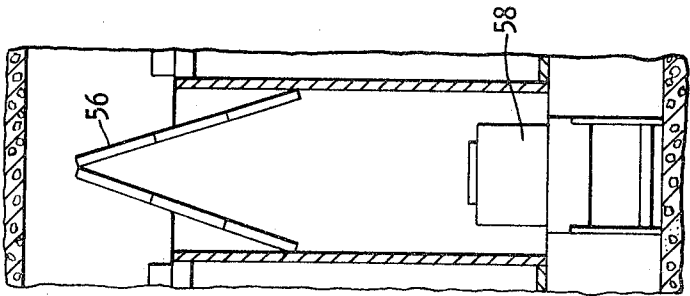


FIG. 8

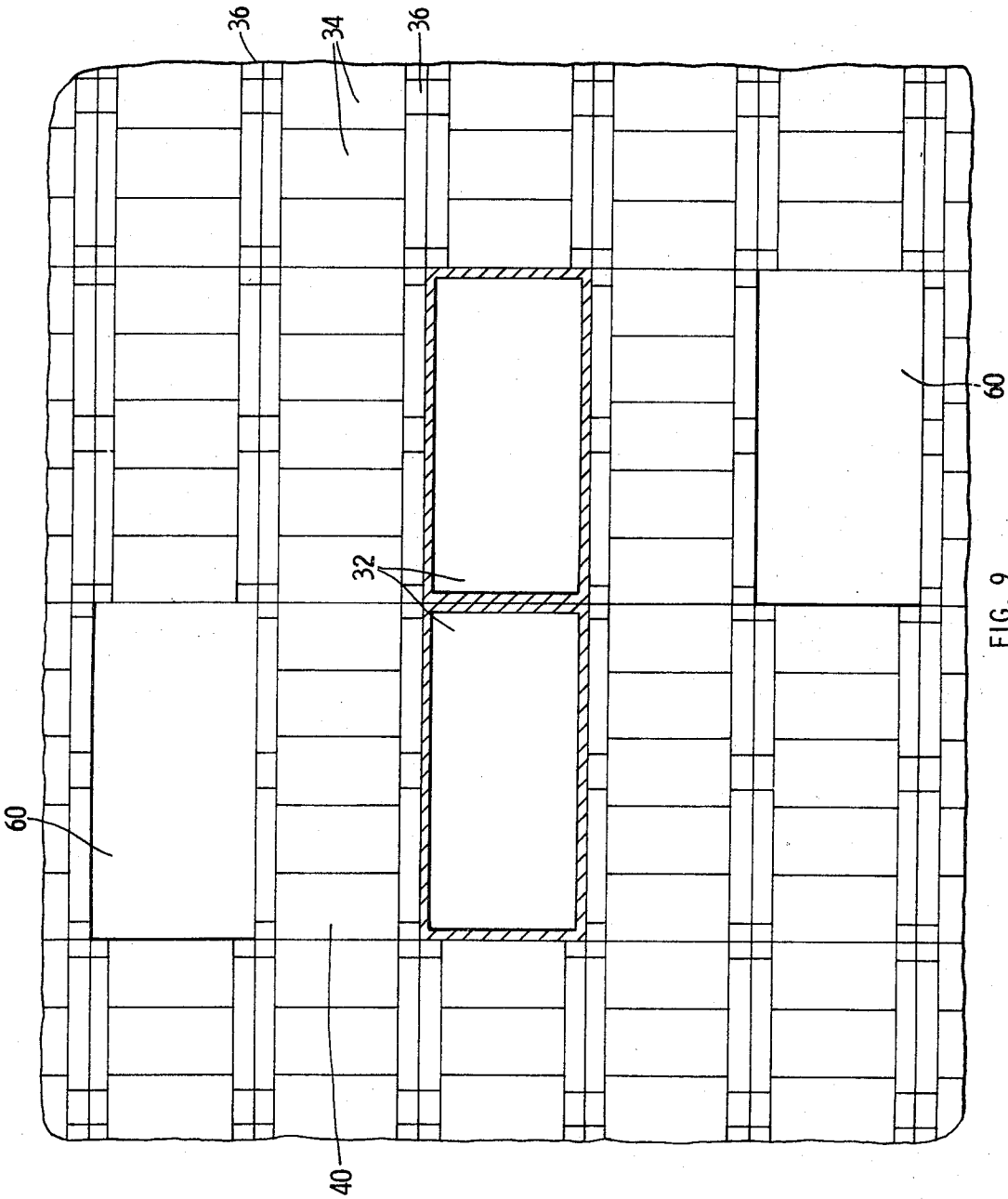


FIG. 9

VERTICAL LAMINAR-FLOW CLEAN ROOM OF FLEXIBLE DESIGN

BACKGROUND OF THE INVENTION

So-called clean rooms are now well known and are used to fabricate precision electronic and mechanical equipment, as well as other applications which require ultraclean atmospheres, such as hospital operating rooms. The basic function of a clean room is to remove from the atmosphere substantially all particulate matter which might contaminate the products assembled in the room.

As a general rule, the best performing clean rooms for removing all possible particulate matter are of a design which is known in the art as "vertical laminar flow," and such a clean room is described in U.S. Pat. No. 3,158,457, dated Nov. 24, 1964. In the general design of such clean rooms, the ceiling normally comprises so-called high-efficiency particulate air (HEPA) filters, which are now well known in the clean room art. Such HEPA superinterception filters have a 99.97 percent to 99.999 percent efficiency for 0.3-micron particles, as measured with a dioctyl phthalate (DOP) test. In the operation of most clean rooms, air passes from an overhead plenum above the filters, through the filters, vertically downward through the clean room, through an apertured floor in the clean room into an air-receiving plenum, and thence through a very large fan and duct system and back to the air-supply plenum which is located above the superinterception filters. In such a system, the fans for circulating the air are of very large size and are normally located externally of the bounding enclosure for the clean room. In addition, the duct work which connects the air-receiving plenum below the apertured floor and the supply plenum above the filtered ceiling is normally located exteriorly of the clean room proper. The necessity for the very large fans, the location of the connecting duct works have limited the flexibility of design for such clean rooms, particularly for applications where equipments are to be moved within the clean room after initial installation or expansion of the facility is required.

It is the general object of the present invention to provide a vertical laminar-flow clean room which is of flexible design and can be readily altered.

It is another object of the invention to provide a vertical laminar-flow clean room which is constructed on a modular basis in order to facilitate standardization of parts and ease of construction.

It is a further object to provide a vertical laminar-flow clean room wherein all elements which comprise the clean room are located within the bounding enclosure, in order to facilitate maintaining the clean room substantially airtight.

The foregoing objects of the invention, and other objects will become apparent as the description proceeds, are achieved by providing a vertical laminar-flow clean room which comprises a bounding enclosure formed by sidewalls, a top wall and a bottom wall, with the enclosure being substantially airtight except as to permit necessary personnel ingress and egress and to provide for makeup air which may be introduced in a controlled fashion. A raised floor which has apertures therein is positioned over the bottom wall, with the space between the raised floor and the enclosure bottom wall constituting an air-receiving plenum. An air-moving system is supported beneath the top wall of the bounding enclosure and comprises a plurality of blower-hood-filter assemblies, each of which comprises a hood portion having an open air inlet and an air outlet portion terminating in a high-efficiency (HEPA) filter. The space between the air-moving system and the top wall of the bounding enclosure constitutes an air-supply plenum. At least one vertically disposed air return plenum, which is located entirely within the confines of the bounding enclosure, connects the air-receiving plenum and the air-supply in an airtight fashion. Prefilters are desirably positioned within the air return plenum. The lateral dimensions of each air return plenum and each blower-hood-filter assembly are identical in order to facilitate the use of a modular-type of construction.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference should be made to the accompanying drawings wherein:

FIG. 1 is an isometric, diagrammatic view, partly broken away, showing the general positioning of the components which comprise the present clean room;

FIG. 2 is a perspective view of a portion of the interior of the clean room of the present invention showing a portion of the aperture raised floor, a portion of the false ceiling, and air return plenums which contain air-conditioning equipment as well as prefilters;

FIG. 3 is an elevational view, partly in section, of a blower-hood-filter assembly component of the present invention;

FIG. 4 is an end view of the assembly as shown in FIG. 3;

FIG. 5 is a plan view of the assembly as shown in FIG. 3;

FIG. 6 is a bottom view of the assembly as shown in FIG. 3;

FIG. 7 is a fragmentary elevational view, shown partly in section, of a portion of a clean room of the present invention illustrating two blower-hood-filter assemblies and an adjacent air return plenum;

FIG. 8 is a fragmentary elevation, partly in section, illustrating a side view of the air return plenum as shown in FIG. 7;

FIG. 9 is a fragmentary view of a portion of a ceiling for a clean room constructed in accordance within the present invention wherein two air return plenums are positioned adjacent one another and two blower-hood-filter assemblies are replaced by airtight filler members, such as might be used where equipment is to be placed directly therebeneath.

DESCRIPTION OF PREFERRED EMBODIMENTS

With specific reference to the form of the invention shown in the drawings, in FIG. 1 is shown a vertical laminar-flow clean room 10 which comprises a bounding enclosure formed by sidewalls 12, a top wall 14 and a bottom wall 16, and the bounding enclosure is substantially airtight except for ingress and egress of personnel and material and to provide for makeup air which may be introduced therein in a controlled fashion, such as through the conventional air-conditioning equipment.

There is positioned within the bounding enclosure a raised floor 18 which constitutes the floor for the clean room and which has apertures 20 therein in order to permit air to flow therethrough. The raised floor 18 abuts the sidewalls 12 at its periphery and is supported on and positioned over the bottom wall 16 by pedestals 22 and such floors are generally known in the art. The space between the raised floor 18 and the bottom wall 16 constitutes an air-receiving plenum 24.

Beneath the top wall 14 is positioned an air-moving filter system 26 the periphery of which abuts the sidewalls 12 and having a bottom surface 28 which constitutes the ceiling for the clean room, and the air-moving filter system 26 will be described in greater detail hereinafter. The space between the air-moving filter system 26 and the top wall 14 comprises an air supply plenum 30. The only passage for air directly from the air-supply plenum 30 and into the clean room proper is through the air-moving filter system 26. At least one vertically disposed air return plenum 32 is located within the confines of the bounding enclosure and connects the air-receiving plenum 24 and the air-supply plenum 30 in an airtight fashion.

The general layout of the clean room is shown in perspective view in FIG. 2 wherein the raised floor 18 comprises a plurality of individual square or rectangular units which have apertures therein, and the ceiling as viewed from the clean room comprises a plurality of HEPA filters 34, along with the associated lighting units 36. The air return plenums 32 can have positioned on the exterior thereof the necessary temperature and humidity controls 38 for the air-conditioning apparatus contained therein, as well as fan controls for the air-moving filter system.

The air-moving filter system 26 comprises a plurality of blower-hood filter assemblies 40, as shown in FIGS. 3, 4, 5 and 6, which can be supported from the top wall 14 or supported on an inverted T-bar grid. Each of the assemblies comprises a

hood unit 42 and associated blower housing 44 which has an open air inlet portion 46. The air outlet portion 48 of the hood 42 terminates in the superinterception (HEPA) filter combination 34. The motor unit 50 is suitably vibration mounted and the blower housing portion 44 is connected to the rest of the hood by a suitable vibration damping connection 52. The hood 42 is designed to insure uniform air distribution.

As viewed from the bottom, and as shown in FIG. 6, which illustrates the portion of the assembly 40 that is viewed from the clean room proper, each assembly comprises five 2-foot by 4-foot combination HEPA filters 34 sealed together at their edges in an airtight fashion to form one assembly unit measuring 4 feet by 10 feet. Along either side of the assembled filters are affixed the fluorescent lamp fixtures 36 which comprise the usual troffers together with the associated refractor units for such fixtures and the bottom surface of the assemblies 40 comprise the ceiling 28 for the clean room. The entire blower-hood-filter assembly 40 measures 5 feet by 10 feet in overall lateral dimensions, as measured at that portion thereof which comprises a part of the ceiling 28 of the clean room, and when mounted in a clean room, as shown in FIG. 1, each of these assemblies comprises a modular unit and is affixed to adjacent assemblies in an airtight fashion. Between the light fixtures 36 are provided unused panels 54 which can be adapted to receive sprinkler heads, paging systems, emergency lights, or other auxiliary systems.

In FIGS. 7 and 8 are shown two blower-hood-filter assemblies 40 and an adjacent air return plenum 32. In this plenum 32 are mounted prefilter units 56 which operate with an efficiency of up to 85 percent. Also mounted within the air return plenum 32 is conventional air conditioning equipment 58 which may be used for heating, humidity control and/or cooling. The controls for such equipment, as well as the blower units, are readily mounted on the exterior surface of the return plenum 32, generally as illustrated in FIG. 2.

In FIG. 9 is shown a modified ceiling plan for a clean room which illustrates the flexibility of the present design. The air return plenums 32 as shown here are placed in side-by-side relationship and are of the same lateral dimensions as the assemblies 40 to provide a modular construction. If desired, any of the assemblies 40 may be replaced by an airtight filler unit 60 which provides no air-moving or -filtering function. Such a filler unit can be readily installed directly above large apparatus, in order that the airflow through the room is maintained as nearly vertical, from ceiling to floor, as possible. Also, if a room is desired to have only a limited "clean" area with supplemental areas of storage, for example, surrounding the "clean" area, a large number of the filler units 60 can be used over the supplemental areas. These filler units can be replaced thereafter, if desired, with the blower-hood-filter assemblies 40 to upgrade the overall room.

The present system is extremely flexible in design inasmuch as the lateral dimensions of the air return plenums or ducts 32 are the same as those of the modular blower-hood-filter assemblies 40 so that the location of the air return plenums 32 can be individually changed as desired, even after the room is completed and in operation. This permits manufacturing apparatus to be readily shifted from one location to another with a minimum of inconvenience.

In the construction of the preferred embodiment as described hereinbefore, for each air return plenum 32 there should be provided from about eight to about 14 of the blower-hood-filter assemblies 40, in order to ensure proper performance. The preferred ratio is one air return plenum 32 for every 10 blower-hood-filter assemblies 40. The fans for each of the assemblies 40 can be varied in speed in order to carefully control the flow of air in various parts of the room.

Briefly summarizing the operation of the clean room, air passes through the HEPA filters 34 and downward through the clean room in a vertical fashion, through the apertures 20 in the raised floor 18 and into the air-receiving plenum 24. From there the air passes upward through the vertically disposed air return plenums 32, the air is conditioned as required, and then

passed through the prefilters 56 into the air supply plenum 30. The air is then passed through the air inlet 46 of the assembly 40, through the air outlet 48 and again through the HEPA filters 34.

In the preferred embodiment as described hereinbefore, both the prefilter units 56 and the air-conditioning equipment 58 are located in the air return plenums 32. As an alternative embodiment, the prefilter units could be located directly beneath the apertured raised floor. Also, the air-conditioning equipment could be positioned either in the air-receiving plenum 24 or the air-supply plenum 30. With such a construction, the air return plenums 32 could be changed from location to location even more readily, in order to facilitate design changes in an established clean room. Such facility of design changes is made possible by the modular construction wherein the modules 40 which comprise the ceiling are of the same lateral dimensions as the air return plenums 32.

The present clean room has many operational advantages. For example, each blower-hood-filter assembly 40 is provided with its own small motor and fan, and the clean room does not require the massive motors and fans as have been needed to operate most clean rooms of the prior art. The air-supply plenum 30 is maintained at a pressure which is less than the pressure in the clean room proper so that any sealing faults will not constitute paths for leakage of any dirt. Also, each air return plenum 32 is located in the immediate area it serves and handles only the air for a relatively small group of modules 40, thereby eliminating long passages for return air movement and reducing plenum heights over the room. If one of the small fans of the present clean room fails, the operation of the room is substantially unimpaired, in contrast to the failure of a large blower unit. In addition, less gross floor area is required by the clean room of this invention because of the elimination of a separated equipment room, large fans, and ducts, etc., positioned outside the clean room proper. This also permits the clean room to be expanded readily, since there is no need to change the location of a central equipment room. Zoned temperature and humidity control is also facilitated by the individual control which is made possible by the use of the modular air return plenums 32, which have the local controls positioned in the zone desired to be controlled.

It will be recognized that the objects of the invention have been achieved by providing a clean room which is very flexible in design and which is readily fabricated on a modular basis. The room is very efficient in operation and airflow is readily controlled.

We claim:

1. A vertical laminar-flow clean room comprising:

- a. a bounding enclosure formed by sidewalls, a top wall, and a bottom wall, said bounding enclosure being substantially airtight except as to permit necessary personnel and material ingress and egress and to provide for makeup air which may be introduced therein in a controlled fashion;
- b. a raised floor having a periphery which abuts said sidewalls and which constitutes the floor for said clean room, said raised floor having apertures therein to permit airflow therethrough, said raised floor positioned over said bottom wall, and the space between said raised floor and said bottom wall constituting an air-receiving plenum;
- c. an air-moving filter system having a periphery which abuts said sidewalls and a bottom surface which constitutes the ceiling for said clean room, said air-moving filter system supported beneath said top wall and comprising a plurality of blower-hood-filter assemblies, said blower-hood-filter assemblies each comprising a hood unit having an open air inlet portion and an air outlet portion terminating in high-efficiency air filter means which comprises a part of said ceiling, with the overall lateral dimensions of each said blower-hood-filter assembly as measured at that portion thereof which comprises a part of said ceiling being the same, and a blower unit operable to move air from said open air inlet portion and to and

through said high-efficiency air filter means, the bottom surface of said air-moving system as viewed from said raised floor comprising a plurality of said air filter means, an air-supply plenum formed by the space between said air-moving system and said top wall, and the only passage for air directly from said air-supply plenum and into said clean room being through said blower-hood-filter assemblies; and

- d. vertically disposed air return plenum duct means located entirely within the confines of said bounding enclosure and connecting said air-receiving plenum and said air-supply plenum in an airtight fashion, and each said air return plenum duct means having the same overall lateral dimensions as said overall lateral dimensions of each said blower-hood-filter assembly in order to be readily assembled therewith and interchangeable therewith.

2. The clean room as specified in claim 1, wherein air-conditioning equipment is mounted within said air return plenum

duct means.

3. The clean room as specified in claim 2, wherein controls for said air-conditioning equipment and controls for the blower units of said blower-hood-filter assemblies are located on the exterior lateral surface of said air return plenum duct means.

4. The clean room as specified in claim 1, wherein prefilter means is mounted within said air-return plenum duct means.

5. The clean room as specified in claim 4, wherein each said air return plenum duct means is located in the immediate area it is intended to serve, and for each said air return plenum duct means there are provided from about eight to 14 of said blower-hood-filter assemblies thereby to eliminate long passages for return air movement.

6. The clean room as specified in claim 5, wherein for each air return plenum means, there are provided about 10 of said blower-hood-filter assemblies.

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