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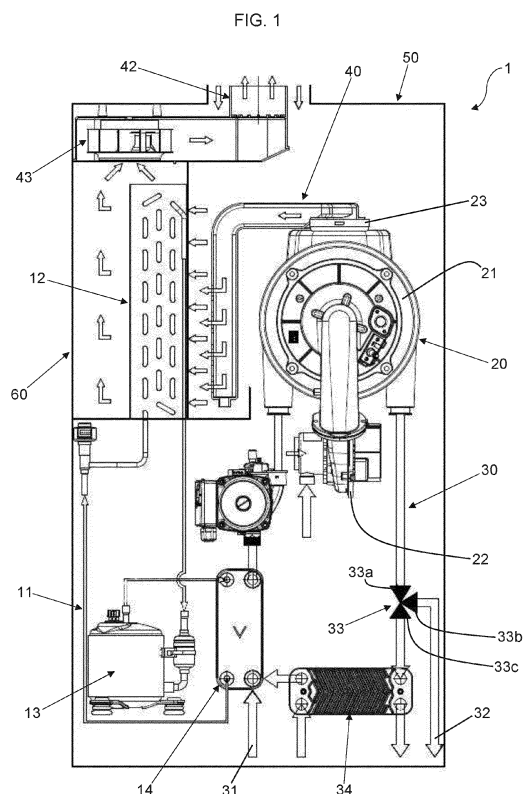
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Remarks:

Amended claims in accordance with Rule 137(2) EPC.

(54) **COMBINED SYSTEM AND PROCESS FOR HEATING A MAIN WATER CIRCUIT**

(57) A combined system for heating (1) a main water circuit (30) comprising a condensing boiler (20) and a heat pump (11, 12, 13, 14, 16). The boiler (20) has a combustion fumes outlet (23), the heat pump (11, 12, 13, 14, 16) comprises a refrigerant circuit (11) in which a refrigerant fluid flows and a first heat exchanger (12) crossed by the circuit (11) in which the refrigerant fluid receives heat passing from a liquid state to a gaseous state. The combined heating system (1) comprises a duct (40) extending between the fumes outlet (23) of the boiler (20) and said first heat exchanger (12) so as to carry the fumes coming from the fumes outlet (23) at the first heat exchanger (12).



Description

[0001] The present invention relates to a combined system and a process for heating a main water circuit. In particular, the heating system comprises a condensing boiler and a heat pump. In the industry, such a combination is often referred to as a "hybrid system".

[0002] Centralised heating systems which simultaneously use a heat pump and a boiler are currently known. In particular, the boiler is of the instantaneous condensation type.

[0003] In these systems, a main water circuit is heated first by the heat pump and then by the boiler. In particular, the heat pump comprises a refrigerant fluid circuit, which receives heat from the ambient air and transfers it to the water. The pre-heated water then reaches the boiler, where it is further heated by heat exchange with the combustion products generated by a burner.

[0004] In this context, the recovery of the heat of the combustion fumes inside the system is known. For example, patent EP2926059 shows a heating apparatus comprising a condensing boiler and a heat pump. In this apparatus, an air flow receives heat from the combustion fumes inside a special heat exchanger. Such an air flow is then used in an evaporator of the heat pump to exchange heat with a refrigerant fluid.

[0005] The main drawback of the solution just described lies in the use of a specific component to heat the air flow, structurally complicating the apparatus. Furthermore, the presence of a double heat exchange (fumes/air and air-refrigerant fluid) causes significant heat losses and a consequent low efficiency.

[0006] In this context, the technical task underpinning the present invention is to provide a combined system and a process for heating a main water circuit, which obviate the drawbacks of the prior art cited above.

[0007] In particular, an object of the present invention is to provide a combined system for heating a main water circuit, which is structurally simpler with respect to the known solutions.

[0008] Another object of the present invention is to propose a combined system and a process for heating a main water circuit, in which the heat of the combustion fumes is recovered with high efficiency.

[0009] The specified technical task and the specified objects are substantially achieved by a combined system for heating a main water circuit, comprising a condensing boiler and a heat pump. The boiler has a combustion fumes outlet, the heat pump comprises a refrigerant circuit in which a refrigerant fluid flows and a first heat exchanger crossed by the circuit in which the refrigerant fluid receives heat passing from a liquid state to a gaseous state. The combined heating system comprises a duct extending between the fumes outlet of the boiler and the first heat exchanger so as to carry the fumes coming from the fumes outlet at the first heat exchanger.

[0010] In accordance with an embodiment, the condensing boiler comprises a sealed chamber in which the

combustion occurs. The fumes outlet and the duct are inside the sealed chamber.

[0011] In accordance with an embodiment, the combined heating system comprises a fan associated with the first heat exchanger so that the fumes exiting the duct are sucked into the first heat exchanger.

[0012] In accordance with an embodiment, the sealed chamber is surrounded by ambient air. The fumes mix with the ambient air exiting from the duct. Preferably, the combined heating system comprises a drain into the atmosphere for the fumes downstream of the first heat exchanger.

[0013] In accordance with an embodiment, the combined heating system comprises a tank for producing sanitary hot water arranged along the main water circuit. The tank has an inlet (71) for water to be heated and an outlet (72) for heated water. The system comprises a further heat exchanger arranged inside the tank and crossed by the refrigerant circuit so as to exchange heat between the refrigerant fluid and the water of the main circuit.

[0014] The stated technical task and specified objects are substantially achieved by a combined process for heating a main water circuit, comprising the steps of:

- carrying out a first heating of the water by heat exchange with a refrigerant fluid in a gaseous state, the refrigerant fluid passing from the gaseous state to a liquid state;
- carrying out a second heating of the water by heat exchange with combustion fumes;
- after carrying out a second heating of the water, carrying the combustion fumes at a first heat exchanger;
- exchanging heat in the first heat exchanger between the combustion fumes and the refrigerant fluid in the liquid state, the refrigerant fluid passing from the liquid state to the gaseous state so as to be used for the step of carrying out a first heating of the water.

[0015] According to an aspect of the process, the step of carrying the combustion fumes at a first heat exchanger occurs inside a sealed chamber.

[0016] Preferably, a wall defining the sealed chamber acts as a seal for the fumes exiting the first heat exchanger.

[0017] Preferably, the heating process comprises a step of mixing the combustion fumes with ambient air prior to the heat exchanging step, said heat exchanging step occurring between a mixture of air and fumes and the refrigerant fluid.

[0018] In accordance with an embodiment of the process, this comprises the steps of:

- accumulating water from the main water circuit;
- heating the accumulated water by heat exchange with the refrigerant fluid;
- exchanging heat between the accumulated and heated water and a sanitary water circuit so as to

produce sanitary hot water.

[0019] Further features and advantages of the present invention will become more apparent from the approximate and thus non-limiting description of a preferred, but not exclusive, embodiment of a combined system and a process for heating a main water circuit, as illustrated in the accompanying drawings, in which:

- figure 1 shows a first embodiment of a combined system for heating a main water circuit, according to the present invention, in schematic view;
- figure 2 shows a second embodiment of a combined system for heating a main water circuit, according to the present invention, in schematic view.

[0020] With reference to the drawings, the number 1 indicates a combined system for heating a main water circuit 30.

[0021] The combined heating system 1 comprises a condensing boiler 20 and a heat pump. The two devices are associated with each other so as to form a single combined system.

[0022] The main water circuit partially extends through the combined heating system 1 so that the water therein is heated first by the heat pump and then by the boiler 20, to then be sent to a heating system. In particular, the main water circuit 30 includes a delivery duct 32 for the hot water to radiators of the heating system and a return duct 31 of the water to the combined heating system 1.

[0023] The heat pump comprises a refrigerant fluid circuit 11, which has the task of heating the water of the main circuit 30 a first time.

[0024] Such a circuit 11 passes through a first heat exchanger 12, in which the refrigerant fluid evaporates, passing from the liquid phase to the gaseous phase. The first heat exchanger 12 is generally indicated as an "evaporator". Hereinafter, the term evaporator 12 is thus used to indicate the first heat exchanger 12.

[0025] From such an evaporator 12, the refrigerant fluid is sent from a compressor 13 to a second heat exchanger 14, in which the refrigerant fluid condenses passing from the gaseous state to the liquid state, transferring heat to the water returning from the heating system. The second heat exchanger 14 is generally indicated as a "condenser". Hereinafter, the term condenser 14 is thus used to indicate the second heat exchanger 14.

[0026] In summary, the compressor 13 has the function of circulating the refrigerant fluid in the circuit 11, sucking it from the evaporator 12 in the form of gas and compressing it so as to convey it to the condenser 14, at high pressure. Any type of compressor 13 which involves volumetric compression can be used.

[0027] The refrigerant fluid circuit 11 also has a lamination valve (adiabatic), which determines the necessary and sufficient pressure drop to maintain the pressure of the refrigerant fluid at the desired values of the evaporator 12 and the condenser 14.

[0028] The condensing boiler 20 comprises components of the known type, therefore it will not be described in detail. By way of explanation, the boiler 20 comprises a burner 21 in which a combustion occurs which generates combustion fumes, a fan 22 to supply ambient air to the burner 21, at least one portion of the fuel gas supply pipe to the burner 21 and a heat exchanger crossed by the main water circuit 30. In the heat exchanger, the heat exchange occurs between the fumes produced by the burner 21 and the water of the main heating circuit 30.

[0029] Appropriately, the boiler 20 comprises a combustion fumes outlet 23.

[0030] Entering into the detail of the main water circuit 30, the water returns from the heating system through the return duct 31 and passes through the condenser 14, in which it is heated a first time as described above for the heat pump. Thereafter, the main circuit 30 passes through the boiler 20, where the water is heated a second time as described above for the boiler 20. At this point, the heated water leaves the combined heating system 1 through a delivery duct 32, moving towards the terminals of the heating system. The terminals can be for example radiators or a floor system. Originally, the combined heating system 1 comprises a duct 40 connected to the fumes outlet 23 of the condensing boiler 20. The duct 40 extends so as to carry the fumes at the first heat exchanger, i.e., the evaporator 12.

[0031] In other words, in the combined heating system 1 proposed herein, a heat exchange occurs directly between the combustion fumes and the refrigerant fluid.

[0032] As is known, a condensing boiler 20 comprises a sealed chamber 50, i.e., a chamber isolated from the surrounding environment, in which the combustion occurs. The air is sucked from the outside by means of a fan, therefore the sealed chamber 50 is in a vacuum.

[0033] By virtue of the duct 40, the fumes remain in the sealed chamber 50 until they reach the evaporator 12.

[0034] Preferably, the combustion fumes exiting the duct 40 mix with the air surrounding the sealed chamber. Thereafter, the mixture of air and fumes generated is sucked into the evaporator 12 by means of a fan 43 associated therewith. Thereby, a heat exchange occurs in the evaporator 12 between the mixture of air and fumes and the refrigerant fluid. Downstream of the evaporator 12 there is a drain 42 into the atmosphere of the mixture of air and fumes.

[0035] Thus the mixture of air and fumes, once heat has been transferred to the refrigerant fluid, is evacuated into the atmosphere.

[0036] In the embodiment described and illustrated herein, the combined heating system 1 comprises a wall 60 arranged near the evaporator 12. The wall 60 delimits a part of the sealed chamber 50 and at the same time performs the function of an insulating or sealing panel for the mixture of gas and air exiting the evaporator 12 towards the drain 42. In the existing solutions, the exhausted gas containment function is performed by a specially provided casing around the evaporator 12.

[0037] In accordance with an embodiment, shown in figure 1 and described so far, the boiler 20 and the heat pump are used to serve only the heating of the water of the main circuit 30.

[0038] In accordance with another embodiment, shown in figure 2, the instantaneous condensing boiler and the heat pump are intended for heating the water of the main circuit 30 and for the production of sanitary hot water, known with the acronym SHW.

[0039] In this case, the combined heating system 1 comprises a tank 70 for producing sanitary water. In particular, the tank 70 has a function of accumulating water from the main circuit 30 which is exchanged for the production of sanitary hot water. Such a tank 70 is arranged along the main water circuit 30 and has an inlet 71 for the water to be heated (cold water) and an outlet 72 for the heated water (hot water). The refrigerant circuit 11 crosses the tank 70 and comprises a third heat exchanger 16 configured to exchange heat between the refrigerant fluid and the water of the main circuit.

[0040] Considering the extension of the refrigerant fluid circuit 11, the third heat exchanger 16 is interposed between the evaporator 12 and the condenser 14. In other words, the refrigerant fluid evaporates in the first heat exchanger 12 by virtue of the mixture of air and fumes, transfers heat in the third heat exchanger 16 to the main water used to produce sanitary hot water and subsequently condenses in the second heat exchanger 14, heating the main water returning from the heating system.

[0041] Preferably, a three-way valve 33 is arranged along the main water circuit 30. The valve 33 has an inlet 33a for the water heated by the boiler, a first outlet 33b for the delivery of the heating water and a second outlet 33c communicating with a fourth heat exchanger 34. The operation of the three-way valve 33 is of the exclusive type. In other words, the first outlet 33b and the second outlet 33c are alternatively enabled and cannot be crossed by water at the same time: the incoming water is sent to either the heating system or to the exchanger 34 for producing SHW. In said fourth heat exchanger 34, the hot water transfers heat to a sanitary water circuit 80. The exiting cold water is sent to the tank 70 to be heated again.

[0042] In this embodiment, the main water circuit 30 is thus obtained: the cold water returns from the heating system by means of the return duct 31, passes in the condenser 14 and then in the boiler 20, thus obtaining hot water. After the passage in the boiler 20, the hot water encounters the three-way valve 33: the water can be sent to either the delivery duct 32 of the system by means of the first outlet 33b or to the fourth heat exchanger 34, where sanitary hot water is produced, by means of the second outlet 33c. The cold water exiting the fourth heat exchanger 34 passes through the tank 70, where it is again heated by the exchanger 16 and conveyed towards the boiler 20. A combined process for heating a main water circuit, according to the present invention, is de-

scribed below. Such a process is advantageously implemented by a combined heating system 1 as described above.

[0043] The combined heating process comprises the step of carrying out a first heating of the water by heat exchange with a refrigerant fluid in a gaseous state. The heat exchange is such that the refrigerant fluid passes from the gaseous state to a liquid state.

[0044] Then, a second heating of the water is carried out by heat exchange with combustion fumes. The combustion fumes are generated in the condensing boiler 20.

[0045] After carrying out the second heating of the water, the combustion fumes are withdrawn from the condensing boiler 20 and carried at a first heat exchanger 12, or evaporator. The heat exchange with the refrigerant fluid in the liquid state occurs here. Thereby, the heat of the fumes allows the fluid to pass from the liquid to the gaseous state and it is possible to again use the refrigerant fluid for the step of carrying out a first heating of the water.

[0046] In other words, an energy recovery of the combustion fumes occurs in the process to heat the refrigerant fluid. Thus the heat of the combustion fumes is reused within the process, with a great advantage in terms of efficiency.

[0047] Preferably, the step of carrying the combustion fumes at a first heat exchanger 12 occurs inside a sealed chamber 50.

[0048] Preferably, after withdrawing the combustion fumes and prior to the heat exchange with the refrigerant fluid, the combined heating process comprises a step of mixing the combustion fumes with ambient air. As a result, the heat exchange occurs between a mixture of air and fumes and the refrigerant fluid.

[0049] Preferably, the process comprises a step of draining the fumes into the atmosphere by forced ventilation.

[0050] Preferably, the process further comprises a step of accumulating water from the main circuit 30. The accumulated water is then reheated by heat exchange with the refrigerant fluid. In particular, the refrigerant fluid is in the gaseous state.

[0051] Subsequently, the accumulated and heated water exchanges heat with a sanitary water circuit so as to produce sanitary hot water.

[0052] From the description provided, the features of the combined system and process for heating a main water circuit in accordance with the present invention are clear, as are the advantages thereof.

[0053] In particular, having provided a duct which carries the combustion fumes from the boiler to the evaporator allows a heat exchange between the fumes (or the mixture of ambient air and fumes) and the refrigerant fluid. It is thus no longer necessary to include a special heat exchanger between the combustion fumes and an ambient air flow or include a second fumesrefrigerant fluid evaporator. Thereby, the combined heating system is structurally simpler and, having introduced the "direct"

heat exchange between fumes and refrigerant fluid, the efficiency is increased with respect to the known solutions.

Claims

1. A combined system for heating (1) of a main water circuit (30) comprising a condensing boiler (20) and a heat pump (11, 12, 13, 14, 16), said boiler (20) having a combustion fumes outlet (23), said heat pump (11, 12, 13, 14, 16) comprising a refrigerant circuit (11) in which a refrigerant fluid flows and a first heat exchanger (12) crossed by said circuit (11) in which the refrigerant fluid receives heat passing from a liquid state to a gaseous state, **characterized in that** it comprises a duct (40) extending between the fumes outlet (23) of the boiler (20) and said first heat exchanger (12) so as to carry the fumes coming from the fumes outlet (23) at the first heat exchanger (12).
2. The combined heating system (1) according to claim 1, wherein the condensing boiler (20) comprises a sealed chamber (50) where the combustion occurs, said fumes outlet (23) and said duct (40) being inside the sealed chamber (50).
3. The combined heating system (1) according to claim 1 or 2, comprising a fan (43) associated with the first heat exchanger (12) so that the fumes exiting the duct (40) are sucked into the first heat exchanger (12).
4. The combined heating system (1) according to any one of the preceding claims, wherein said sealed chamber (50) is surrounded by ambient air, said fumes mixing with the ambient air exiting from said duct (40).
5. The combined heating system (1) according to any one of the preceding claims, comprising a drain (42) into the atmosphere for the fumes downstream of said first heat exchanger (12).
6. The combined heating system (1) according to any one of the preceding claims, comprising:
 - a tank (70) for producing sanitary hot water arranged along the main water circuit (30), said tank having an inlet (71) for water to be heated and an outlet (72) for heated water;
 - a further heat exchanger (16) arranged inside the tank (70) and crossed by the refrigerant circuit (11) so as to exchange heat between the refrigerant fluid and the water of the main circuit.
7. A combined process for heating a main water circuit

(30), comprising the steps of:

- carrying out a first heating of the water by heat exchange with a refrigerant fluid in a gaseous state, said refrigerant fluid passing from the gaseous state to a liquid state;
 - carrying out a second heating of the water by heat exchange with combustion fumes;
 - after carrying out a second heating of the water, carrying the combustion fumes at a first heat exchanger (12);
 - exchanging heat in the first heat exchanger (12) between the combustion fumes and the refrigerant fluid in the liquid state, said refrigerant fluid passing from the liquid state to the gaseous state so as to be used for the step of carrying out a first heating of the water.
8. The combined heating process according to claim 7, wherein the step of carrying the combustion fumes at a first heat exchanger (12) occurs inside a sealed chamber (50).
 9. The combined heating process according to claim 8, wherein a wall defining the sealed chamber (50) acts as a seal for the fumes exiting the first heat exchanger (12).
 10. The combined heating process according to any one of the preceding claims, comprising a step of mixing the combustion fumes with ambient air prior to the heat exchanging step, said heat exchanging step occurring between a mixture of air and fumes and the refrigerant fluid.
 11. The combined heating process according to any one of claims 7 to 10, comprising the steps of:
 - accumulating water from the main water circuit (30);
 - heating the accumulated water by heat exchange with the refrigerant fluid;
 - exchanging heat between the accumulated and heated water and a sanitary water circuit so as to produce sanitary hot water.

Amended claims in accordance with Rule 137(2) EPC.

1. A combined system for heating (1) of a main water circuit (30) comprising a condensing boiler (20) and a heat pump (11, 12, 13, 14, 16), said boiler (20) having a combustion fumes outlet (23), said heat pump (11, 12, 13, 14, 16) comprising a refrigerant circuit (11) in which a refrigerant fluid flows and a first heat exchanger (12) crossed by said circuit (11) in which the refrigerant fluid receives heat passing

from a liquid state to a gaseous state;

said combined system comprising a duct (40) extending between the fumes outlet (23) of the boiler (20) and said first heat exchanger (12) so as to carry the fumes coming from the fumes outlet (23) at the first heat exchanger (12), wherein the condensing boiler (20) comprises a sealed chamber (50), that is a chamber isolated from a surrounding environment where the combustion occurs, the air being sucked from outside by means of a fan, therefore the sealed chamber (50) is in depression, said fumes outlet (23) and said duct (40) being inside the sealed chamber (50).

2. The combined heating system (1) according to claim 1, comprising a fan (43) associated with the first heat exchanger (12) so that the fumes exiting the duct (40) are sucked into the first heat exchanger (12).

3. The combined heating system (1) according to any one of the preceding claims, comprising a drain (42) into the atmosphere for the fumes downstream of said first heat exchanger (12).

4. The combined heating system (1) according to any one of the preceding claims, comprising:

- a tank (70) for producing sanitary hot water being arrangeable along the main water circuit (30), said tank having an inlet (71) for water to be heated and an outlet (72) for heated water;
- a further heat exchanger (16) arranged inside the tank (70) and crossed by the refrigerant circuit (11) so as to exchange heat between the refrigerant fluid and the water of the main water circuit (30).

5. A combined process for heating a main water circuit (30) by means of the combined heating system (1) according to any of the preceding claims, comprising the steps of:

- carrying out a first heating of the water by heat exchange with a refrigerant fluid in a gaseous state, said refrigerant fluid passing from the gaseous state to a liquid state;
- carrying out a second heating of the water by heat exchange with combustion fumes;
- after carrying out a second heating of the water, carrying the combustion fumes at the first heat exchanger (12), wherein the step of carrying the combustion fumes at the first heat exchanger (12) occurs inside the sealed chamber (50);
- exchanging heat in the first heat exchanger (12) between the combustion fumes and the refrigerant fluid in the liquid state, said refrigerant

fluid passing from the liquid state to the gaseous state so as to be used for the step of carrying out a first heating of the water.

6. The combined heating process according to claim 5, wherein a wall defining the sealed chamber (50) acts as a seal for the fumes exiting the first heat exchanger (12).

7. The combined heating process according to any one of the preceding claims, comprising a step of mixing the combustion fumes with ambient air prior to the heat exchanging step, said heat exchanging step occurring between a mixture of air and fumes and the refrigerant fluid.

8. The combined heating process according to any one of claims 5 to 7, comprising the steps of:

- accumulating water from the main water circuit (30);
- heating the accumulated water by heat exchange with the refrigerant fluid;
- exchanging heat between the accumulated and heated water and a sanitary water circuit so as to produce sanitary hot water.

FIG. 1

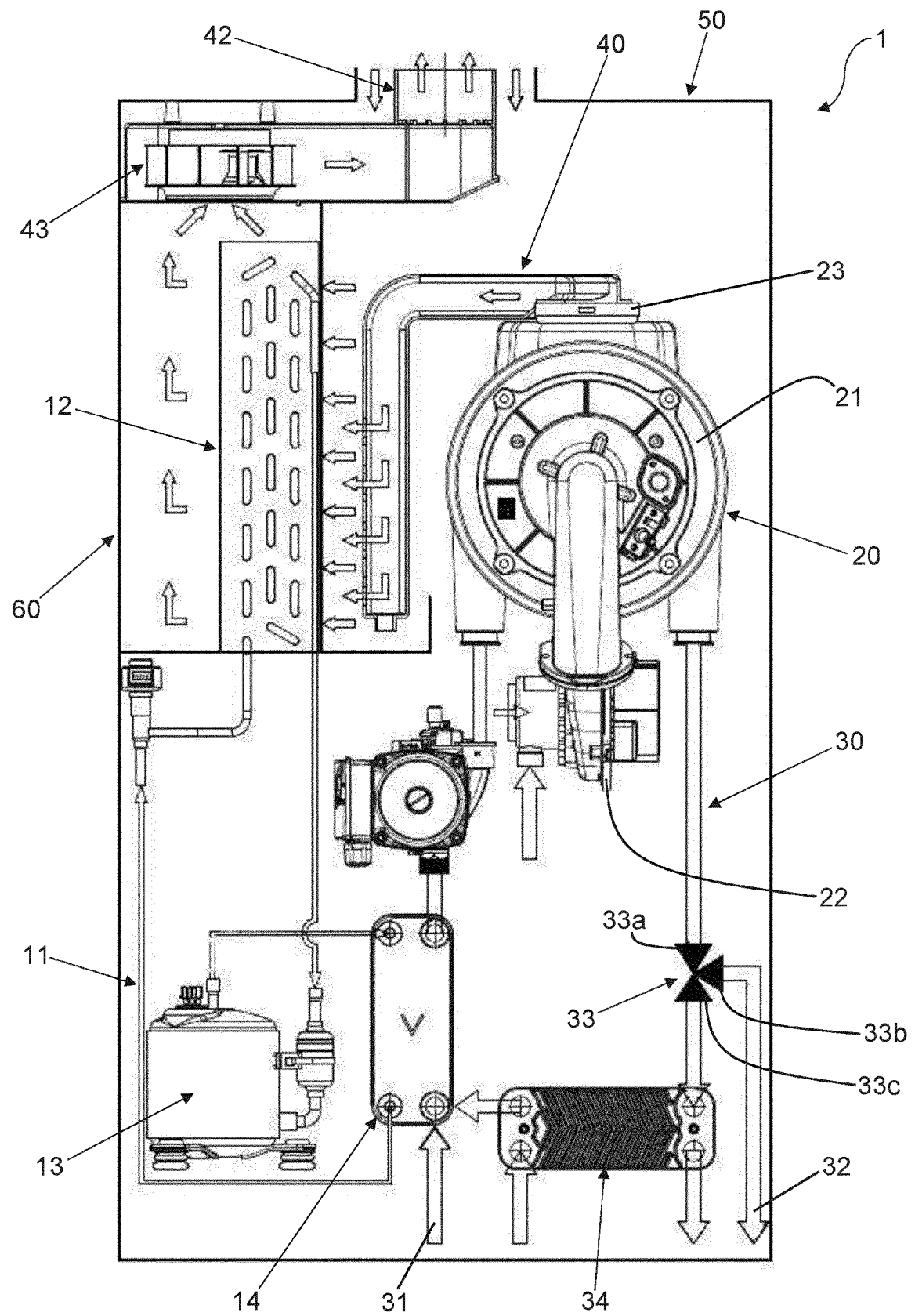
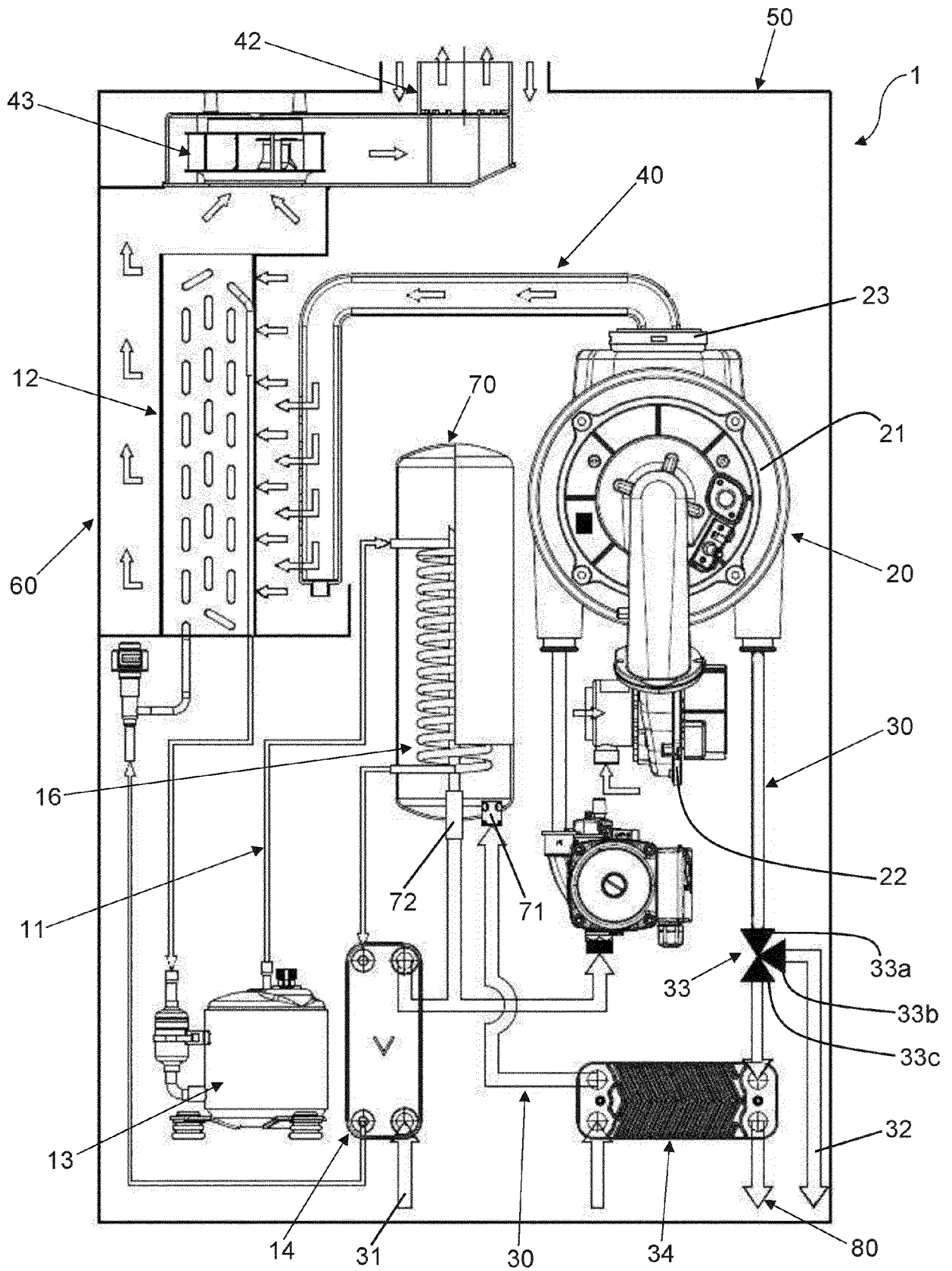


FIG. 2





EUROPEAN SEARCH REPORT

Application Number

EP 22 16 1158

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	IT BO20 120 458 A1 (GAS POINT S R L) 1 March 2014 (2014-03-01) * page 3 - page 26; figures 1-5 * -----	1-5, 7-10	INV. F24H4/06 F24H9/00 F24H8/00
X	CN 107 101 374 A (XI'AN FUKAI ENERGY TECH CO LTD) 29 August 2017 (2017-08-29) * paragraph [0024] - paragraph [0031]; figure ! * -----	1-3, 5-11	F24H4/04 F24D3/18 F24D3/08
X	WO 2014/083440 A1 (GAS POINT S R L [IT]) 5 June 2014 (2014-06-05) * page 3, line 6 - page 25, line 25; figures 5-6 * -----	1-3, 5-7, 9, 10	

TECHNICAL FIELDS SEARCHED (IPC)

F24H
F24D

The present search report has been drawn up for all claims

2

Place of search

Munich

Date of completion of the search

18 June 2022

Examiner

Ast, Gabor

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 22 16 1158

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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18-06-2022

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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