Dec. 31, 1968 R. I. MARBLE 3,418,915

CLEAN AIR CEILING MODULE

Filed Aug. 18, 1966 Sheet 1 of 3

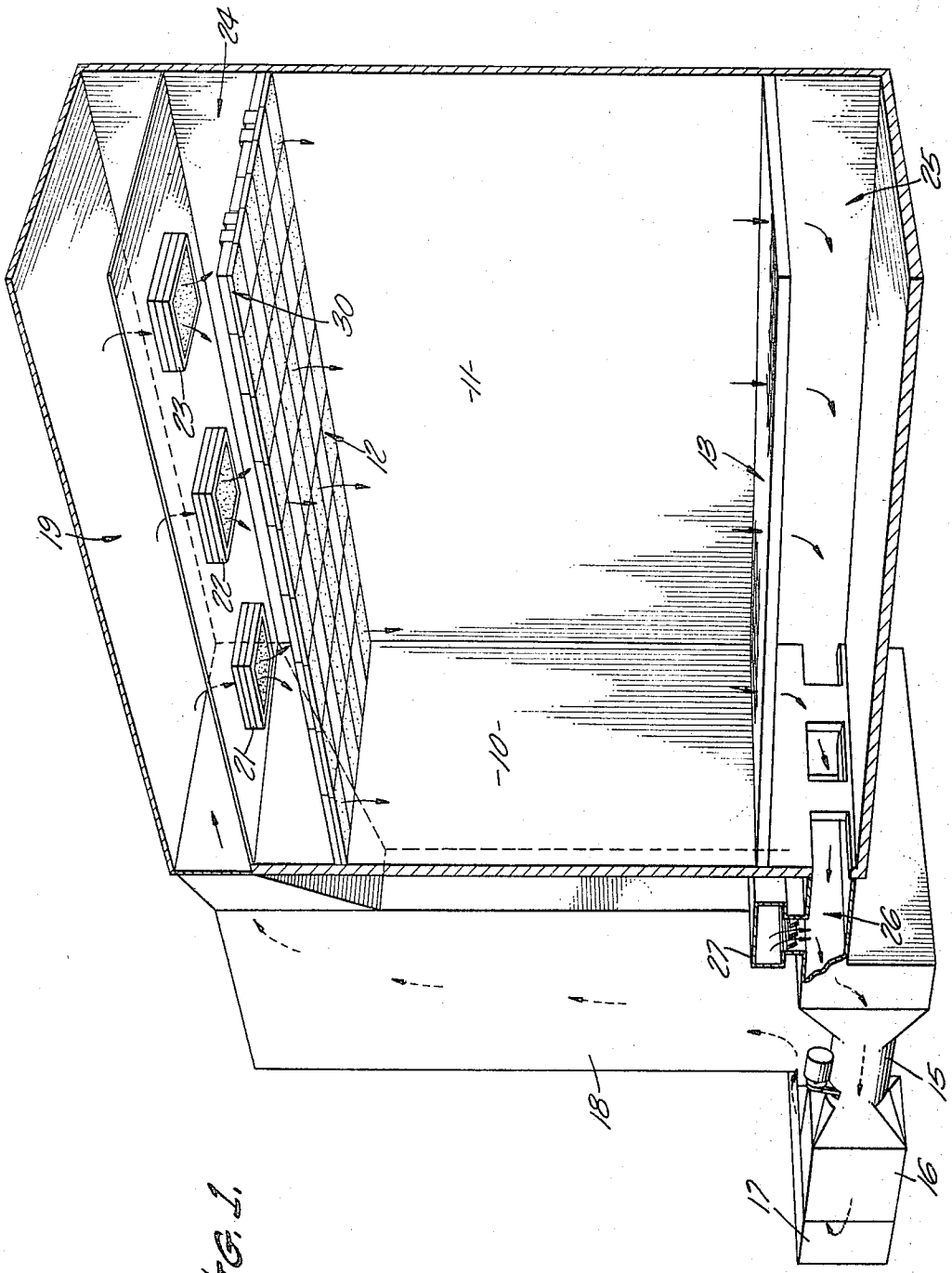


FIG. 1.

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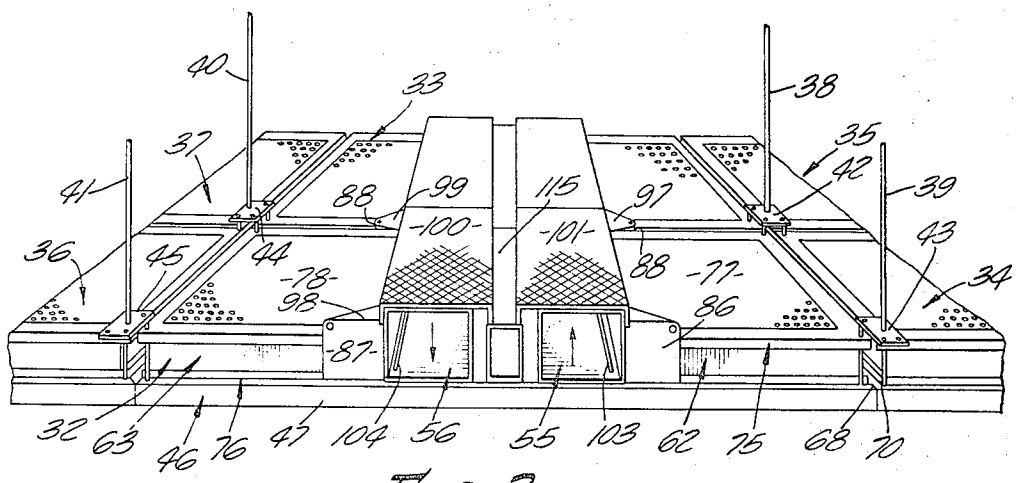


FIG. 2.

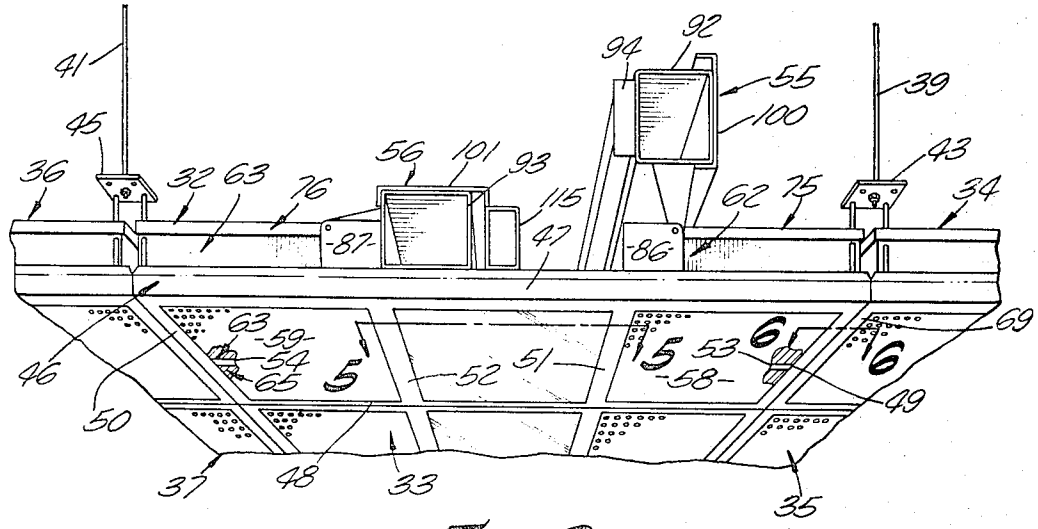


FIG. 3.

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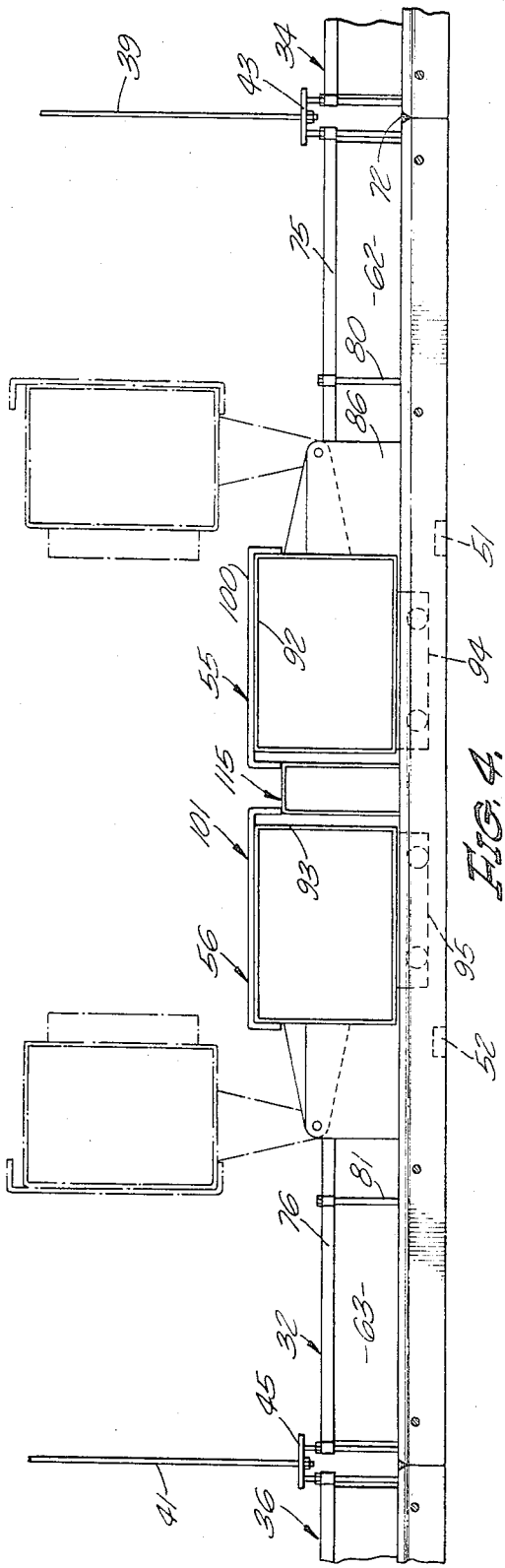


FIG. 4.

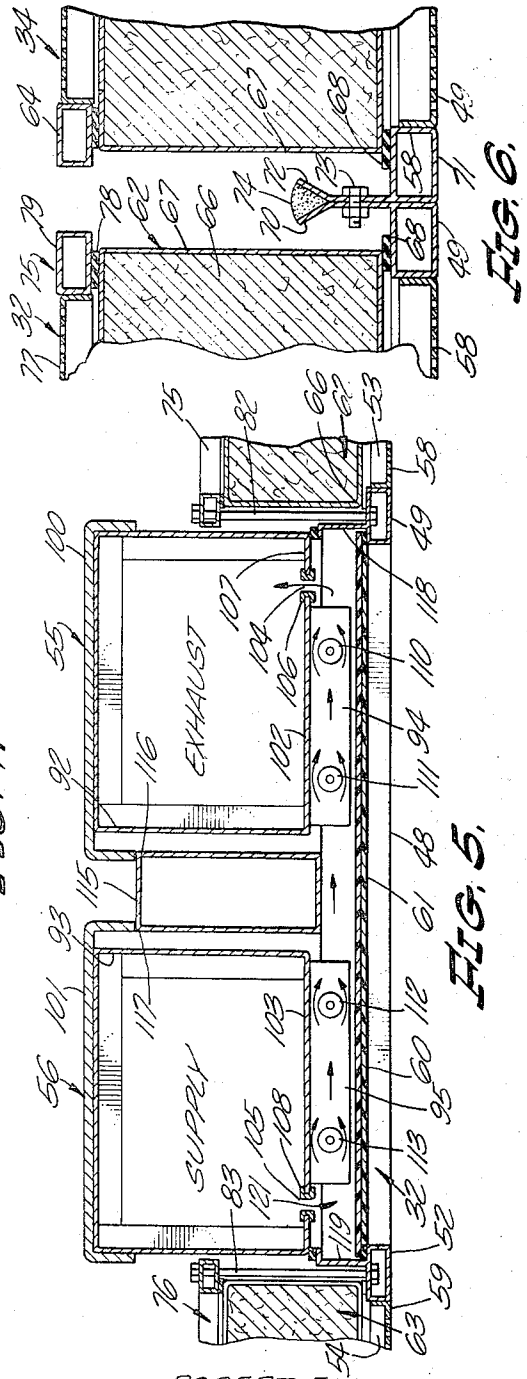


FIG. 5.

FIG. 6.

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3,418,915

CLEAN AIR CEILING MODULE

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13 Claims. (Cl. 98—40)

This invention relates to air filtration and lighting and more particularly to a ceiling module including air filtration and lighting means. A plurality of such modules may be interconnected to form a ceiling unit for various uses, typically for use in a laminar downflow clean room.

Various arrangements have been proposed and used in the past for supplying filtered air into a room. A typical "clean room" is provided with a laminar downflow of air or a laminar crossflow, and each has certain advantages over the other. For example, a cross-flow system permits the installation of a more efficient lighting system inasmuch as lighting fixtures mounted on the ceiling present only a minimum interruption of the airflow pattern. On the other hand, the laminar downflow system is markedly superior in the cleanliness afforded thereby. In a typical system of this latter type, air is supplied from an upper supply plenum system through ceiling filters, and the air moves downwardly through the room to a floor grating or the like and into an underfloor plenum. A system of this nature imposes certain limitations on the lighting system as well as the filtration system when lighting fixtures must be provided, and also other design and construction limitations.

Accordingly, it is an object of the present invention to provide an improved filtering and lighting unit.

It is an additional object of this invention to provide an improved ceiling module including one or more filters and light fixtures which may be structurally joined in a multi-module array to form a ceiling unit.

A further object of this invention is to provide an improved ceiling module structure having an integral lighting fixture and means for supporting a filter, and including duct means for removing the heat generated by the lighting fixture lamps.

A still further object of this invention is to provide an improved ceiling module construction characterized by ease of assembly of the modules in multiple units, and which provides duct means for removing lamp heat and a catwalk for facilitating maintenance.

These and other objects of this invention will be better understood from a consideration of the following description taken in conjunction with the drawings in which:

FIGURE 1 is a partial perspective view in section of a "clean room" employing a plurality of ceiling modules according to the present invention;

FIGURE 2 is a perspective view of a ceiling module according to this invention showing the upper side thereof;

FIGURE 3 is another perspective view of a ceiling module according to this invention showing the lower side thereof and one duct and fixture in the raised position;

FIGURE 4 is an end elevational view of a ceiling module according to the present invention;

FIGURE 5 is a cross-sectional partial elevational view of the light fixtures and lamp cooling arrangement for a ceiling module according to this invention; and

FIGURE 6 is a partial cross-sectional view illustrating the manner in which adjoining ceiling modules are structurally interconnected and sealed.

Briefly, in accordance with the concepts of the present invention a ceiling module is provided having one or more lighting fixtures mounted on frame means which serves to support several "absolute" filters. Air for a room may flow through the filters and cooling air may be supplied to the fixtures for cooling the lamps therein, but the filters

and fixtures are sealed with respect to each other whereby the air supplies are separate. The peripheral edges of the frame are formed to facilitate structural interconnection and sealing of adjoining modules and to allow the formation of a sealed ceiling structure of a plurality of the modules. The lighting fixtures are mounted on air ducts which provide both a catwalk when a plurality of the modules are interconnected and provide a path for cooling air about the lamps in the fixtures for removing the heat generated thereby. Typically, exhaust air from the room may be used as the cooling air. The module construction enables the provision of sufficient lighting capacity with a minimum interruption of the air-flow pattern through the filters and simplifies design and construction of a ceiling unit, as well as means for removing the heat generated by the lamps. Thus, the module includes the lighting fixtures as an integral part thereof and serves to retain the filters while enabling isolation of the lighting heat load from the main air stream.

Referring now to the drawings, FIGURE 1 illustrates a cross sectional perspective view of a "clean room" employing a plurality of ceiling modules according to the present invention forming a ceiling unit or assembly. It will readily be understood by those skilled in the art that the ceiling unit of this invention may be used in arrangements which differ substantially from the hereafter described "clean room" without departing from this invention. Two walls **10** and **11** of the room are shown along with a ceiling assembly **12** and a floor grating **13**. A recirculating fan **15** supplies air through a roughing filter **16** to a continuous supply header **17** which supplies air through an air riser duct **18** to an upper supply plenum **19**. The air flows from the upper supply plenum **19** through medium efficiency filters **21** through **23**, which may include heating coils and air volume dampers, to a lower supply plenum **24**. The air then flows through the "absolute" filters of the ceiling assembly **12**, down through the "clean room" and the floor grating **13** to an underfloor plenum **25**. The air then flows into a mixing chamber **26** along with fresh air from a make up air duct **27** back to the recirculating fan **15**.

The ceiling assembly **12** is formed from a plurality of ceiling modules, such as a module **30**. A number of these modules may be interconnected end to end to form a row, one or more rows forming the ceiling assembly **12**. Typically, up to ten of the modules are connected end to end (from left to right as shown in FIGURE 1) with any suitable number of rows of modules being connected side by side to provide the ceiling assembly.

The construction of each module is shown in greater detail in FIGURES 2 through 6. FIGURE 2 illustrates a module **32** coupled with the end of a module **33**, with portions of modules **34** and **35** shown coupled with the right-hand sides of the respective modules **32** and **33**, and portions of modules **36** and **37** coupled with the left-hand side of the respective modules **32** and **33**. The modules are suspended in a conventional manner from the upper room structure by rods, such as rods **38** through **41** having respective leveling plates **42** through **45** coupled with the ends thereof. The leveling plates are coupled at the corners of the modules. Thus, for example, the corners of the modules **32** through **35** are coupled with the leveling plate **42** which in turn is secured to the lower end of the rod **38** extending downwardly from a structural member (not shown) of the overall room or room module in which the ceiling unit is provided.

Inasmuch as each of the ceiling modules is constructed alike, only the module **32** will be described in detail. This module includes a rectangular channel type bottom frame **46** having end members **47** and **48**, and side members **49** and **50**. Longitudinal cross-leg members **51** and **52** (note FIGURES 3 and 5) extend between the mem-

bers 47 and 48, and traverse cross-leg members 53 and 54 (only portions thereof being seen in FIGURE 3) extend respectively between the members 49 and 51, and the members 50 and 52. The members 47 through 50 define the periphery of the module, with the cross-leg members 51 and 52 providing intermediate structural support for lighting fixture and lamp cooling assemblies 55 and 56 and the cross-leg members 53 and 54 providing intermediate support for filter elements which will be described subsequently.

A perforated anodized aluminum sheet 58 is secured to the inwardly facing sides of the members 47, 48, 49 and 51 of the frame 46 as best seen in FIGURES 3 and 6. A similar perforated aluminum sheet 59 is secured to the inwardly facing sides of the members 47, 48, 50 and 52 of the frame 46. These aluminum sheets improve both the appearance and the air distribution of the module 32. A clear Plexiglas panel 60 is secured to the members 47, 48, 51 and 52 either as shown in FIGURE 3 or flush with the bottom side of the frame members. A clear diffuser panel 61 is mounted above the panel 60 to spread light more evenly. The panel 60 may be secured to the members in any suitable manner, as by an adhesive, both to retain the panel and to provide an air seal between the assemblies 55, 56 and the lower side of the module.

Two absolute filter cartridges are positioned on the frame 46 above each of the aluminum sheets 58 and 59, and the bottom edges of the filter cartridges are sealed with respect to the frame 46 by face gaskets. The forward sides of cartridges 62 and 63 are seen in FIGURES 2 through 5, but only a portion of the cartridges 64 and 65 are seen in FIGURE 3. It will be apparent that the cartridge 62 rests on a face gasket positioned on the upper sides of the members 47, 49, 51 and 53, and the cartridge 64 is similarly mounted on a gasket on the upper sides of members 48, 49, 51 and 53. FIGURE 6 illustrates the relationship between a frame member, aluminum screen, gasket and cartridge. Thus, the cartridge 62 having a filter 66 and backing 67 around the edges thereof rests on a face gasket 68 on the upper side of the frame member 49, it being appreciated that the gasket 68 extends around the upper sides of the members 47, 49, 51 and 53 upon which the lower peripheral edge of the cartridge 62 rests. The other cartridges are mounted in a similar manner. It will be apparent that the entire lower portion of the module 32 as defined by the frame 46 is a sealed assembly with respect to the room below.

The outer sides of the peripheral frame members 47 through 50 include upstanding flanges which are inwardly flared to provide a lip for facilitating sealing of adjacent modules. Referring to FIGURE 6, the member 49 includes an inwardly flared upstanding flange 70 and a member 71 of a frame for the module 34 includes an inwardly flared upstanding flange 72. These upstanding flanges are secured together by a plurality of fasteners, such as a screw fastener 73, and a sealing or caulking material 74 is applied in the lip between the flanges 70 and 72 to provide an airtight seal between the lower frames of adjacent modules. The sealant is applied after installation and mechanical interconnection of the frames of the modules.

A pair of top frame sections 75 and 76 are provided for retaining the respective filter cartridges 62 through 65 in position. Perforated anodized aluminum sheets 77 and 78 are secured to the respective top frame sections 75 and 76. Gaskets are provided on the undersides of the frame sections 75 and 76 to provide a seal around the top edges of the filter cartridges 62 through 65. A portion of a gasket 78 secured to the bottom of a side member 79 of the frame section 75 is shown in FIGURE 6. Each of the top frame sections 75 and 76 is secured to the lower frame section 46 by a plurality of bolts spaced around the periphery thereof, such as bolts 80 and 81 seen in FIGURE 4 and bolts 82 and 83 seen in FIGURE 5. Typically, one or more bolts are provided on each side of each of the frame sections.

According to a principal feature of the present invention, the light fixture and lamp cooling assemblies 55 and 56 form an integral part of the ceiling module for lighting the room below, and for providing cooling air for removing heat generated by the lamps as well as a maintenance walkway which is hinged for providing access to the lamps of the fixtures. Brackets 86 through 89 are provided at the ends of the module 32 and are secured to the end members 47 and 48 of the frame 46. The lighting and lamp cooling assemblies 55 and 56 include respective cooling ducts 92 and 93 with respective light fixtures 94 and 95 mounted on the bottoms thereof. Preferably, these ducts are insulated on the inside walls and top as shown in FIGURE 5. The duct 92 includes hinge tabs 96 and 97 affixed at the ends thereof and hinged to the respective hinge brackets 96 and 88. The duct 93 likewise includes hinge tabs 98 and 99 affixed to the ends thereof and hinged to the respective brackets 87 and 89. Covers 100 and 101 are secured to the tops of the respective ducts 92 and 93 and provide a catwalk for a means of access to the filters and the lights. By standing on one of the ducts 92 or 93 the other may be hinged open as shown in FIGURE 3 to replace light tubes or perform other maintenance. If desired, these covers 100 and 101 may be coated or have applied thereto a material for ensuring a safe footing thereon for anyone walking on the catwalk.

The ducts 92 and 93 include respective elongated slots substantially along the entire length thereof through the bottom sides 102 and 103 for supplying cooling air to the lamps of the lighting fixtures. Thus, the duct 92 includes a slot 104 in the bottom side 102, and the duct 93 includes a slot 105 in the bottom side 103 as shown in FIGURE 5. Split tubes 106 and 107 are attached to the longitudinal edges of the slot 104 to increase the strength of the bottom side 102 of the duct 92 along the slot and to provide a venturi action for airflow therethrough. Similarly, split tubes 108 and 109 are provided along the edges of the slot 105. The lighting fixtures 94 and 95 are conventional and include pairs of lamps 110, 111, and 112, 113, although a greater number of lamps may be used if desired. Either of the ducts 92 or 93 may serve as a supply or exhaust duct. As shown in the drawings, the duct 93 serves as the supply duct and may receive ventilation air from the underfloor exhaust plenum 25 in FIGURE 1.

One or more rows of ceiling modules may be employed. The ducts in a row are connected end to end with cooling air being fed to the supply duct of a module at one end of the row so that the air may flow through the various supply ducts of a row. The end of the supply duct of the module at the opposite end of the row is closed. The exhaust ducts are connected in a similar manner. In this manner the cooling air enters the end of one supply duct and moves into all supply ducts of a row, the air passes through the slots in the supply duct, moves across the lamps and exits through the exhaust slots in the exhaust ducts. For example, the air in the supply duct 93 flows through the slot 105 and past the lamps 113, 112, 111 and 110 and is discharged through the slot 104 into the exhaust duct 92, and this airflow pattern takes place in each of the ceiling modules. When several rows are used, a supply header is coupled with the supply ducts and the end modules of the various rows, and an exhaust header may be similarly coupled with the exhaust ducts of the end modules at the opposite ends of the rows. The ends of the ducts have gaskets (not shown) affixed thereto for providing a seal between adjacent modules of a row for the lamp cooling air. The lamp heat load is thus isolated from the main airstream supplied to the room below.

The slots in the lamp cooling ducts are selected to provide the proper air velocity for optimum cooling and

maximum lamp efficiency. The size and shape thereof is selected to obtain uniform flow across the lamps of each module along a row. The spacing between the top and bottom of the lamps is selected to control the heat transfer rate to obtain proper lamp temperature for maximum light output. Since the ducts are insulated, a greater heat barrier between the main air supply and lamp cooling air is provided. The lamp cooling air normally is exhausted to the atmosphere. A typical lamp cooling load may be over forty percent of the normal room cooling load, but the present arrangement eliminates this load which otherwise would be imposed upon the room cooling system. The waste heat removed from the lamps may be employed through the use of heat exchangers to aid in heating the room during cold weather.

A typical ceiling module may be approximately six feet wide as viewed from left to right in FIGURES 2 and 3 and approximately four feet deep. The ducts **92** and **93** may have an exterior cross section size of approximately nine by eleven inches. The passageway through the slots **104** and **105** typically is approximately three-sixteenths of an inch wide, and the lamps **110** through **113** are spaced approximately one-fourth inch from the bottoms **102** and **103** of the ducts and from the diffuser panel **61**.

A channel member **115** is provided along the center of the module and is secured to the end members **47** and **48** of the frame **46**. This channel member provides structural support as well as a convenient place through which cables for the lighting fixtures may be run. The lips **116** and **117** of the covers **100** and **101** may be resilient or have a gasket thereon to provide a seal with the member **115**. Members **118** and **119** may extend upwardly from frame members **49** and **52** and have gaskets **120** and **121** thereon to provide a seal at the bottom of the ducts **92** and **93** as seen in FIGURE 5.

The present embodiment of the invention is to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims therefore are intended to be embraced therein.

What is claimed is:

1. A lighting and filtration module comprising

frame means for supporting filter means and lighting means, said frame means comprising side members and cross members for supporting the edges of said filter means in a sealed relationship with said frame means and allowing air to pass through said filter means and for supporting said lighting means with the interior thereof in a sealed relationship with respect to air passing through said filter means, and

said lighting means including lighting fixture means for receiving lamps and including duct means upon which said lighting fixture means are mounted for receiving air and supplying cooling air to said lamps, said duct means comprising bottom wall means to which said lighting fixture means are attached with said bottom wall means including a plurality of elongated slots near the sides of said fixture means for allowing air supplied to said duct means to pass through a first slot and across said lamps to a second slot for cooling said lamps and exhausting the air after it has passed across said lamps.

2. A module as in claim **1** wherein

at least some of the side members of said frame means include inturned flanges for facilitating the application of a sealing material between adjacent modules when plural modules are coupled together.

3. A module as in claim **1** wherein

said duct means includes a pair of ducts and said bottom wall means comprises the bottom walls of said respective ducts each with an elongated slot therein, and

said lighting fixture means includes a pair of lighting fixtures respectively secured to the bottom walls of said ducts for allowing air supplied to a first of said ducts to pass through the slot therein, across lamps in said fixtures and exit through the slot in the second of said ducts.

4. A module as in claim **3** wherein

at least some of the side members of said frame means include inturned flanges for facilitating the application of a sealing material between adjacent modules when plural modules are coupled together.

5. A module as in claim **3** wherein

said ducts are hinged with respect to said frame means for facilitating installation of lamps in said lighting fixtures, and the tops of said ducts provide a walking surface.

6. A lighting and filtration module comprising

frame means for supporting filter means and lighting means, said frame means including side and cross members defining at least one air outlet and at least one light outlet, said air outlet being covered with a perforated sheet attached to said members and said light outlet being covered with an optical element attached to said members, said side and cross members serving to support the edges of said filter means in a sealed relationship with said frame means and allowing air to pass through said filter means and through said perforated sheet, and for supporting said lighting means for supplying light through said optical element,

top frame means for retaining said filter means on said bottom frame means, and

said lighting means including lighting fixture means for receiving lamps and including duct means upon wnich said lighting fixture means are mounted for receiving air and supplying cooling air to said lamps, said lighting means being sealed with respect to said frame means for preventing air supplied to said duct means for passing through said filter means, said duct means comprising bottom wall means to which said lighting fixture means are attached with said bottom wall means including a plurality of elongated slots near the sides of said fixture means for allowing air supplied to said duct means to pass through a first slot and across said lamps to a second slot for cooling said lamps and exhausting the cooling air after it has passed across said lamps.

7. A module as in claim **6** wherein

the periphery of said side members of said frame means include inturned flanges for facilitating the application of a sealing material between adjacent modules when plural modules are coupled together.

8. A module as in claim **6** wherein

said duct means includes a pair of ducts and said bottom wall means comprises the bottom walls of said respective ducts each with an elongated slot therein, said ducts are hinged with respect to said frame means, and

said lighting fixture means includes a pair of lighting fixtures respectively secured to the bottom walls of said ducts for allowing air supplied to a first of said ducts to pass through the slot therein, across lamps in said fixtures and exit through the slot in the second of said ducts.

9. A module as in claim **8** wherein

the periphery of said side members of said frame means include inturned flanges for facilitating the application of a sealing material between adjacent modules when plural modules are coupled together.

10. A lighting and filtration module comprising

frame means for supporting filter means and lighting means, said frame means supporting said filter means in a sealed relationship with respect to said frame means and allowing air to pass through said filter means, and

said lighting means comprising duct means hinged to said frame means and including lighting fixture means attached to said duct means for receiving lamp means, said duct means having a supply passageway for receiving cooling air for lamp means and an exhaust passageway, said duct means having bottom wall means to which said lighting fixture means are attached and including slots communicating with said respective supply and exhaust passageways for allowing air fed to said supply passageway to pass through a first slot, by said lighting fixture means for cooling said lamp means and to a second slot for exhausting the air through said exhaust passageway.

11. A lighting and filtration ceiling unit comprising a plurality of modules interconnected in an adjacent relationship, each of said modules comprising

frame means for supporting filter means and lighting means, said frame means supporting said filter means in a sealed relationship with respect to said frame means and allowing air to pass through said filter means,

said lighting means comprising duct means hinged to said frame means and including lighting fixture means attached to said duct means for receiving lamp means, said duct means having a supply passageway adapted to be coupled with a supply passageway of an adjacent module for receiving cooling air for said lamp means and an exhaust passageway adapted to be coupled with an exhaust passageway of an adjacent module, said duct means having bottom wall means to which said lighting fixture means are attached and including slots communicating with said respective supply and exhaust passageways for allowing air fed to said supply passageway to pass through a first slot, by said lighting fixture means for cooling said lamp means and to a second slot for exhausting the air through said exhaust passageway, and

said frame means including peripheral inturned flanges for facilitating the application of a sealing material between adjacent modules.

12. A unit as in claim **11** wherein

said duct means includes a pair of ducts defining said supply and exhaust passageways and said bottom wall means comprises the bottom walls of said respective ducts each with an elongated slot therein, and

said lighting fixture means includes a pair of lighting fixtures respectively secured to the bottom walls of said ducts for allowing air supplied to a first of said ducts to pass through the slot in the bottom wall thereof, across said lamp means and exit through the slot in the bottom wall of the second of said ducts.

13. A lighting and filtration ceiling unit for clean rooms, comprising

frame means coextensive with the ceiling unit,

filter means sealably mounted in said frame means for filtering air passing downwardly therethrough, lighting means mounted in said frame means, said lighting means having downwardly illuminating lights,

said lighting means including a pair of ducts for conducting supply and return cooling air to and from said lights and separately mounted on said frame means for movement from operating position to a position exposing said lights for maintenance, and

said lights and ducts sealed from the air passing through said filter means.

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