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(54) **Heater**

(57) There is provided a heater for a room heating system. The heater comprises a heating element and a housing for the heating element. The housing comprises opposed first and second ends and a longitudinally extending sidewall there between. The heating element is mounted to and extends longitudinally from the first end. A thermal distribution fluid inlet to the housing and outlet from the housing are provided. The housing contains the thermal distribution fluid as it follows a flow path from the inlet to the outlet. One of the inlet and the outlet extends through the sidewall of the housing. The heater is a back-up heater in a room heating system mostly powered by a heat pump.

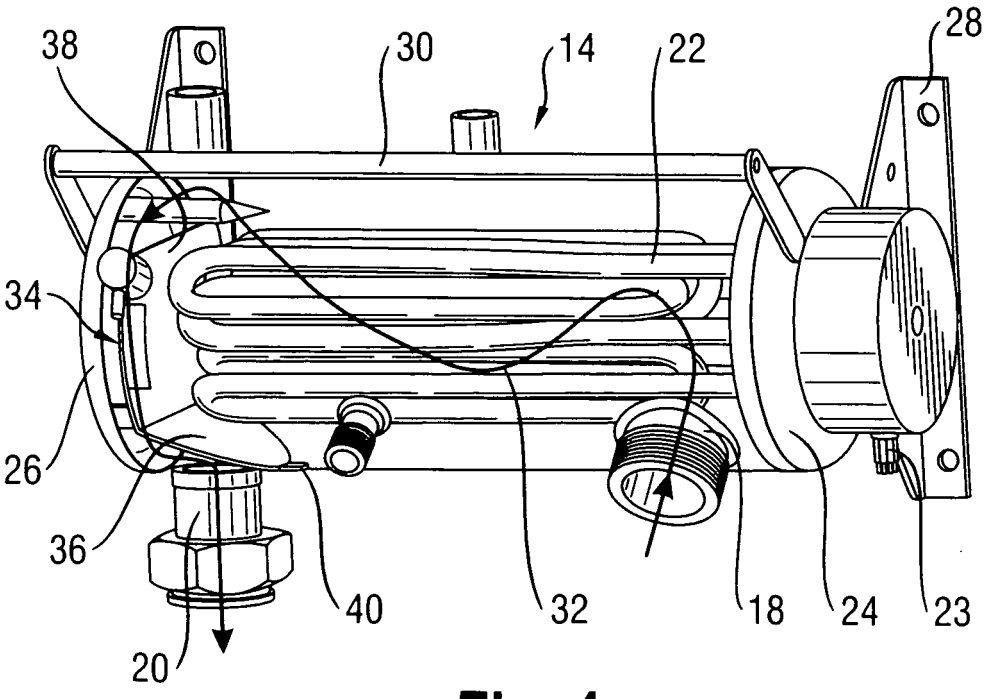

Fig. 4

EP 2 103 886 A1

Description

Field of the Invention

[0001] The present invention is concerned with a heater for heating a thermal distribution fluid. The heater includes a housing containing a heating element, which operates to heat the thermal distribution fluid as it follows a flow path from an inlet to the housing and an outlet from it.

Background of the Invention

[0002] Room heating systems are in use all over the world to provide warmth to residential, commercial and industrial buildings. Known in such room heating systems are heaters as described above for heating a thermal distribution fluid as it circulates around a network of pipes to give off heat in heating units such as radiators and under-floor heating. In common use as the thermal distribution fluid is water.

[0003] One application of a heater to which the present invention is particularly concerned is a backup heater in a heat pump based room heating system. A heat pump based room heating system is discussed below with reference to figure 1. As will become clear in the following, there may arise situations in which the heat pump can not efficiently or sufficiently provide the required heat to the water in the room heating system. In such a case, the backup heater is able to provide a heat boost to the water. The backup heater may, for example, be a backup heater with an electric heating element.

[0004] Although the present invention is particularly suited to a backup heater as given above, it is envisaged that the invention, which is about to be revealed, is applicable to all kinds of thermal distribution fluid heaters. For example, the invention would have application with a conventional boiler.

[0005] It is an object of the present invention to provide a compact and efficient heater.

Summary of the Invention

[0006] The present invention provides a heater for a room heating system. The heater comprises a heating element and a housing for the heating element. The housing comprises opposed first and second ends and a longitudinally extending sidewall there between. The heating element is mounted to and extends longitudinally from the first end. A thermal distribution fluid inlet to the housing and outlet from the housing are provided. The housing contains the thermal distribution fluid as it follows a flow path from the inlet to the outlet. According to the heater of the present invention, one of the inlet and the outlet extends through the sidewall of the housing.

[0007] The longitudinal extent of the heater can be reduced by providing the inlet and/or the outlet at the sidewall of the housing as opposed to the ends. This then opens up the possibility of mounting the heater sideways, but with the heater still being suitably compact. A side mount also allows a twist to be provided in the flow path between the inlet and the outlet connection, which can improve the heating efficiency of the heater.

[0008] Preferably, the one of the inlet and the outlet extending through the sidewall is positioned adjacent the first end and the other of the inlet and outlet is positioned at an opposite end.

[0009] The heating element, which will generally require power connections such as electrical connections, extends from the first end. Positioning the one of the inlet and outlet that is located at a sidewall of the housing at this end and the other at the opposite end means that the inlet and outlet can be formed without interfering with the heating element or its power connections. The alternative, that is having one of the inlet and outlet extending through the first end, may require the heater to have a radial or cross-sectional extent larger than required by the heating elements alone. This would have adversely impacted on the heating efficiency of the heater.

[0010] Preferably, both of the inlet and outlet extend through the sidewall of the housing. This serves to further reduce the longitudinal extent of the device, thereby making it more compact in a sideways mounting. It also means that a heating efficient spiral type flow pattern could be introduced when mounted sideways as will become clearer in the following. Preferably, the inlet and outlet are positioned longitudinally at or adjacent the opposed first and second ends of the housing. This ensures that the fluid flows the full extent of the housing and enables maximum heating by the heating element, which preferably also extends at least from the first end to the inlet or outlet at the opposite end or even beyond this point.

[0011] In order to further increase the heating efficiency of the heater, the inlet and outlet in the sidewall of the housing are radially offset from one another with respect to a longitudinal axis of the housing, for example by between 35° and 45°. This can provide a twist to the flow path, thereby increasing the extent of contact between the flow path and the heating element.

[0012] As briefly mentioned above, placing the inlet and outlet in a sidewall of the housing makes it possible to more compactly mount the heater sideways or with the longitudinal axis of the heater substantially aligned with the horizontal. There may be certain applications, as will become clear below, where it is preferable to have the inlet and outlet extend from about a bottom of the sidewall of the housing when it is in the predetermined orientation. A majority of the housing is thus above a longitudinal line intersecting the highest point of the inlet and the outlet. An alternative way of defining this, instead of with respect to the horizontal when the housing is mounted in its predetermined orientation, is to say that the inlet or the outlet extends from a bottom most part of the housing. The bottom of the housing is thus defined with respect to the inlet or the outlet and the lower half,

upper half and top of the housing are to be considered with respect to that.

[0013] Although the above sideways mounting of the heater can be advantageous, it has been found that the heater efficiency can be further increased in such a configuration when a baffle plate is provided. Thus, the housing preferably includes a baffle plate so that the flow path between the inlet and outlet passes over the baffle plate. It has been found that this configuration avoids a problem with a flow path forming between the inlet and outlet that does not sufficiently pass over the full extent of the heating element. In particular, a direct flow path could form which passes under or only impacts on a relatively small bottom portion of the heating element. The baffle plate mitigates this problem by blocking such a shortest distance flow path and insisting on it passing over the top of the baffle plate.

[0014] A unique safety facility is also provided. Preferably, a flow detector is associated with an outlet side of the baffle plate, with respect to the flow path between the inlet connection and the outlet connection, which provides a control signal when liquid flow (so, a thermal distribution liquid rather than fluid is being used) is reduced to a predetermined level. The baffle plate preferably extends in a plane perpendicular to the longitudinal axis to a point above the top of the heating element, while still providing a gap between the top of the baffle plate and the top of the housing for the flow path to pass through.

[0015] If gas accumulates between the top of the heating element and the top of the housing, for example because of an excess in evaporation of the fluid or a leaky valve somewhere in the room heating system, flow over the baffle plate will be reduced or stopped entirely. This is called an airlock. A flow detector in association with an outlet side of the baffle plate can be used to detect the lack of flow to provide a control signal to stop power to the heating element. The flow switch will give the control signal before the water level drops to the height of the heating element because the top of the baffle plate is positioned above the heating element. This can be an important safety mechanism. If the gas pocket is allowed to reach the heating element, heat from the exposed part of the heating element will not be dissipated by the flowing liquid and will cause temperatures escalating to potentially damaging degrees.

[0016] As stated above, objects of the present invention include providing a compact and efficient heater. The baffle plate could be arranged so as to reduce the compactness of the heater. In a preferred embodiment, however, the baffle plate includes a portion facing an end of the heating element positioned over the outlet at or adjacent the second end of the housing or is positioned beyond that outlet toward the second end of the housing and wherein the baffle plate is bent to extend under the heating element and to a position between the inlet and the outlet.

[0017] The baffle plate is present at the axial extreme of the flow path before it leaves through the outlet connection, or even beyond this point, which is found to be a desirable arrangement in terms of heating efficiency. Further, the baffle plate should take up as little as possible of the space contained by the housing that could more usefully be occupied by the heating element. At the same time, however, it should not cause substantial pressure changes in the fluid as a result of a restricted flow path to the outlet.

[0018] In the preferred configuration the facing portion of the baffle plate can be positioned axially at or beyond the outlet connection. Thus, the heating element can extend the full useful extent of the flow path. The bent portion extends underneath the heating element so that a flow path passing under the heating element is still blocked. The bend also provides for an expanded flow path portion as it extends to the outlet connection, which avoids undesirable pressure changes being created by flow path defined by the baffle plate.

[0019] Consider a straight baffle plate, for example, between an end of the heating element and the second end of the housing. Such a baffle plate would have to be positioned just before the outlet at the second end as you go from the first end in order to provide the required undesirable flow path blocking function. This would create a gap between the second end and the baffle plate where the housing extends longitudinally, but no heating element is provided. The space requirements of the device are thus increased, without improving its thermal capacity.

[0020] Draining problems can arise when a baffle plate is included. This is because water can get caught between the inlet and the baffle plate during draining. A drain hole is preferably provided at the bottom of the baffle plate, which allows the water to pass, but is sufficiently small so as to provide a negligible flow path when the heater is in normal operation.

[0021] Preferred embodiments also offer improved safety features. Air can become caught in the top of the backup heater. When this backup heater is mounted horizontally, a large amount of air can be accommodated. The air is only a real problem when either the flow to the outlet connection, such as over the baffle plate, is substantially affected or when the heating element becomes exposed by the presence of air.

[0022] Preferably, a first thermal cut off device is provided that is positioned at substantially the same height as the top of the heating element. The thermal cut off device may be of the type to provide a control signal when a predetermined maximum temperature is reached. A control system is configured to respond to the control signal by switching off the heating element. The first thermal cut off device maintains the operating temperature of the housing of the backup heater below a desired maximum and is positioned level with the point where the fluid following the flow path is heated to its maximum. Further, any air pockets above the heating element will also be above the first thermal cut off device and thus will not interfere with the thermal distribution liquid tem-

perature detection.

[0023] Preferably, the first thermal cut off device senses a temperature of the housing of the backup heater. The first thermal cut off device may have its temperature sensing element in contact with the housing, preferably the outside of the housing. The first thermal cut off device may be mounted to the housing, preferably the outside of the housing. Sensing the temperature of the housing is a relatively reliable method.

[0024] As soon, however, as the air pocket exposes the heating element, rapid heating will occur due to lack of thermal dissipation. Before that, the thermal pocket will actually be at a lower temperature than the liquid. A second thermal cut off device is preferably provided for such an instance, which is positioned above the first thermal cut off device and preferably with its temperature responsive element positioned in the flow path of the thermal distribution fluid in proper operation. The second thermal cut off device will be triggered to cause the power to the thermal heating element to be cut when the first thermal cut off device is not functioning properly or in case the heating element becomes exposed. The second thermal cut off device is preferably a thermal fuse as it would need to be replaced once used, thereby bringing attention to such serious fault conditions. A reliable safety mechanism is provided by this combination of first and second cut off devices where the first has its temperature responsive element contacting the housing and the second has its temperature responsive element positioned in the flow path.

[0025] The compactness, thermal efficiency and mounting possibilities offered by the heater described above make it particularly suitable for use as a backup heater in an indoor unit for a room heating system powered by a heat pump.

[0026] Thus, the present invention also provides an indoor unit for a room heating system comprising a heat pump having refrigerant piping circulating a refrigerant, an indoor piping circulating a thermal distribution fluid and a heat exchanger for exchanging heat between the refrigerant in the refrigerant piping and the thermal distribution fluid in the indoor piping. The indoor unit comprises the heat exchanger and the heater described above.

[0027] The heater is preferably mounted in the predetermined, preferably horizontal, orientation discussed above. Preferably, the heater is mounted at a top part of the indoor unit. This top mounting is made more feasible by downward extension of inlet and outlet pipes connected to the inlet and outlet connections. The top mounting can be particularly advantageous for collecting air trapped in the piping. Thus, preferably the indoor unit is mounted with respect to the indoor piping such that the heater forms an uppermost component connected by the indoor piping.

[0028] There follows a detailed description of a preferred embodiment, with reference to the figures, of the heater where it is used as a backup heater in a heat pump based room heating system.

Brief description of the drawings

[0029]

Figure 1 shows a room heating system.

Figure 2 shows a backup heater mounted in an indoor unit of the room heating system.

Figure 3 shows a side view of the backup heater.

Figure 4 shows the backup heater if the outer housing could be seen through. A flow path is also shown.

Figure 5 shows trapped water in the bottom of the backup heater.

Figure 6 shows the backup heater including a baffle plate that has a drain hole.

Figure 7 shows a cross sectional view into a side of the indoor unit.

Figure 8 shows a view into the backup heater from one end.

Figure 9 shows a view of thermal safety devices from an outside of the backup heater.

Figure 10 shows the thermal safety devices extending into the inside of the backup heater.

Figure 11 shows the room heating system with a heat pump.

Description of a preferred embodiment

[0030] Figure 1 shows an exemplary room heating system 2. The system comprises an indoor unit 4, an outdoor unit 6, refrigerant piping 8 and room heating piping 10. The outdoor unit 6 is a heat pump of the known kind, and is briefly discussed in the context of the present room heating system below with reference to figure 11. The shown outdoor unit 6 is an air heat pump for extracting heat energy from the air, but may also be an under-soil heat pump for extracting under-soil heat energy or other types of heat pump known to the skilled reader.

[0031] The outdoor unit 6 comprises an evaporator 64, a four way valve 66, a compressor 68 and an expansion device 70, which is an electric valve. The indoor unit 4 comprises inter alia a pump 74 for circulating the water in the piping 10 and a condenser 72. These components form a heat pump. The evaporator 64, the four way valve 66, the compressor 68, the expansion device 70 and the condenser 72 are connected in this order by a refrigerant piping 8 (figure 1) circulating a refrigerant. The circulation

of the refrigerant is forced by the compressor 68. In a heating mode, the refrigerant circulates clockwise in figure 11.

[0032] Liquid refrigerant leaves the condenser 72 at a first temperature T1 and passes through the expansion device 70, where the pressure of the refrigerant is reduced and the refrigerant is barely liquid. Afterwards, the refrigerant passes the evaporator 64 and is evaporated by heat from the outside atmosphere. After leaving the evaporator 64, the refrigerant passes through the compressor 68, where the pressure is increased. The refrigerant is at a temperature T2 at this point, which is greater than T1. Finally, the refrigerant is condensed in the condenser 72 by transferring heat from the refrigerant to water in the indoor piping 10 (figure 1) connected to the indoor unit 4.

[0033] In the heating mode, water enters the indoor unit 4, passes the condenser 72 in a heat exchanger. Here, heat is transferred to the water from the refrigerant. A pump 74 in the indoor unit 4 downstream of the backup heater 14 circulates the heated water which downstream of the pump 74 passes through a backup heater 14, discussed in more detail below, and then around the indoor piping 10 circuit.

[0034] Refrigerant piping 8, in which refrigerant material circulates, is connected between the indoor unit 4 and the outdoor unit 6. The room heating piping 10 shown is an under-floor arrangement, whereby heat is transferred from the water in the piping 10 up through the flooring and into a room space being heated. The room heating piping 10 may be arranged to be connected to wall mounted radiators (not shown) instead of or as well as arranged in an under-floor heating arrangement. The indoor unit 4 includes a heat exchanger to transfer heat from the refrigerant in the refrigerant piping 8 to water circulating in the room heating piping 10.

[0035] Also shown as part of the system 2 of figure 1 is a sanitary hot water tank 12 for heating sanitary water. The sanitary hot water tank 12 is not particularly relevant to an understanding of the present invention and thus will not be described further.

[0036] The outdoor unit 6, a heat pump, extracts low temperature energy from the environment and increases its temperature for heating purposes in a manner known to the skilled reader. The upgraded heat is then transmitted via the refrigerant to a heat exchanger in the indoor unit 4. The heat exchanger transfers the heat in the refrigerant to the water circulated in the room heating piping 10, which forms the under-floor heating arrangement and which may also be connected to heating radiators and the sanitary hot water tank 12.

[0037] Heat pumps operate more efficiently when the temperature differential between the heated refrigerant and the temperature of the environment from which the heat pump is extracting heat energy is kept small. It is known in the art to provide a backup heater so that the temperature differential can be kept small and the heat pump kept efficient, while still providing heating capacity to match the year round heating requirements of the room heating system 2. The heat pump is, for example, sized to provide 90 to 95 % of the annual heating requirement, with the remaining 5 to 10 % provided by a small electric backup heater. The backup heater may be sized to cover 60 % of the heating demand for the coldest day of the year. The present invention is concerned with such a backup heater, which is discussed fully below.

[0038] An exemplary backup heater 14 is shown in figure 2, 3 and 4. The backup heater 14 includes a tubular outer housing 16 (figure 3) closed at each end by a first end plate 24 and an opposed second end plate 26, which can be seen in figure 4. The backup heater 14 of figure 2 includes a thermally insulative outer cladding (not labelled, but shaded in black) about the outer housing 16 and the end plates 24, 26. The backup heater 14 includes a water inlet connection 18 and a water outlet connection 20. As can be seen in figures 3 and 4, the outer housing 16 and the end plates 24, 26 enclose a space that will, in use, be filled with water flowing between the inlet connection 18 and the outlet connection 20. An electric heating element 22 occupies the space (figure 4).

[0039] With reference to figure 4, the electric heating element 22 comprises one or more resistance heating filaments that become hot as electricity flows through them. The filaments are attached at both ends to the first end plate 24. The power cable 23 to the heating element 22 passes through the first end plate 24 and electrical circuitry connecting the heating element 22 to the power supply takes place in the first end plate 24. As can be seen, the first end plate 24 is deeper than the second end plate 26 in an axial direction so as to enclose the power circuitry for the heating elements and also to provide support for the heating element 22 attached to it. Each filament extends from the first end plate 24 almost all the way to the opposed second end plate 26. The filaments turn when in the proximity of the second end plate 26 and extend back to the first plate 24, where it either terminates at the first end plate 24 or where a further turn takes place. There can be a number of such turns to define a wave-like pattern as the heating filament extends from one end of the space inside the outer housing 16 and between the end plates 24, 26 to the other end.

[0040] The backup heater 14 includes a mounting bracket 28 connected to each end plate 24, 26. The mounting brackets are for mounting the backup heater 14 to the indoor unit 4, as will be discussed more fully below. The backup heater also includes a handling bar 30 connected at opposed ends to an end plate 24, 26. The handling bar 30 is positioned on the other side of the outer housing 16 to the mounting brackets 28 and is spaced radially from the outer housing 14. The handling bar 30 is useful for ease of assembly when mounting the backup heater 14 to the indoor unit 4.

[0041] A water flow path 32 will be defined between the inlet connection 18 and the outlet connection 20 when the backup heater 14 is in operation. It is desirable to have a flow path 32 that extends over as much as possible

of a surface area of the heating element 22 so as to ensure adequate heating. The inlet connection 18 and the outlet connection 20 are positioned at longitudinal opposite ends of the outer housing 16, adjacent respective first and second end plates 24, 26 for this reason.

[0042] It is also considered desirable, for reasons that will become clear in the following, to have the inlet and outlet connection 18, 20 at a bottom of the outer housing 16. Top and bottom are used herein with respect to a top of the backup heater 14 and a bottom of it when it is properly horizontally mounted in the indoor unit 4. Alternatively, one can define bottom as where the inlet and outlet connections 18, 20 are and term top accordingly. Having the inlet and outlet connection 18, 20 at the bottom of the outer housing 16, however, provides a direct flow path from the inlet connection 18 to the outlet connection 20 that runs only or mostly along the bottom of the space enclosed by the outer housing 16 and the two end plates 24, 26. The upper part of the heating element 22 would not be optimally used to heat the water flowing between the inlet connection 18 and the outlet connection 20 in such a construction.

[0043] In order to address the above problem, the inlet and outlet connection 18, 20 are both provided in a bottom of the outer housing 16, but they are radially offset from one another by an amount of, for example 35° to 45°, as can be seen for example in figures 3, 4 and 7. In particular, the outlet connection 20 is provided at a bottom most position in the outer housing 16 and the inlet connection 18 is radially offset from this. This radial offset means that a more curved or spiral flow path will be provided between the inlet and outlet connection 18, 20, which can provide a more efficient heating of the water.

[0044] Further, and with reference to figure 4, the backup heater 14 includes a baffle plate 34 that blocks a direct flow path between the inlet connection 18 and the outlet connection 20 along the bottom of the space. The baffle plate 34 redirects the flow path 32 so that the water must flow over the top of it and thus to the top of the space enclosed by the backup heater 14 in order to reach the outlet connection 20.

[0045] The baffle plate 34 is spaced a small distance from the second end plate 26 of the backup heater 14 and mostly extends in a radial plane. The baffle plate 34 extends almost to the top of the space defined within the outer housing 16 and the end plates 24 and 26. A gap is thus defined between the top of the baffle plate 34 and the inner surface of a top of the outer housing 16. The baffle plate 34 has an outer periphery generally mating with an inner surface of the outer housing 16 so that water flow between the baffle plate 34 and the outer housing 16 is negligible or eliminated entirely.

[0046] With continued reference to figure 4, the baffle plate 34 includes an upper portion 38 extending in a generally radial plane and a bottom portion 36 that is bent to extend axially in the direction of the inlet connection 18 and downwardly to intersect with the inner surface of the bottom of the outer housing 16 between the outlet connection 20 and the inlet connection 18. The upper portion 38 extends in a radial plane that intersects the outlet connection 18 or is even beyond the outlet connection 18, closer to the second end plate 26. The upper portion 38 faces and is in close proximity to the turns in the filaments of the heating element 22. The bottom portion 36 is bent so as to extend to an inner surface of the outer housing 16 at a point between the inlet connection 18 and the outlet connection 20. The bend is such that while the upper portion 38 faces the heating element 22, the bottom portion 36 extends underneath it.

[0047] The bottom portion 36 extending axially toward the inlet connection 18 and downwardly to contact the inner surface of a bottom of the outer housing 16 in combination with the outer periphery of the bottom portion mating with the inner surface of the outer housing 16 results in the bottom portion 36 having the shown shape. Specifically, the bottom portion 36 tapers to a tip 40. The tip 40 contacts the inner surface of the outer housing 16 at the bottom most point.

[0048] A baffle plate 34 without the bend and extending only in a radial plane would define a large space between it and the second end plate 26. This would mean that the longitudinal extent of the backup heater 14 occupied by the heating element would be limited. The above described structure for the-baffle plate 34 means that the heating element 22 can occupy an increased longitudinal extent of the backup heater 14, while still providing a flow path 32, and further that flow path 32 is a sufficiently large flow path, to the outlet connection 20. The bottom portion 36 provides an expanded volume as the water flows to the outlet connection 20 as compared to if the baffle plate 34 extended all the way to the bottom in its radial plane. This expanded volume as the water reaches the bottom of the backup heater 14 in the proximity of the outlet connection 20 means that pressure changes in the water, which would be undesirable, are avoided. The angle between the upper portion 38 of the baffle plate and the lower portion 36 should be selected so as to minimise such undesirable pressure changes.

[0049] The water flow path 32, still referring to figure 4, between the inlet connection 18 and the outlet connection 20 thus passes through the gap over the baffle plate 34 and to the outlet connection 20. The water flow path 32 also includes a spiral element to it as provided by the radially offset inlet and outlet connections 18, 20. Good heating efficiency is ensured by such a flow path 32. The water flow path 32, after passing over the baffle plate 34, flows in a space between the baffle plate 34 and the second end plate 26. The flow path 32 beyond the bend in the baffle plate 34 turns to conform to the bottom portion of the baffle plate and thus passes to the outlet connection 20.

[0050] A draining process may need to be performed on the backup heater 14, for example after a production test has been run. Water to be drained can pass over the top of the baffle plate 34 and out of the outlet connection 20 to drain some of it. A lot of the water will also pass

through the inlet connection 18 during draining. There will, however, be an amount of water that could become trapped in the bottom most portion of the outer housing 16 and can not pass through the inlet connection 18 because the inlet connection 18 is radially offset from the bottom most portion. This body of water will also be prevented from passing to the outlet connection 20 by the presence of the baffle plate 34 blocking a flow path between the inlet and outlet connection 18, 20 along the bottom of the outer housing 16. The trapped water 62 can be viewed in figure 5 by a shaded region and where the level of the trapped water 62 is shown by the dark line 60 extending from the baffle plate 34 to the first end plate 24. The water level line 60 passes horizontally along the bottom at a height where the water level no longer communicates with the opening to the inlet connection 18.

[0051] In light of the above potential problem and with reference to figure 6, the baffle plate 34 includes a drain passage 42 through it, which is positioned at or adjacent the tip 40 of the bottom portion 36. The drain passage 42 is sufficiently small that it provides a negligible flow path in use to the outlet connection 20 as compared to the flow path 32 over the top of the baffle plate 34. The drain passage 42 ensures that the body of trapped water 62 in draining of the backup heater 14 has a way out.

[0052] It can be imagined that during a draining process, complete draining could be performed without tilting or other movement of the backup heater 14. A backup heater 14 full of water can drain water from the inlet and outlet connections 18, 20. The outlet connection 20 flow will drop to a negligible amount relative to the flow out of the inlet connection 18 once the water level drops below the top 54 of the baffle plate 34. The inlet connection 18 will continue to drain water from the backup heater 14 until the level drops below a lip of the inlet connection 18. It is at this point that the flow through the drain passage 42 to the outlet connection 20 becomes significant and finishes the draining of the backup heater 14.

[0053] Referring to figure 8, the top 54 of the baffle plate 34 is shown. The top 54 extends to a radial height greater than a top of the heating element 22, but not so far as the top of the backup heater 14 so that the gap discussed above is still provided. If the backup heater 14 is horizontally mounted and the water contained in the space provided by the outer housing 16 and the end plates 24, 26 was slowly drained, the baffle plate should be revealed before the heating element 22. The backup heater 14 includes a flow switch 55 on the outlet connection 20 side of the baffle plate 14. A tip of the flow switch 55 is shown by the shaded box in figure 8. The skilled reader will appreciate that this illustration is purely schematic, presented for the purposes of giving an indication of where the flow switch might be positioned to achieve its function. In reality, the flow switch 55 may be arranged below the top 54 of the baffle plate and spaced from it, meaning it would be hidden from view by the baffle plate 34 in figure 8. If the water level in the backup heater 14 drops below the top 54 of the baffle plate 34 a reduced or absent water flow condition will be detected by the flow switch 55. A control system can react to the detected faulty flow condition by cutting the power to the heating element 22. The relative positioning between the top 54 of the baffle plate 34 and the top of the heating element 22 means that the power is cut before a heating element, which is still on, is exposed by the dropping water level. This could damage the backup heater 14.

[0054] The top 54 of the baffle plate 34 is shown as being flat. That is, the top 54 would be parallel with the water level in the backup heater 14 when the backup heater 14 is horizontally mounted. This means that the flow to the outlet connection 20 stops, rather than gradually reduces as would be the case with a curved top 54 to the baffle plate 34. The flow switch 55 can thus be of a relatively reduced sensitivity and still detect the dangerous water level condition immediately.

[0055] Referring to figure 7, a side view of the indoor unit 4 can be seen. The backup heater 14 is mounted at the top of the indoor unit 4. In fact, the indoor unit 4 is mounted such that the backup heater 14 is the topmost water containing component connected by the water piping 10 in the room heating system 2 for reasons that will become clear in the following. It is mounted horizontally, that is with its longitudinal axis in line with the horizontal, which can also be seen with reference to figure 2. The horizontal mounting is such that the outlet connection 20 is positioned at a radial bottom of the backup heater 14.

[0056] The backup heater 14 includes a number of safety connections through the outer housing 16 and these can be seen with reference to figure 2. The mounting brackets 28 are used to mount the backup heater 14 to the indoor unit 4 and the handling bar 30 makes the mounting process easier to manage.

[0057] With reference to figure 2, a connection for a system safety valve 46 is also provided, which is in liquid communication with the water in the backup heater 14. The connection for the safety valve 46 is positioned at the top of the outer housing 16, longitudinally positioned adjacent the outlet connection 20 on the inlet connection 18 side of the outlet connection 20. The valve 46 is of a known type, whereby once the pressure in the room heating system 2 reaches a certain degree that is predetermined to be unsafe, the valve opens and releases water and/or steam from the backup heater 14 and thus the system 2. The valve 46 is in communication with an outlet pipe 50 that transports the released fluid to a collection drain (not shown).

[0058] The backup heater 14 also includes a connection 50 for a pipe 54 leading to an expansion vessel (not shown). The connection 50 is provided between the inlet and outlet connections 18, 20 and in a lower half of the outer housing 16, radially just above the inlet connection 18. The connection 50 is in liquid communication with the water in the backup heater 14. An expansion vessel is known to the skilled reader. Briefly, an expansion vessel includes some means to accommodate volume

changes in the water in the room heating system 2. For example, the expansion vessel can be a pressurised container including a flexible membrane providing a dividing line between a water side and a gas side in the container. The volume of the water can increase with increased temperature and the membrane will move against the gas to accommodate the volume change. The expansion vessel thus avoids large pressure increases.

[0059] The backup heater 14 also includes a gas release valve 48. Gas can become trapped in a water based room heating system 2. The gas can cause inefficient heating as it does not conduct heat as readily as liquid. It can also cause undesirable knocking noises in the piping 10 of the room heating system 2. The backup heater 14 is mounted as a top water containing component connected by the piping 10 in the room heating system 2, as discussed above. Gas will naturally rise in the room heating system 2 and so will make its way eventually into the backup heater 14. The gas release valve 48 allows the gas to be released from the room heating system 2 at a central point. The gas release valve 48 is mounted at the top of the outer housing 16 at a longitudinal centre and the backup heater 14 is mounted horizontally. Like in a spirit level, the gas bubble in a backup heater so arranged will collect in the position of the gas release valve 48 and so all gas can be released.

[0060] All of the safety connections 46, 48, 50 discussed above extend into a space contained by the backup heater 14 so that they communicate with the water therein. They extend through the tubular outer housing 16, where there is more space than at the end plates 24, 26.

[0061] The backup heater 14 includes further important safety devices. The backup heater 14 includes a thermal fuse 56 and a thermal cut off device such as a thermostat 58, as can be seen in figure 9 and 10. The thermostat 58 is positioned at the top of the heating element 22 with respect to the horizontal, which means it is just below the top 54 of the baffle plate 34. The thermal fuse 56 is positioned above this point, above the top of the heating element 22.

[0062] The thermostat 58 includes a thermistor attached to the outer housing 16. The thermistor is axially located at about the end of the heating element 22 adjacent the second end plate 26. The thermostat 58 contacts the tubular outer housing 16 so that its thermistor can sense the temperature of the housing 16 and provide a control signal in response to the sensed temperature.

[0063] The thermal fuse 56 includes a fuse element that melts once it is exposed to a predetermined maximum temperature. The thermal fuse 56 must be replaced once this occurs. The thermal fuse 56 extends through the second end plate 26 to an axial position extending a small way past the end of the heating element 22 adjacent the second end plate 26. The thermal fuse 56 thus extends to an axial position beyond the axial position of the thermostat 58. The fuse element extends correspondingly inside the thermal fuse 56. The thermal fuse 56 lies in the flow path 32 as it passes through the gap between the top 54 of the baffle plate 34 and the top of the outer housing 16.

[0064] If the water level drops so that the heating element 22 is exposed, then the flowing water inside the backup heater will not dissipate the heat generated by the heating element 22. This can create dangerous overheating of the backup heater 14. The flow switch 55 discussed above provides one safety mechanism against this danger. A control system is responsive to the temperature detected by the thermostat 58 and cuts the power to the heating element 22 if it goes above a predetermined safe limit. An air pocket will not cause system failure unless it exposes the heating element 22. The air pocket will, however, be at a lower temperature than the water. The positioning of the thermostat at the height of the heating element ensures that the housing temperature is sensed for as long as feasible before the heating element is exposed by the air pocket.

[0065] In the case that the water level drops below the top of the heating element 22, then the temperature that the thermal fuse 56 is subjected to could breach the maximum temperature safety limit. The thermal fuse 56 offers an immediate response to such a condition and is connected to the power supply to the heating element 22 so that the power supply is cut off in such an instance. The thermal fuse 56 will also be called into play in the case of malfunction of the thermostat 58.

[0066] An advantage of the use of a thermal fuse 56 in addition to a flow switch 55 and the thermostat 58 is that a further layer of safety response is provided. A temperature safety layer that is internal to the housing 16 and a temperature safety layer responsive to the housing temperature provides an effective safety response combination. Another advantage of the use of a thermal fuse is that if it is ever required, a fault in the backup heater 14 could very well be the problem. Simply resetting a flow switch or thermostat 58 would not solve the problem and may cause damage to the backup heater 14. An expired thermal fuse 56, on the other hand, will not work again and will need to be replaced. The replacement would generally be performed by a maintenance professional and the expired thermal fuse 56 would signify to the professional that the cause of the fault needs to be investigated before the thermal fuse 56 is replaced.

[0067] In use, the water travels around the piping 10 in the room heating system 2, releasing its heat to the room. The water enters a heat exchanger contained in the indoor unit 4 to collect heat provided by the outdoor unit 6, which is a heat pump. The water thus heated passes through the inlet connection 18 to the internal space of the backup heater 14 and passes out of the outlet connection 20 via a flow path 32. The flow path 32 has a twist induced in it by the radial offset between the inlet connection 18 and the outlet connection 20. The flow path 32 passes over the top of the baffle plate 34 and behind it towards the outlet connection 20. The flow path 32 to the outlet connection 20 then turns under the heat-

ing element 22 as directed by the bottom portion 36 of the baffle plate 34. The heating element 22 may or may not be switched on to provide a heat boost to the water. The turning on of the heating element 22 will be managed by a control system depending on whether peak demand conditions require it. The heated water then passes back into the piping 10 to fuel radiator or the under-floor heating 10.

[0068] All the while, the safety features are operable. So, any gas in the room heating system 2 will creep to the top most water containing component connected by the piping 10, namely the backup heater 14. This will be periodically released by a user or by a maintenance professional by operating the gas release valve 48. Changes in temperature in the water will result in volume changes that are accommodated by the expansion vessel. Specifically, the excess volume can pass from the backup heater 14 through the connection 50 to the expansion vessel via the pipe 54. In the case of a malfunction, the pressure of the water in the room heating system could become dangerously high. In this situation, the system safety valve 46 will open to release enough water from the backup heater 14 to bring the pressure back down to a safe operating level. The released water will drain through the drain pipe 50.

[0069] Further, dangerous temperature safety devices will also be operative in the case of water level drop. So, if the water level drops below the top 54 of the baffle plate 34 for any reason, for example because of excess gas accumulation in the top of the backup heater 14, the flow to the outlet connection 20 will cease. The flow switch 55 will recognise this and cut power to the heating element 22. The knowledgeable user, perhaps assisted by an instruction manual, could for example suspect the cause of the problem as excess gas build up and release it with the gas release valve 48.

[0070] If the water level suddenly drops to expose the heating element 22, the temperature to which the thermal fuse 56 is subjected would breach the predefined maximum. Power to the heating element 22 would be immediately cut by melting of the fuse element in the thermal fuse 56.

[0071] The thermostat 58, in normal operation of the backup heater 14, will provide a signal corresponding to a sensed temperature to a control system. The control system will keep the temperature of the housing below an upper temperature limit based on a control algorithm. In exceptional cases, the thermostat 58 may not be operating correctly or the water level may have dropped to expose the heating element 22. Here, the thermal fuse will respond to cut the power to the heating element 22 to prevent temperatures being reached that could damage the backup heater 14 or other components of the room heating system 2.

Claims

1. A heater for a room heating system, comprising:

a heating element;
a housing for the heating element comprising opposed first and second ends and a longitudinally extending sidewall there between, the heating element mounted to and extending longitudinally from the first end;
a thermal distribution fluid inlet to the housing and a thermal distribution fluid outlet from the housing; the housing containing the thermal distribution fluid as it follows a flow path from the inlet to the outlet;
one of the inlet and the outlet extending through the sidewall of the housing.

2. The heater of claim 1, wherein the housing is adapted to be mounted in a predetermined orientation and the inlet and outlet are positioned in the lower half of the housing when it is in the predetermined orientation.

3. The heater of claim 1, wherein a longitudinal axis of the housing is substantially horizontal when the housing is in the predetermined orientation.

4. The heater of claim 2 or 3, the housing including a baffle plate so that the flow path between the inlet and outlet passes over the baffle plate.

5. The heater of claim 4, wherein the top of the baffle plate is positioned substantially at the height of the heating element.

6. The heater of claim 4 or 5, wherein the baffle plate includes a portion facing an end of the heating element positioned over the inlet or outlet, when the housing is in the predetermined orientation, at or adjacent the second end of the housing or is positioned beyond that inlet or outlet toward the second end of the housing.

7. The heater of claim 4, 5 or 6, wherein the baffle plate is bent to extend under the heating element and to a position between the inlet and the outlet.

8. The heater of claim 6, wherein a bottom of the baffle plate, when the housing is in the predetermined orientation, includes a drain hole.

9. The heater of any one of claims 2 to 8, wherein the outlet is positioned at a bottom of the sidewall of the housing when it is in the predetermined orientation.

10. The heater of any one of claims 2 to 9, comprising a first thermal cut off device positioned substantially

at a same height as the top of the heating element, when the housing is in the predetermined orientation.

11. The heater of claim 10, comprising a second thermal cut off device, preferably a thermal fuse, positioned above the first thermal cut off device.

12. The heater of any of the preceding claims, wherein said one of the inlet and the outlet extending through the sidewall of the housing is positioned at or adjacent the first end.

13. The heater of any one of the preceding claims, wherein the other of the inlet and the outlet said one of the inlet extending through the sidewall of the housing also extends through the sidewall of the housing.

14. The heater of claim 13, wherein the inlet and outlet are respectively positioned at or adjacent the opposed first and second ends of the housing.

15. The heater of claim 14, wherein the heating element extends longitudinally to or beyond the inlet or the outlet positioned at or adjacent the second end of the housing.

16. The heater of any one of the preceding claims, wherein the inlet and outlet are raidially offset from one another.

17. An indoor unit for a room heating system comprising a heat pump having an outdoor evaporator, a compressor, a condenser and an expansion device connected by refrigerant piping in a cycle and a thermal distribution medium piping formed to circulate a thermal distribution medium and to flow the medium through a heat exchanger between the refrigerant and the medium, the indoor unit comprising:

the heat exchanger, a portion of the thermal distribution medium piping and the heater of any one of the preceding claims.

18. The indoor unit of claim 17 when dependent on claim 2, wherein the heater is mounted to the indoor unit in the predetermined orientation.

19. The indoor unit of claim 17 or 18, wherein the heater is mounted at a top part of the indoor unit.

20. The indoor unit of claim 17, 18 or 19, wherein the indoor unit is mounted with respect to said system such that the heater forms an uppermost component of the system.

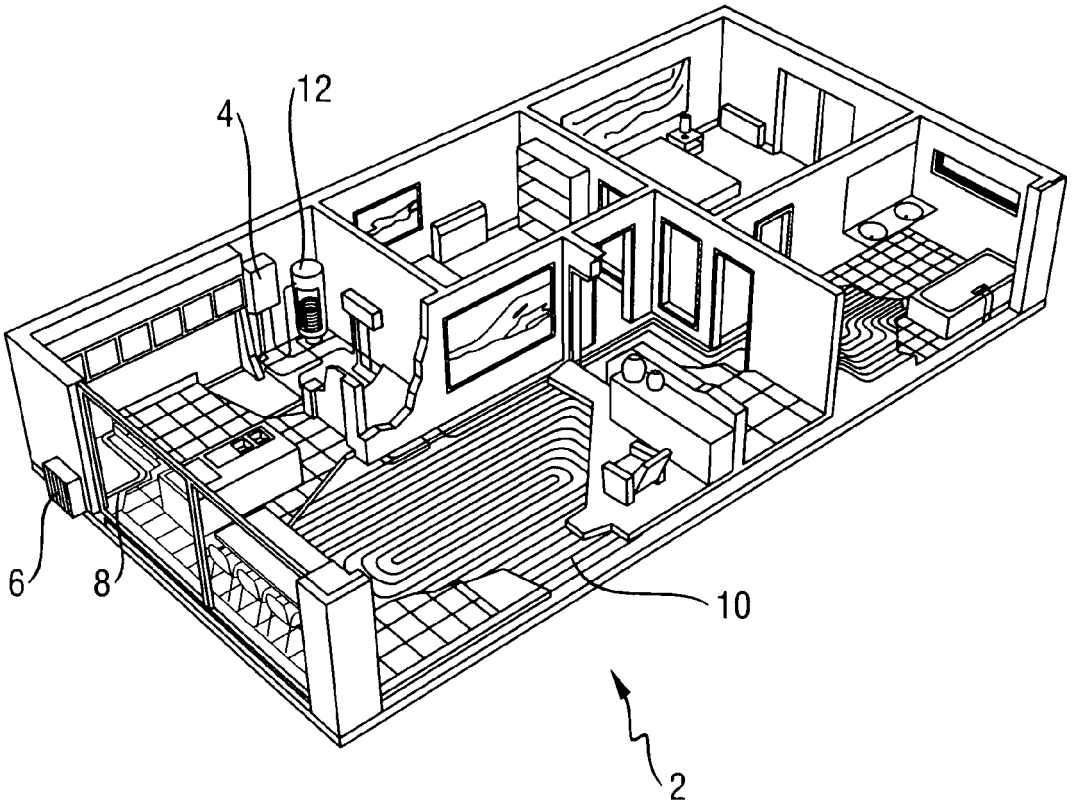

Fig. 1

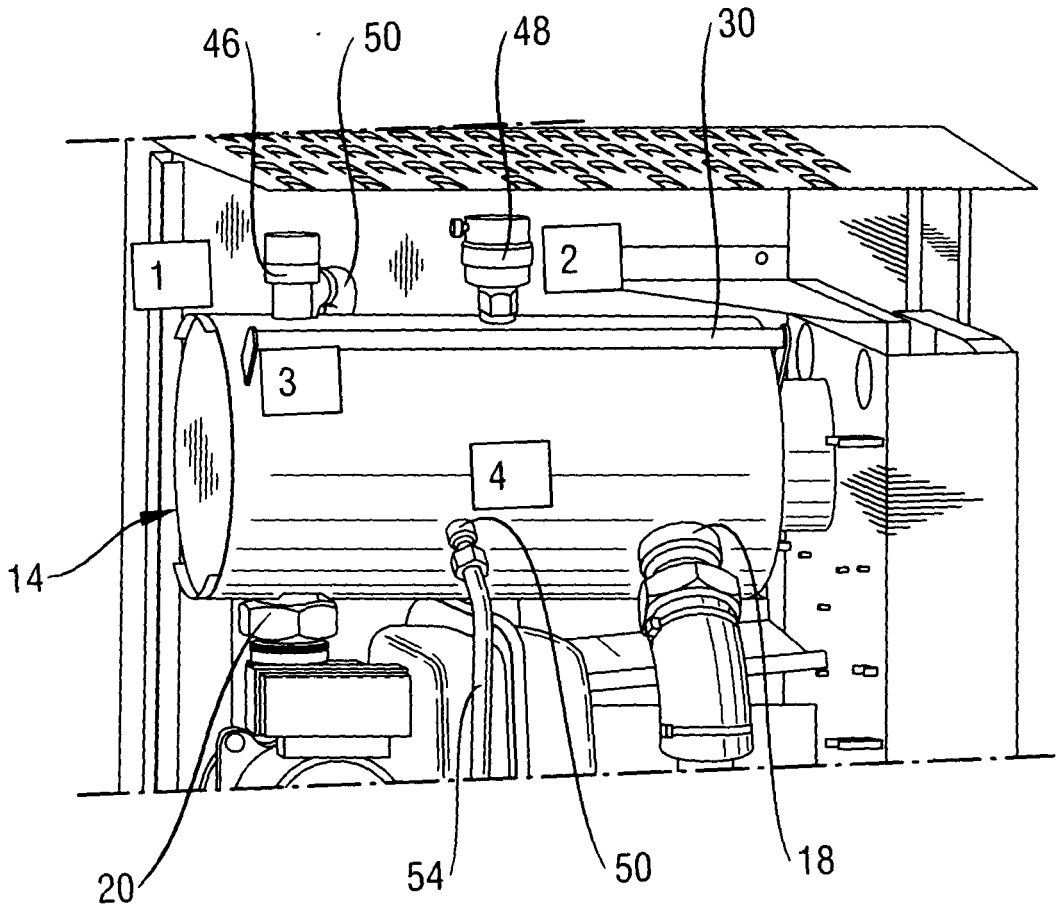

Fig. 2

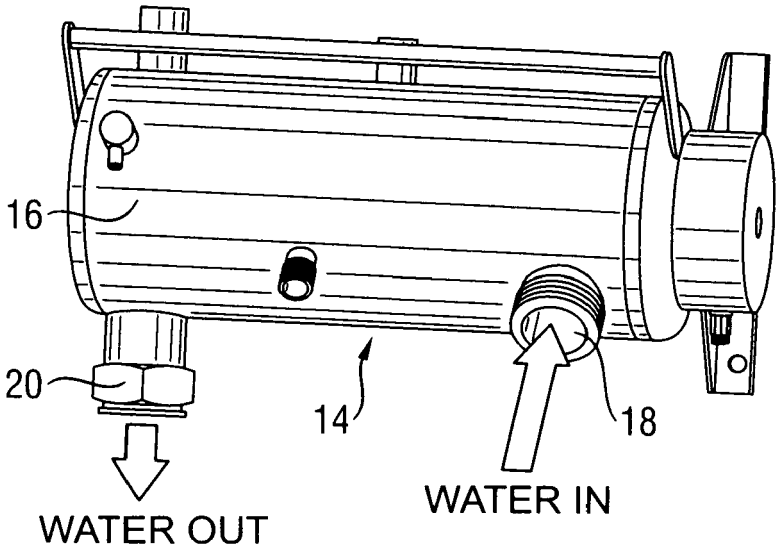
16
20
14
18
WATER OUT
WATER IN

Fig. 3

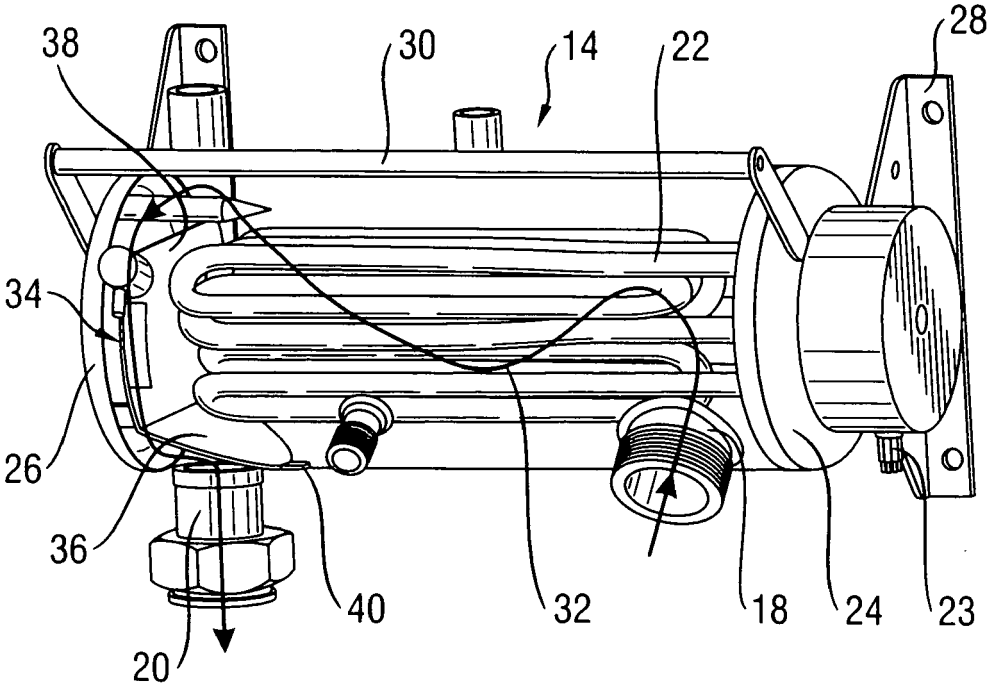
38
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Fig. 4

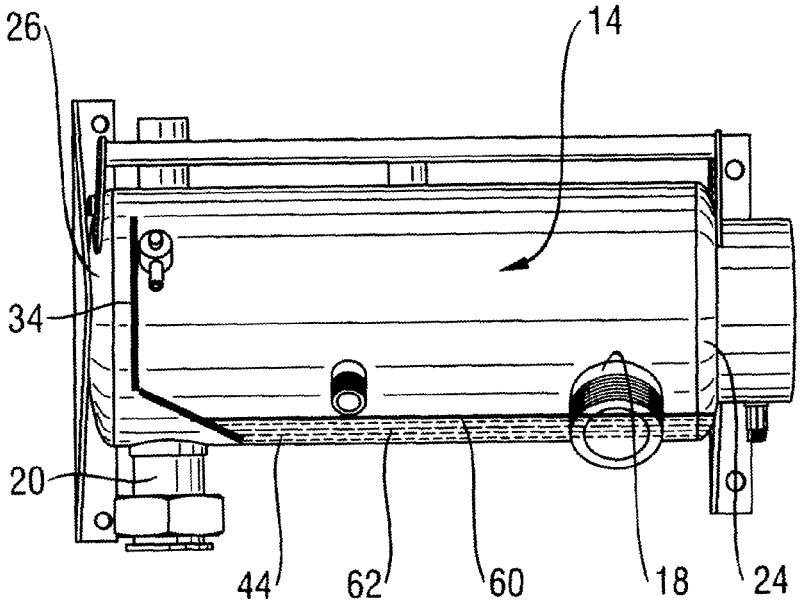


Fig. 5

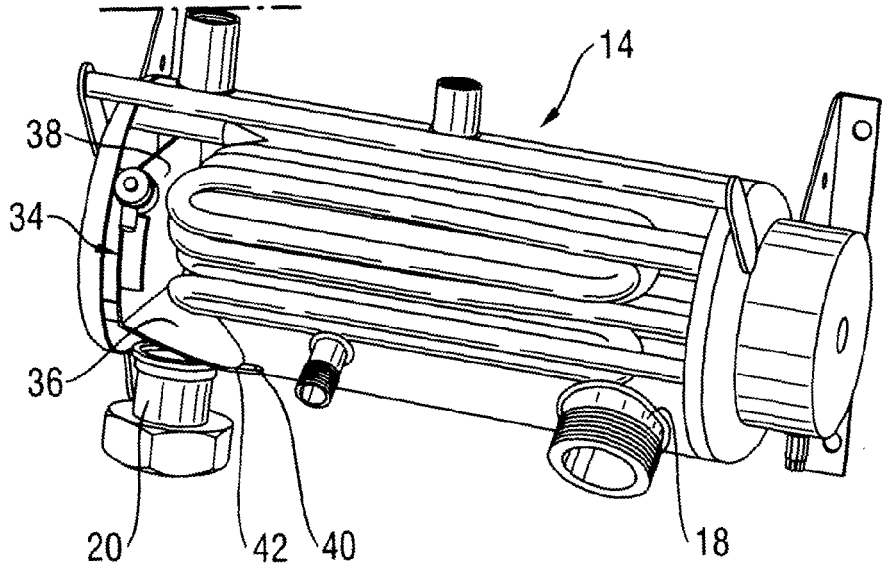


Fig. 6

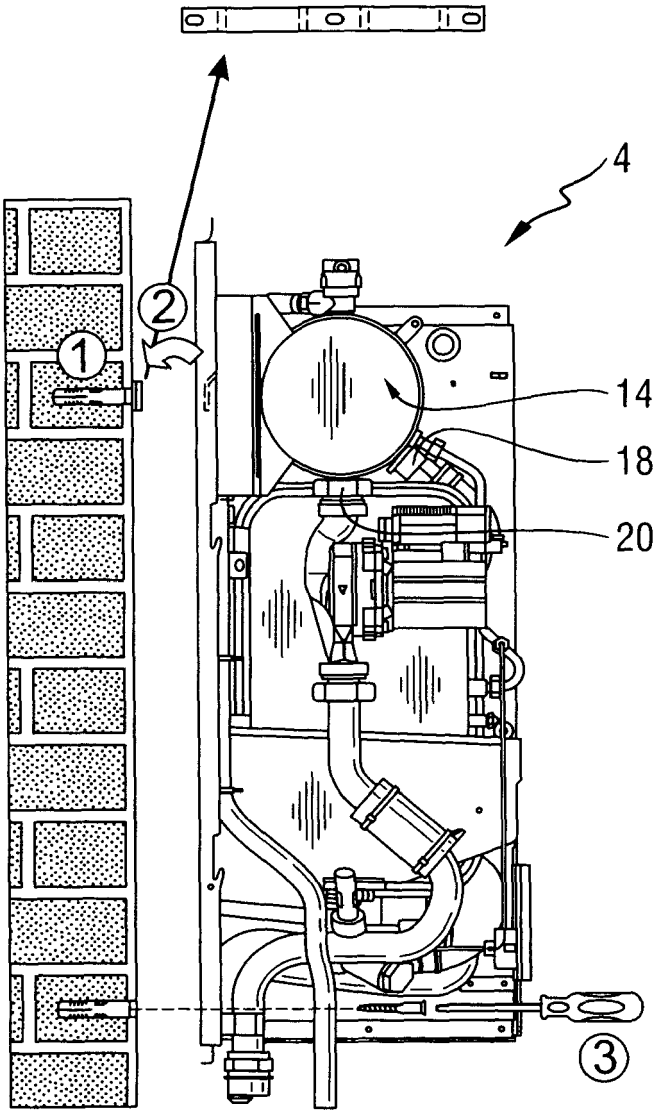


Fig. 7

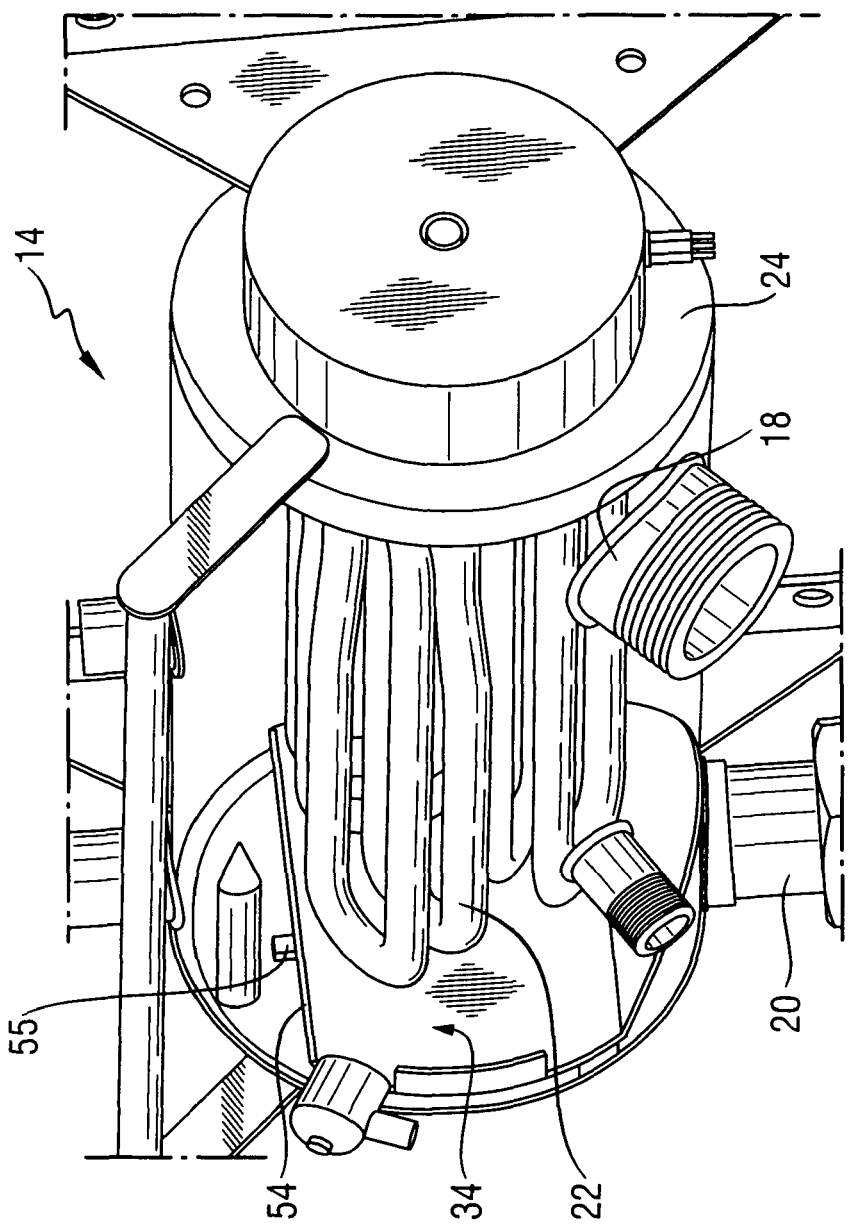


Fig. 8

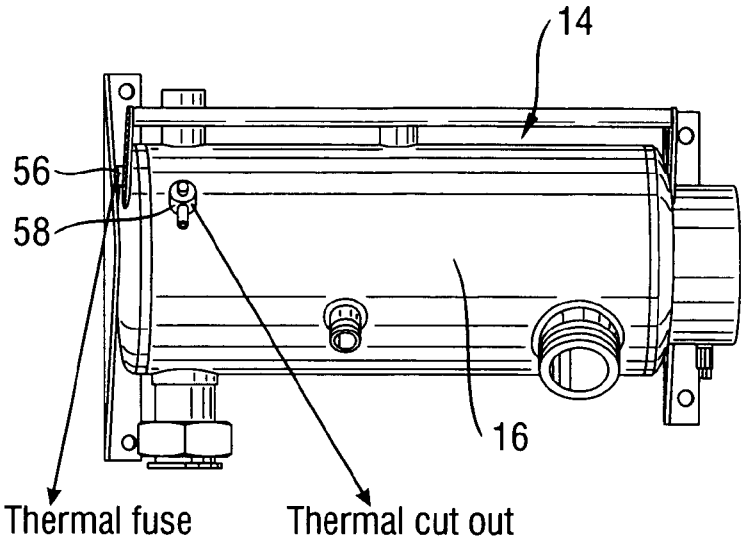


Fig. 9

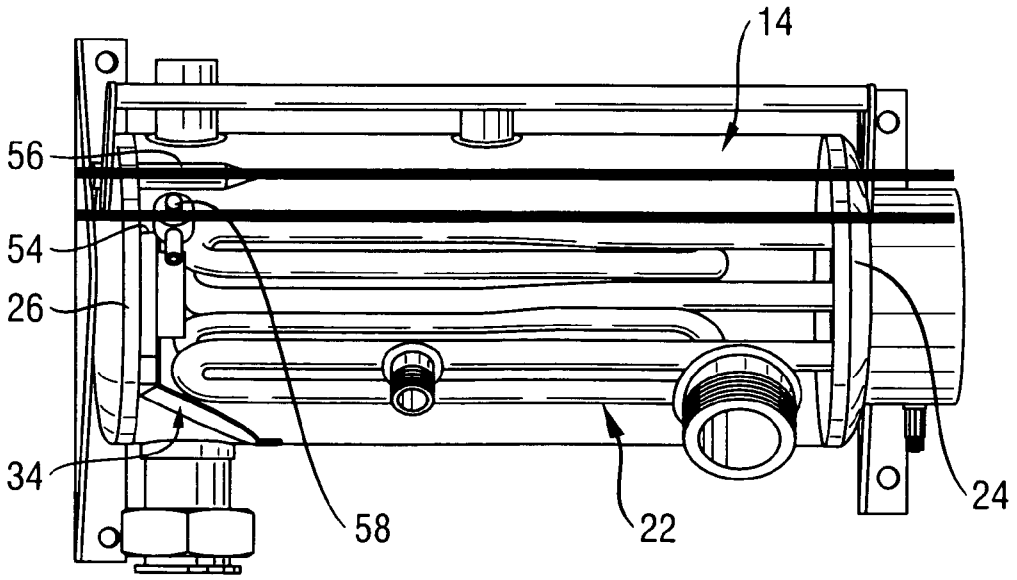
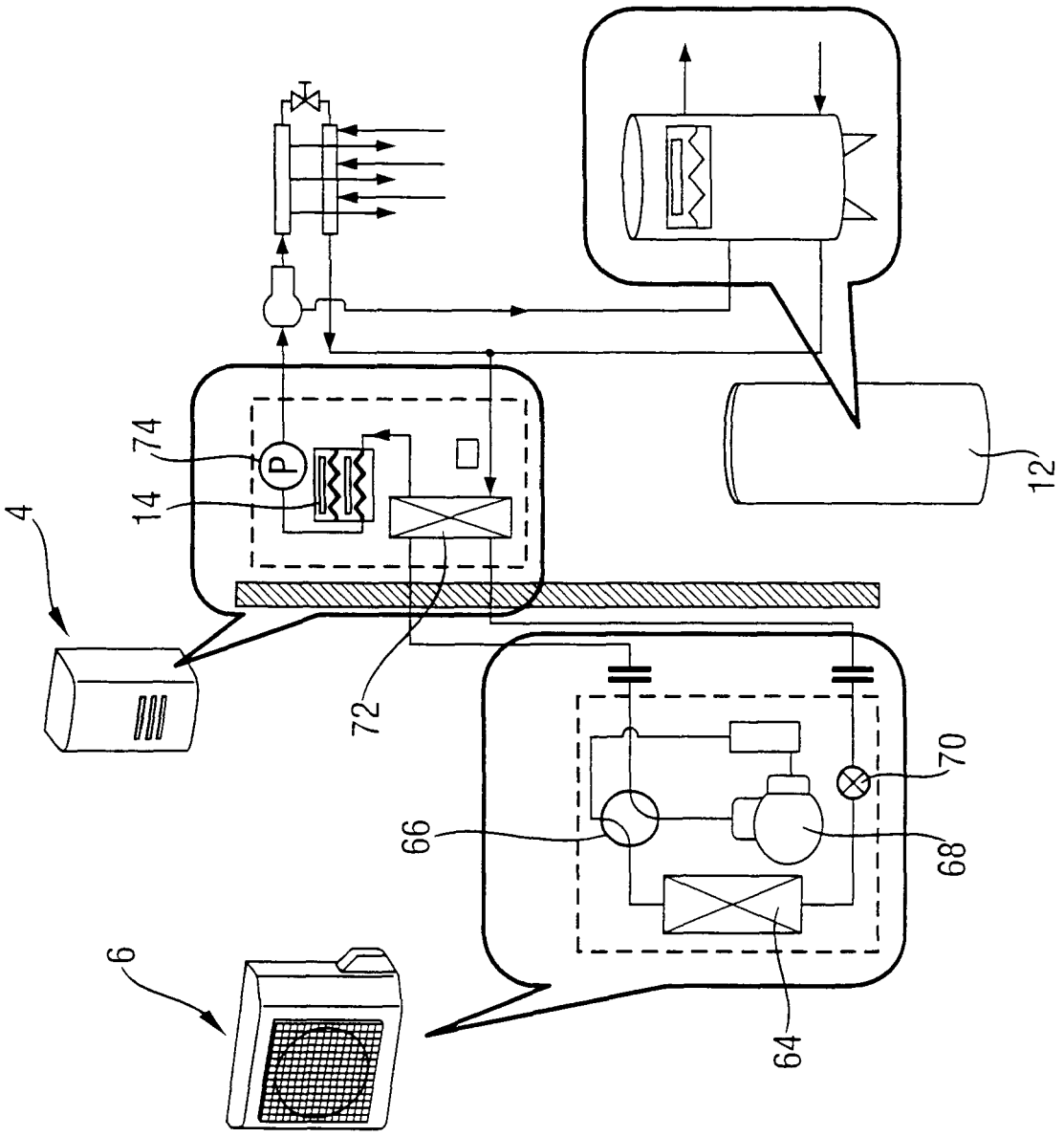


Fig. 10

Fig. 11



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 08 00 5310

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	GB 2 298 479 A (CARADON MIRA LTD [GB]) 4 September 1996 (1996-09-04) * abstract * -----	1,2,4, 12-15	INV. F24H1/22 F24H9/00 F24H9/20

TECHNICAL FIELDS SEARCHED (IPC)

F24H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	1 September 2008	van Gestel, Harrie

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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01-09-2008

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2298479 A	04-09-1996	IE 960168 A1	04-09-1996

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82