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[54] **HEAT EXCHANGE SYSTEM**

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[56] **References Cited**

UNITED STATES PATENTS

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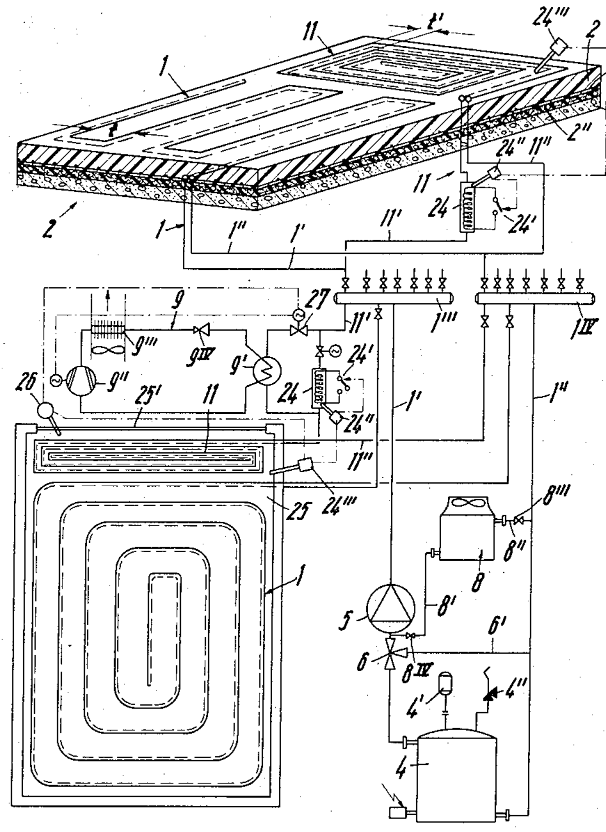
[57] **ABSTRACT**

Two or more separate conduit units are provided, which can be embedded at remote positions in structural elements. Each conduit unit has an inlet portion, an outlet portion and a main body portion communicating with these and including at least two parallel sections of identical internal cross-sectional area arranged in heat-exchanging contact with one another over substantially their entire length. Heat exchange fluid can be circulated through the conduit units individually and can be controlled individually as to its temperature level.

12 Claims, 1 Drawing Figure



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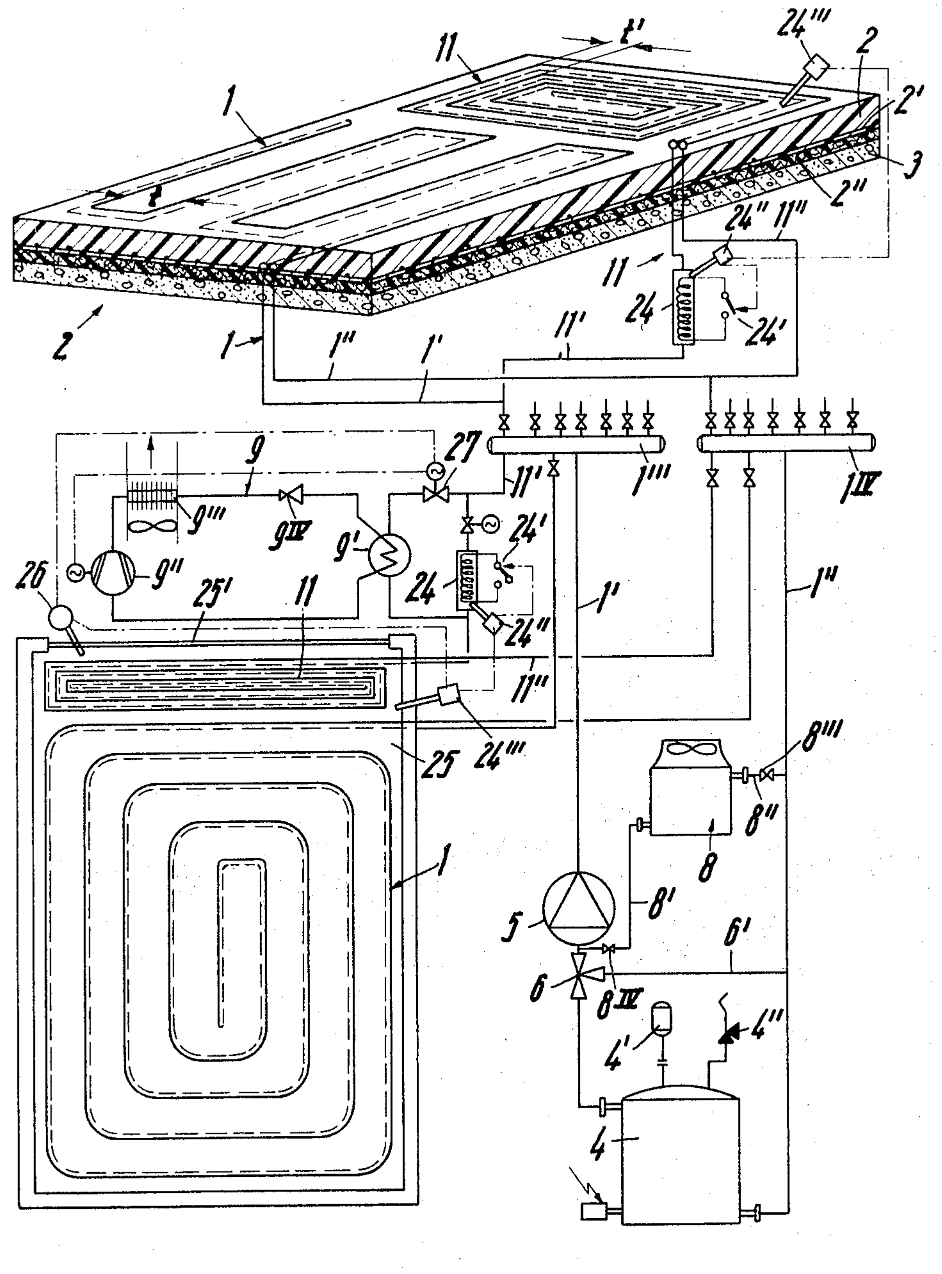

HEAT EXCHANGE SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates generally to a heat exchange system, and more particularly to a heat exchange system which can be embedded in structural elements.

It is often necessary to heat or cool enclosed spaces in structures per influence in the temperature of a structural component thereof. For instance, it is known to embed in a panel which is installed on or as the floor of a room, a conduit for which hot or warm water is circulated. The water yields heat to the panel material in which the conduit is embedded, heating the panel material so that the latter radiates heat to the room at which a surface of the panel is exposed.

It is also known to provide a heating arrangement in which a conduit is embedded in such a panel, with the conduit having an inflow section and a return flow section which are in heat exchanging engagement with one another over at least substantially their entire length. This latter type of prior-art construction is highly advantageous because it makes it possible to afford a completely uniform heating or cooling of the structural element in which the conduit is embedded, over the entire surface area of such element. This, in turn, not only provides for a significant improvement in the level of comfort experienced by persons present in a room wherein the structural element serves for heating or cooling, but also eliminates tensions or stresses and resulting cracks in the structural element itself. Moreover, the economy of operation is substantially improved because more uniform heating requires less energy, and this is of course also true of cooling.

However, it is desirable to still further improve this last-mentioned arrangement, particularly with respect to its economy and with respect to the manner in which the heating or cooling afforded by it can be controlled.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide such improvements.

More particularly it is an object of the present invention to provide an improved heat exchange arrangement of the type under discussion, which incorporates these improvements.

A more particular is to provide such an improved heat exchange arrangement which can be operated more economically than that known from the prior art.

Another object of the invention is to provide such an improved heat exchange arrangement whose level of heating or cooling can be controlled more precisely than what is known from the prior art.

In keeping with these objects, and of others which will become apparent hereafter, one features of the invention resides in a heat exchange arrangement or system which, briefly stated, comprises a combination of conduit means including at least two separate conduit units arranged to be positioned remote from one another and such having an inlet portion, an outlet portion and a main body portion intermediate the inlet and outlet portions and adapted to be embedded in a structural element. Each main body portion includes at least two parallel sections of at least substantially identical internal cross-sectional area arranged in heat exchanging contact with one another over at least substantially their entire length. One of the conduit sections is adapted to receive incoming fresh heat exchange fluid from the inlet portion and the other conduit section is adapted to receive spent heat exchange fluid from the one section and to conduct it to the outlet portion. Circulating means is connected with the respective inlet and outlet portions for circulating heat exchange fluid for each unit independently of the other, and heat exchange means is provided for adjusting the temperature of the heat exchange fluid to circulated it through the respective units.

With this arrangement it is possible to achieve the desired improvements, especially for the heating or cooling of areas where there are substantial transmission losses due to the presence of large areas (large widows or the like) where heat or coolness can be lost. In particular, it is possible to provide heating or cooling of rooms such as bathrooms or the like where the size of the structural element in which the conduit units of the heat exchange system can be embedded, is limited by space considerations. Moreover, this makes it possible to provide sufficient heating and/or cooling without having to provide a separate heating or cooling arrangement for instance in the region of the window or the location where substantial heat or cooling loss occurs.

Moreover, the present invention makes it possible to economically and flexibly cool or heat areas having particularly high transmission losses, due to the fact that the unit embedded in an area having the highest transmission losses (for instance near a window) can be operated with fluid at highest heating or at lowest cooling level. Thus, it is possible to provide a zone of either elevated or reduced temperature in the region where the highest transmission losses occur, which makes it possible to provide a desired comfort level in such zone, without influencing in any manner the temperature conditions which exist in other parts of the room or area which is serviced by the other unit or units of the same system. The conduit unit which is associated with such a region of high transmission losses is therefore in accordance with the present invention provided with additional heating and/or cooling means, so that the heat exchange fluid supplied to it may be given additional heat energy or may be cooled additionally beyond the temperature at which it is supplied to the other unit or units of the system. The heating means may be in form of an electrical heating unit or device, and the cooling means may be in form of a refrigerant unit of appropriate capability.

To make it possible to control the temperature of rooms with simple and inexpensive means while providing high flexability in this control, the present invention further provides that the sections of the conduit in each conduit unit may be arranged at different spacings from one another in the different units. The unit which is located in an area having highest transmission loss will have the convolutions of its sections more closely adjacent one another than the other unit or units. It is important to realize that the uniformity of the surface temperature of the structural element in which the respective unit is embedded, will be the better the closer together the convolutions of the conduit sections are. However, it is difficult to obtain an even surface temperature of the structural element, given the fact that the thickness of material of the element above the conduits should be as low as possible, because with increasing thickness of the material the reluctance of the material of the panel to undergo temperature fluctuations increases. If the thickness of material of the structural element above the embedded conduit is 25 millimeters or less, then the spacing between the adjacent convolutions of the embedded conduit should be no more then 12 centimeters, with the diameter of the conduit advantageously not being in excess of 25 millimeters and the conduit material being a synthetic plastic material.

To provide for highly individualized regulation, and to avoid overheating of the material of the structural element or of the conduit, especially if the latter is of synthetic plastic material, the separate heating unit can be controlled by two thermostats switching it on and off, with one of the thermostats being connected with the outlet for the heat exchange fluid of the unit in question, and the other being arranged in the immediate vicinity of the structural element in which the conduit unit is embedded. If the unit is to be used both for heating and for cooling in appropriate circumstances, and if in the case of cooling it is desired to avoid that the surface temperature of the structural element in which the conduit unit is embedded drop below dew point, then the cooling device associated with the unit can be controlled by a thermostat and a hygrostat, with the latter being located directly on the surface of the structural element whereas the thermostat advantageously is so positioned as to indicate mean room temperature of the room of which the structural element forms a part.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a diagrammatic composite illustration of one embodiment in the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing in detail it will be seen that reference numeral **2** identifies a structural element in which conduits according to the present invention are to be embedded. The structural element is here illustrated as the floor of a room. Conduit means **11** and **12** are embedded, with the incoming conduit sections **1''** and **11''**, that is the conduit sections through which heat exchange fluid enters, being shown in broken lines while the return flow conduit sections, which receive heat exchange fluid from the conduit sections **1''** and **11''** and return it to the source, are illustrated in full lines. The structural element **2** may be in form of a concrete floor, or a floor in which concrete and synthetic plastic material are combined, and embedded in it and mounted on a steel reinforcing mat **2'** are the conduit units **1** and **11**. Between the element **2** and the base, for instance a concrete layer **3**, is an intermediate layer **2''** which serves for various purposes, for instance as a vapor barrier, as a noise barrier and to avoid excessive heat losses.

The sections **1'** and **11'** and the return flow sections **1''** and **11''** are connected via collectors **1'''** and 1^{IV} with a boiler **4** which in the illustrated embodiment is provided with a closed expansion vessel **4'** and a safety valve **4''**. A water pump **5** is interposed in the section **1'** between the collector **1'''** and the boiler **4**, as well as a three-way mixing valve **6** which is connected via an intermediate conduit **6'** with the return flow section **1''** between the collector 1^{IV} and the boiler **4**. In addition, to make possible selective cooling when desired for the conduit sections connected with collectors **1'''** and 1^{IV}, there is provided a cooling tower **8** which is connected via the conduit **8'** and the valve 8^{IV} to the conduit section **1'** and is also connected via the return flow conduit **8''** and the valve **8'''** to the conduit section **1''**.

The unit **1** which is shown in the upper part of the drawing as embedded in the structural element, is provided in form of a continuous convoluted arrangement, and the second smaller unit **11** is in form of a continuous spiral. It should be understood that for purposes of explanation it is assumed here that it is the unit **11** which is embedded in the region of a zone having the highest transmission losses. It will be seen that here the incoming conduit extending from the collector **1'''** branches off shortly before entry into the layer **2** into the conduit sections **1'** and **11'**, whereas the return flow conduit sections **1''** and **11''** are connected via a common conduit to the return collector 1^{IV}.

In the illustrated embodiment a heating unit **24** is interposed in the section **11'** of the unit **11**, having a switch **24** which can be opened via thermostat **24''** to a device having a switch **24'** which can be opened via thermostat **24''** as soon as the temperature of the incoming heat exchange liquid in the section **11'** reaches a certain level. Connected in series with the thermostat **24''** is the room thermostat **24'''** which is so located and connected with the switch **24'** that it closes the same as soon as the room temperature drops due to the high transmission losses in the region where the conduit unit **11** is embedded, thus calling for additional heat.

In the lower left-hand portion of the drawing there is illustrated a plan view of a room **25** having large window area **25'**, and here the units **1** and **11** are embedded in the layer **2** in form of a continuous spiral. The units **1** and **11** are directly connected with the collector **1'''** and the return flow collector 1^{IV}. In the section **11'** of the unit **11** a heat exchange **9'** is connected in parallel with the heating device **24**; the heat exchanger **9'** is interposed in the circulation of a cooling device **9** which essentially is composed of the heat exchanger **9'** acting as an evaporator, a compressor **9''**, a condenser **9'''** and a pressure reducing valve 9^{IV}. The incoming heat exchange fluid has heat removed from it in the section **1'** by a cooling fluid which as a result evaporates and is withdrawn by the compressor **9''** which compresses it and raises its temperature to an appropriate level, whereupon it is cooled in the condenser **9'** by an air stream, the condenser **9''** being for this purpose provided with a sufficiently large exterior heat exchange surface area, to be returned via the pressure reducing valve 9^{IV} as condensate to the evaporator **9'**.

Here, also, the heating device **24** is switched on and off by the room thermostat **24'''** which is located in the immediate vicinity of the unit **11**, via the switch **24'** and is deactivated by the thermostat **24''** which is connected in series with the thermostat **24'''** when the necessary temperature of the incoming heat exchange fluid has been reached.

The operation of the cooling unit **9** is controlled by the room thermostat **24'''** and the hygrostat **26.** If, for instance, the room thermostat **24'''** has been set to a certain temperature and on a hot summer day the heat entering through the window **25'** causes the preselected temperature level to be exceeded, thermostat **24'''** will call for cooling, opening the valve **27** and thereupon operating the compressor **9''** and the condenser **9'''**. As soon as the humidity of the structural element embedding the unit **11** is sensed by the hygrostat **26** to be approaching the dew point the hygrostat **26** switches off the compressor **9''** and closes the valve **27,** so that a condensation of the water vapor in the air on the layer **2** is reliably avoided, this being important because it would seriously detract from the comfort of persons in the room.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in a heat exchange system, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended.

I claim:

1. In a heat-exchange system, in combination, conduit means, including at least a first and a separate second conduit unit which are positioned remote from one another and which each have an inlet portion, an outlet portion and a main body portion intermediate said inlet and outlet portions and adapted to be embedded in a structural element, each of said main body portions including at least two parallel conduit sections of at least substantially identical internal cross-sectional area which are arranged in heat-exchanging contact with one another over at least substantially their entire length, one of said conduit sections communicating with and receiving incoming fresh heat-exchange fluid from said inlet portion and the other conduit section communicating with and receiving spent heat-exchange fluid from said one conduit section for conducting it to said outlet portion; circulating means connected with the respective inlet and outlet portions for circulating heat-exchange fluid through each conduit unit independently of the other; and heat-exchange means for individually adjusting the temperature of said heat-exchange fluid being circulated through the respective conduit units.

2. In a system as defined in claim **1,** said heat-exchange means comprising booster means for supplying heat exchange fluid at optimum temperature to that one of said units which is subject to maximum heat exchange with its surroundings.

3. In a system as defined in claim **2,** wherein said booster means comprises an auxiliary heater for heat exchange fluid to be circulated through said one unit.

4. In a system as defined in claim **2,** wherein said booster means comprises an auxiliary cooling device for heat exchange fluid to be circulated through said one unit.

5. In a system as defined in claim **1,** wherein said main body portions are arranged in form of adjacent loops, and wherein the spacing between adjacent loops of one unit is different from the spacing between adjacent loops of the other unit.

6. In a system as defined in claim **5,** wherein one of said units is subject to more intensive heat exchange with its surroundings than the other unit; and wherein the spacing between adjacent loops of said one unit is smaller than in said other unit.

7. In a system as defined in claim **5,** wherein said spacing is at most 12 cm.

8. In a system as defined in claim **1,** wherein said conduit units are of synthetic plastic material.

9. In a system as defined in claim **1**; further comprising two thermostats associated with one of said units and with said heat exchange means, one of said thermostats being located at said outlet portion of said one unit and the other thermostat being located exteriorly proximal to said one unit.

10. In a system as defined in claim **1**; further comprising a thermostat and a hygrostat associated with one of said units and with said heat exchange means, said hygrostat being located exteriorly proximal to said one unit.

11. In a system as defined in claim **9,** wherein said thermostats are adjustable to selected temperatures.

12. In a system as defined in claim **10,** wherein said thermostat is adjustable to a selected temperature, and said hygrostat is adjustable to a selectable degree of humidity.

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