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H. J. ROUX

3,320,404

VENTILATING CEILING CONSTRUCTION AND COMBINED
HEATING AND VENTILATING PANEL UNITS THEREFOR

Filed Jan. 19, 1965

4 Sheets-Sheet 1

Fig. 1

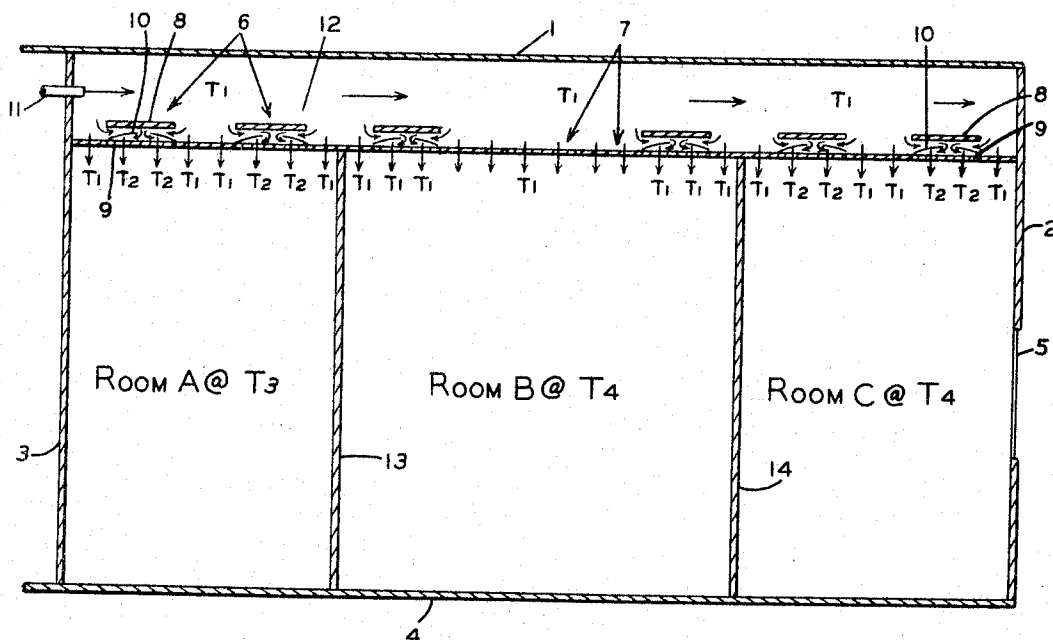


Fig. 3

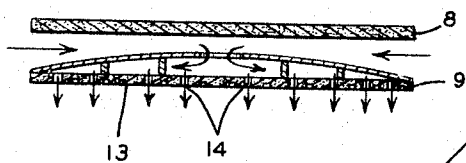
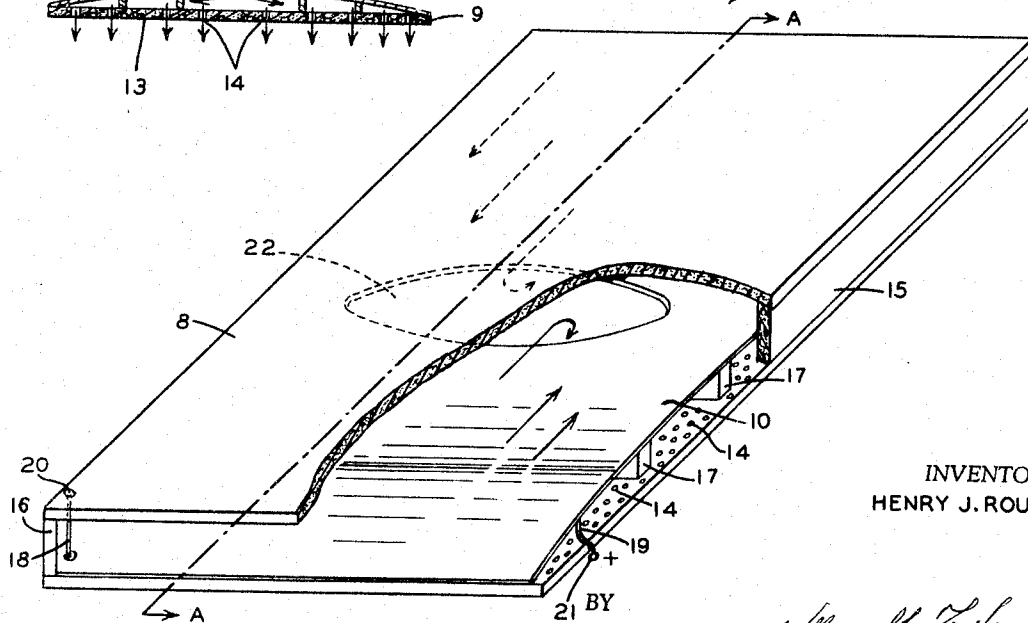


Fig. 2



INVENTOR
HENRY J. ROUX

William H. Taylor
ATTORNEY

May 16, 1967

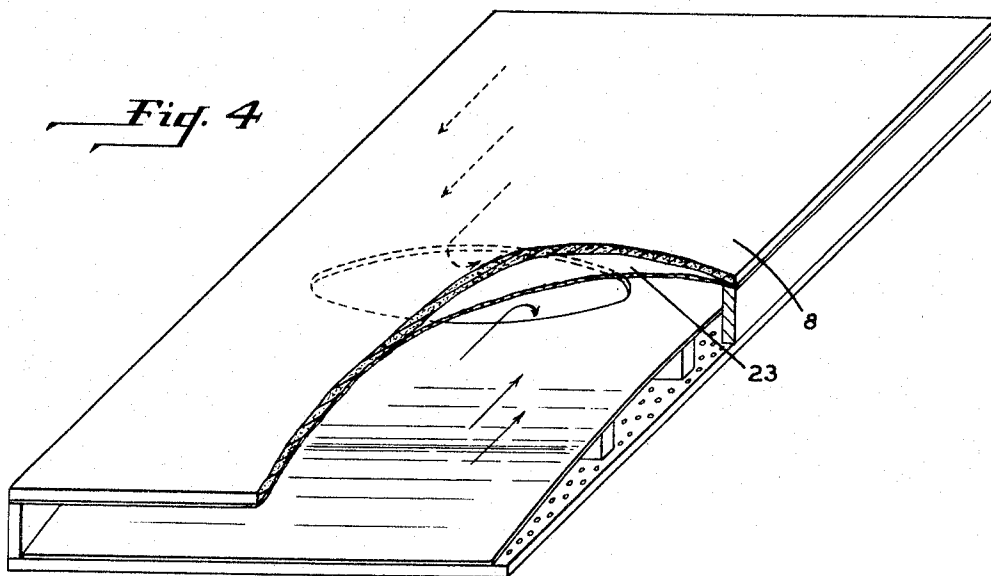
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INVENTOR
HENRY J. ROUX

BY

William H. Taylor
ATTORNEY

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H. J. ROUX

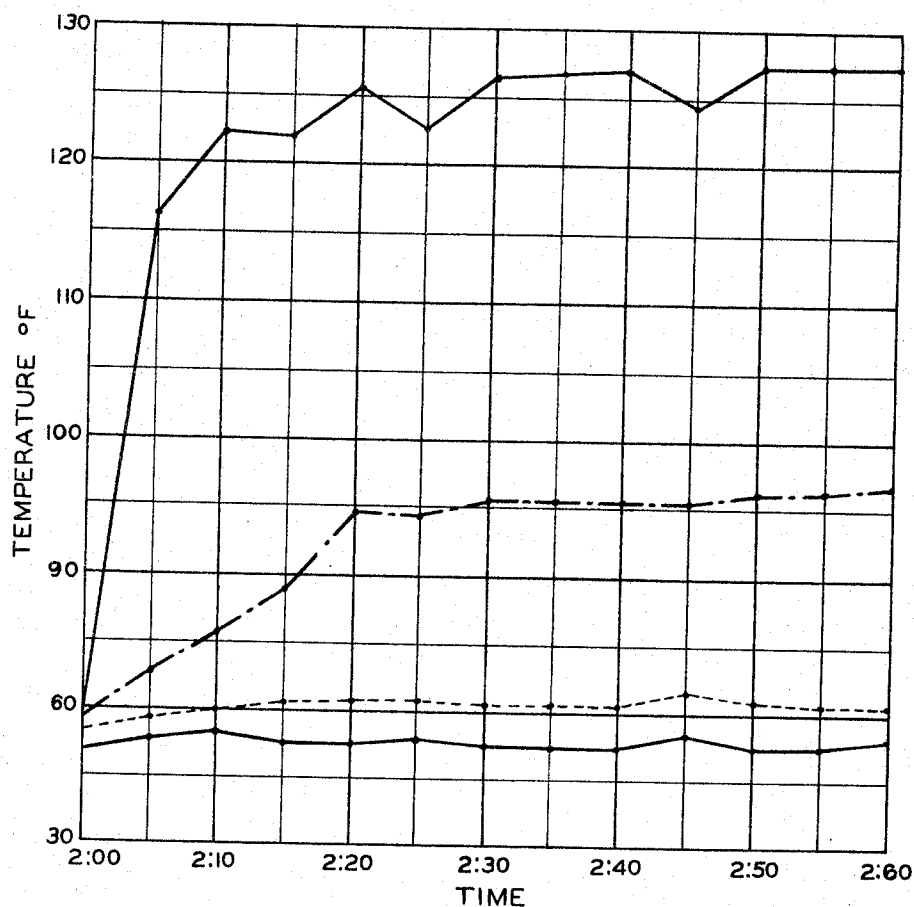
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Fig. 5



INVENTOR
HENRY J. ROUX

BY

William H. Taylor
ATTORNEY

May 16, 1967

H. J. ROUX

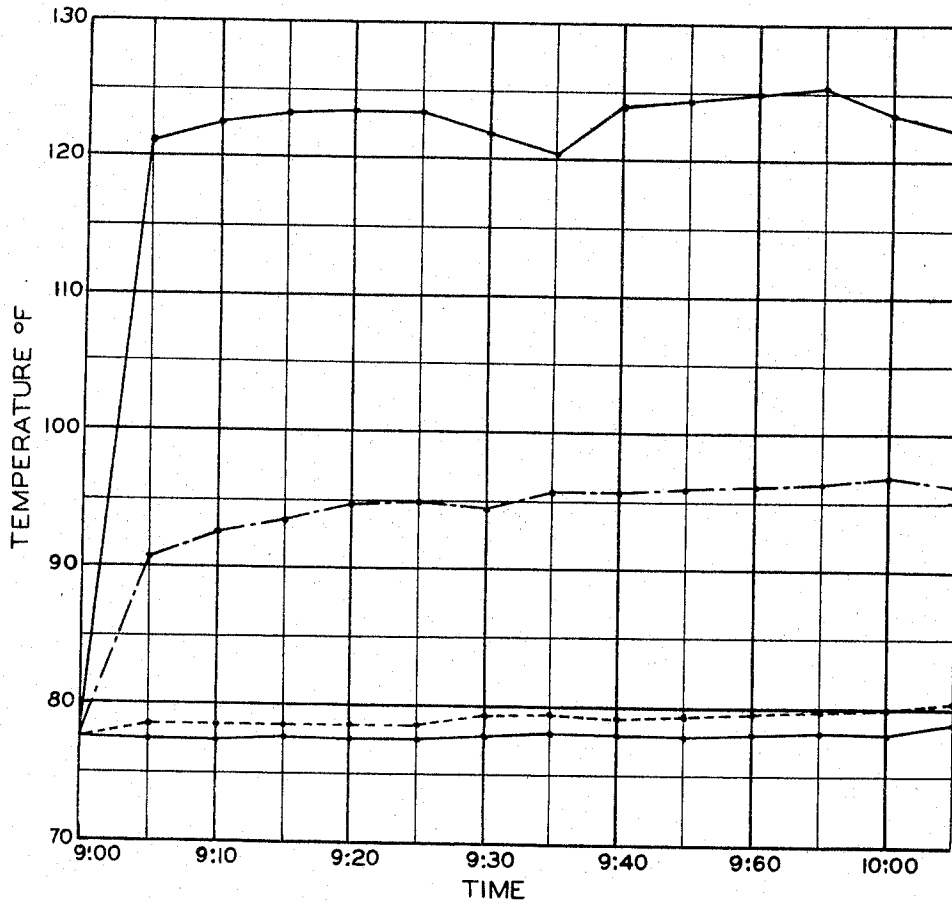
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Fig. 6



INVENTOR
HENRY J. ROUX

BY

William H. Taylor
ATTORNEY

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VENTILATING CEILING CONSTRUCTION AND COMBINED HEATING AND VENTILATING PANEL UNITS THEREFOR

Henry J. Roux, Lancaster County, Pa., assignor to Armstrong Cork Company, Lancaster, Pa., a corporation of Pennsylvania

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10 Claims. (Cl. 219—213)

This invention relates broadly to a ceiling construction for a building conditioned by ventilating air wherein the air is supplied from a plenum chamber defined by the walls and the base ceiling and a false ceiling supported from the base ceiling, the false ceiling being formed of a plurality of ceiling tile or panel units provided with air ventilating holes. It is more particularly concerned with a heating and ventilating tile or panel unit particularly adapted for heating the conditioned air and thus tempering or regulating the temperature of the air supplied from the plenum chamber to the room below.

In modern air-conditioned building construction, conditioned air is often supplied to the various rooms from a common source by means of a common plenum chamber or several plenum chambers connected to the common source. The conditioned air is supplied through air ventilating holes provided in the ceiling tile or panel units which form the false ceilings in the rooms being air conditioned. The plenum chamber to which the conditioned air is supplied is defined by the base structure, including the walls and the base ceiling, and by the false ceiling which is formed of a plurality of ceiling tile or panel units supported from the base ceiling. For convenience the description will be confined to false ceilings formed from ceiling panel units although this descriptive term "panel" could be considered as encompassing ceiling tile units, the terms mainly being used as a convenient means of designating the relative size of the ventilating units. The ceiling panel units are provided with air ventilating holes which extend from the back to the visible surface, the holes providing the means by which the conditioned air is fed from the plenum into the room being air conditioned. In some modern construction the actual base structure may be the base walls, as for instance the outer walls of the building, and the base ceiling and in such construction the plenum, which could be coextensive with a single floor or smaller subdivision, is common to each of the plurality of adjacent compartments or rooms immediately thereunder. It will also be obvious that the base structure could be the walls and base ceiling of a single room which would be the more common case in older construction.

In any event, where conditioned air is supplied to a plurality of rooms from a common source by means of a common plenum or by means of plenums in the individual rooms, many factors enter into the heating or cooling requirements of the individual rooms. Thus the weather conditions on the exterior of the building, the time of the day, the season of the year, the location of the particular room or area thereof being air conditioned, and the number of people using a particular room as well as the amount and type of equipment being used therein are all examples of factors which effect the heating and/or cooling requirements. Where the heating and/or cooling requirements vary between several rooms, i.e. where the heat loads of the individual rooms are different, the temperatures, and thus the comfort, will also vary if the

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conditioned air is supplied at a given temperature, assuming the air to be supplied at the same rate. Even where the volume of air being supplied is adjusted for broad temperature control there is a need for finer temperature control.

The primary object of this invention is to provide a means by which the temperature of conditioned air supplied through ventilating ceiling panels from a common source may be readily adjusted to meet the heat load requirements of the particular room being air conditioned. An ancillary object is to overcome the use of unsightly, costly, cumbersome and space wasting perimeter heating units in common use in building construction.

The invention will be more fully understood and further objects and advantages thereof will become apparent when reference is made to the more detailed description of the preferred embodiments of the invention which follows and to the appendant drawings in which like numerals refer to like parts throughout and in which:

FIG. 1 is a cross-sectional view diagrammatically illustrating the utilization of heating and ventilating ceiling panels produced in accordance with this invention in a series of rooms having a common plenum supplied with conditioned air at a given temperature;

FIG. 2 is a detailed perspective view of a ceiling panel unit provided with heating and ventilating means in accordance with the invention, said perspective view being partially in section to show further details of the ceiling panel unit;

FIG. 3 is a cross-sectional view of reduced scale of the ceiling panel unit shown in FIG. 1 taken along line A—A;

FIG. 4 is a perspective view of a ceiling panel unit modified by means of a reflective foil barrier, the modification being partially in section to show further details; and

FIG. 5 and FIG. 6 are graphs illustrating temperatures with respect to time at various points in the ceiling panel units.

This invention is concerned with a combination heating and ventilating ceiling panel unit for use in a ceiling construction for a room conditioned by ventilating air in which the ventilating air is supplied from a primary plenum chamber defined by a base structure which includes the walls and a base ceiling and a plurality of ceiling panels provided with air ventilating holes supported from the base ceiling to form a false ceiling therewith. In accordance with this invention, I have provided a combination heating and ventilating ceiling panel unit which may be used in place of some or all of the ceiling panels provided with air ventilating holes which form the false ceiling. The combination heating and ventilating panel unit includes a ventilating ceiling panel provided with a plurality of air ventilating holes, means positioned from the ventilating ceiling panel for defining a secondary plenum chamber therewith, heating means positioned within the secondary plenum chamber and means connecting the secondary plenum with the primary plenum. The means connecting the secondary plenum with the primary plenum provides for the passage of conditioned air into contact with the heating means in the secondary plenum for heating and thus tempering the conditioned air prior to its passage through the ventilating holes of the combined heating and ventilating panel unit into the room below.

Although the invention will be described in connection with the use of acoustical ventilating panels of the type

customarily used in modern construction, it will be readily evident that any ventilating ceiling panel may be used in the practice of this invention. Typical of the acoustical materials which may be used to form the acoustical panel are the board-like products formed from a slurry of mineral wool and/or glass wool and the like in which the fibers are present in clumps and are coated with a starch binder, the board-like products formed from water-laid mats of vegetable fibers, similar to conventional insulating board and other acoustical material such as incombustible inorganic cellular glass materials of the type disclosed in U.S. Patent No. 2,946,693. In all of these materials there is a self-supporting body of acoustical material having a plurality of interstices in the body of the acoustical material which provides a means by which sound is attenuated. The acoustical panel is provided with a plurality of sound-absorbing openings extending through the facing and communicating with these sound-absorbing interstices in the acoustical panel body. These may be provided by punching or drilling holes or fissures through the surface of the acoustical material which is adapted to be the visible surface when positioned in the ceiling of a room. Air ventilating holes are drilled or punched completely through the acoustical panel between the visible surface and the back surface thereof.

Practically any means may be provided for defining the secondary plenum with the ventilating ceiling panel. By way of example a conventional insulating board may be spaced from the ventilating ceiling panel using any conventional spacer means. Actually, any sheet material which would define a plenum when positioned from the ventilating ceiling panel would work in the practice of the invention although it is preferable to provide a sheet of some type of insulating material whereby the air being heated by the heating means positioned within the secondary plenum is effectively insulated from the main body of conditioned air in the primary plenum. Openings may be provided in the sides or the back of the combined heating and ventilating ceiling panel unit or between the spacer means for the transmission of conditioned air under pressure from the primary plenum into the secondary plenum chamber.

Although it will be obvious that any heating element or elements may be provided in the secondary plenum as the means for transmitting heat to the conditioned air passing thereover, it is preferable for ease of installation and for convenience of manufacture to use an electrical resistance heater element within the secondary plenum for heating the air passing from the primary plenum through the secondary plenum and thence into the ventilating air holes in the ventilating ceiling panel. Preferably the electrical resistance heater element is positioned in a manner such that the conditioned air supplied through the connecting openings or opening between the primary plenum and the secondary plenum passes completely around and over the heating element prior to passing through the ventilating holes in the ceiling panel. Although a laminated heating sheet of the type disclosed in U.S. patent application Ser. No. 132,496, filed Aug. 18, 1961, will be described as the heating element, it will be obvious to one skilled in the art that other types of electrical resistant heating elements such as graphite-loaded vinyl, wire fabric, and foil serpentine heaters might be used equally as well in the practice of this invention. Additionally, when a laminated heating sheet or foil serpentine heater, for example, is used as the heating element, a portion of the heat generated will be radiated to the room below in addition to the heat transmitted to the air passing through the unit.

In order to further promote the efficiency of the unit, it is preferred that the backing panel be faced interiorly of the secondary plenum with a metallic foil such as an aluminum foil. This foil serves as a reflective barrier and functions to direct the heat from the resistant heater back to the plenum area and thus cuts down on heat losses in the direction away from the room being heated.

The use of ventilating and heating ceiling panel units in combination with ordinary ventilating ceiling panel units is diagrammatically illustrated in FIG. 1 of the drawing. FIG. 1 illustrates a ceiling construction in a cross section of a building for each of a plurality of adjacent room compartments conditioned by ventilating air. The ceiling construction comprises a base structure including a base ceiling 1, exterior wall 2 with window 5, interior wall 3, and a plurality of ceiling panel units 6 and 7 suspended in each compartment to form a false ceiling in each compartment. The false ceiling is spaced from the base structure and thereby forms a common primary plenum chamber 12 over the room compartments, the plenum chamber 12 being used as a fluid duct for the ventilating air which is introduced from a duct stub 11 into the plenum chamber 12 and which passes through the ventilating ceiling panels 6 and 7 into the rooms below. Walls 13 and 14 define, along with walls 2 and 3 and floor 4, the adjacent room compartments which are labeled Rooms A, B, and C in FIG. 1. In the diagrammatic illustration the heating and ventilating panel units are illustrated by the numeral 6 and the regular ventilating panel units are illustrated by the numeral 7.

By way of illustration, Room B, which is the largest compartment, could be considered as, for instance, a secretarial pool and would contain a fairly large number of people as well as numerous pieces of equipment which would generate a fair amount of heat. Room A, for purposes of illustration, will be considered as an executive's office and thus a room having a relatively low heat load. Room C, which is at the exterior of the building, could also be considered, for purposes of illustration, to be a private office. The heat load of this room would be considerably affected by the exterior environment of the building and, for purposes of illustration, we will consider it to be a relatively cold day with overcast conditions. Also for purposes of illustration, we will consider that the executive in Room A wishes to maintain a relatively high temperature T_3 , 75° F., while Rooms B and C are maintained at a lower temperature T_4 , 70° F. The conditioned air which is supplied to the primary plenum is, for purposes of illustration, supplied at a given temperature T_1 of 60° F.

Because of the large heat loss to the exterior of the building on a cold, overcast day, the air from the primary plenum must be heated to a considerable extent to maintain the conditioned air in Room C at a temperature of 70° F. Therefore, the combination heating and ventilating ceiling panel units in the suspended ceiling in Room C are all in use to bring the air to a temperature T_2 of 80° F. In Room B, wherein the large number of people and the several pieces of equipment give off a considerable degree of heat, the conditioned air is supplied at the 60° F. to cool the air circulating through Room B and maintain the 70° F. temperature in the room. Thus, although a series of combination heating and ventilating tile units are illustrated in the suspended ceiling in Room B, these are not operative under these conditions. Room A, which has a low heat load, requires that the conditioned air from the primary plenum be heated to a temperature T_2 , also 80° F., so that the conditioned air within Room A will be at a 75° F. temperature. Obviously thermostatic controls in the individual rooms would probably be used to control the operation of the heating elements within the heating and ventilating units. Such controls being well known would not be considered as an aspect of this invention and thus are not illustrated. As illustrated in FIG. 1, the combination heating and ventilating units 6 are basically comprised of a ventilating panel 9, an imperforate insulating panel 8, and a heating element 10. The flow of conditioned air in the primary plenum 12 through the conventional ventilating panels 7 and through the combined heating and ventilating panel units 6 into the rooms below is indicated by the directional arrows.

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The following examples will illustrate specific embodiments of combined heating and ventilating ceiling panel units.

EXAMPLE 1

As shown in FIGS. 2 and 3, a 12" x 24" ventilating mineral fiber acoustical panel 9, formed from an aqueous slurry of, based on total solids, 75% by weight mineral wool, 14% clay, 3% hydrated virgin kraft pulp, and 8% starch was sanded to about 5/8" thickness and the visible surface of the panel facing the interior of the room when positioned in a suspended ceiling was then punched as indicated by the numeral 13 with .050" and .100" punches to form the sound absorbing openings extending into the acoustical panel 9 and communicating with the sound absorbing interstices therein. Additional ventilating openings, indicated in FIGS. 2 and 3 at 14, were punched through the body portion of the panel between the visible surface having the acoustical openings therein and the back surface. Imperforate side walls 15 and 16 and an imperforate insulating backing panel 8, all of which were formed of a 1/2" board of the same composition as acoustical panel 9 were secured as shown in FIGS. 2 and 3 and a series of spacing means, small spacers of the same composition and designated by the numeral 17, were secured in place on the back of panel 9 and were used to position and support the large electrode heater 10 in the secondary plenum. The large electrode heater, a laminating heating sheet the surfaces of which were painted black for better emissivity and of the type disclosed in U.S. patent application Ser. No. 132,496, filed Aug. 18, 1961, was connected to a source of current (not shown) through wires 18 and 19 at terminals 20 and 21. The large electrode heater 10 was comprised of two .0007" copper foil sheets laminated together by means of a semi-conductive core of the following composition:

Ingredient:	Parts by weight
67% ethyl acrylate—33% methyl methacrylate copolymer—44% solids latex	400.8
Polyethylene glycol tert. dodecyl thioether	2.4
Tributyl phosphate	4.0
Dispersing agent—sodium salt of polymeric carboxylic acid (Tamol 731)	14.4
Aqueous dispersion of carbon black (Aqua-blak 15—30% solids)	98.3
Calcium carbonate	700.0

the average thickness of the electrode heater being .011775". Wires 18 and 19 were formed of #14 gauge copper wire and were spot soldered, respectively, to the top and bottom copper sheets of the heater. At 10 volts and a current of 4 amps, a total output of 20 watts per square foot, the heater gave off 68 B.t.u. per hour per square foot. The electrode heater 10 was provided with an elliptical hole 22 for circulating the conditioned air, as indicated by the directional arrows, through the unit and over the surface of the heater.

EXAMPLE 2

A second heating and ventilating tile unit, illustrated in FIG. 4, was constructed in accordance with the description set forth under Example 1 except that a shiny aluminum foil was secured as a reflective facing sheet 23 to the face of the imperforate backing panel 8 facing the secondary plenum.

FIGS. 5 and 6 are graphs illustrating temperature measurements taken with respect to time at various critical points in the heating and ventilating tile unit illustrated in Examples 1 and 2, respectively. The solid line at the bottom of each of the graphs gives the temperature of the air at the inlet point. Going up the graph, the next line, in this case a dotted line, gives the average temperature of the air at the back of the unit. The third line, the dash-dot line, shows the average temperature at the face and subsurface of the heating and ventilating tile unit and

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the final line at the upper portion of the graph, a solid line, shows the average temperature reached by the large electrode heating unit. The air circulation rate was 4 cubic feet per minute through the units or 2 cubic feet per square foot.

I claim:

1. A combination heating and ventilating ceiling panel unit comprising a ventilating ceiling panel provided with air ventilating holes for metering air from a primary plenum to a room below, imperforate means spaced from the back of said ventilating ceiling panel and defining a secondary plenum chamber therewith, a heating element positioned within said secondary plenum chamber, and passage means whereby conditioned air from the primary plenum may be directed into heat exchange relationship with said heating means prior to its passage through the air ventilating holes.

2. A combination heating and ventilating ceiling panel unit in accordance with claim 1 in which said heating element is an electrical resistance heater.

3. A combination heating and ventilating ceiling panel unit in accordance with claim 2 in which said imperforate means is a panel of heat insulating material.

4. A combination heating and ventilating ceiling panel unit in accordance with claim 3 in which the panel of heat insulating material is provided with a heat reflective foil facing on the surface bounding the secondary plenum.

5. A combination heating and ventilating ceiling panel unit in accordance with claim 2 in which the ventilating ceiling panel is an acoustical panel provided with air ventilating holes.

6. In a ceiling construction for a room conditioned by ventilating air supplied from a primary plenum chamber defined by a base structure and a plurality of ceiling panel units provided with air ventilating holes supported from the base structure to form a false ceiling, the improvement comprising, in combination with selected ceiling panel units, imperforate means spaced from the backs of said selected ceiling panel units and defining a secondary plenum chamber therewith, a heating element positioned within said secondary plenum chamber and passage means whereby conditioned air from the primary plenum chamber is directed into heat exchange relationship with said heating means prior to its passage through the air ventilating holes of said selected ventilating ceiling panels.

7. A ceiling construction in accordance with claim 6 in which said heating element is an electrical resistance heater.

8. A ceiling construction in accordance with claim 7 in which said imperforate means defining a secondary plenum with said selected ventilating ceiling panels is a panel of heat-insulating material.

9. A ceiling construction in accordance with claim 8 in which the plurality of ceiling panel units provided with air ventilating holes are acoustical ceiling panels.

10. In a ceiling construction for each of a plurality of adjacent room compartments conditioned by ventilating air having a base structure and a plurality of ceiling panels provided with air ventilating holes suspended to form a false ceiling in each compartment and in which said false ceilings are suspended from the base structure to form a common primary plenum chamber over the room compartments, said primary plenum chamber being used as a fluid duct for the ventilating air, the improvement comprising providing a selected number of combination heating and ventilating panels in said false ceiling, said combination panels being comprised of, in combination, a ceiling panel provided with air ventilating holes, imperforate means spaced from the back of said ceiling panels and thereby defining a secondary plenum chamber therewith, heating means positioned within said secondary plenum chamber and means for directing the conditioned air from the primary plenum chamber into contact with the heating means in the secondary plenum chamber to heat said air

prior to its passage through the ventilating holes in the combined heating and ventilating panel.

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RICHARD M. WOOD, *Primary Examiner.*

10 C. L. ALBRITTON, *Assistant Examiner.*