Sept. 9, 1969 J. V. KNAB 3,465,666

CLEANROOM FILTERING METHOD

Original Filed May 24, 1967 2 Sheets-Sheet 1

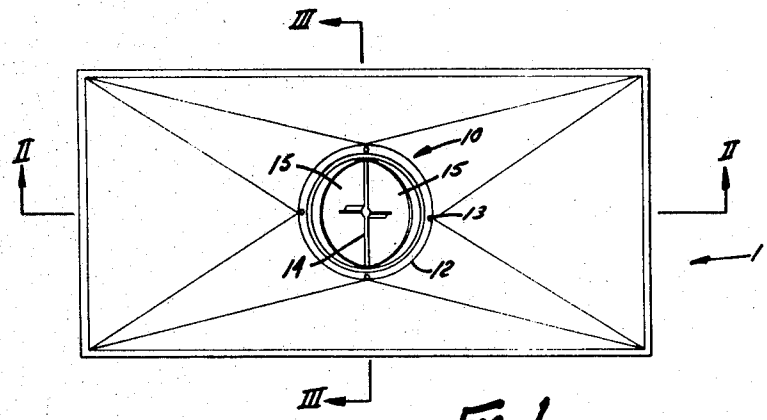

FIG. 1

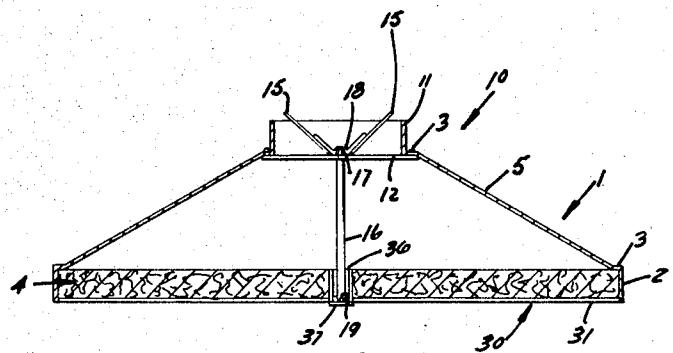

FIG. 2

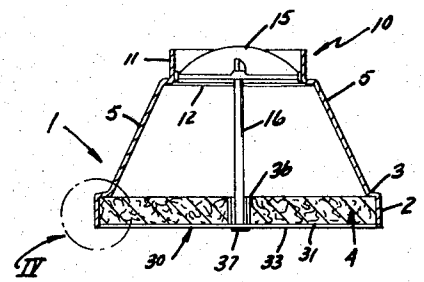

FIG. 3

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CLEANROOM FILTERING METHOD

Original Filed May 24, 1967 2 Sheets-Sheet 2

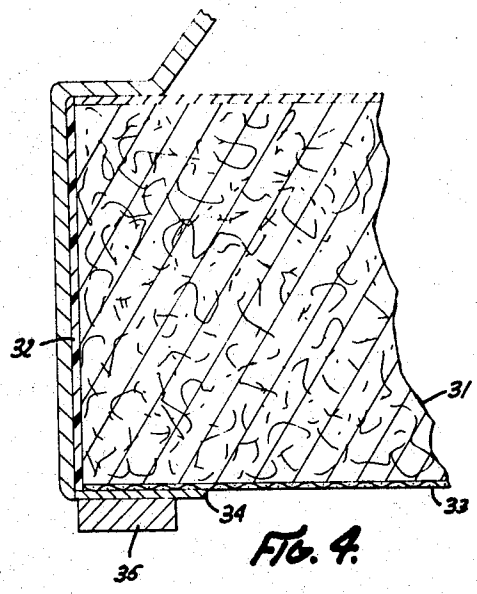

FIG. 4.

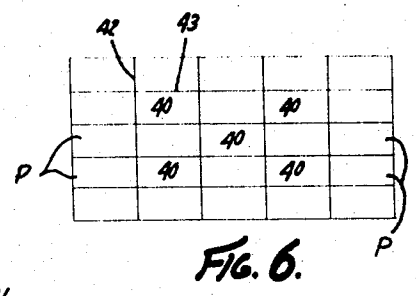

FIG. 6.

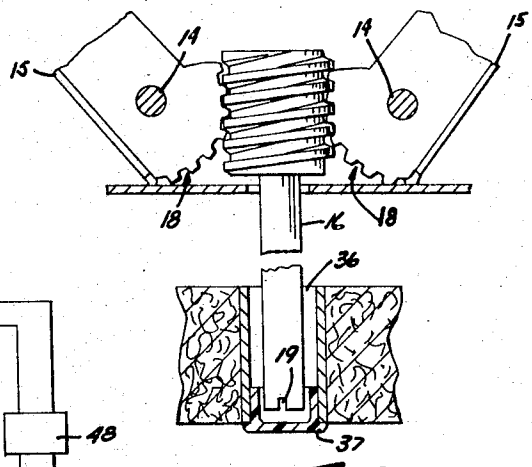

FIG. 7.

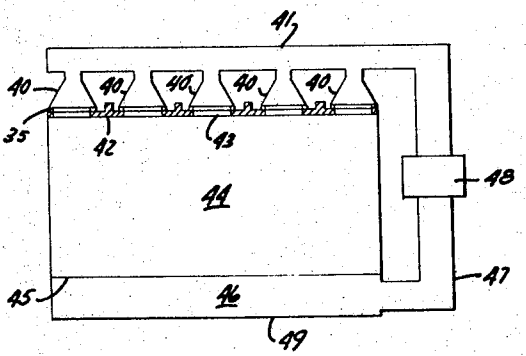

FIG. 5

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CLEANROOM FILTERING METHOD

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Continuation of application Ser. No. 640,965, May 24, 1967. This application Dec. 10, 1968, Ser. No. 785,033
Int. Cl. F24f *13/06;* B01d *46/10*
U.S. Cl. 98—33 2 Claims

ABSTRACT OF THE DISCLOSURE

A method of supplying air to a cleanroom having a plurality of individual, modular plenum units suspended adjacent the ceiling thereof and opening toward the floor. Each of the units has a highly efficient filter positioned over the room facing outlet thereof. The plenum units are pressurized with pre-filtered, suitably conditioned air and this air passes through the filters and downwardly through the room in generally laminar fashion. The air is then passed through a perforate false floor, collected and recirculated. The filters in the units act to diffuse the air as well as filter it.

This case is a stream-lined continuation of application No. 640,965 filed May 24, 1967, now abandoned, which was a divisional of application No. 481,249 filed Aug. 20, 1965, now Patent No. 3,323,437, issued June 6, 1967.

BACKGROUND

This invention relates to a method for circulating air and, more specifically, to such a method employing self-contained, relatively small plenum units which may be cascaded to form a cleanroom of and desired dimensions or grade.

Modern electronic manufacturing techniques often require that critical components be assembled and packeted inside what has come to be known as a cleanroom. Basically, these rooms are merely enclosures within which temperature, humidity and dust conditions are maintained at desired levels. They usually comprise some system for constantly recirculating and filtering the air contained in the cleanroom to insure that it is kept free from minute dust particles.

It is customary in the art of cleanroom construction to provide a single plenum of sufficient dimensions to cover the entire ceiling or the entire wall of the cleanroom. This mode of construction has not been found completely satisfactory for several reasons. The tolerances for construction of a plenum are in micron measurements to insure that it will be airtight. As contemporary plenums become larger, the normal expansion and contraction due to outside changes in temperature and humidity often defeat the desire for absolutely tight construction. Another drawback to the present method of constructing cleanrooms is that the entire, self-contained room must be constructed initially. This necessitates either the provision of a plenum large enough to enclose cleanroom space sufficient for future expansion, or the complete, later, construction of another cleanroom. Either of these alternatives are very expensive.

In cleanrooms currently in use, there is not means whereby the air flow at an individual section of the cleanrooms can be controlled. Since it is often desirable to maintain the air velocity above one work table at a relatively small level, systems now in use require that the air velocity in the entire cleanroom be retarded.

The current mode of construction of cleanrooms requires architects and engineers who are specialists in the

cleanroom field. Ordinary construction techniques and workmanship are not sufficient because of the small acceptable tolerances involved.

OBJECTS AND SPECIFICATION

It is an object of this invention, therefore, to provide a mode of cleanroom construction and method of utilizing the same which is not subject to the difficulties and drawbacks outlined above.

More specifically, it is an object of this invention to provide a method employing plenum unit of standard shape and size which may, if desired, be cascaded with like plenum units to form a cleanroom ceiling or wall of any desired shape and size.

It is an object of this invention to provide a method employing a plenum unit which is capable of being cascaded with already existing groups of plenum units so that a previously constructed cleanroom may be enlarged.

It is an object of this invention to provide a method employing a standard size plenum unit having means whereby the air velocity therethrough may be controlled, and thereby provide a means whereby, in a cleanroom composed of a plurality of such plenum units, individual work areas may be velocity regulated.

It is an object of this invention to provide a mode of cleanroom construction which is sufficiently simple to be executed by architects and engineers utilizing ordinary construction techniques and workmanship.

It is an object of this invention to provide a mode of cleanroom construction which is less expensive than that previously utilized.

These and other objects of this invention will be completely understood by reference to the following specification and figures in which:

FIG. 1 is a plan view of the plenum unit which is the subject of this invention;

FIG. 2 is a cross-sectional view taken along line II of FIG. 1;

FIG. 3 is a cross-sectional view taken along line III of FIG. 1;

FIG. 4 is an enlarged view of the area indicated by circle IV of FIG. 3;

FIG. 5 shows a cleanroom, partially in cross section, which has been constructed utilizing the teachings of this invention;

FIG. 6 is a schematic view of a ceiling of a room showing an exemplary manner of mounting the plenum units of this invention therein; and

FIG. 7 is an exploded cross-sectional view showing the damper pivot gear.

Briefly, the objects of this invention are accomplished by providing a plurality of individual plenum units removeably suspended adjacent the ceiling of the cleanroom. Pre-filtered, conditioned air is pumped into the room passing through filters at the room abutting surface of the plenum units immediately prior to entry. Thus, the filters act to diffuse the air within the room as well as filter it.

Referring now to the figures a preferred embodiment of this invention will be discussed in detail. FIGS. 1, 2, 3, 4 and 7 illustrate the details of the plenum. The housing **1** comprises a vertical base **2** within horizontal ledge **3** extending therefrom. These two members form a filter receptacle indicated generally at **4**. Extending from the entire periphery of the filter receptacle are frusto-converging housing segments **5**. These segments converge at the bi-valve damper assembly indicated generally at **10**. Obviously, the envelope formed by the frusto-converging housing segment **5** could be attached directly to the vertical base **2** without departing from the spirit of this invention.

The upper portion of the envelope is affixed to a stack **11** as shown. This connection, as well as that to the filter receptacle, must be airtight. Preferably, the entire housing includes members **2, 3, 5** and **10** is formed as one piece. White fiber glass is one material that has been found suitable for this purpose.

The bi-valve damper assembly has a circular valve supporting member **12** affixed to the lower portion of stack **11** by suitable fastening means **13**. A valve pivot **14** extends across the circular valve supporting member **12** in diametrical fashion. Pivotably attached to the valve pivot **14** are two semi-circular valves **15**. Each of these valves are provided with a pivot gear **18** positioned as shown best in FIG. 2. A bi-valve adjustment shaft **16** having a worm gear extremity **17** is operatively mounted with respect to the pivot gear **18** as is well-known in the art. The bi-valve adjustment shaft **16** extends into the envelope and terminates with an adjustment slot **19** at a point just short of the plane formed by the lower edges of vertical base **2**.

The filter assembly, indicated generally at **30**, comprises a filter **31** which is preferably permanently sealed into filter receptacle **4** by means of a suitable sealant such as silicone construction cement. The filter **31** should have particle efficiencies better than 99.97 percent for 0.3 micron diameter particles as determined by Standard Chemical Core Dioctyl Phthalate Tests. As viewed best in FIG. 4, filter **31** is additionally secured by means of a grill work **33** which is secured to the filter receptacle by means of securing strips **34**. Grill **33** may, for example, be a No. 0.081 anodized aluminum flattened expanded grill and the strips **34** may be one inch wide by 0.062 inch thick anodized aluminum.

A vertical sleeve **36** is provided through filter **31**. This sleeve is so positioned that the bi-valve adjustment shaft **16** passes therethrough and extends approximately the outer surface of the filter. A sealing cap **37** is provided for plugging the sleeve **36** after the desired damper assembly adjustments have been executed. Peripherally disposed about the inner surface of the housing is a sealing gasket **35**. Conveniently, this gasket may be affixed to securing strips **34**. The gasket may, for example, be of polyurethane material.

Referring now to FIG. 5, a cleanroom utilizing the plenum unit which is the subject of this invention will be described. While FIG. 5 shows the plenum units positioned in the ceiling, it is to be understood that they might also be positioned in the wall. This modification, of course, would also necessitate moving the collection chamber to the opposite wall. The ceiling is formed initially from a plurality of mutually perpendicular supporting members **42** and **43**. Conveniently, these supporting members may be inverted T-beams. They are positioned such that a plurality of rectangular openings are formed in the ceiling having dimensions somewhat less than the dimensions of the plenum units to be utilized. Where an inverted T-beam is utilized, it is desirable that the edges of the plenum unit closely approach the legs of the T-beam on all four sides of the opening. Members **42** and **43** are so positioned that the frame formed by the T-beam cross-members is planar. It will be noted, that when the plenum unit **40** is placed within the rectangular frame formed by mutually perpendicular support members **42** and **43**, sealing gasket **35** lies between the support member and the periphery of the plenum unit. The presence of this gasket is sufficient protection against dust leakage, because of the direction of air flow as will be described. A plenum unit **40** is positioned within each rectangular frame. While FIG. 5 does not illustrate the details of these plenum units, it is to be understood that they are preferably identical to those described in connection with FIGS. 1–4.

A supply duct **41** connects the stacks of the plenum units **40**. It has been found that one supply duct may be utilized for each two rows of plenum units. The room **44** is provided with a false floor **45** through which the air exits. Conveniently, the space between false floor **45** and the floor **49** may form a collection chamber **46**. The air leaves the collection chamber **46** via return duct **47** and passes into compressor unit **48**. The compressor unit **48** preferably includes some form of pre-filtering unit and also means for exhausting stale air and intaking and conditioning fresh air to replace it. The air is forced from compressor unit **48** into supply duct **41**.

The plenum units which are the subject of this invention are preferably constructed with dimensions such that they may be easily handled and also cascaded to form a cleanroom of the desired size. Suitable dimensions are, for example, on the order of two feet by four feet.

In operation, air is fed from compressor **48** into supply duct **41**. The air passes into the individual plenum via the bi-valve assemblies which are adjusted to achieve the correct volumes and velocities. The air exits from the plenum unit by passing through the filters **31**. It flows in laminar fashion through the cleanroom, through false floor **45**, and passes into collection chamber **46**. It is then returned to the compressor unit and the process is repeated.

The plenum units of this invention may also be utilized in rooms which do not require a high degree of cleanliness by spacing the plenum units further apart in the ceiling or wall. A schematic showing of such a situation is illustrated in FIG. 6 which shows a ceiling **6** with intersecting beams **42** and **43**. In such a case, many rectangular supports are sealed by some type of wall panel.

Certain of the supports only would include a plenum unit, as shown by the reference numeral **40**. If it were later desired to improve the cleanliness of the room, it would merely be necessary to remove these alternate wall or ceiling panels and replace them with plenum units.

Thus it may be seen that this invention has provided a means whereby cleanrooms may be constructed at a minimum initial cost while still preserving maximum opportunities for later expansion. Since the critical components come in pre-assembled form, a means is also provided whereby a satisfactory cleanroom may be assembled utilizing ordinary construction techniques and workmanship. The overall results of these, and previously discussed advantages, are to increase the cleanroom efficiency while substantially reducing its cost of construction.

While several preferred embodiments of this invention have been described together with minor modifications, it will be recognized that other modifications may be made without departing from the scope and spirit of the invention. Such modifications are to be deemed as included within the scope of the following claims unless these claims, by their language, expressly state otherwise.

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

1. A method of supplying treated air to a cleanroom having a plurality of closely adjacent individual, modular plenum units suspended adjacent the ceiling thereof and opening toward the floor of said room, each of said units including individual plenum chambers having a stack at one end thereof and a room facing outlet enlarged with respect to said stack at the other end thereof, said stack and said outlet being interconnected by an airtight envelope of smoothly increasing interior cross section from said stack to said outlet, each of said chambers communicating with an air duct means at the stack end thereof and having a filter positioned over and affixed to the room facing outlet thereof, each said filter having at least a 75 percent efficiency for 0.3 micron particles as determined by the Standard Chemical Core D.O.P. Test, said method comprising the steps of:

routing a stream of pressurized air into each of said chambers through said stack means, the air flowing through said duct means prior to entry into said chambers;

expanding smoothly the cross section of said streams within each of said chambers as it flows toward said

filter from said stack means;

filtering said air immediately prior to its entry into the room by forcing it from said plenum units through said filters directly into said room without it contacting any diffusing means other than said filters so that said filters act to finally diffuse the air within said room as well as filter it;

passing said air downwardly from said filters in generally laminar fashion through said room such that, after leaving said filter and during said downward passage, it contacts only the personnel and equipment disposed within said room prior to striking the floor;

passing said air through perforations in the floor of said room to collect it; and

returning at least a major portion of the air so collected to said duct means for rerouting into said chambers, refiltering and repassage through said room.

2. A method of supplying treated air to a cleanroom having a plurality of individual, modular plenum units suspended adjacent the ceiling thereof closely adjacent each other and opening toward the floor of said room, each of said units including individual plenum chambers communicating with an air duct means at one end thereof and having a filter positioned over and affixed to a room facing outlet at the other end thereof, each said filter having at least a 75 percent efficiency for 0.3 micron particles as determined by the Standard Chemical Core D.O.P. Test, said method comprising the steps of:

pressurizing said adjacent plenum chambers with air from said air duct means;

filtering said air immediately prior to its entry into the room by forcing it from said plenum units through said filters directly into said room without it contacting any diffusing means other than said filters so that said filters act to finally diffuse the air within said room as well as filter it;

passing said air downwardly from said filters in generally laminar fashion through said room such that, after leaving said filter and during said downward passage, it contacts only the personnel and equipment disposed within said room prior to passing therefrom, the air flow from adjacent of said filters joining to provide a downward laminar flow throughout the working area of said room;

passing said air through a perforate false floor in said room to collect it;

returning at least a major portion of the air so collected to said plenum chambers for refiltering and repassage through said room; and

controlling the volume of air flow through each of said chambers and its associated filter in accordance with a desired pattern.

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WILLIAM E. WAYNER, Primary Examiner

U.S. Cl. X.R.

55—420, 484; 98—40