AIR CONDITIONING PLANT FOR BUILDINGS

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ABSTRACT

An air conditioning plant for a building basically contains one conduit for admitting air to the building and a further conduit for evacuating air therefrom. The heat applied to the in-coming air largely remains in the out-going air, or may even on occasion have been increased. This heat content may be transferred back to the inlet air conduit by means of a heat pump having at least one heat exchanger in each conduit. A major problem in an installation of that type is the need for defrosting the evaporating heat exchangers in the exhaust conduit. This problem is solved by providing two heat exchanges in parallel in the exhaust conduit and arranged in such a manner that they will become operative alternately, one serving as evaporator, while the other is being defrosted. By suitable connections, the function of the two types of heat exchangers may be switched, whereby the exchanger in the inlet conduit, instead of working as a condenser, will serve as an evaporator, thereby to cool the incoming air.

6 Claims, 5 Drawing Figures
AIR CONDITIONING PLANT FOR BUILDINGS

BACKGROUND OF THE INVENTION

The present invention relates to an air conditioning plant for buildings. By using air-borne heat, where the air is heated by means of a heat pump, it is possible to provide the desirable heating and ventilating in an easy and economic manner. A very rapid adjustment of the temperature is obtained, and the inclusion of a heat pump means that a high rate of ventilation may be maintained without the use of the unreasonably large heat exchanger surfaces, which otherwise would have been necessary to obtain a high efficiency. When a heat pump is used for heating the air, it is possible, by simple means, and at a comparatively low cost to convert the plant to air-cooling purposes in order to obtain a satisfactory indoor temperature during the summer.

SUMMARY OF THE INVENTION

The invention is applicable to a plant in which a first conduit conveys air to the building and a second conduit conveys at least a major part of the air to the building therefrom, and is characterized in a heat pump working in an evaporating fluid and comprising a condenser and at least one first heat exchanger operable as a condenser in connection with the first, inlet air conduit as well as at least two heat exchangers operable as evaporators in connection to the second exhaust conduit, and means alternately to bring the evaporating heat exchangers operable in connection with the exhaust conduit into and out of operation in step with the requirements for defrosting.

DESCRIPTION OF THE DRAWINGS

FIG. 1 shows schematically a first embodiment of the invention,
FIG. 2 schematically shows a further embodiment, FIG. 3 is a horizontal section through a heat pump and the heat exchanger belonging thereto,
FIG. 4 is a vertical section through the latter, and FIG. 5 is a section along line IV — IV in FIG. 4, the view looking in the direction of the arrows.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 schematically shows the arrangement of an air conditioning plant for a building. Air is supplied to the building by way of a first conduit 12, and the major part of the air is evacuated from the building by way of a second conduit 16. The conduit 16 is divided into two branch conduits 16a and 16b, respectively.

The air supplied to the building is heated in a heat exchanger 21 located in conduit 12, and this heat is largely extracted from the out-going air by means of heat exchangers 20a and 20b fitted into the exhaust branch conduits 16a and 16b. These three heat exchangers form part of a heat pump working according to known principles, and on this occasion operating with an easily evaporable fluid, such as freon, or any similar fluid well known in connection with refrigerators. This heat pump comprises a compressor 19 driven in any suitable manner and provided with governing means of known type including throttling valves 22a and 22b. The pump draws fluid from the heat exchangers 20a or 20b, thereby cooling the out-going air, compresses the vapor and delivers it to heat exchanger 21, where it is condensed, thereby heating the in-coming air. The heat exchanger further includes a main recipient 8 for the heat transferring fluid.

One important problem relating to the heat exchangers in the exhaust air conduit 16 is that they, after some time of use, will be covered with ice and therefore will require defrosting. One of these heat exchangers is in operation, while the other is being defrosted and prepared for action, and the inlet air is provided with the butterfly valve 7a and 7b, respectively, and in the conduit from the recipient 8 to these heat exchangers is a shutoff valve 6a and 6b, respectively.

As illustrated in the drawing, the exhaust air butterfly valve 7a is open, which means that exchanger 20a is in operation, while exchanger 20b is being defrosted. Fluid valve 6a is open and fluid valve 6b closed.

Defrosting is brought about by vapor, bled off by way of a conduit 5 from the high pressure side of the compressor 19 being transferred to the exchanger about to be defrosted. There is a valve 4a and 4b to govern the flow of this defrosting vapor to the appropriate exchanger 20a or 20b, respectively.

Defrosting vapor becomes condensed in the heat exchanger and is, by way of a non-return valve 3a and 3b, respectively, transferred to an auxiliary recipient 2a and 2b, respectively. The latter is, by way of a shutoff valve 100a and 100b, respectively, as well as for further non-return valves 101a and 101b connected to the inlet end of the heat exchanger. In the return fluid conduit there is for each heat exchanger 20a and 20b, a main shutoff valve 102a and 102b, respectively, which is by passed by a branch conduit including a throttling member 103a and 103b and an auxiliary shutoff valve 104a and b 104b respectively.

The defrosting operation of exchanger 20b means that valve 4b is open so high pressure vapor can pass through the heat exchanger thereby to melt the ice. The water thus obtained may be conducted away by a drain 105b. While melting the ice the vapor is condensed in the heat exchanger and the fluid is collected in the auxiliary recipient 2b. Valves 100b, 102b and 103b are closed during this part of the operation.

In order to bring this exchanger into operating condition, i.e., to bring the pressure and the temperature thereof to the same level as in exchanger 20a, which is about to be defrosted, valve 4b is closed and valves 100b and 103b are opened. Fluid can then pass from the auxiliary recipient to the inlet of the exchanger.

While passing through the exchanger the fluid is evaporated, as the exchanger surfaces will reach room temperature a short time after the ice has melted away. This arrangement is done in order to prevent liquid fluid from being drawn from the auxiliary recipient to the compressor, which would imply an apparent risk of damage.

When the recipient is almost emptied the exchanger is ready for operation and valve 102b, as well as butterfly valve 7b in the exhaust air conduit may be opened. Simultaneously, butterfly valve 7a is closed, and as soon as the auxiliary recipient is completely empty valve 6b is opened to permit supply of fluid directly from the main recipient.

At the same time valve 6a pertaining to exchanger 20a has, of course, been closed and valve 4a opened so the defrosting of exchanger 20a can proceed as above described in connection with exchanger 10b.
The operation of the various valves may be brought about automatically by arbitrary means known in the art, and the time for starting the switching-over operation may be determined by means sensitive to the increasing pressure at the exchangers 20a and 20b, respectively, which is caused by a growing ice cover on the heat exchanger surfaces.

The plant above described is used to heat the incoming air. During the summertime it may be desirable instead to cool the air, and this can be arranged in a similar manner, basically by changing the direction of flow of the fluid. Evaporation will then occur in heat exchanger 21 and condensation in one of the exchangers 20a or 20b, respectively. The supply from the compressor 19 to the heat exchanger 21, which during this working condition is serving as an evaporator, is shut off by means of a valve 106. The compressor 19 thus delivers the fluid via conduit 5 to one or both of heat exchangers 20a and 20b, which are serving as condensers, and give off heat to the outlet air in conduits 16a and 16b. Via the non-return valves 3a and 3b, respectively, the media is transferred from the condensers 20a and 20b to the recipients 2a and 2b respectively, and as the valves 100a and 100b respectively are closed, the fluid via conduits 107a and 107b respectively will be fed to the evaporating heat exchanger 21, which cools down the in-coming air flowing through conduit 12. At this working condition, the valves 108a and 108b are open as well as a valve 109 provided in a by-pass conduit 110, which connects the evaporator 21 with the suction side of the compressor 19.

As the in-coming air is not cooled below 0°C, there will be no formation of ice at the evaporator and therefore no defrosting is required. Under this working condition, the valves 6a, 6b, 102a, 102b, 104a, 104b, 106a and 100b of course are closed.

A building may include compartments of two basic types. An ordinary apartment house first of all includes apartment, in which it is desirable to adjust the temperature individually in each room, and secondly sections, such as staircases, cellars and other common compartments, wherein a predetermined temperature is maintained in all these compartments a continuous exchange of air is desirable.

In FIG. 2 a building is schematically shown as a rectangular frame divided into three compartments, of which outer ones 10, are intended to denote apartments and each may include a number of rooms, each being provided with a mixing box of the type to be described below, as well as an intermediate compartment 11, which likewise may include a number of spaces such as cellars, a staircase and other common spaces, in which the requirements for adjustment of the temperature are not so great.

The plant comprises an air inlet conduit 12 provided with a fan 13, which draws in air from the atmosphere to the system. The in-coming air is divided between two branch conduits 14 and 15. The first mentioned conduit communicates with the compartments of type 10, as well as with compartments of type 11, while branch conduit 15 communicates with compartments of type 10 only. The air is evacuated from the building by means of an exhaust conduit 16 provided with a fan 17. Branches 16a from the exhaust conduit reach into all compartments within the building, and the total amount of air supplied to the building will be evacuated through this conduit.

A counterflow heat exchanger 18 is mounted in the exhaust conduit, and the inlet branch conduit 15 is led through this heat exchanger. This branch conduit basically conveys unheated air from the compartments for mixing with the heated air in the apparatus in the manner to be described below. In order to prevent condensation of moisture in the conduits, this part of the air is slightly heated in heat exchanger 18. This heating may be already effected at the still undivided air inlet conduit 12, whereby the amount of condensing in the heat exchanger proper is diminished. The main heating of the air occurs in a heat pump 9, which in a well-known manner, consists of a compressor 19, a first heat exchanger 20 located in the exhaust conduit 16, downstream of counterflow heat exchanger 18, and a second heat exchanger 21 located in the inlet branch conduit 14. In a cross connection between the two exchangers there is a throttling valve 22 for governing the flow of the heat transfer fluid. The heat pump operates with an evaporating fluid of the type used in refrigerators, such as freon. This fluid is evaporated in exchanger 20, compressed in compressor 19 and condensed in exchanger 21, thereby heating the air flowing through branch conduit 14. A branch 14a from this conduit is united with a branch 15a from the other air inlet branch conduit 15 in a mixing box 23 within each room of the compartments, in which it is desirable to adjust the temperature. The amount of air passing through the inlet branch conduits is constant, and the temperature may be adjusted accordingly to the occasional need.

One disadvantage with a heat pump 9 of the above indicated type is that it is necessary occasionally to defrost the heat exchanger surfaces. It is, however, preferable to be able to provide a continuous defrosting, partly in order to be able to withdraw as much as possible of the available heat content from the evacuated air without diminishing the heat transfer in the evaporator, and partly in order to prevent variations in the temperature of the in-coming air, when the heat exchanger is closed down for defrosting. A continuously working heat pump may, according to a development of the invention, be designed in such a manner that the heat exchangers 20 and 21 form parts of a rotating heat exchanger unit in which valves governing the supply and the withdrawal of heat transfer fluid are operated electrically, mechanically, pneumatically or hydraulically from the rotating unit.

A preferred embodiment of a rotating heat exchanger 9 is shown in FIGS. 3 - 5. The in-coming air from branch conduit 14 passes the heat exchanger unit from below and upwards by way of an internal rotating distributor housing 25, while the evacuated air from conduit 16 passes the unit from above and downwards by way of an outer circular housing 26. The heat exchanges are formed into a cylindrical drum 27, which is subdivided into a number of sector-shaped heat exchanger packages. FIG. 4 shows 12 such sectors. Each of these may include a number of pipe coils provided with external flanges. Each package may work as a condenser and as an evaporator. The coils are schematically indicated only and they will, on different occasions, be supplied with fluid from the high pressure side of the compressor, or deliver fluid to the low pressure side thereof, respectively.

The heat exchanger surfaces, thus, are stationary, whereas the inner housing for the in-coming air rotates and thereby evenly distributes the in-coming, as well as
the out-going air over the heat exchanger packages. The inner housing is, as is best shown in FIG. 5, provided with two radially extending, cowl-shaped arms, the downwardly open faces of which each has the same size as two sectors. The in-coming and the out-going air will, in this manner, be evenly distributed over the front area of the heat exchanger unit. In order to balance the rotating system, two diametrically opposite exchanger packages always have the same function. The top and the bottom portions of the outer and of the inner housing are mutually alike, and the top and bottom portions of the inner housing rotate synchronously.

The inner housing is provided with cover plates 28, which will extend over the sections about to switch from one function to the other. The valves for switching from the high to the low pressure side are governed from the rotating part by mechanical, electrical, hydraulic or pneumatic means. Throttling conduits 45 – 48 between the condensers and evaporators are schematically shown in the core of the heat exchanger drum. Each condenser will always supply the same evaporator with fluid. Possible throttling occurs in both directions whereby the number of connections may be reduced. The number of heat exchanger packages shall be sufficient to prevent detrimental influences in connection with the switching over of the valves.

The heat exchanger unit shown in FIG. 3 consists, as above mentioned, of twelve sectors, 31 – 42. The rotating housing is provided with four cover plates 28. The diametrically opposite sectors 31 and 32, as well as 37 and 38, operate in the position illustrated as evaporators, while sectors 34, 35 and 40, 41, respectively, operate as condensers. Sectors 33, 36, 39 and 42 are simultaneously covered by the rotating plates 28.

The high pressure side of the compressor is, by way of a first annular conduit 43 encircling the unit, connected to every one of the sectors, and in the same manner the low pressure side of the compressor, by way of a second annular conduit 44, is connected to every sector. Between each annular conduit and the various sectors there are branch conduits, each of which is provided with a valve, governed by the rotating housing 25 in the manner indicated above. FIG. 3 shows how, on the occasion illustrated, sectors 34, 35 and 40, 41 by way of valves 34H, 35H, 40H and 41H, respectively, are connected to annular conduit 43, while simultaneously sectors 31, 32, 37 and 38 by way of valves 31L, 32L, 37L and 38L, respectively, are connected to annular conduit 44. Low pressure valves 36L and 42L are also open to drain the pertaining sectors 36 and 42.

The coil of sector 40 connected to annular conduit 43 is shown in full lines, as is a coil 51 in sector 37 connected to annular conduit 44. These two coils are interconnected and in a similar manner high pressure vapor from the compressor will be conveyed to sectors 34, 35, 40 and 41 wherein it is condensed, whereupon the condensate is transferred to the pertaining sectors serving as evaporators. Each sector will, in this manner, always supply the same sector with fluid. The connecting conduits, which are operative in the present occasion, are shown in full lines, while the inoperative conduits are shown in dash lines.

Condensed fluid from sector 34 is thus by way of conduit 45 within the core transferred to sector 31, while condensed fluid from sector 35 by way of conduit 46 is transferred to sector 32. In the same manner, sector 40 is connected to sector 37 by way of conduit 47, and sector 41 is connected to sector 38 by a further conduit 48. By means of these central connections, it is further possible to obtain a draining by opening two valves 36L and 42L, as the pertaining sectors 36 and 42, respectively, is each connected to one of the other sectors, viz 33 and 39.

As the fluid will have to be transferred in both directions between the exchanger packages, it is preferable to arrange the latter stationary and have a rotating air distributor. coil 52 at sector 40, which is connected to annular conduit 44 and in turn is connected to a corresponding coil, not shown, in sector 31 is denoted by dash lines. In the same manner, coil 53 at sector 37, which communicates with a coil, not shown, at sector 34 is denoted by dash lines.

Both coils at every sector may be interconnected at their inner or outer ends, respectively, but it is evident that it, in practice, may be necessary to provide a number of such coils in order to obtain the required heat exchange surface.

The number of sectors will have to be suited to the size of the plant, and the heat transfer is governed in the manner common with heat pumps.

Conduits 45 – 48 with the pertaining throttling valves (not shown) which divide the coils into a high pressure side and a low pressure side, respectively, may be located outside the exchanger unit. The valves denoted by H and L in the annular conduits 43 and 44 preferably are mounted at a common panel.

In the same manner as indicated in connection with FIG. 1 it will also be possible here to change the direction of flow of the fluid in such a manner that the plant may be used alternately to cool the in-coming air. The pipe work required for this purpose is not shown in the drawing but is, by itself, of conventional nature.

What we claim is:

1. An air conditioning plant for a building in which a first conduit conveys air to the building and a second conduit conveys at least a major part of the air supplied to the building therefrom, the improvement of a heat pump operating with an evaporating fluid, said pump comprising a compressor, at least one first heat exchanger operable as a condenser in connection with the first conduit, at least one heat exchanger operable as an evaporator in connection with the second conduit, and the evaporating and the condensing heat exchangers being formed into a cylindrical, rotating unit working on the general principle of a rotating regenerative heat exchanger, whereby said exchangers will switch position as well as function.

2. The air conditioning plant according to claim 1, in which the exchanger unit comprises a stationary outer, cylindrical housing for the second conduit, an inner, rotatable housing subdivided into sectors, for the first conduit, and an intermediate, stationary cylindrical drum divided into a number of sector-shaped heat exchanger packages each designed to operate alternately as a condenser or as an evaporator.

3. The air conditioning plant according to claim 2, in which the high pressure and the low pressure side of said compressor is each connected to every heat exchanger package by means of a outer annular conduit, said annular conduits being provided with a valve at each package, and the rotatable housing being provided with means automatically to operate said valves in step with its rotation.
4. The air conditioning plant according to claim 2 in which there is an even number of sectors within the heat exchanger unit, the arrangement being such that two diametrically oppositely located sectors always work in the same manner, the inner housing being designed to maintain a connection between at least one sector to each side of a middle plane through the drum in connection with the first conduit and a corresponding number of similarly located sectors in connection with the second conduit, the number of these sectors being less than the total number sectors within the drum, and the remaining sectors being separated from both types of air conduits by means rotating together with the housing.

5. An air conditioning plant for use in a building including compartments of two basic types having different requirements for heating, including a first conduit for conveying air to the building and a second conduit for conveying at least a major part of the air supplied to the building therefrom, the improvement of a heat pump operating with an evaporating fluid, said pump comprising a compressor, at least one first heat exchanger operable as a condenser in connection with the first conduit, at least one heat exchanger operable as an evaporator in connection with second conduit, said first conduit being divided into two branch conduits of which a first one is further subdivided into two branches to communicate with both types of compartments, the second branch conduit being connected to one of the types of compartments only, the second conduit evacuating both types of compartments having a first condensing heat exchanger in the first inlet branch conduit and a second evaporating heat exchanger in the second conduit, a branch from the second inlet branch conduit being united with a branch from the first branch conduit through a mixing box at the pertaining type of compartment.

6. The air conditioning plant according to claim 5, in which the second inlet branch conduit is made to pass a counterflow heat exchanger fitted into the second conduit upstream of the second heat exchanger belonging to the heat pump.

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