Aug. 4, 1970 J. V. KNAB 3,522,724

METHOD AND APPARATUS FOR TESTING CLEAN ROOM FILTRATION EFFICIENCY

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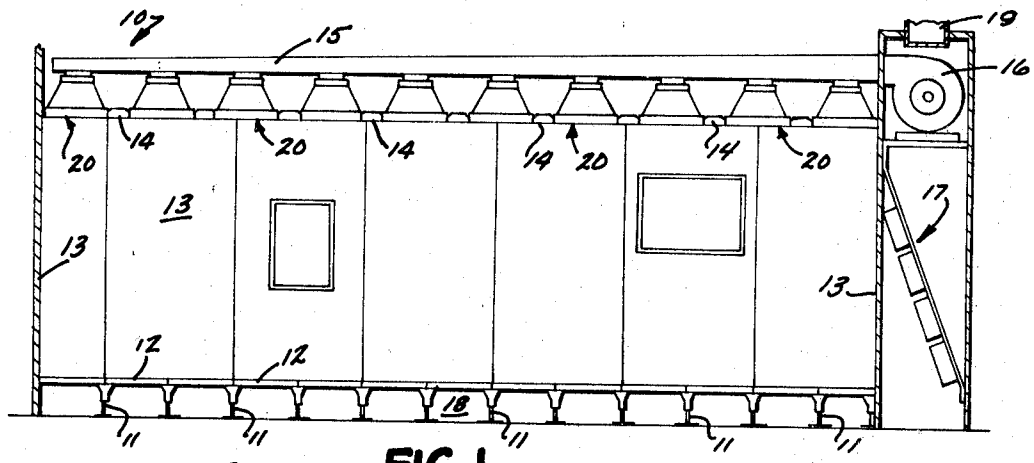

FIG. 1.

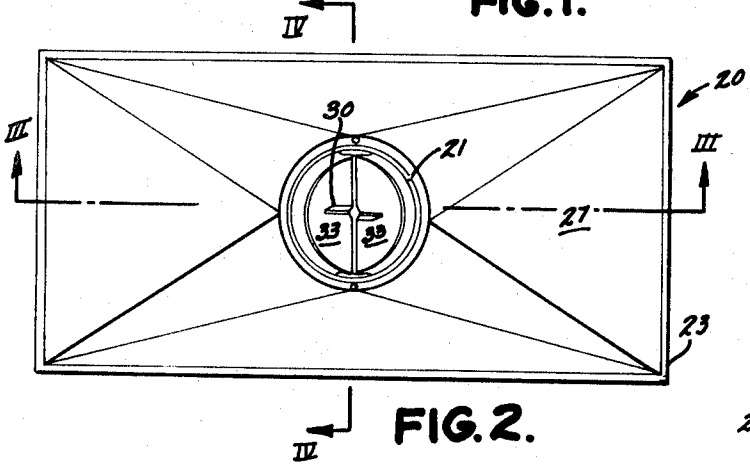

FIG. 2.

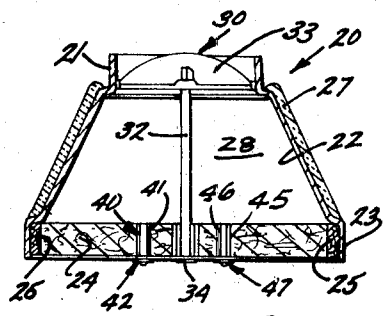

FIG. 4.

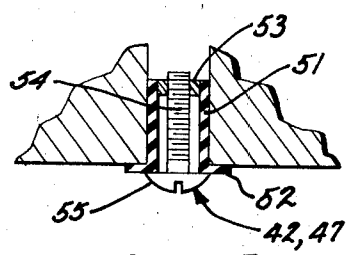

FIG. 5.

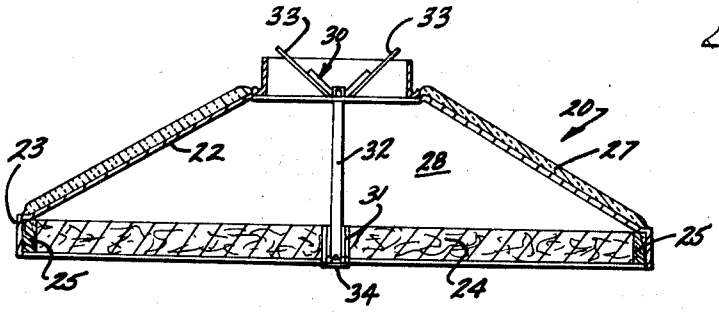

FIG. 3.

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METHOD AND APPARATUS FOR TESTING CLEAN ROOM FILTRATION EFFICIENCY

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U.S. Cl. 73—40.7 4 Claims

ABSTRACT OF THE DISCLOSURE

A clean room having a series of air diffusing units across one surface thereof, the individual units being fed by compressed air ducts which, ordinarily, are each connected to a series of the units. Each of the units is provided with two sealable apertures for access into the interior thereof. Smoke is introduced into the individual diffuser units through one of the apertures and the smoke concentration within the unit is monitored through the other of the apertures. The exterior of the unit is then scanned utilizing conventional photometer techniques. Each unit, thus, can be tested individually and it is not necessary to fill the entire system with smoke as required in the past.

This invention relates to clean rooms and, more particularly, to a method of and apparatus for testing clean room filtration efficiency.

It is often desirable and/or necessary in the art of environmental control to provide a room, specific area or the like wherein temperature, humidity and dust conditions are maintained within prescribed limits. Such environments are necessitated, for example, in the manufacturing of specialized electronic components, the performance of medical surgery and the like. This particular field of environmental control has become known as the "Clean Room Field" and, as of late, a great deal of research and development has been expended to provide satisfactory environment control for specialized operations such as those noted. It is not unusual, for example, for a manufacturing technique to require that the dust level within the assembly area be reduced to a virtually non-existent level and this reduction is accomplished ordinarily by the process of filtering the air entering the particular area in question through high efficiency filters.

In U.S. Pat. No. 3,323,437 there is illustrated a mode of clean room construction wherein the ceiling of the particular room in question is formed from a plurality of side-by-side air filtration units. Each of the units comprises an air plenum with a high-efficiency filter positioned across the room-abutting surface thereof. The filters, ordinarily, have particle efficiencies exceeding 99.97 percent for 0.3 micron diameter particles as determined by the Chemical Corp D.O.P. tests.

It is customary in the installation of such rooms to prefabricate as many of the parts as possible prior to their actual installation at the job site such that manufacturing tolerances may be controlled effectively to insure satisfactory operating characteristics subsequent to installation. The patent noted above, thus, contemplates the pre-fabrication of the air diffuser units within the supplier's manufacturing facility prior to its actual installation at the job site. Once the diffusers have been transported and positioned, elongated supply ducts are connected to the intakes thereof, one such duct usually being utilized to supply compressed, pre-filtered air to a series of the diffuser units in a line or the like. Installation specifications invariably require that, subsequent to completion of the installation, a test be run as a means of insuring that all

of the filters are in proper operating condition and, thus, that there exists no means within the room wherethrough contaminated matter may gain access. These tests are accomplished, ordinarily, by introducing dioctyl phthalate smoke into the air circulation system. The filter surfaces and their connection with the plenum units are then scanned with a photometer to detect any excessive amount of leakage.

It has been the practice in the past, during the testing of the filters in the manner described, to introduce the smoke into the air circulation system near the fans supplying one particular air duct. The smoke is transmitted to the individual diffusers via the supply duct and, of course, it is necessary to keep at least that duct and all of the filter units communicating therewith filled with smoke at the proper concentration until each of the diffuser units can be scanned with a photometer. Photometer scanning, as will be readily appreciated, is a rather long and drawn out process and, consequently, it has been necessary to retain the smoke charge within an appreciable portion of the clean room filtration system for rather lengthy periods. In addition to the length of time which the smoke must be kept in the system, it is highly difficult, if not impossible, to determine the smoke concentration within a given unit during the testing thereof and it is very possible that a unit will be tested without having the concentration of smoke therein up to the specification level. This latter problem of course, results occasionally in the approval of a unit which, in reality, would not have been approved had the proper smoke concentration been present within the indivdual plenum during testing of the specific diffuser unit.

It is an object of this invention, therefore, to provide a method and apparatus for testing clean room filtration efficiency which is not subject to the disadvantages noted above.

More particularly, it is an object of this invention to provide such a method and apparatus wherein the individual air diffuser units are filled with smoke to the proper concentration only during the period in which they are being scanned and, thus, wherein valuable filter life is not reduced needlessly during the testing procedure.

It is yet another object of this invention to provide a method and apparatus for monitoring the smoke concentration within the individual diffuser units during the scanning thereof and, thus, wherein all non-acceptable uints can be readily detected during the testing process.

It is yet a further object of this invention to provide such a method and apparatus wherein the filtration efficiency test can be accomplished quickly and positively providing a marked reduction in the amount of labor involved in the testing procedure as well as the amount of smoke utilized therefor.

It is a more specific object of this invention to provide an air diffuser apparatus incorporating integrally therein means whereby the smoke may be introduced into the interior of the unit during the testing procedure and, additionally, whereby the smoke concentration may be constantly monitored.

These as well as other objects of this invention will be readily apparent to those skilled in the art by reference to the following specification and accompanying figures in which:

FIG. 1 is a side-elevation view, partially in cross-section, of an illustrative clean-room installation;

FIG. 2 is a plan view of a diffuser unit similar to that illustrated in the patent noted above which has been modified in accordance with the teachings of the instant invention;

FIG. 3 is a cross-sectional view taken along plane III—III of FIG. 2;

FIG. 4 is a cross-sectional view taken along plane IV—IV of FIG. 2; and

FIG. 5 is a fragmentary view of the aperture sealing structure.

Briefly, this invention comprises a method of and apparatus for testing the filtering effectiveness of an air diffuser including a plenum with a filter positioned across one portion thereof. The method and apparatus contemplate the provision of a first sealable aperture into the interior of the diffuser through which smoke is injected directly into the diffuser unit. Subsequent to completion of the scanning of the exposed portion of the exterior surface of the diffuser to ascertain the existence of excessive smoke leakage and, thus, the acceptability of the unit, the aperture is sealed off. In its more specific form, this invention contemplates additionally the provision of a second sealable aperture into the interior of the diffuser, the second aperture being utilized to monitor the concentration of smoke within the diffuser during the scanning process.

Referring now to the figures, a preferred embodiment of this invention will be described in detail. FIG. 1 illustrates a typical clean-room installation having a series of pedestals **11** positioned upon the sub floor of the particular enclosure within which the room is assembled. Mounted upon the pedestals **11** in conventional fashion are a series of perforate floor panels **12** from which walls **13** extend vertically.

Conventional construction techniques provide for the assembly of a grid work of inverted T bars across the ceiling of the room and these bars are utilized to support the light fixtures **14** and the individual diffuser units **20**. The diffuser units **20** are fed by means of a supply duct **15** into which compressed air is pumped by fan **16**. The air is prefiltered by means of filters **17** prior to being taken into the intake of fan **16**.

As will be readily understood by those skilled in the art, FIG. 1 illustrates only a single row of plenum units **20** within the particular clean-room. Several such rows, ordinarily, would be positioned in side-by-side relationship to form the ceiling of the particular installation. Each of the rows is provided with its own supply duct **15** and pressurization fan **16**.

The operation of the clean-room, briefly, involves the laminar diffusion of air through the diffuser units **20** in a downward fashion. This air passes through the perforate floor panels **12** into the return air plenum **18**. The air is then drawn to the side of plenum **18** as illustrated in FIG. 1 through the prefilter and back into the intake of fan **16**. Prescribed quantities of conditioned air are introduced into the system during this process via the inlet **19**.

Referring now to FIGS. 2 through 4, the diffuser units **20** each comprise a stack **21** to which the supply duct **15** is connected during the installation process. From the stack **21** there extends in smoothly diverging fashion a plenum envelope **22** which is fabricated, preferably, of plastic. The plenum envelope **22** terminates in a rectangular filter receptacle **23** (formed integrally with the envelope **22**) within which is positioned the filter **24**. Filter **24**, as will be readily appreciated by those skilled in the art, must be sealed virtually perfectly to the edges of the filter receptacle **23**. To this end, the interior of the filter receptacle **23** is bordered with wooden strips to which the filter edge is glued by means of a suitable construction sealant. If desirable, a retaining grill as illustrated in the patent noted heretofore may be utilized to assist in the retention of the filter within filter receptacle **23**.

The exterior surface of plenum envelope **22**, preferably, is coated with an insulation such as a foamed vinyl in order to minimize heat loss, sweating and the like during operation. This coating, as will be readily appreciated, may be omitted in certain types of operative environments.

The air diffuser unit **20** is provided with an air volume control assembly. The control assembly consists of an aperture **31** through the filter or the filter-connecting strip in the event it is necessary to utilize two or more filters within the receptacle. Within the apertures **31** is suspended an elongated shaft **32** which ties directly to a bi-valve damper assembly **33**. The downward extremity of shaft **32** is provided with a slot for reception of a screwdriver or other suitable tool and, by rotating the shaft **32**, the dampers **33** are caused to close and open by means of a conventional worm gear assembly. A flexible plug **34**, such as that to be discussed in connection with FIG. 5, is provided for sealing the aperture **31** subsequent to adjustment of the damper assembly **30**.

As described to this point, the filter diffuser unit **20** is identical to the unit described in detail in U.S. Pat. No. 3,323,437, noted previously. The instant invention relates to the incorporation within the diffuser unit **20** of a smoke input aperture **40** and a smoke monitoring aperture **45**. These apertures, preferably, are positioned within the filter **24** or the connecting strip in the manner illustrated in order to permit testing of the unit from the interior of the room rather than requiring the provision of walk ways and the like overhead. As will be readily apparent to those skilled in the art, however, the apertures could be placed elsewhere in the diffuser unit such as in the plenum envelope **22** when convenient.

The aperture **40** comprises a hollow sleeve **41** which is positioned within and glued to the sides of the filter in a manner similar to the sleeve utilized in conjunction with the damper control shaft **32**. The sleeve **41** is provided with a removable plug **42**. The smoke monitoring aperture **45**, similarly, comprises a sleeve **46** positioned within filter **24** having a cap **47** removably positioned thereover.

Where, for the reasons noted there is a wooden strip across the plenum unit separating two filters, apertures **40** and **45** may be drilled directly through the strip. In this event, of course, it is not necessary to utilize sleeves within the apertures. Such a structure is illustrated, for example, in FIG. 5.

Subsequent to installation of the units in the manner illustrated in FIG. 1, one of the fans **16** is activated. Each of the filters are then tested by removing the caps **42** and **47** therefrom. Smoke is fed into the interior **28** of plenum envelope **22** via aperture **40**. This smoke, as noted, will ordinarily be dioctyl phthalate having a 0.3 micron dispersion factor. Installation specifications will require ordinarily that the smoke concentration within the envelope **22** be maintained at or above a specified figure—i.e. 100 micrograms per liter or equivalent of a No. 4 on the Sinclair Phoenix Photometer—during the testing procedure. The instant invention permits monitoring of the smoke concentration within the plenum **28** by means of the aperture **45**.

As smoke is inserted into the interior plenum **28** via aperture **40**, thus, and its concentration monitored by a probe or the like through aperture **45**, the exterior surface of the filter as well as its connection to the receptacle **23** are scanned by means of a photometer in conventional fashion. Subsequent to completion of the tests, the plugs **42** and **47** are reinserted into the apertures **40** and **45** to seal them and the particular diffuser unit is ready for use. The process is then repeated with each of the diffuser units in the particular installation and, if necessary, they are replaced or repaired until such time as the entire room is ready for use.

FIG. 5 illustrates a plug **42** or **47** suitable for use in conjunction with the practice of the instant invention. This plug, as noted previously, is positioned within an aperture in a wooden joining strip as opposed to within a sleeve such as those indicated at **41** and **46** passing directly through the filter. The plug has a cylindrical section **51** with a shoulder **52** extending outwardly from the downward extremity thereof. Sections **51** and **52** are integrally formed from rubber, polyvinyl chloride or some other elastic material. The upper extremity of section **51** has positioned therein and joined thereto a nut **53** into which is threaded a screw **54**. The head **55** of screw **54** rests on shoulder **52**. The relaxed diameter of section **51** slightly less than the diameter of the aperture to be sealed.

When testing of a particular unit has been completed, the plug is inserted into the aperture and the screw **54** tightened to draw nut **53** toward shoulder **52**. Since nut **53** is bonded to the section **51**, such drawing causes cylindrical section **51** to expand in diameter, tightly sealing the aperture.

By utilizing the teachings of the instant invention, it will be apparent readily that each of the diffuser units may be tested without filling the entire system with smoke as required previously. The head of air at the stack **21** will prevent nearly all, if not all, of the smoke from finding its way into other diffuser units during the testing process and, thus, other filters will not be needlessly contaminated. The instant invention provides, additionally, a means whereby the smoke concentration within the unit being tested may be monitored to insure that is it up to specification. This invention, thus, provides a method and apparatus whereby the filtering effectiveness may be tested more easily and more accurately than has been possible heretofore.

While a preferred embodiment of this invention has been described in detail, it will be readily apparent to those skilled in the art that other embodiments may be conceived and fabricated without departing from the spirit and scope of the instant specification and accompanying drawings.

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

1. A method of testing the filtering effectiveness of a series of closely adjacent air diffusers connected to a common supply duct, each diffuser including a plenum with a filter positioned across one portion thereof and having a compressed air intake thereinto, said method having the steps of:

providing first and second sealable apertures into the interior of said diffusers;

pressurizing positively the plenums of the diffusers to be tested by maintaining the pressure in said duct at a level exceeding both ambient pressure and the pressure within said plenums;

injecting smoke into the interior of the particular diffuser which is being tested through one of the apertures therein;

confining by means of said plenums and the pressure differential between said duct and said plenums the smoke so injected to the interior of the particular diffuser which is being tested;

scanning at least portions of the exterior surface of said diffuser to ascertain the existence of any smoke leakage therefrom;

metering the concentration of smoke within the interior of the diffuser which is being tested through the other of said apertures during the scanning thereof; and

sealing said apertures prior to utilization of the diffuser.

2. A clean room suitable for specialized electronic production, medical surgery and the like comprising a plurality of closely adjacent air diffuser means positioned along one surface thereof, each of said diffuser means having a plenum chamber with a filter positioned across one surface thereof and having a compressed air intake thereinto, a series of said diffuser means having their respective intakes connected to common supply lines, the pressure in each said supply line exceeding the pressure in the plenum chambers connected thereto when said room is in operation, first sealable aperture means opening to the interior of each said diffuser means wherethrough smoke may be introduced into the interior of each said diffuser means for purposes of testing the filtering effectiveness thereof; second sealable aperture means opening to the interior of each said diffuser means wherethrough the smoke concentration within each of the diffuser means may be monitored during testing thereof; and, means for sealing said first and second aperture means after testing and monitoring has been completed.

3. The structure as set forth in claim **2** wherein said first aperture means extend through the room-facing surfaces of said diffuser means.

4. The structure as set forth in claim **3** wherein said second aperture means extend through the room-facing surfaces of said diffuser means.

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U.S. Cl. X.R.

55—97, 270; 98—40