(19) Europäisches Patentamt
European Patent Office
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(11) **EP 4 361 523 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
01.05.2024 Bulletin 2024/18

(21) Application number: **23206523.5**

(22) Date of filing: **27.10.2023**

(51) International Patent Classification (IPC):
F24H 8/00 *(2022.01)* ***F24H 9/00*** *(2022.01)*
F24H 9/1836 *(2022.01)* ***F24D 3/18*** *(2006.01)*
F24H 1/36 *(2022.01)*

(52) Cooperative Patent Classification (CPC):
F24H 8/00; F24D 3/18; F24H 9/0015; F24H 9/0031; F24H 9/1836; F24H 1/36

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

(30) Priority: **31.10.2022 IT 202200022365**

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(54) CONDENSING BOILER WITH BURNER AND STORAGE FOR HYBRID PLANTS WITH HEAT PUMP

(57) A condensing boiler (1) for a hybrid plant is described comprising two heat sources, namely said boiler (1) and a heat pump, wherein the boiler (1) is provided with a burner suitable for generating hot flue gas, a bundle of exchanging plates (7), an inlet (41) and an outlet (42) of technical liquid for a room heating apparatus of the hybrid plant. The boiler (1) has a head (2), a bottom (3), and a shell (4) adapted to define an internal volume for the storage of technical liquid. A separation frame (6) is provided in the internal volume of the boiler (1), adapted to divide said internal volume into a first chamber (51) and a second chamber (52).

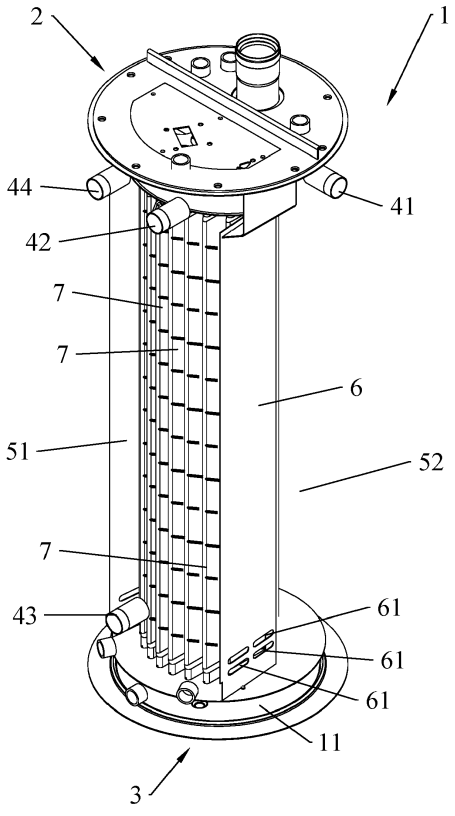

FIG.2

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Description

[0001] The present invention relates to a condensing boiler with a burner and storage for hybrid heat pump plants.

[0002] Recently, hybrid plants, i.e., plants with both an air-water heat pump and a boiler, have become established in the small- and medium-sized heating market, prevalently but not exclusively for domestic use. This is in order to optimize efficiency and operating costs: the heat pump works most of the time, and the boiler intervenes to supplement it or, more often alternatively, as the outside temperature drops, because the capacity and efficiency of the heat pump rapidly decrease in these climatic conditions.

[0003] A heat-pump-only plant would require sizing the machine to meet the heat load at the lowest outside temperatures; this machine would be excessive and operating at unoptimized efficiencies during practically all hours of operation; then, as the outside temperature rises, it would become enormously excessive.

[0004] Hybrid plants permit to drastically reduce the power of the heat pump, choosing it so as to optimize the efficiency and costs, both investment and operational, of the plant.

[0005] Furthermore, the boiler allows the generation of domestic hot water at high temperatures, preventing the heat pump from working at temperatures at which not all heat pumps can operate, and in any case would operate at low efficiencies.

[0006] The highest efficiency of operation is achieved by running the boiler at low outdoor temperatures as a supplement rather than as a substitute for the heat pump; the latter should operate at its maximum output ensuring high efficiency; the boiler should modulate by supplying the load share that the heat pump cannot deliver. With integrated (hybrid) operation, the hours of operation of the heat pump and thus of the total plant efficiency during the winter season are maximized.

[0007] Hybrid plants comprising a heat pump and a condensing boiler comprising a separate inertial storage of technical liquid (e.g., water) are known.

[0008] The heat pump and boiler are in fluid connection with the inertial storage by respective circulation pumps working at different flow rates.

[0009] The heat pump needs a higher flow rate to work effectively, normally over 150 1 (liters) per kW (kilowatts), preferably around 170 1/kW for normal domestic use.

[0010] For the same plant, the boiler circulation pump operates at a much lower flow rate, in the range of 40 1/kW.

[0011] It is also known that heat pumps require the plant to have a water content (technical liquid) such that the compressor can meet the low load at high ambient temperatures without switching off and on frequently after reaching its minimum capacity; in order not to compromise reliability, compressors must not perform more than 5-6 cycles per hour. Furthermore, the amount of water must be sufficient so as not to cool excessively during the defrost cycle, when the plant water is cooled to heat the external heat exchanger and melt the frost formed there. In addition to compromising comfort in the living spaces, excessive cooling could bring water to near-freezing conditions.

[0012] Therefore, it is good practice to equip the hydraulic plant with appropriately sized inertial water storage.

[0013] It is worth noting that said inertial water storage does not correspond to domestic hot water storage, which remains a component of the plant that said inertial storage function cannot perform.

[0014] WO-2022/112661 describes a hybrid plant comprising a first energy source, a second energy source, and an inertial storage of technical liquid.

[0015] US-9341383 describes a hybrid plant comprising a heat pump, boiler, and domestic hot water storage.

[0016] EP-2613098 shows a hybrid plant comprising a heat pump, a condensing boiler, and a bypass line for combined or separate operation.

[0017] WO-2010/058397 describes a hybrid plant comprising a boiler, a heat pump, and an inertial storage of technical liquid.

[0018] EP-1398579 describes a condensing-type boiler for a hybrid plant comprising two heat sources, namely the boiler and a heat pump.

[0019] Disadvantageously, the known hybrid plants are complex, bulky, and most importantly, require a large number of components for their operation, e.g., technical liquid circulation pumps, which greatly reduces the efficiency of the hybrid plant.

[0020] The hybrid plants described in said patent documents comprise a complicated hydraulic plant with significant volumes of moving technical fluid which results in pressure drops and thus wasted energy.

[0021] It is the object of the present invention to make a condensing boiler for a hybrid plant, which is compact and efficient.

[0022] It is a further object of the present invention for said boiler to integrate with standard heat pumps and equipment to produce domestic hot water.

[0023] It is a yet further object of the present invention for the boiler to have a structure, which is simple to assemble and disassemble for maintenance operations.

[0024] According to the invention, said further objects are achieved by a boiler of the condensation type as defined in claim 1.

[0025] Advantageously, the boiler allows the use in series with the heat pump because the technical liquid is the same and is pumped by the same circulating pump, with a flow rate typical of heat pumps needing a high flow rate.

[0026] The hybrid plant comprising the boiler according to the present invention does not need any additional inertial storage of technical liquid, because the internal volume of the boiler is such that it ensures said thermal inertia function.

[0027] Advantageously, hot flue gases move in counter-current with respect to the technical liquid in the boiler.

[0028] The significant integrated storage of technical liquid avoids close cycles of the heat pump compressor and excessive temperature reductions (freezing) during defrosting.

[0029] The heating of technical liquid for domestic water equipment reduces the volume of liquid for said equipment by speeding up the heating of domestic water.

[0030] The hybrid plant using the boiler covered by the present invention also guarantees:

- low pressure drops in series with the heat pump;
- high water flow rate in the boiler, identical to that of the heat pump;
- elimination of hydraulic component duplication: there is a single circulation pump, a single safety valve, a single expansion tank, a single flow meter, and a single air vent.

[0031] These and other features of the present invention will become more apparent from the following detailed description of practical embodiments thereof shown by way of non-limiting examples in the accompanying drawings, in which:

figure 1 shows a perspective view of a boiler according to the present invention;
figure 2 shows a perspective view of the boiler without a shell;
figure 3 shows a side view of the boiler;
figure 4 shows a section view taken along line IV-IV in figure 3;

[0032] A condensing type boiler 1 for a hybrid plant is provided with a head 2, a bottom 3, and a shell 4 adapted to define an internal volume to create a storage of technical liquid, e.g., water.

[0033] The hybrid plant comprises two heat sources, i.e., the boiler and the heat pump.

[0034] As will be more apparent below, the heat pump and the boiler 1 work in series by heating the same technical liquid, which is used to generate room heat by means of a room heating apparatus comprising, for example, common radiators. Very simply, the technical liquid heated by the boiler 1 and/or the heat pump enters the radiators and exchanges heat with the environment, e.g., an apartment.

[0035] Optionally, the hybrid plant may also be provided with equipment to produce domestic hot water, comprising means to exchange heat between the technical liquid and domestic water.

[0036] Consequently, the technical liquid contained in the boiler 1 fulfills the function of technical liquid for both the heat pump, the room heating apparatus, and, possibly, the domestic water equipment.

[0037] No additional inertial storages are provided because the boiler 1 is provided with a sufficient internal volume to perform the same function.

[0038] In detail, with reference to the figures, on the head 2 there is a connection 26 for an external burner (not shown), a flue gas outlet 81 of a flue gas chimney 8, and control and actuation means including a pressure gage 21, a vent valve 22, an ignition electrode 23, a thermometer 24, and a small motor 25 to disperse the flue gases.

[0039] A separation frame 6 is provided in the internal volume (figure 2), preferably C-shaped, which divides said internal volume into a first chamber 51 inside the second outer chamber 52.

[0040] The first chamber 51 contains the bundle of exchanging plates 7, which extends vertically like the separation frame 6, while the second chamber 52 contains a flue gas chimney 8.

[0041] The separation frame 6 is provided with, at the bottom, slots 61 to make a liquid connection between the two chambers 51, 52, in which the same technical liquid is therefore contained.

[0042] The exchanger plates 7, on the other hand, are in gaseous connection with the chimney 8 by means of a liquid-tight lower chamber 11 at the bottom 3 of the boiler 1.

[0043] Figure 1 shows an inlet 41 of the technical liquid coming from a heating apparatus of the hybrid plant, and an outlet 42 of the technical liquid to the same heating apparatus.

[0044] The boiler 1 is further provided with an inlet 43 of the liquid coming from a domestic water heating equipment, preferably part of the hybrid plant, and an outlet 44 of the liquid for said equipment.

[0045] There is also a condensate drain 9 and a safety valve 10 on the shell 4.

[0046] The head 2 further comprises a combustion chamber 21 (below the burner), which is provided with a grid 22 located below for feeding hot flue gas into the exchanger plates 7. The combustion chamber 21 is shaped so that the outlets 42, 44 are close to it so as to efficiently heat the technical liquid shortly before it comes out of the first chamber 51. The combustion chamber 21 is conformed to be lapped by the technical liquid in the first chamber 51.

[0047] Operationally, by means of a single circulation pump (not shown) it is possible to achieve a first circulation of technical liquid in the boiler 1, from the inlet 41 to the outlet 42, along a path that is provided with a descent along the second chamber 52, the passage through the slots 61 and the ascent along the first chamber 51 in contact with the exchanging plates 7.

[0048] In said first circulation, the heating of the technical liquid takes place not only because of the exchanger plates 7 immersed in the moving technical liquid but also because of the flue gas chimney 8, which is in the second chamber 52 and which substantially preheats the technical liquid by optimizing the heat exchange of the heat produced in the combustion chamber; and with counter-current circulation first in the exchanger plates 7 and in

the flue gas chimney 8 afterward, to the flue gas outlet 81.

[0049] The hot flue gas circulation is provided by appropriate means of gaseous circulation (ventilation, not shown) located on the head 2 of the boiler 1.

[0050] Simultaneously with said first circulation of technical liquid, a second circulation of technical liquid from the inlet port 43 to the outlet port 44 may be created to heat domestic hot water.

[0051] It is understood that the second circulation of the technical liquid actually overlaps with the first circulation of technical liquid, which occurs in the first chamber 51, thus generating a single upward current of technical liquid, which heats up in contact with the exchanger plates 7.

[0052] As mentioned above, the domestic water equipment can be operated separately from boiler 1, i.e., the second circulation of technical liquid can be absent.

[0053] Operationally, assuming a hybrid plant able to serve a home, a hybrid plant control unit is adapted to control the temperature outside the dwelling and inside the dwelling.

[0054] It is known that for external temperatures above about 5°C, it is convenient to use a heat pump to heat a home.

[0055] On the other hand, when the external temperature drops, especially below 0°C, the use of the boiler 1 is necessary, possibly in combination with the heat pump.

[0056] Advantageously, the boiler 1 allows the use in series with the heat pump because the technical liquid is the same and is pumped by the same circulating pump, with a typical flow rate for heat pumps needing a high flow rate, over 100 1/kW.

[0057] The hybrid plant comprising the boiler 1 according to the present invention does not need any additional inertial storage of technical liquid, because the internal volume of the boiler 1 is such that it ensures said thermal inertia function.

[0058] Advantageously, in the boiler 1, the hot flue gases move in counter-current with respect to the technical liquid.

[0059] The significant integrated storage of technical liquid, in the order of 50-70 1, avoids close cycles of the heat pump compressor, and excessive temperature reductions (freezing) during defrosting.

[0060] The heating of technical liquid for domestic water equipment reduces the volume of liquid for said equipment by speeding up the heating of domestic water.

[0061] The hybrid plant also guarantees:

- low pressure drops in series with the heat pump;
- high water flow rate in the boiler, identical to that of the heat pump;
- elimination of hydraulic component duplication: there is a single circulation pump, a single safety valve, a single expansion tank, a single flow meter, and a single air vent.

[0062] Advantageously, to optimize hybrid operation, the heat pump and boiler are in series and both crossed by the same flow rate of technical liquid, i.e., the high flow rate required by the heat pump, i.e., over 100 1/kW.

[0063] The boilers normally used have high pressure drops, such that they cannot process the same flow rate of technical liquid as the heat pump, unless two pumps are used in series, which not only significantly decreases efficiency but also increases the costs, in terms of both investment and operation, of the system.

[0064] The boiler 1 according to the present invention can make a hybrid plant with a heat pump in series with the boiler, wherein the hybrid plant comprises a condensing flue gas boiler 1, which, inherently, also constitutes an inertial storage tank of adequate size for the reliable operation of the heat pump, to be installed directly in series therewith, with low pressure drop and thus, traversed by the same high flow rate of technical liquid required by the heat pump.

[0065] The hybrid plant comprising the boiler 1 can operate both with adequate technical liquid content necessary to ensure the reliability of the heat pump and to avoid excessive cooling of the technical liquid during defrosting cycles, and with minimal technical liquid content when serving the domestic hot water equipment, speeding up its heating and therefore reducing the time of availability of domestic hot water at the desired temperature.

[0066] The paths of the technical liquid and flue gases, from combustion to the flue gas outlet 81 of the chimney 8, allow for maximum heat exchange efficiency; they are such as to ensure perfect counter-current flows; flue gas heat is recovered at the highest level from the technical liquid which invests the chimney 8; the shape of the combustion chamber 21 is such as to force water to lap it completely, optimizing heat exchange in the zone with the highest flue gas temperature.

[0067] The boiler 1, designed specifically to operate in series with a heat pump, as a single, coordinated assembly, allows the elimination of the hydraulic component duplication typical of hybrid systems available on the market today, which, by assembling two separate apparatuses, each with their own hydraulic and protection systems, lead, inevitably, to the duplication of hydraulic components (pumps, safety valves, expansion vessels, flow meters, air filling and venting apparatus, etc.). The elimination of duplicate components allows the optimization and a significant reduction in product and installation costs, and thus in the final costs to the customer.

[0068] The boiler 1 is designed to provide the necessary storage for both the operation of the heat pump coordinated with the boiler 1 in heating mode and the heat pump operating in reverse refrigeration cycle by cooling the technical liquid; at the same time, it can provide domestic hot water, in both operating modes.

[0069] The integrated system also saves considerable occupied space.

[0070] The configuration of heat pump and boiler assembly 1 allows optimized control as a system, develop-

ing logic that coordinates the two heat sources in the most efficient manner and with the lowest possible operating cost, under each specific condition.

Claims

1. Condensing boiler (1) for a hybrid plant comprising two heat sources, namely said boiler (1) and a heat pump, wherein the boiler (1) is provided with a burner able to generate hot flue gas, a bundle of exchanging plates (7), an inlet (41) and an outlet (42) for technical liquid for a room heating apparatus of the hybrid plant,

   wherein the boiler (1) is provided with a head (2), a bottom (3) and a shell (4) adapted to define an internal volume suitable for accumulating technical liquid, wherein on the head (2) there are provided a connection (26) for the burner, a flue gas outlet (81) and control and actuation means (21-25) of the boiler (1) which also provides on the bottom (3) a condensate drain (9) and a safety valve (10),
   characterized in that
   a separation frame (6) is provided in the internal volume of the boiler (1), able to divide said internal volume into a first chamber (51) and a second chamber (52),
   wherein the first chamber (51) contains the bundle of exchanging plates (7) which develop vertically like the separation frame (6), while the second chamber (52) contains a flue gas chimney (8),
   wherein the separation frame (6) is provided with, at the bottom, slots (61) to make a liquid connection between the two chambers (51, 52) where the same technical liquid is therefore contained,
   wherein the exchanging plates (7), which are arranged to receive the hot flue gas generated by the burner, are in gaseous connection with the flue gas chimney (8) through a lower chamber (11) that is liquid-tight on the bottom (3) of the boiler (1),
   wherein the boiler (1) is suitable for allowing the circulation of technical liquid in the internal volume, in counter-current with respect to the circulation of the hot flue gas carried out by gaseous circulation means, from the inlet (41) to the outlet (42), along a path that is provided with a descent along the second chamber (52), the passage through the slots (61) and the ascent along the first chamber (51) in contact with the exchanging plates (7).

2. Boiler (1) according to claim 1, **characterized in that** the head (2) also comprises a combustion chamber (21), under the burner, which is provided with a grid (22) located below for the introduction of the hot flue gas in the exchanging plates (7), the combustion chamber (21) being shaped so as to be lapped by the technical liquid in the first chamber (51).

3. Boiler (1) according to claim 2, **characterized in that** the combustion chamber (21) is shaped so that the outlet (42) of the technical liquid is close to it so as to efficiently heat the technical liquid shortly before it comes out of the first chamber (51).

4. Boiler (1) according to any one of the preceding claims, **characterized in that** it is provided with a second inlet (43) and a second outlet (44) for technical liquid for an apparatus for heating domestic water, wherein the boiler (1) is suitable for allowing a further circulation of technical liquid simultaneously with said circulation of technical liquid, from the inlet (43) to the outlet (44) in the first chamber (51) thus generating a single upward current of technical liquid which heats up in contact with the exchanging plates (7).

5. Hybrid plant comprising two heat sources, namely a boiler (1) and a heat pump, liquid circulation means and a room heating apparatus, **characterized in that** the boiler (1) is according to any one of the preceding claims, wherein the heat pump and the boiler (1) work in series by heating the same technical liquid that is used to generate room heat through the room heating apparatus, wherein the internal volume of the boiler (1) is suitable for exhaustively carrying out the inertial storage function of technical liquid of the hybrid plant.

6. Hybrid plant according to claim 5, **characterized in that** it comprises an apparatus for heating sanitary water, wherein the technical liquid for said apparatus is the same technical liquid contained in the boiler (1).

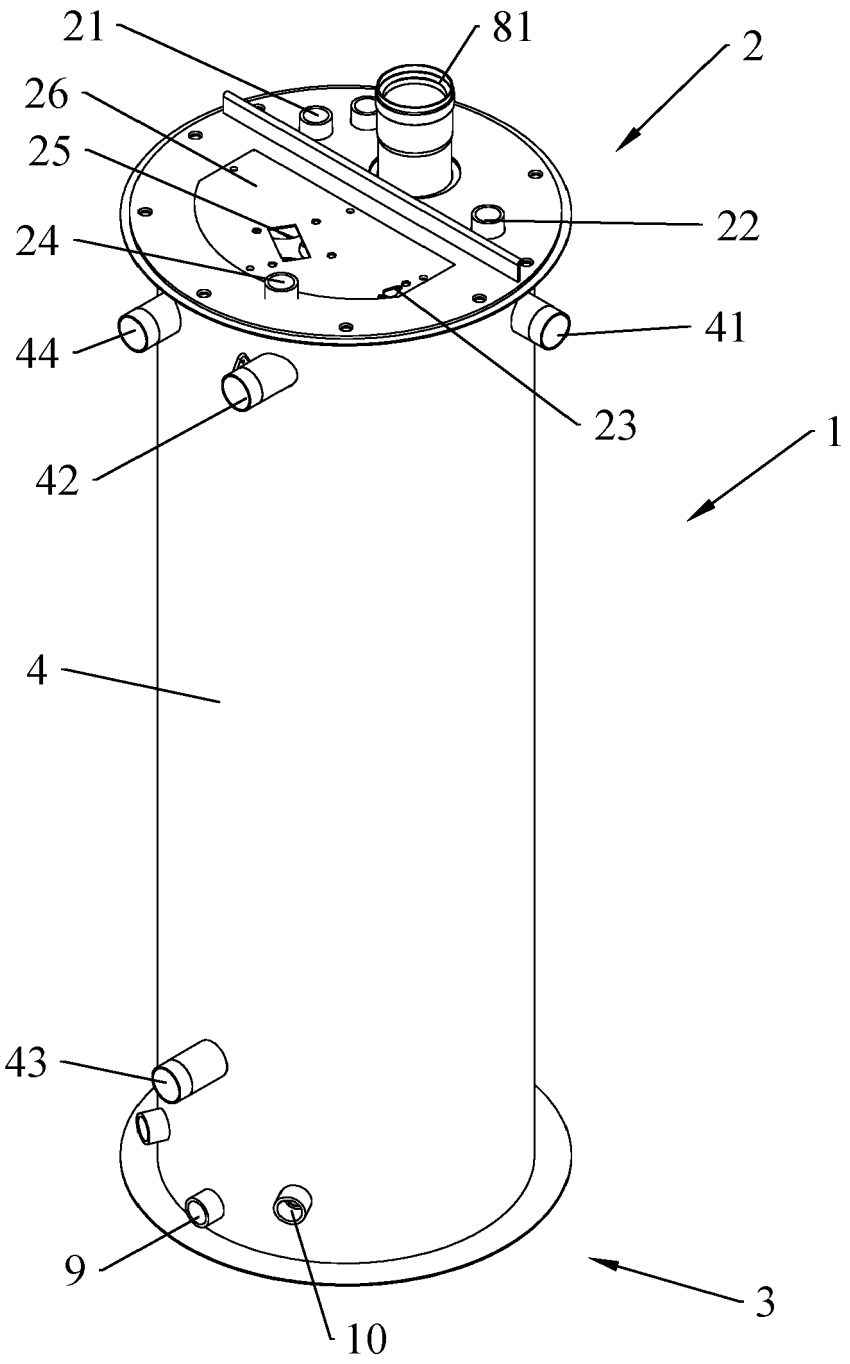

FIG.1

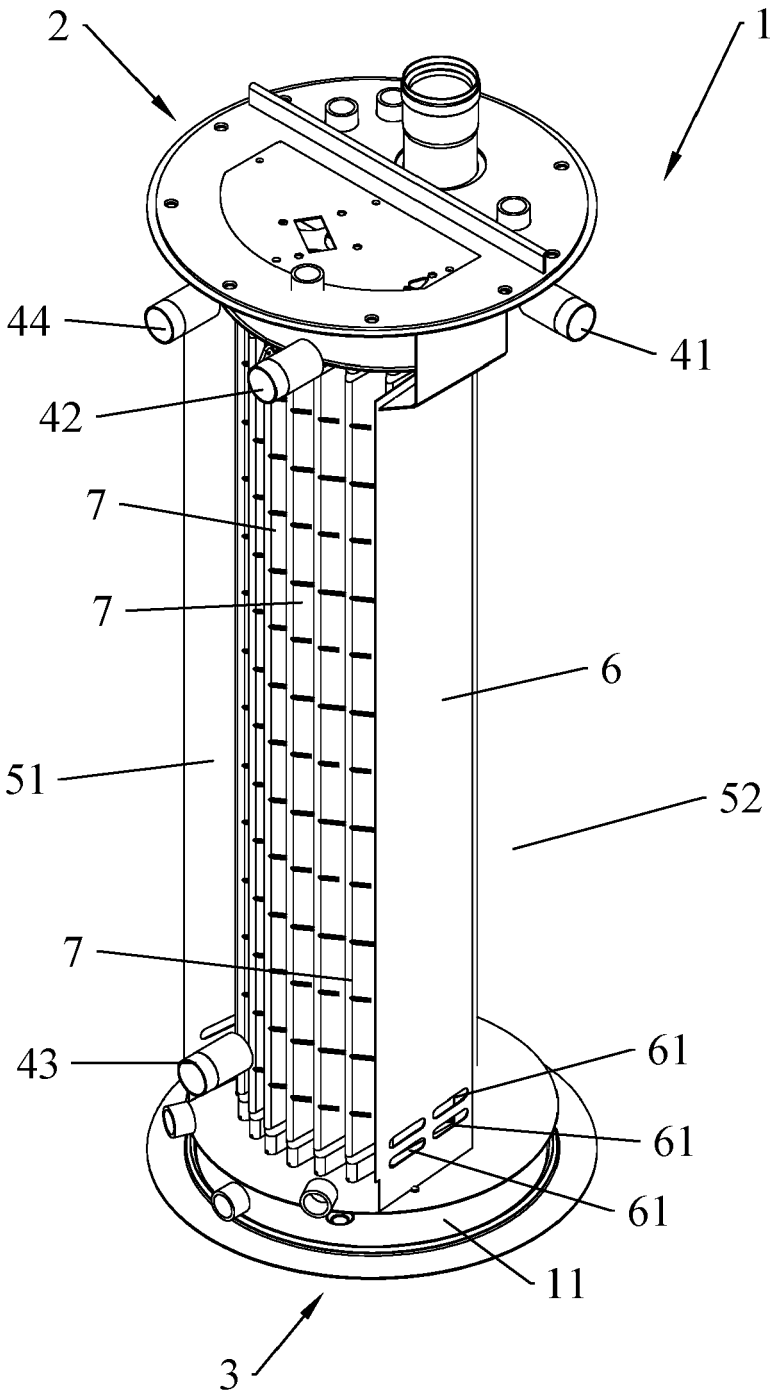

FIG.2

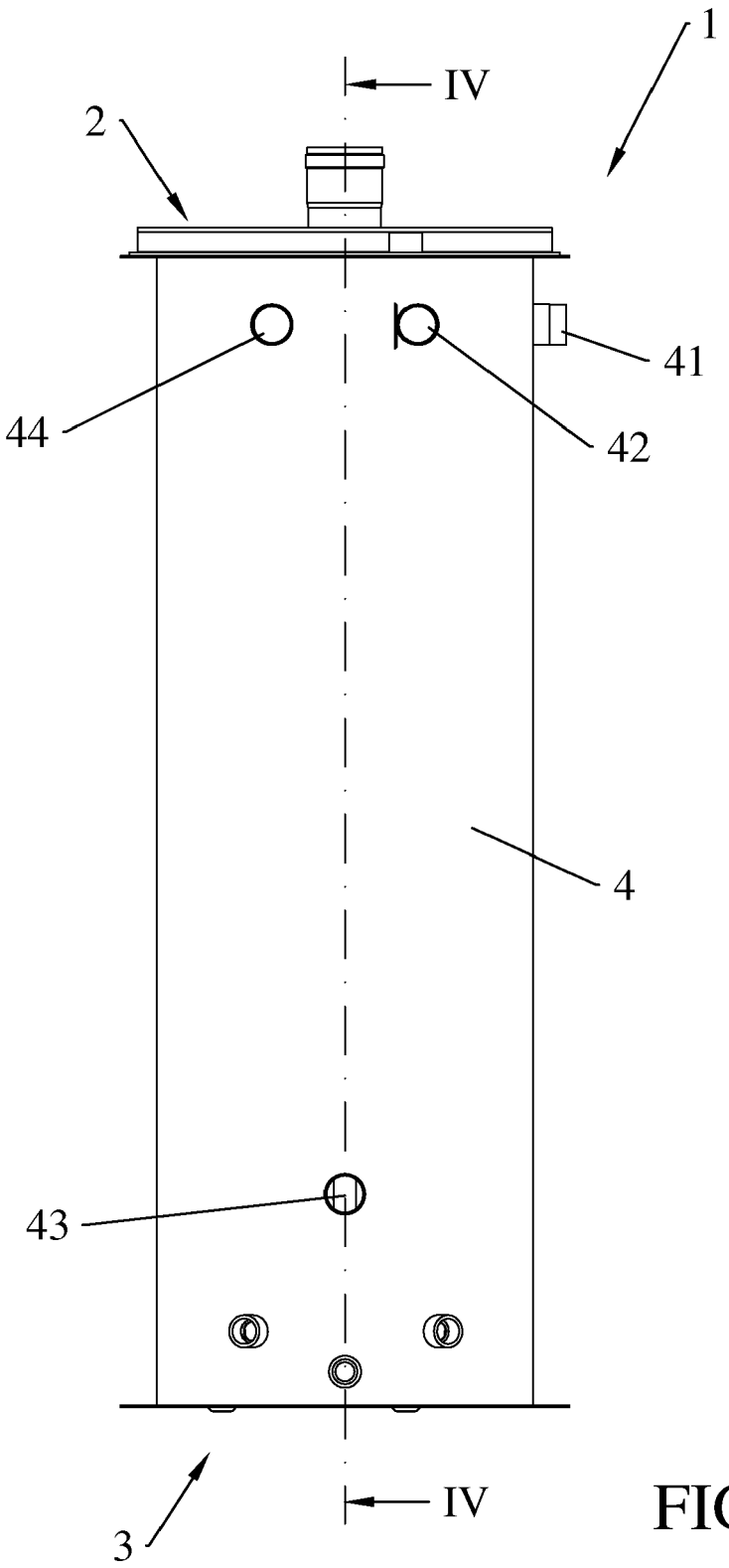

FIG.3

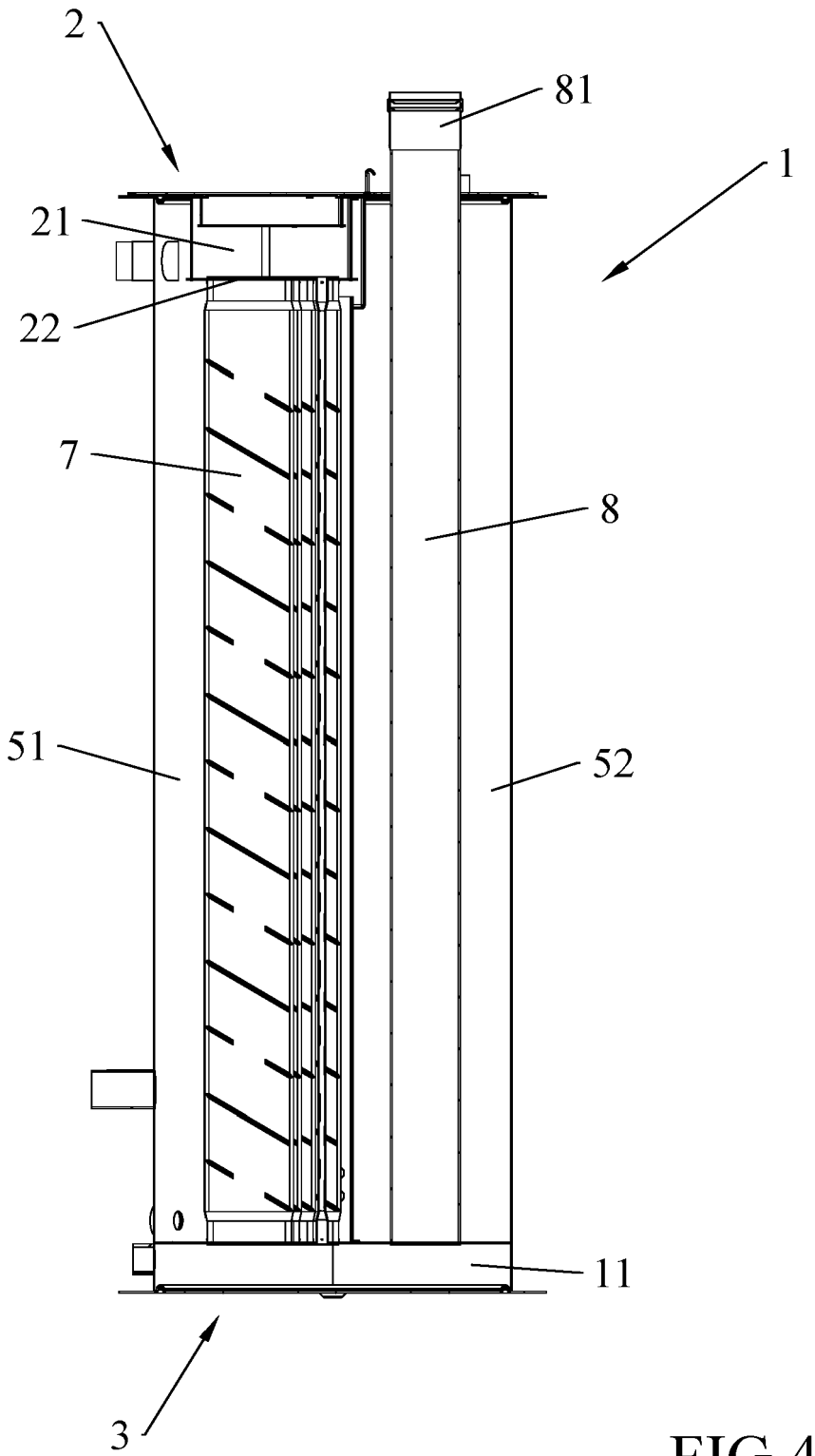

FIG.4

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 6523

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TECHNICAL FIELDS SEARCHED (IPC)

F24H
F24D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 February 2024	Schwaiger, Bernd

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