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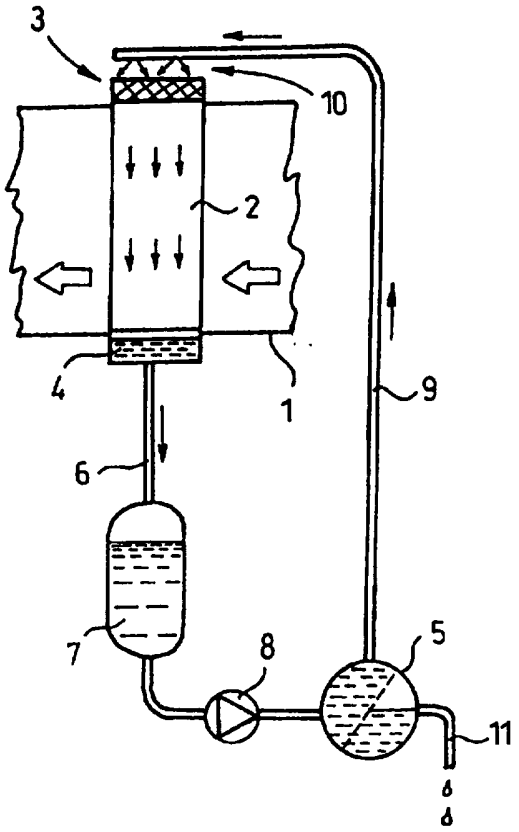
(54) Title: A METHOD AND ARRANGEMENT FOR RECOVERING HEAT INCLUDING FREEZING PREVENTION MEANS INVOLVING THE SPREADING OF NON-FREEZING LIQUID

(57) Abstract

The invention relates to a method and an arrangement for recovering heat, in which heat is recovered from exhaust air by a heat recovery unit (2) on the exhaust side and the recovered heat is transferred to the supply air. To eliminate the problem of freezing and to increase the efficiency of heat recovery, non-freezing liquid is spread on the surfaces of the heat recovery unit (2) on the exhaust side.



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A METHOD AND ARRANGEMENT FOR RECOVERING HEAT INCLUDING FREEZING PREVENTION MEANS INVOLVING THE SPREADING OF NON-FREEZING LIQUID

The invention relates to a method for recovering heat, in which method heat is recovered from exhaust air by a heat recovery unit arranged on the exhaust side and the recovered heat is transferred to supply air. The invention also relates to an arrangement for recovering heat.

The above methods and arrangements are now very generally used for arranging heating and air-conditioning systems of a building. Recovery of heat from exhaust air has been recently developed quite intensively, since energy costs have become a significant factor in the last few years.

When heat is recovered from exhaust air with the intention of heating supply air, a severe problem encountered is that the heat recovery unit on the exhaust side will freeze. Indoor air usually contains so much moisture evaporated from human-beings and house plants or in connection with cooking and washing or even from structures and fittings that if one attempts to cool exhaust air notably below 0°C, the water condensing from air will freeze on the surfaces of the recovery unit and gradually block the whole unit.

To prevent freezing, either the degree of recovery has to be lowered, which means that the exhaust air does not cool much below 0°C and so the supply air does not heat up correspondingly, or the unit has to be defrosted either continuously or periodically. Many kinds of equipment have been designed for defrosting of an exhaust air heat recovery unit. Examples for equipment known in the field include the solutions disclosed in Finnish Patents 76,210 and 76,420.

The above-described known solutions are characterized in that the lower the outdoor temperature, the lower the efficiency of heat recovery. In practice this means that the maximum efficiency of energy consumption is reduced much less than the annual consumption. All investments in consumer equipment, distribution networks and energy production, however, must be planned in view of the maximum efficiency. This is apparent from the statistical numbers of the energy plants. A change in the relation of maximum consumption and annual consumption has been a major concern discussed in training in the field of district heat.

The object of the invention is to provide a method and an arrangement by which the drawbacks of the prior art can be eliminated. This is achieved by the method and arrangement provided by the invention. The method of the invention is characterized by spreading non-freezing liquid on the surfaces of the heat recovery unit on the exhaust side. The arrangement according to the invention, in turn, is characterized in that in connection with the heat recovery unit are arranged means for spreading non-freezing liquid on the surfaces of the heat recovery unit.

The advantage of the invention is, above all, that it makes it possible to provide protection against freezing and, in addition, that the efficiency of heat recovery is increased unlike in the previously known units, where it is reduced. The improvement in the heat recovery results from the fact that the heat-transfer coefficient of a wet heat-transfer radiator is higher than that of a dry radiator. This is described in Finnish Patent Application 933,534. In fact, the efficiency of the unit in the summer can be increased and the freezing in the winter prevented with one and the same unit. A further advantage is that the non-

freezing liquids used are hygroscopic, in other words, they significantly drop the partial pressure of saturated steam. They dry the air, and so the heat of evaporation can be recovered.

In the following the invention will be discussed in greater detail with reference to the preferred embodiments illustrated in the attached drawing, in which

fig. 1 shows a general view of a first embodiment of an arrangement according to the invention,

fig. 2 shows a general view of a second embodiment according to the invention,

fig. 3 shows a general view of a third embodiment according to the invention, and

fig. 4 shows a general view of a fourth embodiment according to the invention.

Fig. 1 shows a general view of an arrangement according to the invention. Reference number 1 indicates an outlet channel through which the indoor air flows from the building. The flow of the indoor air through the outlet channel 1 is indicated in the figure by arrows. Reference number 2 indicates, generally, a heat recovery unit, i.e. heat exchanger, arranged in the outlet channel 1 to recover heat from the exhaust air. The heat recovered from the exhaust air is transferred from the heat recovery unit 2 to a second heat exchanger arranged in the inlet channel, and the recovered heat is transferred by the heat exchanger to the supply air. The inlet channel and the second heat exchanger arranged in it are not shown in fig. 1, since they are conventional technology to a person skilled in the art.

According to the basic idea of the invention, non-freezing liquid is spread on the surfaces of the

heat recovery unit 2 on the exhaust side. Means spreading non-freezing liquid are indicated in the figure by number 3. The means 3 may comprise, for example, a moistening mat, which is moistened with non-freezing liquid and which spreads the liquid on the surfaces of the heat recovery unit. The non-freezing liquid spread on the surfaces of the heat recovery unit runs along the surfaces in the manner indicated by arrows in the figure. The non-freezing liquid may be any non-corrosive substance that is safe to the environment. Examples for suitable liquids include calcium magnesium acetate/water, propylene glycol/water, urea/water, etc.

The water that condenses onto the surfaces of the heat recovery unit 2 as the air cools only dilutes the liquid; the liquid does not freeze if its concentration has been selected to be sufficiently high. In connection with the heat recovery unit 2 is also arranged an accumulating device 4, which is arranged to receive the non-freezing liquid running from the surfaces of the heat recovery unit 2. The accumulating device 4 may be, for example, a reservoir. The arrangement further comprises a concentrator 5, which is arranged to increase the concentration of the non-freezing liquid before the liquid is re-spread on the surfaces of the heat recovery unit. The diluted but still non-freezing liquid running from the heat recovery unit 2 is conducted from the accumulating device 4 through a pipe 6 to the concentrator 5. The pipe 6 can be provided with an equalizing reservoir 7. To ensure the flow, a pump 8 can also be arranged in the pipe 6. The concentration of the liquid is increased in the concentrator 5 and the liquid is conducted with a spray pipe 9 from the concentrator 5 to a moistening mat serving as a spreader 3. The liquid

is spread on the moistening mat by means of nozzles 10 arranged in the spray pipe 9. The flow direction of the liquid from the accumulating device 4 to the moistening mat serving as a spreader 3 is indicated in the figure by arrows. The concentrator 5 may be any suitable apparatus, such as a reverse osmosis apparatus, an apparatus operating on the evaporation principle, etc. The water separated from the liquid can be removed from the concentrator e.g. by means of an aggregate 11.

The combined effect may be e.g. the following:

exhaust air 21°C, relative humidity 30%
outdoor air -25°C, relative humidity 100%
supply air 21°C.

In a conventional apparatus, the minimum temperature of the exhaust air is 0°C:

nominal efficiency of recovery 70%
actual efficiency 46%
recovered energy 32.5 kJ/kg dry air
heating energy needed 47.5 kJ/kg dry air
additional heating demand 15.0 kJ/kg dry air.

The apparatus provided by the invention does not have a temperature limit for the exhaust air:

actual efficiency > 70%
final temperature of exhaust air > -12.5°C
recovered energy > 45.5 kJ/kg dry air
additional heating demand < 2.0 kJ/kg dry air.

In reality, the final temperature of the exhaust air may be slightly below 0°C without causing too much freezing. On the other hand, the effects of a wet radiator and of hygroscopicity have not been taken into account except with marks < and >.

The basic idea of the invention can also be applied by not attempting to prevent freezing

altogether but by stopping icing and/or by defrosting when the ice starts to impair heat recovery. Heat recovery then becomes periodical. The advantage of this kind of embodiment is that less non-freezing liquid is needed.

The above operation can be controlled e.g. such that the supply of liquid is started when the pressure loss of the heat recovery unit exceeds a certain value, or when the outdoor temperature is below a certain value. The start-up can also be based on measuring the temperatures of the heat transfer liquid and/or the exhaust air and/or the supply air of the heat recovery unit, or in more advanced systems, on reduction of the efficiency of recovery computed at a control centre. All these control methods, which are known per se, are naturally included in the invention.

Especially in periodically operating embodiments and/or in smallish apparatuses in which the consumption of liquid is small, the equipment can be simplified by not including a regeneration unit. In this kind of embodiment, the liquid is accumulated in a reservoir 7, from where it can be taken elsewhere for regeneration, or the regeneration can also be performed on the spot e.g. by manually adding concentrated liquid, salt, etc. This kind of embodiment is shown in fig. 2. Accumulation is not always necessary, if the liquid can be directly conducted e.g. by a pipe 15 e.g. to sewage purification or to a utilization process. This kind of embodiment is shown in fig. 3. In the embodiment of fig. 3, the liquid is supplied from a supply reservoir 14.

Further, it is often not necessary to moisten the whole heat exchanger but only those parts that are susceptible to freezing/condensation, whereby the liquid quantities needed are reduced further. This can

be implemented the most easily by spraying the liquid inside the heat exchanger e.g. through perforated pipes provided in the heat exchanger for this purpose.

The non-freezing liquid can also be concentrated without an actual concentrator using the air-conditioning unit itself e.g. in a situation where air-conditioning units are used for heating a building at night or at other times when the building is not in use. This kind of embodiment is presented in fig. 4. In the embodiment, exhaust air is conducted from the heat recovery unit 2 back to the building, to which no outdoor air is supplied at all. A heat exchanger for supply air is indicated in fig. 3 by reference number 12. Additional air L is supplied to the recovery unit 2 e.g. at point 13. The additional heat heats the air and also vaporizes water from the liquid spread on the surfaces of the recovery unit 2, whereby the liquid is concentrated.

The above embodiment is not intended to restrict the invention in any way but the invention can be varied quite freely within the scope of the claims. It is thus clear that the claimed arrangement or its parts need not necessarily be exactly as described in the drawing but that other kinds of solutions are also possible. For spreading non-freezing liquid, other means than a moistening mat used in the example can also be used. Examples for other possible solutions are different nozzle solutions, by means of which the liquid can be e.g. sprayed or run to the surfaces of the heat recovery unit, etc. Also, a concentrator may be an apparatus that supplies liquid having a higher concentration to the liquid that has run from the surfaces of the heat recovery unit and has been diluted with concentrated water.

Claims

1. A method for recovering heat, in which method heat is recovered from exhaust air by a heat recovery unit (2) arranged on the exhaust side and the recovered heat is transferred to supply air, c h a r a c t e r i z e d in that non-freezing liquid is spread only on the surfaces of the heat recovery unit (2) on the exhaust side.

2. A method according to claim 1, c h a r - a c t e r i z e d in that non-freezing liquid spread on the surfaces of the heat recovery unit (2) is recovered and that the concentration of the recovered liquid is increased before the liquid is re-spread on the surfaces of the heat recovery unit (2).

3. A method according to claim 2, c h a r a c t e r i z e d in that the concentration of the non-freezing liquid is increased by adding new liquid and/or salt to the recovered liquid.

4. A method according to any one of preceding claims 1 to 3, c h a r a c t e r i z e d in that non-freezing liquid is spread periodically on the surfaces of the heat recovery unit (2).

5. An arrangement for recovering heat, in which a heat recovery unit (2) arranged in a flow of exhaust air is arranged to recover heat from the flow of exhaust air in order to transfer it to supply air, c h a r a c t e r i z e d in that only in connection with the heat recovery unit (2) are arranged means (3) for spreading non-freezing liquid on the surfaces of the heat recovery unit (2).

6. An arrangement according to claim 5, c h a r a c t e r i z e d in that in connection with the heat recovery unit (2) is arranged an accumulating device (4) that is arranged to receive the non-freezing

liquid running from the surfaces of the heat recovery unit (2), and that the arrangement comprises a concentrator (5) that is arranged to increase the concentration of the non-freezing liquid before the liquid is re-spread on the surfaces of the heat recovery unit (5).

7. An arrangement according to claim 5 or 6, c h a r a c t e r i z e d in that the means (3) for spreading non-freezing liquid on the surfaces of the heat recovery unit comprise a moistening mat.

8. An arrangement according to any one of preceding claims 5 to 7, c h a r a c t e r i z e d in that the concentrator (5) is a reverse osmosis apparatus.

9. An arrangement according to any one of preceding claims 5 to 7, c h a r a c t e r i z e d in that the concentrator (5) is an apparatus operating on the evaporation principle.

10. An arrangement according to any one of preceding claims 5 to 7, c h a r a c t e r i z e d in that the concentrator is an air-conditioning unit.

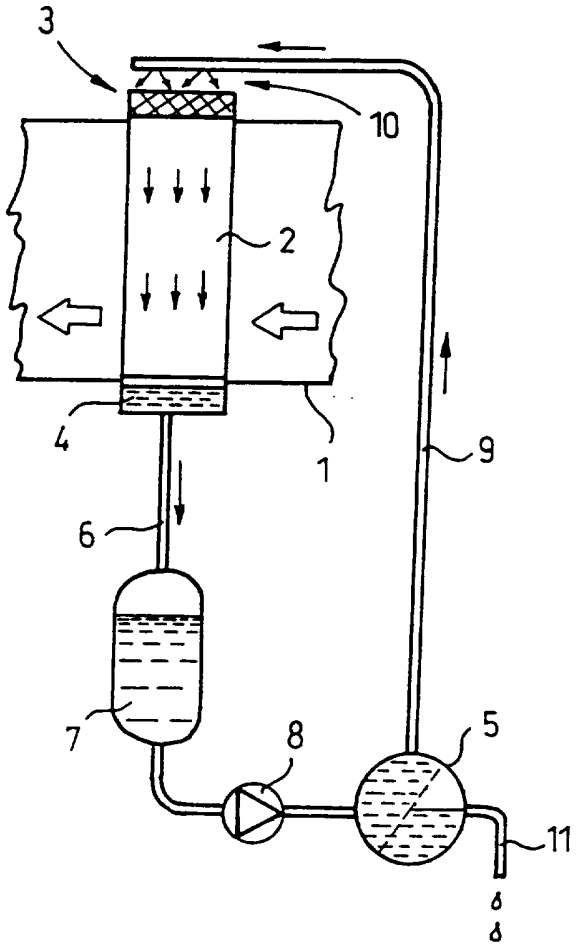

FIG. 1

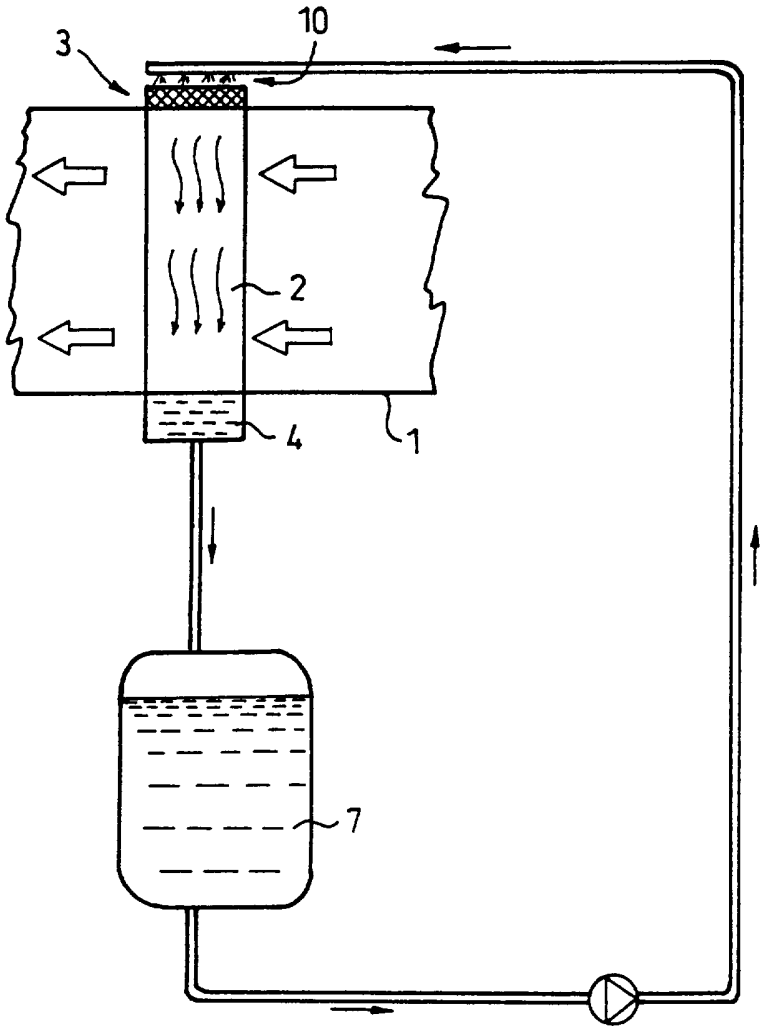

FIG. 2

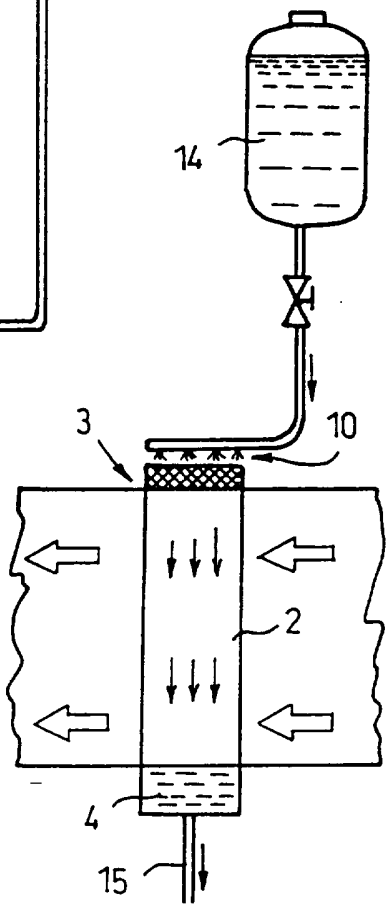

FIG. 3

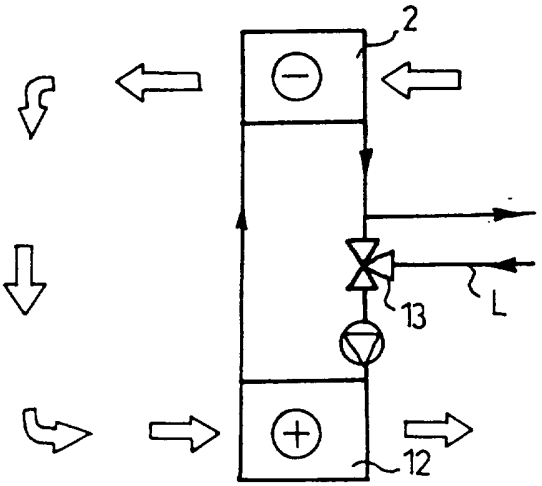

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 96/00492

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F24F 12/00, F28F 19/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F24F, F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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International application No.
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