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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Int. Cl.:—F 25 b, d//F 24 d, f, F 25 g

COMPLETE SPECIFICATION

Radiant Heating or Cooling Systems

We, FRENGER INTERNATIONAL CORPORATION, a corporation organised under the laws of Switzerland, of 21 Zentweg, Berne, Switzerland, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to radiant heating or cooling systems and particularly to an air-conditioning system comprising a combined radiant heating, cooling and ventilating sub-ceiling including a plurality of pipes adapted to be heated or cooled by means of a heat exchange fluid flowing through said pipes and a plurality of plate elements arranged in heat exchange relationship to said pipes so as to form a radiant heating or cooling panel.

In sub-ceilings of this kind, the plate elements are preferably made of metal sheet such as aluminium or another metal of high thermal conductivity and are heat conductively and detachably associated with the pipes.

The present invention consists in a radiant heating or cooling system comprising a combined radiant heating, cooling and ventilation sub-ceiling including a plurality of pipes and a plurality of plate elements in heat exchange association with said pipes, wherein the pipes of the sub-ceiling are inserted in the secondary circuit of a liquid-to-liquid heat exchanger, the primary circuit of which contains a reversible heat pump comprising a compressor, an expansion valve and an air-to-liquid heat exchanger, the components of said heat pump being enclosed in a compartment communicating with the atmosphere and comprising means for causing an air current derived from the atmosphere to flow through said compartment.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings, in which:

Fig. 1 is a plan view of a room provided with an air conditioning system according to the invention,

Fig. 2 is a vertical section at a reduced scale taken along the lines II—II in Fig. 1.

Fig. 3 is likewise a vertical section at a reduced scale taken along the lines III—III in Fig. 2.

Fig. 4 is a diagrammatic view of the combined sub-ceiling and heat pump system.

Referring to the drawings, and more particularly to Figs. 1, 2, and 3, a room having an air-conditioning sub-ceiling is defined by an outer wall Wx, inner walls Wi and a ceiling T below which a sub-ceiling U is suspended as illustrated in Fig. 2 and 3.

The sub-ceiling U, Fig. 1, comprises a pipe frame U1 and a plurality of plate elements U2, heat conductively associated with the pipes of the frame U1. As shown in Figures 1 and 2, a compartment is formed by the outer wall Wx, inner walls Wi, wall Wu, the ceiling T and a base plate Q, to accommodate the machinery pertaining to the heat pump system including compressor, heat exchangers and ventilation components, and is subdivided into the following chambers:

Air-intake chamber Ki, defined by walls Wx, Wi, Wu; Wix, Wic,

Compressor chamber Kc, defined by walls Wic, Wxc, Wcx, Wzc,

An air expulsion chamber Kx, defined by walls Wcx, Wxy, Wxr and outer wall Wx,

A room air chamber Kr, defined by walls Wx, Wxr, Wu and Wi.

Moreover, the machinery compartment comprises air connection channels Kcx, Ky and Kz. The chambers thus defined comprise the following components:

Ki: A blower Bi, an air filter L, an air-to-

[*Price 4s. 6d.*]

liquid heat exchanger Hi. An aperture Oi is provided in the outer wall Wx and in aperture Ou is provided in the wall Wu connecting the chamber Ki with the space TU intermediate the ceiling T and the sub-ceiling U.

Kc: A compressor unit comprising a compressor C and driving motor M. This chamber may also comprise auxiliary machinery such as pumps, etc.

Kx: A blower Bx and an air-to-liquid heat exchanger Hx, arranged adjacent an opening Ox in the outer wall Wx.

Kr: A liquid-to-liquid heat exchanger G. This chamber further comprises an opening in the botom plate Q connecting the chamber Kr with an air duct R as shown in Fig. 2 for recirculation of the room air.

The walls defining these chambers comprise the following devices for regulating the air circulation:

Air valves comprising dampers or obturators D1, D'1, D2 and D'2 in the wall WZC and D3 and D'3 in the wall Wic. Moreover, a similar air valve D4, D'4 is provided in the wall Wcx.

Adjustable air valves Sr and Sy are provided in the wall Wxr for regulating the air flow to the channel Ky and between the chambers Kx and Kr.

The connections between the heat pump components and the pipe frame pertaining to the sub-ceiling and the circuits formed by these connections will be explained with reference to Fig. 4:

The pressure side of the compressor C is connected with a reversing valve X through a conduit cx and one branch of the reversing valve X is connected with the low pressure side of the compressor C through the conduit xc. Another branch of the reversing valve X is connected with the primary circuit N of the liquid-to-liquid heat exchanger G through the conduit xn. The primary circuit N is furthermore connected with a pair of uni-directional valves V1 and V4 through a conduit nv, and the air-to-air heat exchanger Hx is similarly connected with uni-directional valves V2 and V3. The valves V1 and V2 are connected with a container F for collecting the condensed liquid flowing through the primary circuit N, and an expansion valve E is inserted between the container F and the pipe connecting valves V3 and V4.

The components C, X, E, F, Hx and N constitute a heat pump system for circulating a heat exchange fluid (hereinafter referred to as the primary fluid) such as the fluid known under the Registered Trade Mark "FREON".

The secondary circuit of the liquid-to-liquid heat exchanger G is divided into two circuits both of which are connected to the terminals a and b of the heat exchanger G.

One of these circuits comprises the air-to-liquid heat exchanger Hi and a by-pass valve Y; the other circuit comprises the pipe frame U1 of the sub-ceiling and a by-pass valve Z. A circulation pump P is associated with both of these circuits.

The terminals or connecting points of the components inserted in the heat pump system are designated by small letters corresponding to the capital letters designating the components with which they are connected through the pipe lines each of which is designated by two small letters indicating the terminals which are interconnected by the pipe lines. The small letters designating the terminals of the components also appear in Fig. 1 showing the arrangement of the heat pump components within the compartment defined by the inner walls, the outer wall and the partition wall Wu, but the pipes interconnecting the components have been omitted in this figure for the sake of clarity. In Fig. 4 the thick lines a-y, h-y and a-z indicate the connecting pipes through which the secondary fluid is flowing in the positive direction from Ga to Gb, whereas the thin lines h-p, p-b and u-p indicate the return lines from the components towards the terminal Gb.

The operation of the heat pump system will now be explained with reference to Figs. 1 and 4:

A. Heating.

The Compressor Circuit (Primary Circuit)

When operating on the heating cycle, the heating of the pipe frame U1 and of the fresh air Ai entering through the opening Oi is effected in the following manner:

The reversing valve X is adjusted so as to provide the following circuit for the flow of the primary fluid:

C—cx—X—xn—N—nv—V1—F—E—V3—hv—Hx—xh—X—xc—C.

The primary fluid flowing through this circuit will absorb heat calories from the air-to-air heat exchanger Hx and hence from the air flow Ax, Fig. 1, which is expelled through the opening Ox. The heat thus absorbed is delivered from the primary circuit N in the liquid-to-liquid heat exchanger G and is transferred to the secondary heat exchange fluid flowing therethrough through the terminals a and b.

The heated secondary fluid is circulated through the two secondary circuits, i.e.:

Circuit Hi:

a—ay—Y—Hi—hp—P—pb—b and

Circuit U:

a—az—Z—zu—U1—up—P—pb—b.

The heat absorbed by the secondary fluid will thus be delivered on the one hand to the in-coming air through the air-to-liquid heat

exchanger Hi and on the other hand to the radiant heating sub-ceiling U1, U2.

The distribution of the heat delivered from the secondary fluid between the components Hi and U1 can be selectively adjusted by means of the by-pass valves Y and Z associated with the by-passes yp and pz shown in broken lines.

Air Circuit Fig. 1.

When operating on the heating cycle, the ventilation air, i.e. the air flowing through the opening Oi into the chamber Ki and conveyed by the blower Bi into the space TU, Fig. 3, intermediate the upper ceiling and the sub-ceiling, must also be heated. This heating is partly achieved by means of the heat exchanger Hi and partly through mixing the in-coming air Ai with the room air Ar which passes through the compressor chamber Kc cooling the compressor C and the motor M.

The air flow through the compressor chamber Kc is obtained by adjusting the air valves D1, and D2 in the position shown in full lines in Fig. 1 in which both ends of the by-pass channel Kz are closed. Simultaneously the air valves D3 and D4 are likewise adjusted in their closing position as shown in full lines in Fig. 1.

The room air Ar flowing into the room air chamber Kr through the return air channel R will flow through the channel Ky and the compressor chamber Kc into the air intake chamber Ki and will be mixed in this chamber with the fresh air Ai entering through the opening Oi. The mixture of fresh air and room air will pass through the heat exchanger Hi and flows into the space TU between the upper ceiling T and the sub-ceiling U through the opening Ou in the wall Wu.

As shown in Fig. 3, the mixed air will flow through openings U3 in the sub-ceiling and will enter the room subjacent the sub-ceiling U as ventilation air.

This air flow will cause a draughtless and uniform ventilation, and the room air will subsequently flow through the return channel R into the room air chamber Kr. From this chamber one portion of the room air Ar will flow through the damper Sr into the expulsion chamber Kx and will be conveyed by the blower Bx through the heat exchanger Hx and the opening Ox into the atmosphere. Simultaneously another air current Ac derived from the atmosphere will flow through the opening Oc in the outer wall Wx and the channel Kcx into the chamber Kx and after delivering heat to the heat exchanger Hx will be expelled through the opening Ox.

B. Cooling.

Compressor circuit.

When operating on the cooling cycle the fresh air Ai entering through the opening Oi and the pipe frame U1 of the sub-ceiling will be cooled as a consequence of the adjustment of the reversing valve X so as to form the following circuit for the primary fluid:

C—cx—X—xh—Hx—hv—V2—F—E—V4—nv—N—xn—X—xc—C.

In this circuit cooling calories will be absorbed from the heat exchanger Hx and transferred to the primary circuit N of the liquid-to-liquid heat exchanger G, wherein the cooling calories will be delivered to the secondary fluid. The cooled secondary fluid will flow through the two secondary circuits Hi and U in the same manner as explained above with reference to the heating cycle, and the fresh air flowing through the heat exchanger Hi and the pipe frame will thus be cooled.

Air Circuit.

When operating on the cooling cycle, the air valves D are adjusted in the positions shown by the thin broken lines, i.e. the positions D'1, D'2, D'3 and D'4. The room air Ar will now flow from the chamber Kr through the damper Sy and the channels Ky and Kz into the chamber Ki and the ventilation will be effected in the same manner as when operating on the heating cycle. On the other hand, the cooling of the compressor and motor in the chamber Kc will be effected by the fresh air derived from the atmosphere through the opening Oc. The cooling air will pass through the open valves D3 and D4 into the chamber Kx, whence it will be expelled by the blower Bx through the opening Ox into the atmosphere.

Acoustic Damping.

The perforated plate elements U2 of the sub-ceiling and the base plate Q of the machinery compartment may readily be adapted for sound absorption in a manner well-known per se by providing a layer of acoustic damping material above the said plate elements. Thus, an air conditioning system according to the invention may be adapted to the combined effects of heating, cooling, ventilation and sound damping without substantially increasing the costs of manufacture or installation.

WHAT WE CLAIM IS:—

1. A radiant heating or cooling system comprising a combined radiant heating, cooling and ventilation sub-ceiling including a plurality of pipes and a plurality of plate elements in heat exchange association with said pipes, wherein the pipes of the sub-ceiling are inserted in the secondary circuit of a liquid-to-liquid heat exchanger, the primary circuit of which contains a reversible heat pump comprising a compressor, an expansion valve and an air-to-liquid heat exchanger, the components of said heat pump being enclosed in a compartment communicating with the

exchanger Hi and on the other hand to the radiant heating sub-ceiling U1, U2.

The distribution of the heat delivered from the secondary fluid between the components Hi and U1 can be selectively adjusted by means of the by-pass valves Y and Z associated with the by-passes yp and pz shown in broken lines.

Air Circuit Fig. 1.

When operating on the heating cycle, the ventilation air, i.e. the air flowing through the opening Oi into the chamber Ki and conveyed by the blower Bi into the space TU, Fig. 3, intermediate the upper ceiling and the sub-ceiling, must also be heated. This heating is partly achieved by means of the heat exchanger Hi and partly through mixing the in-coming air Ai with the room air Ar which passes through the compressor chamber Kc cooling the compressor C and the motor M.

The air flow through the compressor chamber Kc is obtained by adjusting the air valves D1, and D2 in the position shown in full lines in Fig. 1 in which both ends of the by-pass channel Kz are closed. Simultaneously the air valves D3 and D4 are likewise adjusted in their closing position as shown in full lines in Fig. 1.

The room air Ar flowing into the room air chamber Kr through the return air channel R will flow through the channel Ky and the compressor chamber Kc into the air intake chamber Ki and will be mixed in this chamber with the fresh air Ai entering through the opening Oi. The mixture of fresh air and room air will pass through the heat exchanger Hi and flows into the space TU between the upper ceiling T and the sub-ceiling U through the opening Ou in the wall Wu.

As shown in Fig. 3, the mixed air will flow through openings U3 in the sub-ceiling and will enter the room subjacent the sub-ceiling U as ventilation air.

This air flow will cause a draughtless and uniform ventilation, and the room air will subsequently flow through the return channel R into the room air chamber Kr. From this chamber one portion of the room air Ar will flow through the damper Sr into the expulsion chamber Kx and will be conveyed by the blower Bx through the heat exchanger Hx and the opening Ox into the atmosphere. Simultaneously another air current Ac derived from the atmosphere will flow through the opening Oc in the outer wall Wx and the channel Kcx into the chamber Kx and after delivering heat to the heat exchanger Hx will be expelled through the opening Ox.

B. Cooling.

Compressor circuit.

When operating on the cooling cycle the fresh air Ai entering through the opening Oi and the pipe frame U1 of the sub-ceiling will be cooled as a consequence of the adjustment of the reversing valve X so as to form the following circuit for the primary fluid:

C—cx—X—xh—Hx—hv—V2—F—E—V4—nv—N—xn—X—xc—C.

In this circuit cooling calories will be absorbed from the heat exchanger Hx and transferred to the primary circuit N of the liquid-to-liquid heat exchanger G, wherein the cooling calories will be delivered to the secondary fluid. The cooled secondary fluid will flow through the two secondary circuits Hi and U in the same manner as explained above with reference to the heating cycle, and the fresh air flowing through the heat exchanger Hi and the pipe frame will thus be cooled.

Air Circuit.

When operating on the cooling cycle, the air valves D are adjusted in the positions shown by the thin broken lines, i.e. the positions D'1, D'2, D'3 and D'4. The room air Ar will now flow from the chamber Kr through the damper Sy and the channels Ky and Kz into the chamber Ki and the ventilation will be effected in the same manner as when operating on the heating cycle. On the other hand, the cooling of the compressor and motor in the chamber Kc will be effected by the fresh air derived from the atmosphere through the opening Oc. The cooling air will pass through the open valves D3 and D4 into the chamber Kx, whence it will be expelled by the blower Bx through the opening Ox into the atmosphere.

Acoustic Damping.

The perforated plate elements U2 of the sub-ceiling and the base plate Q of the machinery compartment may readily be adapted for sound absorption in a manner well-known per se by providing a layer of acoustic damping material above the said plate elements. Thus, an air conditioning system according to the invention may be adapted to the combined effects of heating, cooling, ventilation and sound damping without substantially increasing the costs of manufacture or installation.

WHAT WE CLAIM IS:—

1. A radiant heating or cooling system comprising a combined radiant heating, cooling and ventilation sub-ceiling including a plurality of pipes and a plurality of plate elements in heat exchange association with said pipes, wherein the pipes of the sub-ceiling are inserted in the secondary circuit of a liquid-to-liquid heat exchanger, the primary circuit of which contains a reversible heat pump comprising a compressor, an expansion valve and an air-to-liquid heat exchanger, the components of said heat pump being enclosed in a compartment communicating with the

atmosphere and comprising means for causing an air-current derived from the atmosphere to flow through said compartment.

2. A system as claimed in Claim 1, wherein the secondary circuit of the liquid-to-liquid heat exchanger comprises a further air-to-liquid heat exchanger arranged in an air-intake chamber within the said compartment.

3. A system as claimed in Claim 2, wherein the pipes of the sub-ceiling and the air-to-liquid heat exchanger in the air-intake chamber are inserted in separate branches of the secondary circuit of the liquid-to-liquid heat exchanger, said branches being connected in parallel and comprising valves for adjusting the flow of liquid therethrough.

4. A system as claimed in any of Claims 1 to 3, wherein the components pertaining to the heat pump system including a compressor unit, heat exchangers and blowers for conveying air-currents through the air-to-liquid heat exchangers and for the re-circulation of room air, are mounted in a self-contained unit adapted to be mounted below the upper ceiling of the room to be air-conditioned intermediate the sub-ceiling and an outer wall provided with air-intake and air-outlet openings.

5. A system as claimed in Claim 4, wherein the unit comprising the said components is provided with partitions dividing the interior of said unit into an air-intake chamber, a compressor chamber, an air-expulsion chamber and by-pass channels interconnecting said chambers.

6. A system as claimed in Claim 5, wherein the partitions between said chambers and channels are provided with adjustable air-valves arranged so as to cause an air-flow passing through the compressor chamber to be derived from the room air, when the heat pump is operating on the heating cycle and from the atmosphere when it is operating on the cooling cycle.

7. Radiant heating or cooling systems constructed substantially as hereinbefore described.

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