

(51) Int Cl.: **F24F 3/044** ^(2006.01) **F24F 5/00** ^(2006.01)

(22) Date of filing: **31.03.2007**

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A building having a room (10) in which the method is implemented, and a system for rapidly controlling the room temperature are also provided.



Description

[0001] This invention relates to a method of rapidly controlling room air temperature by use of a radiant ceiling coil in combination with pre-heated or pre-cooled supplementary air to reduce energy, carbon emissions and maintenance requirements when compared to a traditional system, and also to a building having a room in which the said method is implemented, and a system corresponding to the method.

[0002] Room-by-room heating and cooling systems in large buildings, such as hotels, typically utilise a fan coil heating and cooling unit in each room, settable by an occupant. A ducted unforced fresh air supply is also provided to each room. A fan of the unit circulates room air, which includes the fresh air entering the room, over a coil of the unit, through which is passing either cold or hot water depending upon whether heating or cooling of the room is desired. Heated or cooled air is thus forcibly discharged from the unit into the room.

[0003] This well known fan coil unit provides zonal temperature control and quick response. However, it is high maintenance, since there is a fan and filter in every room, and it is noisy due to the fan. Condensation resulting from warm room air being passed over a cold coil can also be problematic. All the energy required for heating and cooling the room is derived solely from the temperature of the water being passed through the coil. The fan coil unit is relatively bulky, requiring space for location within the room, and the power demand for the operation of such a unit is high, due to the fan.

[0004] A known arrangement which has been developed in an attempt to mitigate some of the above-mentioned disadvantages is known as a 'chilled beam'. The fan in each room is dispensed with, and a forced fresh air supply, the source of which is external of the room, is ducted to the coil in each room for heating or cooling prior to discharge.

[0005] This known 'chilled beam' reduces noise and maintenance due to the fan in each room being dispensed with. However, the heating and cooling response is slower, and due to the forced air supply, the coil requires regular cleaning.

[0006] The present invention seeks to provide a solution to these problems.

[0007] According to a first aspect of the invention, there is provided a method of rapidly controlling room temperature, the method comprising the steps of : a) providing primary heating and cooling means which is or includes a radiant ceiling coil as hereinbefore defined in or on a ceiling of a room; and b) providing secondary heating and cooling means which is or includes supplementary air which is dischargeable into the room, the supplementary air being or including forced air from a forced air supply external of the room, the supplementary air being selectively pre-heated or pre-cooled to accelerate a heating or cooling effect of the primary heating and cooling means.

[0008] The phrase 'radiant ceiling coil' which is used throughout is a phrase common in the field and means a plurality of pipes, typically polypropylene, which form part of a water circuit, the pipes being arranged as a panel, which is located or locatable on or in a ceiling, so as to be typically hidden from an occupant's view. In use and depending on ambient conditions, hot or cold water is pumped around the water circuit and through the pipes, thus resulting in convective and radiant heating or cooling of the ceiling and thus the room. A 'radiant ceiling coil' which is suitable for use in the present invention is available from Aquatherm GmbH of Biggen 5, D-57439, Attendorn, Germany.

[0009] Preferable and/or optional features of the first aspect of the invention are set forth in claims 2 to 9, inclusive.

[0010] According to a second aspect of the invention, there is provided a building comprising a room, a radiant ceiling coil in or on a ceiling of the room, the radiant ceiling coil being fed with water from a chilled water supply and/or a heated water supply; a forced air supply having a source external of the room; supplementary air which is dischargeable into the room, the supplementary air being or including forced air from the forced air supply; an air flow rate control device for controlling a volume of the said supplementary air dischargeable into the room; a supplementary air temperature control device or devices for selectively pre-heating or pre-cooling the supplementary air; and a control unit for selectively setting a desired room temperature of the room, the control unit controlling the temperature of the radiant ceiling coil based on the set room temperature, and the air flow rate control device allowing a predetermined volume of the said supplementary air to be discharged into the room so as to accelerate a heating and cooling effect of the radiant ceiling coil.

[0011] Preferable and/or optional features of the second aspect of the invention are set forth in claims 12 to 14, inclusive.

[0012] Preferably, the building includes a humidifier and/or dehumidifier device for humidifying and/or dehumidifying the supplementary air.

[0013] More preferably, the building according to the second aspect of the invention uses the method according to the first aspect of the invention to rapidly control room temperature.

[0014] According to a third aspect of the invention, there is provided a rapid temperature control system for a room, the system comprising primary heating and cooling means which is or includes a radiant ceiling coil as hereinbefore defined in or on a ceiling of a room; and secondary heating and cooling means which is or includes supplementary air which is dischargeable into the room, the supplementary air being or including forced air from a forced air supply external of the room, the supplementary air being selectively pre-heated or pre-cooled to accelerate a heating or cooling effect of the primary heating and cooling means.

[0015] Preferably, the system in accordance with the third aspect of the invention is in combination with a room in accordance with the second aspect of the invention.

[0016] The present invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, in which :

Figure 1 is a schematic plan view of a room utilising a first embodiment of the method and system of the present invention; and

Figure 2 is a schematic plan view of a room utilising a second embodiment of the method and system of the present invention.

[0017] Referring firstly to Figure 1, there is shown a plan view of a typical room 10, such as a bedroom, of a building, such as a hotel.

[0018] The room 10 has a four walls 12, a floor 14 and a ceiling 16, and is partitioned to define a bedroom 18, a bathroom 20 and an entrance hall 22. A rapid room temperature control system comprises primary heating and cooling means which is or includes a radiant ceiling coil 24 provided in or on the ceiling 16 of the bedroom 18. The radiant ceiling coil 24 is connected to a water circuit 26 of the building. The water circuit 26 includes a hot water plant H and a cold water plant C which are located externally of the room 10, but within or on the building. The hot and cold water plants H and C selectively provide water on demand to the radiant ceiling coil 24.

[0019] To alter the temperature of the radiant ceiling coil 24, a flow of water fed to the radiant ceiling coil 24 is controlled by an occupant-operable control unit 28 provided in the room 10.

[0020] The system also comprises secondary heating and cooling means which is or includes supplementary air SA dischargeable into the room 10. The supplementary air SA is formed from a forced air stream FA which is ducted along a duct 30 into the room 10, in this case through or above the bathroom 20 or hall 22, so as to discharge into the bedroom 18. An air pumping plant AP is provided externally of the room 10, in or on the building. The air pumping plant AP includes one or more heating and cooling devices (not shown) to selectively pre-heat or pre-cool the air. The air which is treated by the air pumping plant AP is typically ambient air drawn from outside the building. The ambient air is filtered in the air pumping plant AP, and one or more humidification and/or dehumidification devices (not shown) can be provided to humidify and/or dehumidify the ambient air, dependent on necessity.

[0021] An air flow rate control device 32 is provided on the flow path of the forced air stream FA. In this case, the air flow rate control device 32 is a damper, for example a butterfly damper, in the duct 30. The damper is controlled via the occupant-operable control unit 28. The speed of cooling or heating can be selected by the oc-

cupant via the occupant-operable control unit 28, thus causing the damper to be adjusted to vary the volume of supplementary air SA being discharged into the room 10, or the damper can in sequence with the radiant ceiling coil be automatically controlled based on the required room temperature and a present temperature differential.

[0022] In this embodiment, a further control unit CU is provided externally of the room 10 for controlling a temperature of the supplementary air SA supplied to the room 10. Typically, the further control unit CU is not accessible by an occupant of the room 10, and the temperature of the supplementary air SA is set by the owner of the building based on seasonal ambient conditions.

[0023] The room 10 also includes a room air exhaust 34, which is commonly provided to ensure sufficient room air circulation. In this case, the room air exhaust 34 is provided in the bathroom 20, and will exhaust up to approximately 100 litres of air per second (1/s).

[0024] Comfortable room temperature for the majority of people is considered to be in the range of 19°C and 26°C. In summer, therefore, when ambient temperatures are typically highest, the air pumping plant AP is set to cool the ambient air being drawn in to a temperature which is at, towards, or below the lower end of the range; in winter, the air pumping plant AP is set to heat the ambient air being drawn in to a temperature which is at, towards, or greater than the higher end of the range.

[0025] With an occupant in the room 10 wishing to cool the room temperature, for example when the room 10 is too hot during summer, the occupant-operable control unit 28 is set to the desired lower temperature, for example 20°C. Cold water from the cold water plant C is thus admitted to the radiant ceiling coil 24, and the radiant ceiling coil 24 alone starts to cool the room 10.

[0026] If the occupant requires the room 10 to be cooled more quickly, or if the occupant-operable control unit 28 determines that the temperature differential between the actual room temperature and the required room temperature is too great, then supplementary cooling can be utilised through the discharge into the room 10 of the supplementary air SA. To achieve this, the occupant-operable control unit 28 controls the air flow rate control device 32 to open and to thus provide a greater volume of supplementary air SA being discharged into the room 10. This has the effect of, in conjunction with the radiant ceiling coil 24, reducing the room temperature to or towards the desired temperature much more rapidly. As the desired temperature is reached or approached, the air flow rate control device 32 is controlled to reduce the volume of supplementary air SA being discharged into the room 10 to a minimum, and further cooling or maintenance of the desired room temperature is then achieved primarily by the radiant ceiling coil 24.

[0027] With the opposite scenario, in which an occupant wishes to raise the room temperature, for example when the room 10 is too cold during winter, the occupant-operable control unit 28 is set to the desired higher temperature, for example 25°C. Hot water from the hot water

plant H of the building is admitted to the radiant ceiling coil 24, and the radiant ceiling coil 24 initially alone starts to heat the room 10.

[0028] If the occupant requires the room 10 to be heated more quickly, or if the occupant-operable control unit 28 determines that the temperature differential between the actual room temperature and the required room temperature is too great, then supplementary heating can be utilised through the discharge into the room 10 of the supplementary air SA. Again, the occupant-operable control unit 28 controls the air flow rate control device 32 to provide a greater volume of supplementary air SA being discharged into the room 10. This has the effect of, in conjunction with the radiant ceiling coil 24, increasing the room temperature to or towards the desired temperature much more rapidly. As the desired temperature is reached or approached, the air flow rate control device 32 is controlled to reduce the volume of supplementary air SA being discharged into the room 10 to the minimum, and further heating or maintenance of the desired room temperature is then achieved primarily by the radiant ceiling coil 24.

[0029] To provide for required air circulation within a room 10, there is a permanent low flow rate of supplementary air SA into the room 10. However, the air flow rate control device 32 controls the volume flow rate of the supplementary air SA from the minimum when it is fully closed, which is typically 25 l/s, to the maximum when it is fully open, which is typically 50 l/s or more, such as 100 l/s.

[0030] Referring now to Figure 2, the above described method and system can also be implemented utilising a 'chilled beam' arrangement. Figure 2 shows a room 110 similar to that shown in Figure 1. The room 110 has a four walls 112, a floor 114 and a ceiling 116, and is partitioned to define a bedroom 118, a bathroom 120 and an entrance hall 122. Primary heating and cooling means which is or includes a radiant ceiling coil 124 is provided in or on the ceiling 116 of the bedroom 118. The radiant ceiling coil 124, water circuit 126, and occupant-operable control unit 128 are as described above, and further detail is omitted.

[0031] Secondary heating and cooling means which is or includes supplementary air SA' is again dischargeable into the room 110. The supplementary air SA' includes air of a forced air stream FA' which is ducted along a duct 130 into the room 110, and which is discharged into a heating and cooling coil unit 136 provided in the room 110.

[0032] As in the first embodiment, an air pumping plant AP' is provided externally of the room 110, in or on the building. However, the or each heating and cooling device of the air pumping plant AP of the first embodiment can be dispensed with, since the coil unit 136 provides selective local heating and cooling at the room 110 via hot and cold water supplies HWS and CWS from hot water plant H' and cold water plant C'. The forced air stream FA' which is delivered to the room 110 by the air

pumping plant AP' is typically ambient air drawn from outside the building. The ambient air is filtered in the air pumping plant AP', and one or more humidification and/or dehumidification devices can be provided to humidify and/or dehumidify the ambient air, dependent on necessity.

[0033] Induction is used at or adjacent to the coil unit 136 to entrain room air with the forced air stream FA'. With a forced air supply of approximately 25 l/s, around 110 l/s of supplementary air SA' can be discharged from the chilled beam arrangement. Obviously, this arrangement is therefore particularly suited to the rapid temperature control of larger rooms.

[0034] The chilled beam arrangement is provided with a water flow rate control device 132, typically at the coil unit 136. Dampers for the forced air supply and supplementary air are typically dispensed with.

[0035] The main difference between the first and second embodiments is that the coil unit of the chilled beam provides for local heating and cooling of the supplementary air, whereas in the first embodiment, pre-heating and pre-cooling of the supplementary air occurs remotely from the room. This being the case, in the second embodiment, the occupant-operable control unit can allow the temperature of the supplementary air to be selectively set by the occupant via the water flow control device 132, thus providing a greater degree of flexibility for the occupant than in the first embodiment.

[0036] The present invention is particularly advantageous over the prior art arrangements since the radiant ceiling coil is more economic than the use of a fan coil unit and the chilled beam unit alone. Furthermore, larger quantities of the supplementary air are only discharged as and when rapid cooling or heating of the room is required. At all other times, only small volumes of the supplementary air is discharged into the room for circulation requirements.

[0037] By the provision of the supplementary air, the temperature of the water supplied to the radiant ceiling coil can be moderated, since the temperature control of the room is being 'boosted' or supplemented by use of the pre-heated or pre-cooled supplementary air. As a consequence, the efficiencies of the water plants are greatly improved.

[0038] Cooling and heating energy is split between the radiant ceiling coil and the supplementary air, in comparison to reliance on typically only a single heating and cooling system. Again, this results in efficiencies and cost savings, such as the reduction in system heat losses.

[0039] The provision of the supplementary air at variable temperature allows particularly rapid response to heating and cooling requirements within a room, on a par with fan coil units. However, the maintenance requirements are greatly reduced, and electricity consumption is dramatically decreased compared to fan coil units.

[0040] Although it is suggested that there will always be a flow of supplementary air into the room for circulation requirements, providing ambient air can enter the room

to allow for circulation, then the air flow control device can fully halt the discharge of supplementary air into the room.

[0041] However, it should be noted that the supplementary air can be fully halted, such that there is no or substantially no ambient air entering the room. In this case, for example, an energy tag on a key card used to access the room can automatically activate the supplementary air and thus induce required circulation. This arrangement is considered beneficial to conserve energy when there is no occupant in the room.

[0042] The primary heating and cooling means is in the form of a radiant ceiling coil as defined above. However, the primary heating and cooling means can include further systems for heating and cooling the room, such as under- or in- floor heating and cooling, and in-wall or wall mounted heating and cooling. However, the main benefit envisaged by the present invention is the advantage in terms of economies and savings provided by the combined use of a radiant ceiling coil and pre-heated or pre-cooled supplementary air to accelerate the heating or cooling effect of the radiant ceiling coil, thus reducing energy consumption and carbon emissions.

[0043] Although it is suggested that in winter the air pumping plant is set to heat the ambient air being drawn in to a temperature which is at, towards, or greater than the higher end of the range, due to improving insulation techniques and materials, the air pumping plant may be required to cool the ambient air during winter.

[0044] Although it is also suggested in the second embodiment that the or each heating and cooling device of the air pumping plant AP of the first embodiment can be dispensed with, the or each heating and cooling device can of course be provided to condition the ambient air typically to or substantially to the room temperature range.

[0045] The above described method and system can be easily applied to buildings with many rooms, and is thus ideal for use in public and/or commercial premises, such as hotels, conference centres, hospitals and offices. However, the method and system is equally applicable to residential buildings.

[0046] The embodiments described above are given by way of examples only, and various other modifications will be apparent to persons skilled in the art without departing from the scope of the invention, as defined by the appended claims.

Claims

1. A method of rapidly controlling room temperature, the method comprising the steps of :

a) providing primary heating and cooling means which is or includes a radiant ceiling coil (24; 124) as hereinbefore defined in or on a ceiling (16; 116) of a room (10; 110); and

b) providing secondary heating and cooling means which is or includes supplementary air (SA; SA') which is dischargeable into the room (10; 110), the supplementary air (SA; SA') being or including forced air (FA; FA') from a forced air supply external of the room, the supplementary air (SA; SA') being selectively pre-heated or pre-cooled to accelerate a heating or cooling effect of the primary heating and cooling means.

2. A method as claimed in claim 1, wherein the radiant ceiling coil (24; 124) is fed with water from a chilled water supply and/or a heated water supply, and means are provided for controlling the temperature of the radiant ceiling coil (24; 124) depending on desired room temperature.

3. A method as claimed in claim 1 or claim 2, wherein means are provided for controlling a volume of the said supplementary air (SA; SA') dischargeable into the room.

4. A method as claimed in claim 3, wherein the supplementary air volume controlling means is automatically operable based on a temperature set for the room.

5. A method as claimed in any one of the preceding claims, wherein means are provided externally of the room (10) for controlling the temperature of the said supplementary air (SA), so that the said supplementary air arrives at the room at a predetermined temperature.

6. A method as claimed in any one of the preceding claims, wherein means are provided in the room (110) for controlling the temperature of the said supplementary air (SA').

7. A method as claimed in claim 5 or claim 6, wherein the said temperature of the supplementary air (SA; SA') is in the range of 19°C to 26°C.

8. A method as claimed in any one of the preceding claims, wherein means are provided for humidifying and/or dehumidifying the supplementary air (SA; SA').

9. A method as claimed in any one of the preceding claims, wherein no fan is present in or at the room (10; 110) by which the said supplementary air (SA; SA') is discharged into the room.

10. A building comprising :

a room (10; 110);
a radiant ceiling coil (24; 124) in or on a ceiling (16; 116) of the room, the radiant ceiling coil be-

ing fed with water from a chilled water supply (C; C') and/or a heated water supply (H; H');
 a forced air supply (FA; FA') having a source external of the room (10; 110);
 supplementary air (SA; SA') which is discharge- 5
 able into the room, the supplementary air (SA; SA') being or including forced air from the forced air supply (FA; FA');
 an air flow rate control device (32; 132) for controlling a volume of the said supplementary air 10
 dischargeable into the room;
 a supplementary air temperature control device or devices (AP; 136) for selectively pre-heating or pre-cooling the supplementary air; and
 a control unit (28; 128) for selectively setting a 15
 desired room temperature of the room, the control unit controlling the temperature of the radiant ceiling coil based on the set room temperature, and the air flow rate control device allowing a predetermined volume of the said supplementary 20
 air to be discharged into the room so as to accelerate a heating and cooling effect of the radiant ceiling coil.

ing effect of the primary heating and cooling means.

11. A building as claimed in claim 10, wherein a second 25
 control unit (CU) which is remote from the first said control unit (28) controls the or each supplementary air temperature control device (AP) independently of the set room temperature. 30
12. A building as claimed in claim 11, wherein the or each supplementary air temperature control device (AP) is external of the room.
13. A building as claimed in claim 10, wherein the said 35
 control unit (28; 128) controls the or each supplementary air temperature control device (AP; 136) based on the set room temperature.
14. A building as claimed in claim 13, wherein the or 40
 each supplementary air temperature control device (136) is provided in or at the room.
15. A rapid temperature control system for a room (10; 45
 110), the system comprising :

primary heating and cooling means which is or includes a radiant ceiling coil (24; 124) as here-
 inbefore defined in or on a ceiling (16; 116) of a 50
 room (10; 110); and
 secondary heating and cooling means which is or includes supplementary air (SA; SA') which is dischargeable into the room (10; 110), the supplementary air (SA; SA') being or including forced air (FA; FA') from a forced air supply ex- 55
 ternal of the room (10; 110), the supplementary air (SA; SA') being selectively pre-heated or pre-cooled (AP; 136) to accelerate a heating or cool-

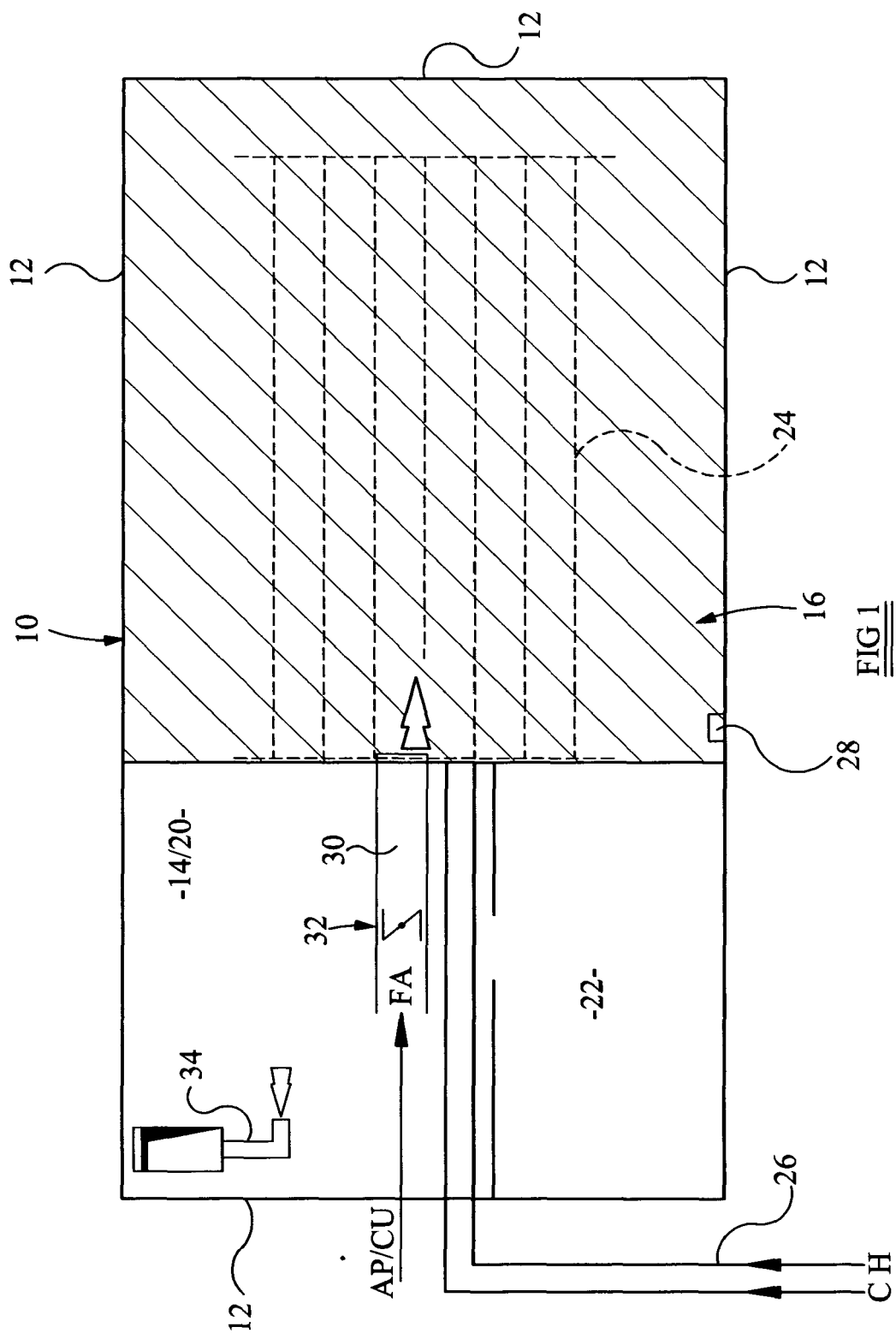


FIG 1

