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Smith

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[54] **LOW PROFILE FILTER SYSTEM**

[75] Inventor: **Irwin M. Smith**, Grand Rapids, Mich.

[73] Assignee: **Walter Kidde & Company, Inc.**, Grand Rapids, Mich.

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[52] **U.S. Cl.** ..... **55/418**, 55/473, 55/484, 55/502, 55/DIG. 29, 98/40 D, 98/41 SV, 137/625.31

[51] **Int. Cl.** **B01d 31/00**

[58] **Field of Search** ..... 55/418, 419, 473, 55/484, 483, 502, 499, 498, 500, DIG. 29; 98/40 D, 33 R, 41 SV, 41 R; 137/625.31; 52/303, 484

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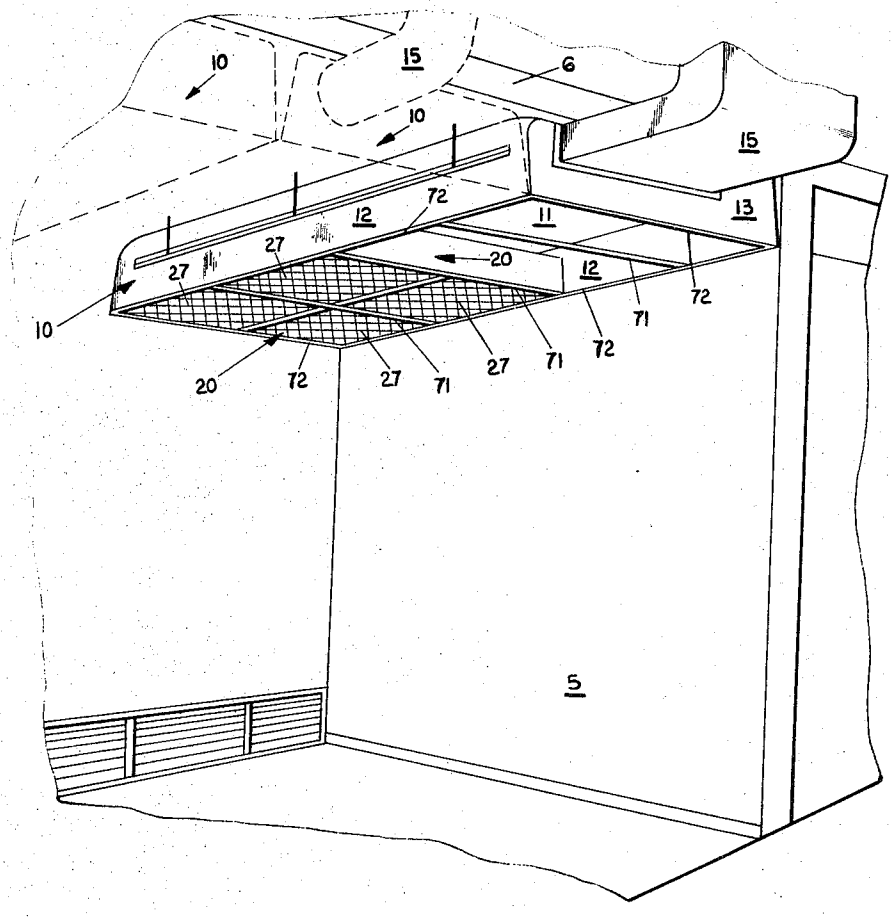
Primary Examiner—Bernard Nozick

Attorney—Price, Heneveld, Huizenga & Cooper

[57] **ABSTRACT**

A plurality of large plenum chambers are provided for hanging from the ceiling of a room. Each supports four low profile filter units. Each filter unit includes a frame, circumscribing a filter which is mounted in the frame, and a sliding plate air flow control valve mounted above the frame. The air flow control valve has a flow control area which is generally coextensive with the area of the filter. A seal is effectuated between the frame and the plenum chamber by means of a sealing flange projecting upwardly from the strips supporting the filter units into a channel at the bottom edge of the frame. The channel is covered by a flexible membrane which is stretched over the top of the sealing flange. The plenums are suspended and joined together by a supension wire passing through matingly engaging joining brackets on adjacent plenum chambers.

22 Claims, 6 Drawing Figures



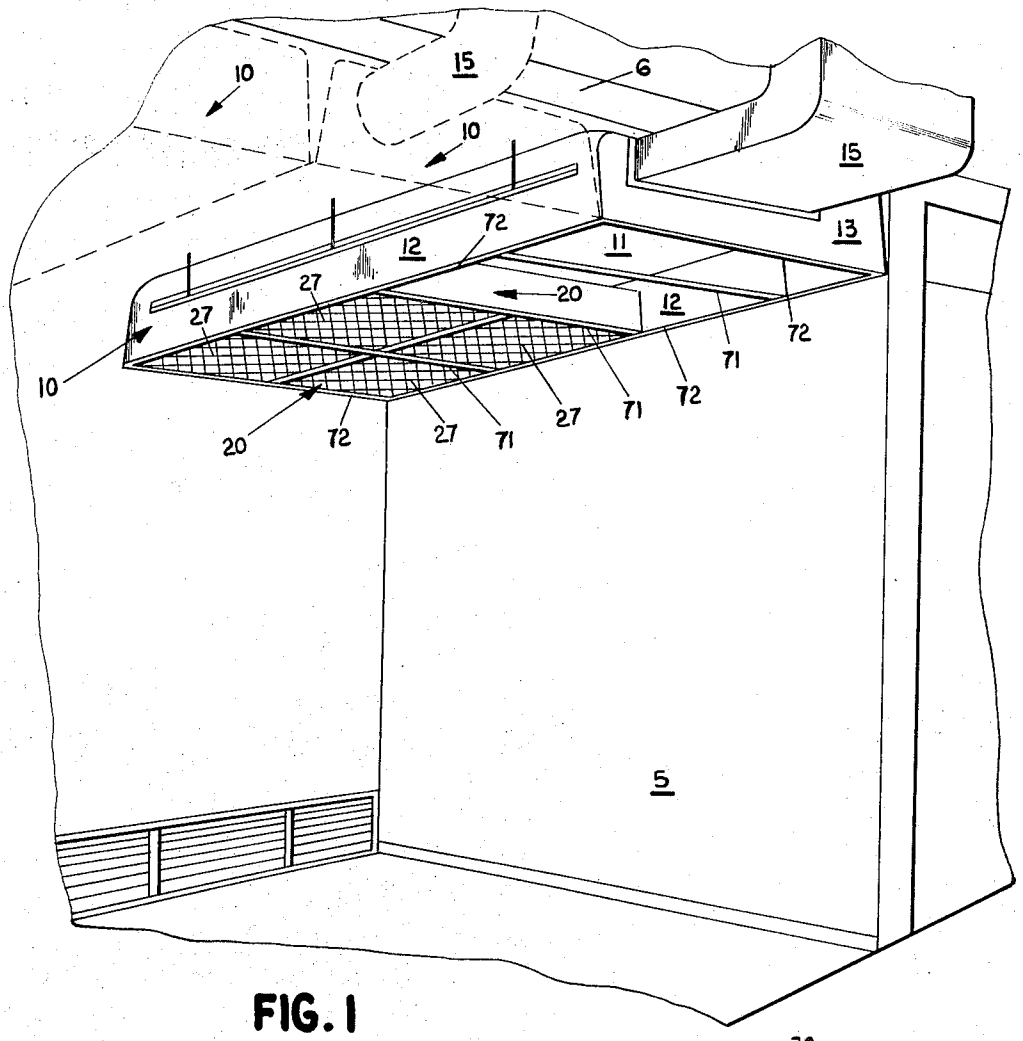

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FIG. 1

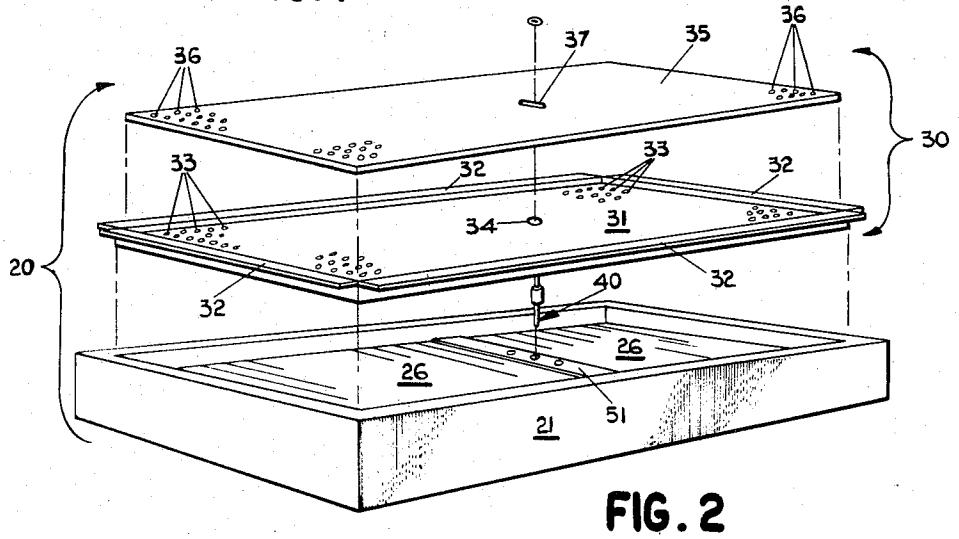
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FIG. 2

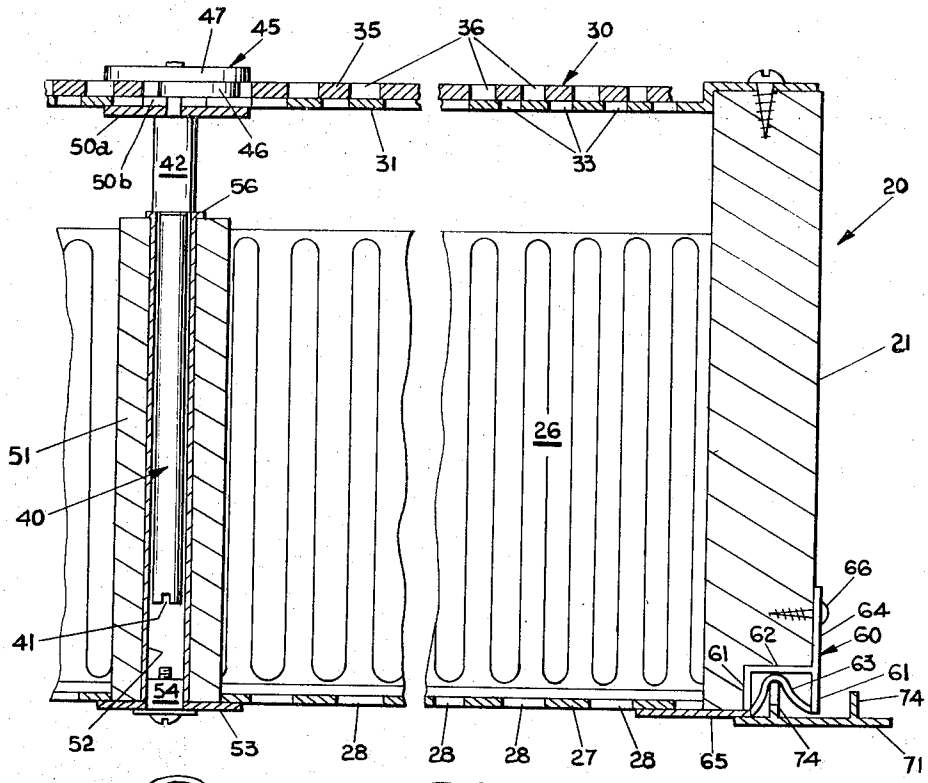


FIG. 3

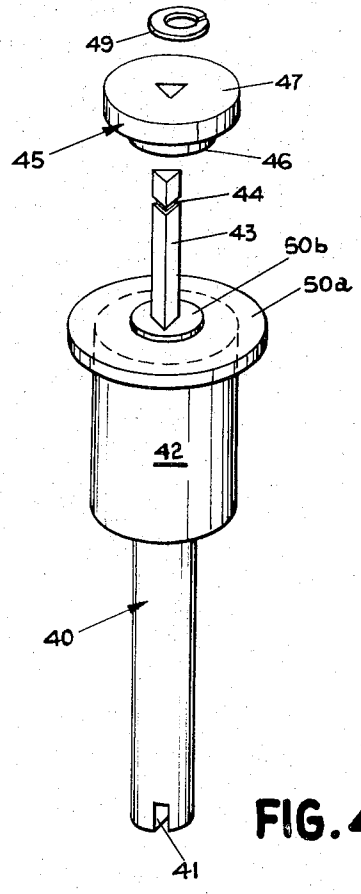


FIG. 4

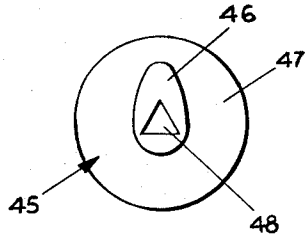
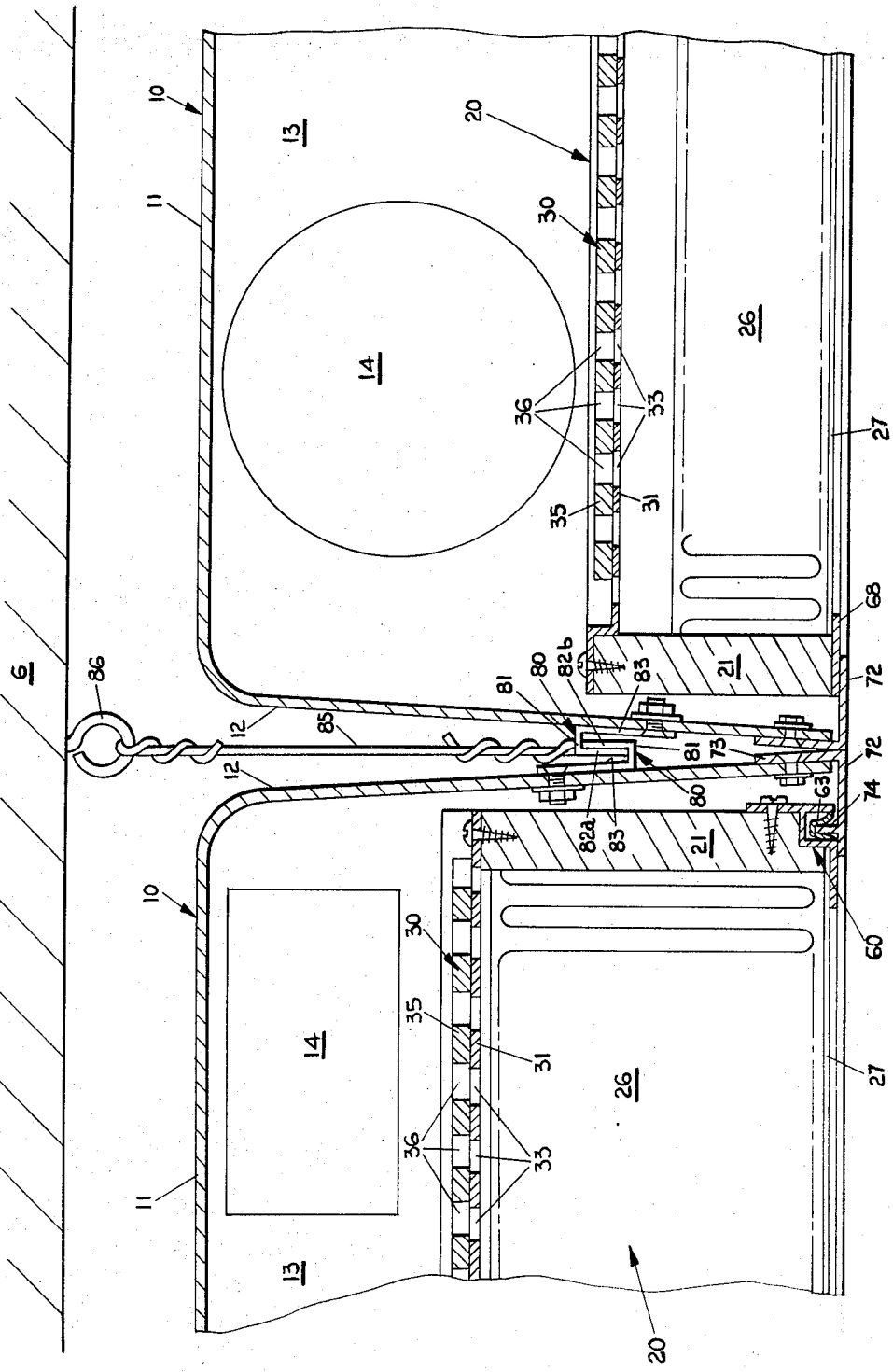


FIG. 5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82b
83
73
63
74
82a
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FIG. 6

LOW PROFILE FILTER SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to clean rooms. More particularly, it relates to apparatus to be used in constructing clean rooms. The two primary goals sought to be achieved through the erection of clean rooms are (1) the provision of a source of ultraclean air which (2) flows in a uniform, generally non-turbulent manner from the ceiling of the room to the floor thereof. The ultraclean air sweeps downwardly through the room and out of the room at the bottom thereof. Because of the absence of turbulence, dust is swept downwardly and out of the room either through a porous floor of some type or through exhaust ducts located along the base of the walls of the room.

It is desirable in most installations that the amount of air flowing out from any one particular filter area within the room be variable. If, for example, there are no individually controllable dampers or the like capable of controlling the flow rate at discrete sections, air being pumped into the room at one end thereof flows more rapidly downwardly at that end of the room than it does at the opposite end of the room. By providing a plurality of individually controllable air flow control valves, one can decrease the effective flow area of the ceiling at that part of the room adjacent the pressure head of incoming air relative to the effective flow area of the ceiling at the opposite end of the room to balance the flow throughout the room.

In order to achieve these goals, prior art systems such as shown in U.S. Pat. No. 3,323,437, issued June 6, 1967 to J. V. Knab, incorporate ducts which carry air into the room from some type of fan. Diverter ducts lead from these main ducts to a plurality of diffuser units positioned at various points about the ceiling. Air flow control valves are then positioned between the main ducts and the units at a point spaced a rather large vertical distance from the filters in order to allow for a deep, large plenum area between the air flow control valve and the filter. This plenum area has been necessary to slow down and smooth out the flow of air as it leaves the main flow duct and before it reaches the filter.

The need for this plenum area creates a need for a great deal of head room in the room which is to be the clean room. Many conventional, pre-existing rooms cannot be outfitted with this type of system. Thus, some manufacturers have found it necessary to use two rooms vertically spaced from one another and knock out the floor of the upper room in order to install a clean room system. Yet another problem with this system is created by the need for creating a tight seal between the filter and the diverter duct which feeds it. This insures that no air will leak past the filter. In prior art systems, this has required, for example, the assembly of the filter and duct at the factory or has required the use of suspended channels containing a fluid or gel into which the edges of the filter must extend. The former is expensive to manufacture and ship while the latter is a nuisance and expensive to install.

One prior art system avoids the need for a great deal of head room by eliminating filters positioned at the ceiling of the clean room. Instead, the filters are located in the adjacent fan room, at the source of air under pressure and the filtered air routed to the ceiling for discharge by conventional ductwork. This system is

not without its drawbacks, however. The main drawback is that it is possible for dirt to gradually build up in the ducts between the filters and the clean room. Eventually, this build-up will result in the introduction of unacceptable foreign particles into the room. Thus, most users of clean rooms prefer to have the air filters positioned directly in the ceiling of the clean room so that the air is filtered immediately prior to its entry into the room.

Thus, current system available in the art either require too much head room for installation in many pre-existing rooms, or fail to provide filtering which is sufficiently efficient for many applications.

SUMMARY OF THE INVENTION

In the present invention, elongated plenum chambers are used to replace conventional ductwork and a plurality of low profile filters are supported in the plenums. A plurality of air flow control valves are positioned above the filters, and the air flow control area of these valves is generally coextensive with the cross-sectional flow area of the filters. (The term cross-sectional flow area refers to the area of a section of the filter which is generally perpendicular to the general direction of air travel through the filter.) The fact that conventional ductwork is replaced by elongated plenum chambers eliminates the need for a plenum space between the main feed duct and the filter. Additionally, the fact that the air flow control area of the air flow control valves is coextensive with the area of the filters eliminates the need for any substantial plenum area between the air flow control valves and the filters.

It is also an object of this invention to provide a filter unit of the type described incorporating a unique sealing means at the edge of the filter whereby a seal can be effectuated between the filter unit and the plenum chamber merely by lowering the plenum chamber into position on a lattice of supporting strips. Each filter unit includes a frame circumscribing a filter, and a downwardly opening channel having a flexible membrane stretched across its opening positioned at the bottom edge of the frame. The supporting strips which define the supporting lattice include an upwardly projecting ceiling flange which projects upwardly into the channel, thereby stretching the flexible membrane over the top edge of the ceiling flange. This provides a sealing means which can be used not only in conjunction with the large plenum chambers incorporated in this invention, but also in conjunction with a lattice of supporting strips merely suspended from the ceiling of a room. If the ceiling were properly cleaned and coated with a suitable sealer, the distance between the ceiling of the room and the filters supported on the lattice work would itself provide a plenum area.

It is yet another object of this invention to provide a means for effectuating a tight seal between adjacent plenums such that there is no possibility of contaminating particles entering the room from the space above the plenum chambers. This eliminates the need for special preparation of the ceiling, other than mere cleaning. Thus, the side wall of one plenum chamber includes an outwardly and downwardly projecting bracket while the side wall of an adjacent plenum chamber includes an outwardly and upwardly projecting bracket. The downwardly projecting portion of one bracket matingly cooperates with the upwardly projecting portion of the other bracket and both include

means for cooperating with a suspension member whereby the plenum chambers are simultaneously suspended from the ceiling and joined together.

These and other objects and advantages of the invention will be seen and understood by reference to the written specification and appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a room outfitted with the apparatus of the present invention;

FIG. 2 is an exploded perspective view of the low profile filter unit utilized in the present invention;

FIG. 3 is a cross-sectional, fragmentary view of the filter unit utilized in this invention;

FIG. 4 is a perspective view of the cam stud and cam drive member utilized to control the air flow control valve utilized in this invention;

FIG. 5 is a bottom plan view of the cam drive member; and

FIG. 6 is a fragmentary cross-sectional view of adjacent plenum chambers suspended from the ceiling of a room.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the preferred embodiment, a plurality of elongated, relatively low profile plenum chambers **10** are provided for suspension from the ceiling **6** of a room **5** (FIG. 1). Each plenum chamber **10** supports four low profile filter units **20**, although only two are shown in position in plenum chamber **10** of FIG. **1**. Filter units **20** are lower in profile than plenum chamber **10** such that a space remains between the top wall **11** of plenum chamber **10** and the upper surfaces of filter units **20** (FIG. **6**).

Each filter unit **20** includes a frame **21**, a pair of adjacent filters **26** mounted in frame **21**, and an air flow control valve **30** positioned on top of frame **21** (FIG. **2**). Air flow control valve **30** is of a low profile type, capable of controlling the flow of air over a large area. Its air flow control area is generally coextensive with the flow cross-sectional area of the filters **26** in order that the need for any substantial plenum space between air flow control valve **30** and filters **26** is eliminated (see FIG. **6**).

While various sealing means can be used to effectuate a seal between filter units **20** and plenum chamber **10**, the preferable sealing means comprises an extruded sealing member **60** positioned at the bottom edge of frame **21** (FIGS. **3** and **6**). It defines a downwardly opening channel covered by a flexible membrane **63** which cooperates with upwardly projecting ceiling flanges **74** on cross supporting strips **71** (FIG. **3**) and on edge supporting strips **72** (FIG. **6**) such that the membrane **63** stretches over the top edge of the ceiling flange **74**.

Plenum chambers **10** are themselves suspended from ceiling **6** by means of brackets **80** secured to the sides thereof. Brackets **80** act to simultaneously join and provide a hanging means for plenum chambers **10** (FIG. **6**).

The term "plenum chamber" as used herein is used somewhat broadly in that the structure which is referred to as plenum chamber **10** does not actually become a plenum chamber until air is pumped into it through feed ducts **15** (FIG. **1**). However, the term as used herein is intended to refer to the structure whether or not air under pressure is actually flowing into the structure.

Plenum chamber **10** is constructed of sheet metal, Fiberglas or some equivalent smooth surfaced structure having a facility for dissipating static electricity. These properties minimize the extent to which dust can build up on the interior surfaces of plenum chamber **10**.

Plenum chamber **10** has a top wall **11**, downwardly depending side walls **12**, and downwardly depending end walls **13** (FIG. **1**). The bottom of plenum chamber **10** is open to allow air to flow therethrough. Air is pumped into each plenum chamber **10** through a duct **15**. A suitable aperture **14** is included in one end wall **13** to facilitate operable connection with the duct **15** (FIG.**6**). Referring to FIG. **6**, it can be seen that ducts of various shapes and sizes can be utilized in conjunction with plenum chamber **10**, and the aperture **14** in end wall **13** can be varied accordingly.

Each filter unit **20** which is supported in plenum chamber **10** includes a frame **21** which is basically a four-sided box (FIG. **2**). In the preferred embodiment, the box is rectangular and has a length approximately equal to the width of plenum chamber **10**(FIG. **1**). The width of frame **21** is approximately equal to one-fourth the length of plenum chamber **10** such that four filter units **20** are suspended in plenum chamber **10** substantially across the entire area of the open bottom thereof. Frame **21** can be constructed of wood, plastic, or other equivalent structural material.

A pair of filters **26** are mounted in frame **21** (FIG. **2**). Actually, it would be possible to use a single continuous filter **26**, except that in the preferred embodiment, a cross piece mount **51** extends across the width of frame **21** to facilitate mounting of a control means for air flow control valve **30** and to restrain the filters **26** against undesirable flexing.

Filters for clean room equipment are well known in the art, and accordingly, an extensive discussion of the construction of filter **26** is not necessary. It is preferable for most ultraclean purposes, however, that a 99.99 percent HEPA filter be utilized.

Except for cross piece mount **51**, almost the entire cross-sectional area of filter unit **20** will allow air to pass therethrough. The walls of frame **21** are preferably quite thin, such that the amount of vertical flow of air which they block is negligable.

Air flow control valve **30**, in accordance with the concepts of the invention, is of a low profile type such that it takes up as little vertical space or head room possible. Additionally, it must have an air flow control area which is generally coextensive with the cross-sectional area of the filters. If the valve were a small 16 inch diameter plate, for example, and the filter to which it controlled the flow of air had an effective area of several square feet, a large plenum space would be required between the air flow control valve and the filter in order to slow down the flow of air and diffuse the turbulence of the air before it reached and passed through the filter. By utilizing an air flow control valve having a large flow control area, generally coextensive with the cross-sectional area of the filter, the need for any substantial plenum space is eliminated.

One type of air flow control valve which is capable of meeting these requirements is the sliding plate type of air flow control valve. Thus, air flow control valve **30** which is mounted on the top of frame **21** (FIGS. **2**, **3**, and **6**) includes a stationary plate which is secured to

frame 21 and a sliding plate 35 which is slidably mounted on top thereof (FIG. 2).

Stationary plate 31 includes flanges 32 projecting upwardly and outwardly therefrom at the perimeter thereof to facilitate mounting to frame 21 by means of screws or the like. Stationary plate 31 includes a plurality of small holes 33 there-through over its entire surface. Similarly, sliding plate 35 includes a plurality of holes 36 therethrough, over its entire surface. The holes 36 through sliding plate 35 and the holes 33 through stationary plate 31 are equal in number and are spaced about the surface of their respective plates in a similar manner. Thus, by slidably moving sliding plate 35 with respect to stationary plate 31, the holes 36 can be brought into alignment with the holes 33 (FIG. 6), or they can be moved partially or completely out of alignment with one another (FIG. 3). In this manner the flow of air through air flow control valve 30 can be shifted from a maximum flow condition to a minimum, almost zero, flow condition. Because there are a large number of holes in sliding plate 35 and in stationary plate 31 over the entire area of the plate, air flow control valve 30 has a very large flow control area.

FIG. 6 shows two alternative filter units 20 embodying the principles of this invention. In both, the use of the low profile air flow control valves 30 has eliminated the need for any substantial plenum space between the valve and the filter. In the filter unit 20 on the right, there is a small plenum space between air flow control valve 30 and filter 26. This space is not substantial, however, and in many cases may prove to be non-essential. Thus, the filter unit 20 shown on the left in FIG. 6 is the preferred unit of the two and uses almost no plenum space between air flow control valve 30 and filter 26. The unit on the left is a deeper unit, only because it is desired to use a thicker filter 26 to provide more filtering surface area.

The control of sliding plate 35 is achieved by a control assembly of which cam stud 40 (FIGS. 3, 4, and 5) is the key element. Cam stud 40 is rotatably mounted in a sleeve 52 which in turn is mounted in cross piece mount 51 (FIG. 3). Cross piece mount 51 comprises a wooden cross piece extending between the opposite sides of frame 21 and being rigidly secured thereto. It includes an aperture drilled therethrough in which a metal or plastic sleeve 52 is mounted. Sleeve 52 includes a sleeve shoulder 53 at its bottom and a flange 56 at its top to hold it in place in cross piece mount 51.

Cam stud 40 includes a slot 41 at the lower end thereof whereby rotation of cam stud 40 can be effected with a screwdriver (FIGS. 3 and 4). At its other end, cam stud 40 includes a shoulder 42 which rests on top of flange 56 of sleeve 52 and which thereby holds cam stud 40 in place in sleeve 52. Projecting upwardly from shoulder 42 is a triangular shaped post 43 to which a cam drive member 45 is secured (FIGS. 3, 4, and 5). Thus, triangular post 43 extends upwardly through an aperture 34 in stationary plate 31 and through an elongated slot 37 in sliding plate 35 (FIG. 2).

Cam drive member 45 comprises a circular head 47 with a cam 46 depending downwardly therefrom (FIGS. 4, 5, and 6). A triangular shaped aperture 48 extends all the way through cam drive member 45 whereby it can be slid down over triangular post 43. A large washer 50*a* slips over triangular post 43 and rests on top of shoulder 42. Washer 50a is sufficiently large that it provides a supporting surface for stationary plate 31 (FIG. 3). A smaller washer 50*b* then slips over triangular post 43 and rests on top of washer 50*a*. Washer 50*b* is merely a spacer washer and must be sufficiently small that it fits within aperture 34 in stationary plate 31. Its function is to insure that when drive member 45 is slipped over triangular post 43, the cam portion 46 thereof will be held in position within elongated slot 37 of sliding plate 35. The width of slot 37 is as great as the length of cam portion 46 so that 360° rotation of cam portion 46 is possible. Washers 50*a* and 50*b* and drive member 45 are then held in place on triangular post 43 by means of a snap on lock washer 49 which cooperates with a groove 44 in triangular shaped post 43 (FIG. 4).

Alternative cam control arrangements could be used. One example is that disclosed in U.S. Pat. No. 3,314,353, issued Apr. 18, 1967, to J. V. Knab.

In order to insure that air passes through filters 26, and does not leak down through sleeve 52, a well nut assembly 54 is positioned within sleeve 52 at the bottom thereof. When one desires to adjust the setting of air flow control valve 30, one merely uses a screwdriver to remove well nut 54 to thereby achieve access to slot 41 in cam stud 40.

Extending across the bottom of each filter unit 20 is a face plate or grill 27 which functions primarily to protect the filter surface from unintentional damage (FIGS. 1, 3, and 6). Grill 27 includes a plurality of apertures 28 therein such that grill 27 does not substantially interfere with the flow of air through filter unit 20 (FIG. 3). One suitable construction material for grill 27 would be expanded metal.

Filter units 20 are supported within plenum chamber 10 by means of a lattice of supporting strips. Cross supporting strips 71 extend across the width of plenum chamber 10 and edge support strips 72 extend along each side wall 12 and along each end wall 13 at the bottom thereof (FIG. 1). These cross supporting strips 71 and edge supporting strips 72 define four supporting cells, each having a configuration approximately equal to the configuration of the frame 21 of filter unit 20 such that each filter unit 20 is supported by the cross supporting strips 71 and edge supporting strips 72 defining a given cell of the lattice. The filter unit 20 merely rests on top of these supporting strips.

A relatively air-tight seal is effectuated between plenum chamber 10 and each filter unit 20 through the cooperation of a sealing member 60 around the bottom edge of frame 21 with the cross supporting strips 71 and edge supporting strips 72. Sealing member 60 includes channel side walls 61 and channel base wall 62 (FIG. 3) defining a downwardly opening channel. Extending laterally and horizontally from the left side channel wall 61 as viewed in FIG. 3, is a mounting flange 65. Extending upwardly from the right side channel wall 61 and being coextensive therewith is a similar mounting flange 64. The bottom edge of frame 21 is notched at the outside thereof such that sealing member 60 can be fitted into the notch with mounting flange 64 extending vertically along the outside wall of frame 21 and with flange 65 extending inwardly slightly beyond the bottom edge of frame 61. Suitable adhesives or screws 66 as shown in FIG. 3 are acceptable means of securing sealing member 60 to the bottom edge of frame 21.

Sealing member **60** also includes a flexible membrane **63** stretched across the opening of the channel defined by channel side walls **61** and channel base wall **62.** The entire sealing member **60** can be simultaneously extruded of two different types of plastics. Thus, the mounting flanges **64** and **65** as well as the channel side walls **61** and channel base wall **62** are extruded of a relatively rigid plastic. A rigid vinyl plastic would be acceptable. The flexible membrane **63** is extruded of a soft, flexible and preferably stretchy plastic. A 50 durometer vinyl would be suitable for this purpose.

In order to effectuate a seal, each cross supporting strip **71** includes a pair of spaced upwardly projecting sealing flanges **74** (FIG. **3**). Two such upwardly projecting sealing flanges **74** are necessary, since each cross piece **71** supports two adjacently disposed filtering units **20.** Each edge supporting strip **72** includes one sealing flange **74** projecting upwardly therefrom (FIG. **6**). The edge supporting strips **72** include mounting flanges **73** whereby they are secured to the side walls **12** and end walls **13** of plenum chamber **10.** Cross supporting strips **71** are then supported directly on top of edge supporting strips **72** at each side wall **12** and may be rigidly secured thereto.

Thus, each supporting cell of plenum chamber **10,** which is defined by a particular set of cross supporting strips **71** and edge supporting strips **72,** includes an upwardly projecting sealing flange **74** extending around the perimeter thereof. The configuration of this perimeter is identical to the configuration of the downwardly opening channel at the bottom edge of frame **21.** Thus, each sealing flange **74** projects upwardly into the downwardly opening channel, and flexible membrane **63** stretches over the top of sealing flange **74** (FIGS. **3** and **6**). This effectuates an excellent seal by means of components which are relatively inexpensive to manufacture while still permitting some relative movement of the various components because of minor structural shifting, etc.

FIG. **6** shows an alternative sealing means on the filter unit **20** which is positioned on the right as viewed in FIG. **6.** Thus, a sealing gasket **68** extends around and is secured to the bottom edge of frame **21.** This gasket **68** provides a seal with edge supporting strip **72** by resting on top thereof. When this type of sealing assembly is used, the upwardly projecting sealing flanges **74** are eliminated both from edge supporting strips **72** and cross supporting strips **71.**

Finally, adjacent plenum chambers **10** are suspended and are simultaneously joined together by means of brackets **80** (FIG. **6**). On the right plenum chamber **10** as viewed in FIG. **6,** the bracket **80** comprises a wall connecting portion **83** whereby the bracket is secured to the wall **12** of plenum chamber **10,** an outwardly projecting portion **81** and a vertically projecting portion **82***a*. This vertically projecting portion **82***a* projects downwardly from outwardly projecting portion **81.** Similarly, the bracket **80** secured to the left plenum chamber **10** as viewed in FIG. **6** includes a wall connecting portion **83,** an outwardly projecting portion **81,** and a vertically projecting portion **82***b*. However, vertically projecting portion **82***b* projects upwardly and into mating engagement with vertically downwardly projecting portion **82***a* of the adjacent bracket **80.** In this manner, adjacent plenum chambers **10** are held laterally with respect to one another.

Preferably, the side walls **12** of each plenum chamber **10** are inclined slightly with respect to the vertical such that each plenum chamber **10** is wider at the bottom than at the top. This leaves a space between adjacent plenum chambers **10** for accommodating brackets **80** and allows the plenum chambers **10** to abut tightly together at the bottom edges thereof (FIG. **6**).

Each of the vertically projecting portions **82**a and **82**b of the brackets **80** include a suitable hole therein through which a suspension wire **85** can be passed (FIG. **6**). Preferably, there is also a hole in the outwardly projecting portion **81** of that bracket **80** having a downwardly projecting portion **82**a such that the suspension wire can be passed through that opening and twisted around itself as shown in FIG. **6.** The opposite end of the suspension wire **85** is then secured to a suitable eye **86** which is mounted in the ceiling **6** of the room **5.** In this manner, adjacent plenum chambers **10** are simultaneously joined together and suspended from the ceiling.

In operation, air is pumped into each plenum chamber **10** through an appropriate duct **15.** Each duct **15** is positioned above the top surfaces of the filter units **20** and there is a space between the top wall **11** of plenum chamber **10** and the upper surfaces of filter units **20** into which the air from duct **15** expands. This space is a plenum space in which the air flow speed decreases and in which the turbulence of the air is diffused.

The air then passes downwardly, first through air flow control valves **30,** then through filters **26,** and finally out through protection grills **27** (which may be omitted in many cases). In most operations, the air flow control valve **30** on the filter unit positioned closest to the opening of duct **15** will be set at a lesser flow area setting than will be the air flow control valve **30** for the filter unit **20** positioned at the far end of the plenum chamber **10.**

These settings can be achieved by rotating cam stud member **40.** The cam portion **46** acts against the sides of elongated slot **37** in sliding plate **35** to thereby move sliding plate **35** either to the left or right with respect to stationary plate **31.** Movement fore and aft of sliding plate **35** would be possible, but is not necessary. Accordingly, an elongated slot **37** is provided such that fore and aft movement is rendered impossible.

The plenum chambers **10,** coupled with filter units **20,** comprise complete integral ceiling members. Because adjacent plenum chambers **10** fit snuggly together, there is no need to specially treat the ceiling **6** of room **5** which is located above plenum chambers **10.** While the ceiling **6** must certainly be cleaned and perhaps painted before installation of the plenum chambers **10,** the fact that no air will ever flow past ceiling **6** itself renders it unnecessary to specially treat ceiling **6** to prevent dust build-up. Any tendency for air to flow between the chambers **10,** moreover, will be in an upward or out-of-the-room direction as viewed in FIG. **6** since the interior of the room will be pressurized positively with respect to the spaces between the chamber exteriors and the ceiling **6.** This direction of air flow, of course, will positively prevent any contaminants from entering the room through these functions.

Thus, the present invention provides a system in which the air is filtered at the entry surface of the clean room yet which can be utilized in a pre-existing room of fairly conventional height. The use of a low profile air flow control valve, such as a sliding plate type air

flow control valve, having an effective flow control area coextensive with the cross-sectional flow area of the filters, eliminates the need for any substantial plenum space between the air flow control valve and the filters. The fact that the air flow control valve is itself of a low profile, aids in eliminating the need for excessive amounts of head room between the real ceiling of the room and the false ceiling provided by the filters **26.**

Finally, the system preferably employs the unique sealing member **60** described above. This insures a tight seal between the filter units **20** and the plenum chambers **10** in such a manner that the filtering units **20** can be assembled into the plenum chambers **10** at the job site. It is not necessary to effectuate such assembly at the plant in order to achieve a suitable seal.

Of course, it is understood that the above is merely the preferred embodiment of the invention and that various changes and alterations can be made without departing from the spirits and broader aspects of the invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

1. Apparatus for a clean room, said apparatus comprising, in combination: a low profile plenum chamber housing for hanging from a ceiling, said plenum chamber having a top wall, side walls, and end walls depending downwardly therefrom, and a generally open bottom, the height of said chamber being substantially small compared to either its width and length; an opening in one of said end walls for operable connection with a duct whereby a flow of air under pressure can be introduced into said plenum chamber; a plurality of filters mounted in said plenum chamber in closely adjacent fashion across said open bottom of said plenum chamber such that filtered air flows through substantially the entire cross-sectional area of said open bottom of said plenum chamber when said plenum chamber is charged with pressurized air through said end wall opening; each of said filters having a lower profile than said plenum chamber such that there is a space between said top wall of said plenum chamber and the upper surfaces of said filters; said opening in said one of said end walls being positioned above the level of said upper surfaces of said filters and below the plane of said top; individually controllable air flow control valves positioned in closely adjacent fashion above said filters and below the level of said end wall opening; each of said plurality of air flow control valves having an air flow control area which is coextensive with the flow cross-sectional area of each of said plurality of filters whereby the need for a substantial plenum space between said air flow control valves and said filters is eliminated.

2. The apparatus of claim **1** in which said air flow control valves are low profile in nature such that they occupy a minimum amount of vertical space.

3. The apparatus of claim **2** in which said air flow control valves are of the sliding plate type.

4. The apparatus of claim **3** in which each of said sliding plate air flow control valves comprises a first plate having a plurality of holes therethrough throughout its cross-sectional area; a second plate being slidably positioned on said first plate; said second plate having substantially the same number of holes as said first plate, with said second plate holes being spaced in the same manner as said first plate holes; said sliding plate valve being individually controllable by a means for sliding said second plate with respect to said first plate to thereby vary the extent to which said second plate holes are aligned with said first plate holes.

5. The apparatus of claim **1** in which each of said plenum chambers includes a bracket secured to each side wall thereof on the exterior of said plenum chamber; the bracket on one side wall extending outwardly therefrom and then downwardly; the bracket on the other side wall extending outwardly therefrom and then upwardly whereby two plenum chambers can be placed in side-by-side adjacent relationship with the said one side wall of one chamber being adjacent the said other side wall of the other chamber the upwardly extending portion of said one side bracket extending into mating engagement with the downwardly projecting portion of said other side bracket of said other plenum chamber; each of said downwardly and upwardly extending portions of said brackets including apertures therein through which means can be passed for simultaneously suspending and joining said adjacent plenum chambers.

6. The apparatus of claim **5** in which said side walls of said plenum chamber are sloped outwardly whereby said plenum chamber is wider at the bottom than at the top; said brackets being positioned a sufficient distance from the bottom of the plenum chamber that the mating engagement of adjacent brackets on adjacent plenum chambers does not prevent the adjacent side walls from abutting at their bottom portions.

7. Apparatus for a clean room, said apparatus comprising, in combination: a plenum chamber housing for hanging from a ceiling, said plenum chamber having a top wall, side walls, and end walls depending downwardly therefrom, and a generally open bottom; an opening in one of said end walls for operable connection with a duct whereby a flow of air under positive pressure can be introduced into said plenum chamber; a plurality of filter units mounted in said plenum chamber in closely adjacent fashion across said open bottom of said plenum chamber such that filtered air flows through substantially the entire cross-sectional area of said open bottom of said plenum chamber when said plenum chamber is charged with pressurized air through said end wall opening; each of said filter units having a lower profile than said plenum chamber such that there is a space between said top wall of said plenum chamber and the tops of said filter units; said opening in said one of said end walls being positioned above the level of said tops of said filter units and below the plane of said top; each of said filter units having a frame, a filter mounted in said frame, and a low profile air flow control valve mounted in said frame; said frame having four walls of relatively narrow thickness such that they block only a minimum flow of vertically moving air; said filter being mounted in said frame between said walls and extending across substantially the entire interior cross-sectional area of said frame; said low profile air flow control valve being mounted at the top of said frame and having a flow control area which is coextensive with the cross-sectional area of said filter whereby the need for a substantial plenum space between said low profile air flow control valve and said filter is eliminated.

8. The apparatus of claim **7** in which said air flow control valves are of the sliding plate type.

9. The apparatus of claim 8 in which said sliding plate air flow control valves comprises a first plate having a plurality of holes therethrough throughout its cross-sectional area; a second plate being slidably positioned on said first plate; said second plate having substantially the same number of holes as said first plate, with said second plate holes being spaced in a similar manner as said first plate holes; said sliding plate valve being individually controllable by a means for sliding said second plate with respect to said first plate to thereby vary the extent to which said second plate holes are aligned with said first plate holes.

10. The apparatus of claim 9 in which said means for controlling the movement of said second sliding plate comprises: means for mounting a cam stud, said means extending between opposite sides of said frame approximately in the middle thereof; a cam stud being rotatably mounted in said mounting means and having a first end accessible from the bottom of said filter unit and having a second end extending to the top of said filter unit; said first plate having an aperture therein through which said second end of said cam stud extends; a cam member being mounted on said second end of said cam stud; said second sliding plate including an aperture therein in which said cam member resides, said aperture in said second sliding plate being sufficiently small that rotation of said cam stud causes said cam member to act against the boundries of said aperture and thereby causes said second sliding plate to move.

11. The apparatus of claim 7 in which: a lattice of supporting strips extends across said open bottom of said plenum chamber for supporting said plurality of filter units; each cell of said lattice having a boundry corresponding approximately to the shape of said frame of said filter unit whereby said filter unit can be supported by placing said frame on the supporting strips defining a given cell of said lattice; said frame including a downwardly opening channel at the bottom edge thereof and a flexible membrane stretched across the opening of said channel; each of said supporting strips including a sealing flange projecting upwardly therefrom for each of said cells which it partially defines, such that an upwardly projecting sealing flange circumscribes said cell in alignment with said channel in said frame; said sealing flange projecting upwardly into said channel whereby said flexible membrane is stretched over said sealing flange.

12. The apparatus of claim 7 in which each of said plenum chambers includes a bracket secured to each side wall thereof on the exterior of said plenum chamber; the bracket on one side wall extending outwardly therefrom and then downwardly; the bracket on the other side wall extending outwardly therefrom and then upwardly whereby two of said plenum chambers can be placed in adjacent relationship with the upwardly extending portion of one side bracket on one plenum chamber extending into mating engagement with the downwardly projecting portion of the adjacent side bracket of the adjacent plenum chamber; each of said downwardly and upwardly extending portions of said brackets including apertures therein through which means can be passed for simultaneously suspending and joining said adjacent plenum chambers.

13. The apparatus of claim 12 in which said side walls of said plenum chamber are sloped outwardly whereby said plenum chamber is wider at the bottom than at the top; said brackets being positioned a sufficient distance from the bottom of the plenum chamber that the mating engagement of adjacent brackets on adjacent plenum chambers does not prevent the adjacent side walls from abutting at their bottom portions.

14. A low profile filter unit comprising: a frame, a filter mounted in said frame, and a low profile air flow control valve mounted in said frame; said frame having four walls; said filter being mounted in said frame between said walls and extending across the entire interior cross-sectional area of said frame; said low profile air control valve being mounted at the top of and to said frame and having a flow control area which is coextensive with the cross-sectional area of said filter whereby the need for a substantial plenum space between said air flow control valve and said filter is eliminated, said air flow control valve comprising a first plate having a plurality of holes throughout its cross-sectional area and a second plate slidably positioned on said first plate, said second plate having substantially the same number of holes as said first plate, said second plate holes being spaced in a similar manner as said first plate holes, said sliding plate valve being individually controllable by a means for sliding said second plate with respect to said first plate to vary the extent to which said second plate holes are aligned with said first plate holes, said means for controlling the movement of said second sliding plate comprising means for mounting a cam stud, said means extending between opposite sides of said frame approximately in the middle thereof; a cam stud being rotatably mounted in said mounting means and having a first end accessible from the bottom of said filter unit and having a second end extending to the top of said filter unit; said first plate having an aperture therein through which said second end of said cam stud extends; a cam member being mounted on said second end of said cam stud; said second sliding plate including an aperture therethrough in which said cam member resides, said aperture in said second sliding plate being sufficiently small that rotation of said cam stud causes said cam member to act against the boundaries of said aperture and thereby causes said second sliding plate to move.

15. A low profile filter unit comprising, in combination: a frame, a filter mounted in said frame, and a low profile air flow control valve mounted in said frame, said frame having four walls; said filter being mounted in said frame between said walls and extending across the entire interior cross-sectional area of said frame; said low profile air control valve being mounted at the top of and to said frame and having a flow control area which is coextensive with the cross-sectional area of said filter whereby the need for a substantial plenum space between said air flow control valve and said filter is eliminated; and a sealing means at the bottom edge of its frame cooperating with a supporting lattice having an upwardly projecting flange whose configuration corresponds to that of said frame; said sealing means including a downwardly opening channel at the bottom edge of said frame and a flexible membrane stretched across the opening of said channel and secured thereto, said flexible membrane is stretched over said flange projecting upwardly into said channel.

16. The low profile filter of claim 15 in which said channel and said flexible membrane comprise an integral plastic extrusion with said channel portion of said extrusion being formed of a relatively rigid plastic material and with said flexible membrane portion of said

extrusion being formed of a relatively flexible plastic material; said extrusion including means to facilitate its securance to said frame at the bottom edge thereof.

17. Apparatus for a clean room comprising: a plurality of filter units for operably hanging from a ceiling; each of said filter units comprising a filter mounted in a frame which circumscribes said filter; a lattice of supporting strips supporting said filter units at a ceiling level; each cell of said lattice having a boundry corresponding approximately to the configuration of said frame, each said filter unit being supported on those supporting strips defining a cell of said lattice; each of said frames including a downwardly opening channel at the bottom edge thereof and flexible membrane stretched across the opening of said channel; each of said supporting strips including a sealing flange projecting upwardly therefrom for each of said cells which it partially defines, such that an upwardly projecting sealing flange circumscribes said cell in alignment with said channel in said frame; said sealing flange projecting upwardly into said channel so that said flexible membrane is stretched over said sealing flange.

18. The low profile filter of claim **17** in which said channel and said flexible membrane comprise an integral plastic extrusion with said channel portion of said extrusion being formed of a relatively rigid plastic material and with said flexible membrane portion of said extrusion being formed of a relatively flexible plastic material; said extrusion including means to facilitate its securance to said frame at the bottom edge thereof.

19. The apparatus of claim **17** which further comprises: a plenum chamber for hanging from a ceiling, said plenum chamber including a top wall, downwardly depending side walls, and end walls, and an open bottom; said lattice of support strips extending across said open bottom of said plenum chamber.

20. An apparatus for a clean room comprising: a plurality of plenum chamber housings for suspension from the ceiling of a room; each of said plenum chambers including a top wall, and downwardly depending side walls and end walls an opening in one of said end walls; a bracket secured to each of said side walls on the exterior of said plenum chamber; the bracket on one side wall extending outwardly therefrom and then downwardly; the bracket on the other side wall extending outwardly therefrom and then upwardly, said plenum chambers being positioned in adjacent relationship with the upwardly extending portion of its one side bracket extending into mating engagement with the downwardly projecting portion of the other side bracket of the adjacent plenum chamber; each of said downwardly and upwardly extending portions of said brackets including apertures for receipt of means for simultaneously suspending and joining said adjacent plenum chambers.

21. The apparatus of claim **20** in which said side walls of said plenum chamber are sloped outwardly whereby said plenum chamber is wider at the bottom than at the top; said brackets being positioned a sufficient distance from the bottom of the plenum chamber that the mating engagement of adjacent brackets on adjacent plenum chambers does not prevent the adjacent side walls from abutting at their bottom portions.

22. An apparatus for a clean room comprising a plurality of plenum chamber housings for suspension from the ceiling of a room each having side and end walls, a top and an open bottom; and an opening in one of said end walls, brackets on adjacent side walls of adjacent plenum chambers; said brackets being in mating engagement with one another; said side walls of said plenum chambers being sloped outwardly whereby said plenum chamber is wider at the bottom than at the top; said brackets being positioned a sufficient distance from the bottom of the plenum chamber that the mating engagement of adjacent brackets on adjacent plenum chambers does not prevent the adjacent side walls from abutting at their bottom portions.

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