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(54) GAS COOLING DEVICE

(57) The invention relates to a cooling device for cooling gas in an internal combustion engine, an internal combustion engine with a cooling device and a method for maintaining a cooling device. A Cooling device (1) for cooling a gas in a large internal combustion engine (100) comprises a housing (2) with a gas inlet (3) and a gas outlet (4). The cooling device (1) comprises a first cleaning device (50), wherein the first cleaning device (50) comprises a fluid spray system (51), the fluid spray system (51) comprising at least two arrays (53) of array spray nozzles (52) and comprises at least one valve (54a, 54b), allowing passage only through a part of the arrays (53) of array spray nozzles (52), in particular only to one array (53) of array spray nozzles (52), at a time.

Alternatively or additionally, the cooling device (1) comprises a second cleaning device (10), wherein the second cleaning device (10) comprises at least one first fluid spray nozzle (11), which is arranged downstream a first cooling stage (12) of the cooling device (1) and upstream a second cooling stage (13) of the cooling device (1). Alternatively or additionally the cooling device (1) comprises a third cleaning device (20) wherein the third cleaning device (20) comprises a lubricant spray system (21), preferably comprising at least one lubricant spray nozzle (22), connected or connectable to a lubricant rail (23), preferably arranged close to the gas inlet (3).

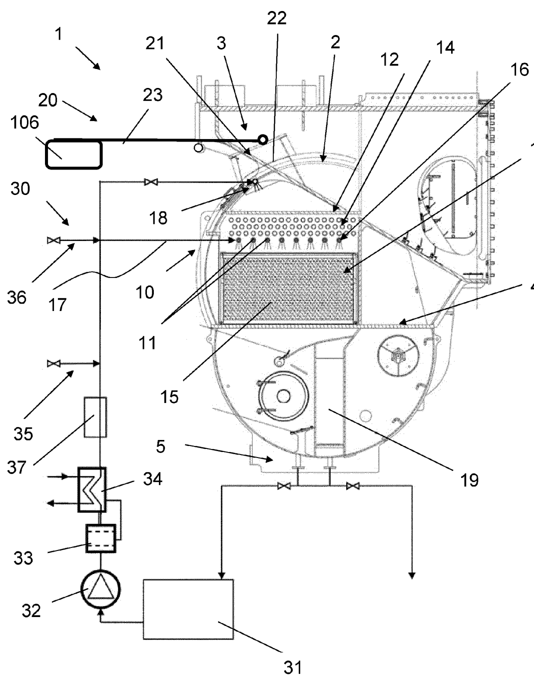

Fig. 3

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Description

[0001] The invention relates to a cooling device for cooling a gas in an internal combustion engine, an internal combustion engine with a cooling device and a method for maintaining a cooling device.

[0002] The present invention preferably relates to an internal combustion engine like a large marine or ship engine or a stationary engine whose cylinders have an inner diameter of at least 200 mm. The engine preferably is a two-stroke engine or a two-stroke cross head engine. The engine can be a diesel or a gas engine, a dual fuel or a multi fuel engine. Burning of liquid and or gaseous fuels in such engines is possible as well as self-igniting or forced igniting.

[0003] The internal combustion engine can be a longitudinally flushed two-stroke engine.

[0004] Typically, the combustion engine comprises at least one cylinder, a cylinder cover, a piston, a fuel supply system, and a scavenging air system. An exhaust valve may be arranged in the cylinder cover being arranged at the top of the cylinder. Exhaust gas may be guided through an exhaust manifold downstream the exhaust valve. The piston is movably arranged in the cylinder along a central axis between bottom dead center and top dead center. Scavenging air inlets may be arranged at the bottom of the cylinder. Scavenging air may be provided by a scavenging air receiver.

[0005] The term internal combustion engine also refers to large engines which can be operated not only in diesel mode, which is characterized by the self-ignition of the fuel, but also in Otto mode, which is characterized by the positive ignition of the fuel, or in mixtures of the two. Furthermore, the term internal combustion engine includes in particular dual-fuel engines and large engines in which the self-ignition of the fuel is used for the positive ignition of another fuel.

[0006] Engine speed is preferably below 800 RPM, especially for 4-stroke engines, and more preferably below 200 RPM, especially for 2-stroke engines, which indicates the designation of low-speed engines.

[0007] Fuel can be diesel or marine diesel oils or heavy fuel oils or emulsions or slurries or methanol or ethanol as well as gases like liquid natural gas (LNG) liquid petrol gas (LPG) and so on.

[0008] Further possible fuels which might be added on request are: LBG (Liquefied Biogas), biological fuels (e. g. oil made from algae or seaweed), ammonia, hydrogen, synthetic fuels from $CO2$ (e. g. made by Power-To-Gas or Power-To-Liquid).

[0009] Large ships, in particular vessels for transport of goods, usually are powered by internal combustion engines, in particular diesel and/or gas engines, mostly two-stroke, cross head engines.

[0010] To reduce the reactivity of gas/air mixture and methane slip, it is known to provide exhaust gas recirculation (EGR), in particular low-pressure exhaust gas recirculation (EGR) as shown for example in EP 3 722 572 A1. A part of the exhaust gas is recirculated into the cylinder, while another part of the exhaust gas is guided to a funnel and is released into the environment.

[0011] Whereas a high pressure EGR path is more or less directly interposed between the exhaust manifold and an intake manifold, the low pressure EGR path may be branched off downstream a turbine of a turbocharger, and recirculated exhaust gas may be guided through a compressor of the turbocharger together with fresh air. Typically, the EGR path is provided with an EGR cooling device.

[0012] A scavenge air cooler may be arranged upstream the air inlets, preferably upstream a scavenge air receiver and downstream a compressor of the turbocharger.

[0013] In case exhaust gas is recirculated, there may be particle matter deposition originating from the combustion on the EGR cooling device and/or on the scavenge air cooler which may cause an increased pressure drop, a reduction of cooling power and/or an early wear.

[0014] It is known to clean cooling devices.

[0015] WO2013165432A1 teaches to remove an EGR cooler from a vehicle and to mount it in a cleaning station. For large engines a removal of the cooler would be uncomfortable or even impossible.

[0016] US8,375,713 B2 discloses a method for dislodging exhaust gas deposits from an EGR cooler by providing an on-board gas source and by providing gas at a superatmospheric pressure to the EGR cooler.

[0017] US2016131088A1 discloses direct injecting of fluid from a reservoir into an EGR cooler. If the EGR cooler is too warm due to the exhaust gas, particularly in case of high loads, the fluid may vaporize without a cleaning effect.

[0018] According to EP3397846B1 for cleaning a charge air cooler water is allowed to condense on the heat exchanger surfaces and dirt is periodically flushed by the condensed water. The temperature of the heat exchanger surfaces has to be adapted accordingly.

[0019] DE 102012009319 A1 concerns a two-stroke large diesel engine with a recirculation gas compressor and a steam turbine coupled thereto. The apparatus comprises one or more nozzles, which inject water into the recirculation line upstream a cooling device, thereby creating a wet environment. The wet environment forms a liquid anti-corrosion protective layer on the walls of the heat exchanger against the adhesion of soot contained in the exhaust gas.

[0020] EP 0701656 B1 discloses a large supercharged diesel engine comprising a recycling passage for returning a part of the exhaust gas to the engine cylinders, wherein the recycling passage includes a unit for humidification of the exhaust gas with water having a number of water atomizer stages.

[0021] The invention is based on the task of providing a gas cooling device and an internal combustion engine which avoid the disadvantages of the known, in particular to provide a gas cooling device, an internal combustion engine and a method for maintaining a cooling device such that the necessity for removing and/or exchanging a polluted cooling device is reduced.

[0022] The object is achieved by the characteristics of the independent claims.

[0023] A cooling device for cooling a gas in a large internal combustion engine comprises a housing, a gas inlet and a gas outlet.

[0024] A large combustion engine comprises at least one cylinder with an inner diameter of at least 200 mm.

[0025] The gas to be cooled may be scavenge air, that is fresh air, a mixture of fresh air and an inert gas or a mixture of fresh air and an exhaust gas. Alternatively, the gas to be cooled may be exhaust gas. The cooling device may be arranged in the internal combustion engine accordingly, for example in a scavenge air path or in an exhaust gas recirculation (EGR) path, in particular in a low-pressure exhaust gas recirculation (lp-EGR) path or in a high-pressure exhaust gas recirculation (hp-EGR) path.

[0026] The cooling device preferably comprises at least one cooling stage, preferably two cooling stages. The at least one cooling stage is arranged in the housing, such that gas to be cooled may enter the housing via the gas inlet, may pass the at least one cooling stage and may leave the housing via the gas outlet.

[0027] In the at least one cooling stage heat is transferred from the gas to be cooled to the cooling device.

[0028] Heat may be transferred to a fluid, such as air or water, or to a heat-conducting material, such as a metal.

[0029] The cooling device comprises a first cleaning device, wherein the first cleaning device comprises a fluid spray system. The fluid spray system comprises at least two arrays of array spray nozzles and comprises at least one valve.

[0030] The at least one valve allows passage only through a part of the arrays of array spray nozzles, in particular only to one array of array spray nozzles, at a time.

[0031] Preferably each array of array spray nozzles is fluidly connected to a respective valve. The cooling device may comprise a multi-way valve for clearing and closing the path to a respective array of array spray nozzles.

[0032] Thus, a fluid can be guided to the cooling device only through a part of a total number of array spray nozzles at a time. This allows for a reduction of the flow rate of the fluid.

[0033] The at least one valve may be controlled by a control unit.

[0034] The flow rate of the fluid may range from 100 l/h to 8000 l/h, preferably from 200 l/h to 6000 l/h, more preferably from 400 l/h to 4000 l/h.

[0035] Fluid, in particular water-based fluid or water, injected into the cooling device may condense on the cooling stage and may form a protective layer, which prevents a fouling of the cooling stage surface. Additionally or alternatively, pollutants may be washed away form the surface.

[0036] Array spray nozzles may be arranged on parallel spray lances. Preferably, at least five, more preferably at least seven, array spray nozzles are arranged on a lance. The array spray nozzles may be arranged equidistantly.

[0037] Each spray lance or a combination of spray lances may define a respective array of array spray nozzles.

[0038] Each spray lance may comprise or may be connected to a valve, or a group of spray lances may comprise or may be connected to a valve. The valves may be controlled by a control unit, such that only a part of the spray lances is active at a time.

[0039] For example, either first spray lances or second spray lances, each of the second spray lances arranged next to a first spray lance, are active alternately.

[0040] The ratio between the diameter of the inner diameter of the spray lance and the opening diameter of the array spray nozzle may range between 10 and 60, preferably between 20 and 50.

[0041] The inner diameter of the spray lance may range from 10mm to 70mm, in particular from 32mm to 50mm. The spray lances may have a constant inner diameter over the length of the spray lance. Alternatively, the inner diameter may vary in dependence of the distance to the valve, in order to provide a constant fluid pressure and/or a constant fluid flow along the spray lance.

[0042] The array spray nozzles may have an opening diameter ranging from 0.5mm to 2.5mm, in particular from 1mm to 1.6mm.

[0043] All array spray nozzles may have the same opening diameter. Alternatively, the opening diameter may vary in dependence of the distance to the valve, in order to provide a constant fluid pressure and/or a constant fluid flow along the spray lance and/or over the array of spray nozzles.

[0044] The valves may be controlled such that for forming a protective film only a part of the array spray nozzles is active and for washing away pollutants all array spray nozzles are active.

[0045] The valves may be controlled such that no fluid is emitted to the cooler, such that an intermitted injection can be achieved. The valves may be controlled such that, for example depending on the temperature of the gas to be cooled, on the engine load, on ambient conditions and/or on the type of fuel, more or less array spray nozzles may be set active at a time. This way, a higher or a lower flow rate of the fluid can be selected.

[0046] Cleaning fluid may hence be saved, if possible.

[0047] The spray lances may be arranged on a holder or a fixation element which reduces vibration. The holder or the fixation element may comprise a vibration damper which absorbs vibration, in particular emanating from the varying fluid flow.

[0048] Alternatively or additionally, the cooling device comprises a second cleaning device comprising at least one first fluid spray nozzle, which is arranged downstream a first cooling stage of the cooling device and upstream a second cooling stage of the cooling device.

[0049] Concerning the position of the first fluid spray nozzle the terms "downstream" and "upstream" are used with respect to the flow direction of the gas to be cooled in the cooling device.

[0050] The first fluid spray nozzle preferably is a water spray nozzle. Typically, the gas to be cooled cools down when passing the first cooling stage. Depending on the temperature of the gas to be cooled entering the gas inlet, the first cooling stage may be heated up to a degree such that any water would evaporate immediately if sprayed on the first stage. Typically, this degree of temperature may be reached during operation of the engine.

[0051] Thus, a fluid spray nozzle arranged close to the gas inlet may have no or only a marginal cleaning effect during operation and may only be used when the engine is not operating or is operated with low load.

[0052] Downstream the first cooling stage the gas to be cooled may have reached a temperature which does not cause the cleaning water to evaporate. The first fluid spray nozzle provides for cleaning the second cooling stage by washing away pollutants and may be used also during operation of the engine and the cooling device.

[0053] The second cleaning device provides for a cleaning of the second cooling stage arranged downstream a first colling stage. In a downstream cooling stage a potential contamination is more critical since the open fluid diameter, defined by the spacing between the heat exchange elements, generally is smaller than in upstream cooling stages.

[0054] Thus, the second cleaning device provides for a very effective cleaning.

[0055] The first cleaning device may be arranged upstream of a first cooling stage. Alternatively, the first cleaning device may be arranged downstream a first cooling stage of the cooling device and upstream a second cooling stage of the cooling device and may form a second cleaning device as described above.

[0056] Additionally or alternatively the cooling device comprises a third cleaning device comprising a lubricant spray system connected or connectable to a lubricant rail. The lubricant spray system preferably comprises at least one lubricant spray nozzle. Within this application a lubricant may comprise any hydrocarbon based liquid.

[0057] At least the lubricant spray system of the third cleaning device may be arranged close to the gas inlet. The lubricant may be distributed within the cooling device by the gas to be cooled.

[0058] Spray nozzles may be arranged within the cooling device to spray lubricant evenly to the inner surfaces of the cooling device.

[0059] The lubricant spray system of the third cleaning device may alternatively be arranged outside the housing of the cooling device and upstream of the gas inlet, such that the lubricant is transferred into the cooling device with the gas to be cooled.

[0060] The lubricant typically has a high evaporating temperature, such that it keeps its cleaning function even when the gas to be cooled still has a high temperature. So, also the third cleaning device may be used during operation of the cooling device, even when the lubricant spray system of the third cleaning device is arranged upstream of all cooling stages, that is at the hot end of the cooler, for example upstream or within a first cooling stage.

[0061] The lubricant rail may be connected or connectable to an engine lubricant supply system of the internal combustion engine, which also provides cylinder oil for the cylinder.

[0062] The lubricant forms a film on the cooling device and wets the surface of downstream the cooling stages. Hence, the surfaces are kept clean from deposits. Draining lubricant may remove any pollutants from the cooling device.

[0063] The lubricant may comprise detergents for cleaning the surface of the cooling stage.

[0064] The cooling device may comprise only one cooling stage, preferably a shell-and-tube cooler.

[0065] The cooling device may comprise a first cooling stage arranged upstream a second cooling stage. The cooling stages are thus arranged such that a gas to be cooled is first guided through the first cooling stage and then through the second cooling stage

[0066] The first cooling stage is arranged downstream the gas inlet and the second cooling stage is arranged upstream the gas outlet, with respect to the flow direction of the gas to be cooled. Both cooling stages may be arranged in the same housing.

[0067] The first cooling stage may be arranged above the second cooling stage. Cleaning fluid may drain through the second cooling stage and may be collected at the lowest point of the second cooling stage.

[0068] Lubricant may drain through the second cooling stage or through the first and the second cooling stage and may be collected at the lowest point of the second cooling stage.

[0069] A fluid collecting zone may be arranged downstream the second cooling stage, preferably below the second cooling stage.

[0070] The fluid collecting zone may be part of a fluid recirculation system, which may comprise a tank, at least one pump, a cooling device for cooling the fluid and/or a separator for separating lubricant.

[0071] The first cooling stage may comprise cooling tubes whereas the second cooling stage may comprise fins and preferably tubes.

[0072] Typically, the open flow diameter for the gas to be cooled is way larger in the first cooling stage than in the second cooling stage. Hence the risk for a detrimental pollution is higher in the second cooling stage. Thus, the arrangement of the first fluid spray nozzle downstream the first cooling stage and upstream the second cooling stage provides for a reasonable cleaning effect.

[0073] The at least two arrays of array spray nozzles may be arranged in a plane. Preferably, spray lances defining an array of array spray nozzles are arranged in parallel and in a plane.

[0074] A plurality of first fluid spray nozzles may be arranged in a first spray nozzle array. The spray nozzle array may be a planar spray nozzle array. Spray nozzles may be evenly arranged above the second cooling stage.

[0075] At least a part of the first spray nozzles may be connected by a common rail. Preferably, all first fluid spray nozzles of the first spray nozzle array are connected by at least one common rail.

[0076] A plurality of lubricant spray nozzles may be arranged in a second, particularly planar, spray nozzle array. The spray nozzles may be evenly arranged above the first cooling stage.

[0077] The cooling device may comprise at least one second fluid spray nozzle, preferably a water spray nozzle, which is arranged close to the gas inlet for providing a cooling fluid, preferably a water-based cleaning fluid. The second fluid spray nozzle may be used for cleaning the first cooling stage when the engine is not operating or when the engine is operated with low load. The second fluid spray nozzle may also be used to wash away lubricant remnants which were supplied by the third cleaning device.

[0078] The first fluid spray nozzle, and preferably at least one second fluid spray nozzle, which is arranged close to the gas inlet, may be connected or connectable to a fluid supply system.

[0079] The fluid supply system may comprise at least one of a tank containing a reservoir of cleaning fluid such as water, a pump, a filter for separating particulate matter, a heat exchanger for controlling a specific temperature range, a chemical dosing feed and a water feed. Water may be mixed with a cleaning agent. The tank may be coupled to a heater to reduce the risk of ice formation within the reservoir.

[0080] Cleaning water, drained below the cooling stages, may be collected, filtered and recirculated within the fluid supply system.

[0081] According to the invention, an internal combustion engine, namely a large vessel engine or a stationary engine, preferably is a two-stroke engine or a two-stroke cross head engine, may comprise at least one cylinder having an inner diameter of at least 200mm and may further comprise a cooling device for cooling gas as described above.

[0082] Within the internal combustion engine the cooling device may be arranged as a scavenge air cooler for cooling scavenge air.

[0083] Alternatively or additionally the internal combustion engine may comprise a system for exhaust gas recirculation and the gas cooling device may be arranged as an EGR cooling device. The gas cooling device may be arranged within the EGR path.

[0084] The internal combustion engine may comprise a control unit for setting the valves in order to control the fluid spray system and to allow passage only through a part of the arrays of array spray nozzles at a time.

[0085] The internal combustion engine may comprise an engine lubricant supply system. The internal combustion engine may comprise a lubricant spray system which is connected to the engine lubricant supply system.

[0086] According to the invention, a method for maintaining a cooling device for cooling gas, preferably as described above, more preferably in a combustion engine as described above, comprises the steps of cleaning and/or of preventing contamination.

[0087] For cleaning, a water based liquid is sprayed onto a second cleaning stage arranged downstream a first cleaning stage of the cooling device by at least one first fluid spray nozzle arranged between the first cooling stage and the second cooling stage.

[0088] For preventing contamination, and preferably for cleaning, a lubricant is sprayed into and/or within the cooling device. The lubricant may be sprayed in the cooling device, and preferably to at least one cooling stage, close to the inlet.

[0089] The lubricant may be sprayed into and/or within the cooling device and may form a lubricant film on at least a part of the inner surface of the cooling device.

[0090] A water based liquid may be sprayed subsequently into and/or within the cooling device to rinse away a remaining lubricant film, during operation of the engine or when the engine is not operated.

[0091] The lubricant may be sprayed into and/or within the cooling device with a constant rate, preferably from 0.01g/kWh up to 2g/kWh per cylinder, or regularly pulsed, or on demand.

[0092] The spray pressure is larger than the gas pressure in the cooling device, preferably larger than 1bar, more preferably more than 2bar.

[0093] The lubricant may be taken from a list of engine oils and may comprise at least one of a mineral or synthetic base oil, a mineral or synthetic thickener, additives such as detergents, acid neutralizing agents (base species e.g. $CaCO3$), dispersants and antioxidants.

[0094] The lubricant may contain other compounds which are not needed for cleaning or stability of oil but have a function in the primary oil application.

[0095] Further advantageous aspects of the invention are explained in the following by means of exemplary embodiments and the figure. In the drawing, in a schematic manner:

Figure 1: shows a schematic illustration of an internal combustion engine;

Figure 2: shows a schematic illustration of a first example of a gas cooling device in a side view;

Figure 3: shows a schematic illustration of a second example of a gas cooling device in a side view;

Figure 4: shows a schematic illustration of a third example of a gas cooling device in a side view;

Figure 5: shows a schematic illustration of a first

cleaning device in a top view.

[0096] Figure 1 shows a schematic illustration of an internal combustion engine 100. The internal combustion engine 100 comprises one cylinder 101 having an inner diameter 102 of at least 200mm. The internal combustion engine 100 comprises a system for exhaust gas recirculation 104 with an EGR valve 111 and a back pressure valve 112 to control the amount of recirculated exhaust gas.

[0097] The internal combustion engine 100 may comprise two cooling devices 1 for cooling gas, a scavenge air cooler 103 and an EGR cooling device 105.

[0098] The EGR cooling device 105 is arranged in the EGR path 107. In this case the system for exhaust gas recirculation 104 is a low pressure EGR system wherein exhaust gas is branched off downstream a turbine 108 of a turbocharger 109 and guided through the compressor 110 of the turbocharger 109 and the scavenge air cooler 103 together with fresh air.

[0099] At least one of the scavenge air cooler 103 and an EGR cooling device 105 may be a cooling device 1 as shown in figure 1 or 2.

[0100] Figure 2 shows a schematic illustration of a first example of a gas cooling device 1 in a side view.

[0101] The cooling device 1 comprising a housing 2 with a gas inlet 3 and a gas outlet 4. The cooling device 1 comprises a first cooling stage 12 arranged within the housing upstream a second cooling stage 13, being also arranged in the housing 2.

[0102] The first cooling stage 12 comprises cooling tubes 14 and the second cooling stage 13 comprises fins 15, such that the open diameter for the gas to be cooled becomes smaller in the way through the cooling device 1. With relatively small spacings between fins 15 bear the risk of clogging when contaminants stick to the surface.

[0103] Thus, it is of major interest to keep the second cooling stage 13 clean.

[0104] The cooling device 1 comprises a second cleaning device 10, wherein the second cleaning device 10 comprises a plurality of fluid spray nozzles 11 arranged in a first spray nozzle array 16 and being connected by a common rail 17.

[0105] The fluid spray nozzles 11 are arranged downstream the first cooling stage 12 and upstream the second cooling stage 13.

[0106] In a separating stage 19 downstream the second cooling stage 13, liquid is separated from the cooled gas, such that the cooled gas is dried.

[0107] A fluid collecting zone 5 is arranged below the second cooling stage 13.

[0108] The cooling device 1 comprises a second fluid spray nozzle 18, which is arranged close to the gas inlet 3.

[0109] Both, the first fluid spray nozzles 11 and the second fluid spray nozzle 18, are connected to a fluid supply system 30.

The fluid supply system 30 comprises a tank 31, a pump 32, a filter 33, a heat exchanger 34, a chemical dosing feed 35 and a water feed 36. Water collected in the fluid colleting zone can be guided into the tank, such that there is a fluid recirculation system. The filter 33 provides for separating contaminants detached from the second cooling stage.

[0110] Figure 3 shows a schematic illustration of a second example of a gas cooling device 1 in a side view.

[0111] The cooling device 1 in the one hand comprises a second cleaning device 10 as shown in figure 2 and described with respect to figure 2. Thus, in figure 3 the same reference numbers are used.

[0112] The cooling device 1 further comprises a third cleaning device 20 wherein the third cleaning device 20 comprises a lubricant spray system 21 with a lubricant spray nozzle 22. The lubricant spray nozzle 22 is arranged upstream of the gas inlet 3.

[0113] The lubricant spray system 21 is connected to a lubricant rail 23 which is connected to an engine lubricant supply system 106.

[0114] Lubricant may be provided to the cooling device and may form a film in the surfaces of the first cooling stage 12 and the second cooling stage 13, such that contaminants are prevented from sticking.

[0115] Rinsing lubricant transports contaminants into the fluid collecting zone 5.

[0116] The lubricant may be washed from the cooling stages 12, 13 by water provided by second spray nozzles 18.

[0117] Lubricant may be separated from cleaning water in a lubricant separator 37.

[0118] While the second cleaning device 10 provides for cleaning the second cooling stage 13 also during engine operation, the third cleaning device 20 provides for preventing contamination and for cleaning of the first cooling stage 12 and the second cooling stage 13.

[0119] Figure 4 shows a schematic illustration of a third example of a gas cooling device 1 in a side view.

[0120] The cooling device 1 comprises only a single cooling stage 13.

[0121] A first cleaning device 50 is arranged upstream the cooling stage 15 comprising a fluid spray system 51.

[0122] The fluid spray system 51 comprising at least two arrays 53 of array spray nozzles 52 comprises at least one valve 54a, 54b (see figure 5), allowing passage only through a part of the arrays 53 of array spray nozzles 52 at a time.

[0123] The array spray nozzles 52 are connected to a fluid supply system 30 as shown in Figures 2 and 3.

[0124] Figure 5 shows a schematic illustration of an example for a first cleaning device 50 for use in a gas cooling device 1 as shown in Figure 4 in a top view.

[0125] The first cleaning device 50 comprises a group of spray lances 55a and a group of spray lances 55b arranged alternately and in parallel in the same plane. Each of the spray lances 55a, 55b comprises array spray nozzles 52 not explicitly shown in Figure 5. Each of the spray lances 55a, 55b defines an array 53 of array spray nozzles 52.

[0126] The first cleaning device 50 further comprises valves 54a, 54b which are in fluid connection with a respect group of spray lances 55a, 55b. The valves 54a, 54b are controlled by a controlled unit 56 and can be set, such that fluid is either guided through the first group of spray lances 55a or through the second group of spray lances 55b.

[0127] This allows an insertion of fluid which is uniformly distributed over the cooling stage with a reduced fluid flow, as compared to the floating of all spray lances 55a, 55b.

[0128] Alternatively, the valves 54a, 54b may be set such that in intermitted fluid release with a full flow, a partial flow or no flow is allowed.

[0129] In this schematic drawing only four spray lances 55a, 55b are shown. Of course, the first cleaning device 50 may comprise a suitable number of spray lances 55a, 55b grouped in a number of bundles with a corresponding number of spray lances 55a, 55b, each of the bundle connected to a valve 54a, 54b.

Claims

1. Cooling device (1) for cooling a gas in a large internal combustion engine (100), the cooling device (1) comprising a housing (2) with a gas inlet (3) and a gas outlet (4), **characterized in that**

   - the cooling device (1) comprises a first cleaning device (50), wherein the first cleaning device (50) comprises a fluid spray system (51), the fluid spray system (51) comprising at least two arrays (53) of array spray nozzles (52) and comprises at least one valve (54a, 54b), allowing passage only through a part of the arrays (53) of array spray nozzles (52), in particular only to one array (53) of array spray nozzles (52), at a time,
   and/or
   - the cooling device (1) comprises a second cleaning device (10), wherein the second cleaning device (10) comprises at least one first fluid spray nozzle (11), which is arranged downstream a first cooling stage (12) of the cooling device (1) and upstream a second cooling stage (13) of the cooling device (1),
   and/or
   - the cooling device (1) comprises a third cleaning device (20) wherein the third cleaning device (20) comprises a lubricant spray system (21), preferably comprising at least one lubricant spray nozzle (22), connected or connectable to a lubricant rail (23), preferably arranged close to the gas inlet (3).

2. Cooling device according to claim 1, wherein the cooling device (1) comprises a first cooling stage (12) arranged upstream a second cooling stage (13), being arranged in the housing (2).

3. Cooling device according to claim 2, wherein the first cooling stage (12) is arranged above the second cooling stage (13) .

4. Cooling device according to one of claims 2 or 3, wherein a fluid collecting zone (5) is arranged downstream the second cooling stage (13), preferably below the second cooling stage (13).

5. Cooling device according to one of claims 2 to 4, wherein

   the first cooling stage (12) comprises cooling tubes (14) and/or
   the second cooling stage (13) comprises fins (15) and/or tubes.

6. Cooling device according to one of the preceding claims, wherein

   - the arrays of array spray nozzles are arranged in a plane,
   and/or
   - a plurality of first fluid spray nozzles (11) is arranged in a first, particularly planar, spray nozzle array (16), preferably connected by a common rail (17),
   and/or
   - a plurality of lubricant spray nozzles (22) is arranged in a second, particularly planar, spray nozzle array (24) .

7. Cooling device according to one of the preceding claims,
wherein

   the array spray nozzles (52)
   and/or
   the first fluid spray nozzle (11),
   and preferably at least one second fluid spray nozzle (18), which is arranged close to the gas inlet (3),
   are connected or connectable to a fluid supply system (30).

8. Cooling device according to claim 7, wherein the fluid supply system (30) comprises at least one of a tank (31), a pump (32), a filter (33), a heat exchanger (34), a chemical dosing feed (35) and a water feed (36).

9. Internal combustion engine (100), namely a large vessel engine or a stationary engine, preferably is a two-stroke engine or a two-stroke cross head engine,

the internal combustion engine (100) comprising at least one cylinder (101) having an inner diameter (102) of at least 200mm,
wherein the internal combustion engine (100) comprises a cooling device (1) for cooling gas according to at least one of the preceding claims.

10. Internal combustion engine according to claim 9,

wherein the cooling device (1) is arranged as a scavenge air cooler (103)
and/or
wherein the internal combustion engine (100) comprises a system for exhaust gas recirculation (104) and the gas cooling device (1) is arranged as an EGR cooling device (105) .

11. Internal combustion engine according to claim 9 or claim 10, wherein the internal combustion engine (100) comprises a lubricant spray system (21) which is connected to an engine lubricant supply system (106).

12. Method for maintaining a cooling device for cooling gas, preferably according to one of claims 1-8, more preferably in a combustion engine according to one of claims 9-11, comprising the steps of cleaning and/or of preventing contamination,

- wherein for cleaning a water-based liquid is sprayed successively onto a cooling stage (12, 13) through different arrays of the at least two arrays of spray nozzles (52);
and/or
- wherein for cleaning a water-based liquid is sprayed onto a second cleaning stage (13) arranged downstream a first cleaning stage (12) of the cooling device (1) by at least one first fluid spray nozzle (11) arranged between the first cooling stage (12) and the second cooling stage (13) ;
and/or
- wherein for preventing contamination, and preferably for cleaning, a lubricant is sprayed into and/or within the cooling device (1).

13. Method according to claim 12, wherein
a lubricant is sprayed into and/or within the cooling device (1) and forms a lubricant film on at least a part of the surface of the cooling device (1), and preferably a water based liquid is sprayed subsequently into and/or within the cooling device (1) to remove the lubricant film.

14. Method according to claim 12 or 13, wherein
a lubricant is sprayed and/or within the cooling device with a constant rate, preferably from 0.01g/kWh up to 2g/kWh per cylinder, or regularly, or on demand.

15. Method according to claim 13, wherein the lubricant comprises at least one of a mineral or synthetic base oil, a mineral or synthetic thickener, additives such as detergents, acid neutralizing agents (base species e.g. CaCO3), dispersants and antioxidants.

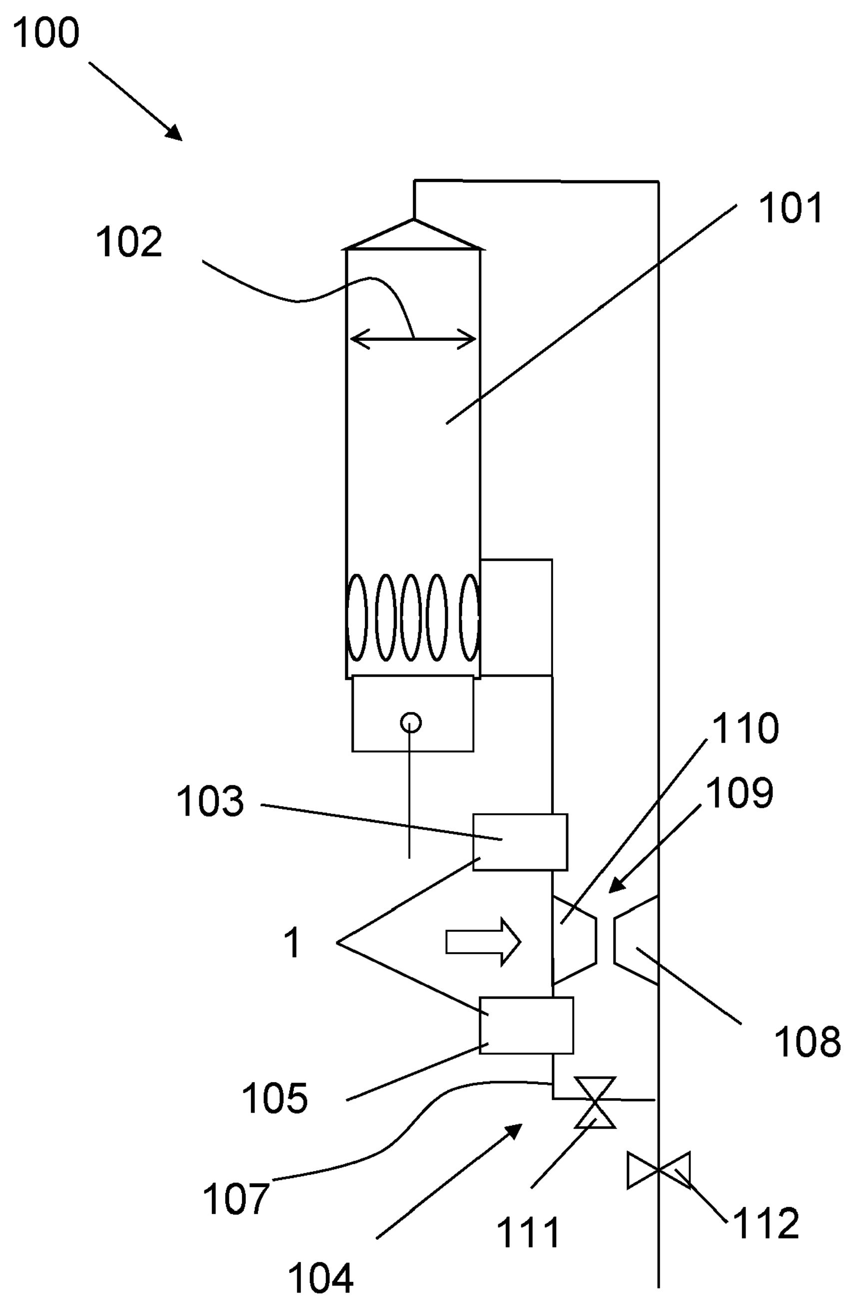

Fig. 1

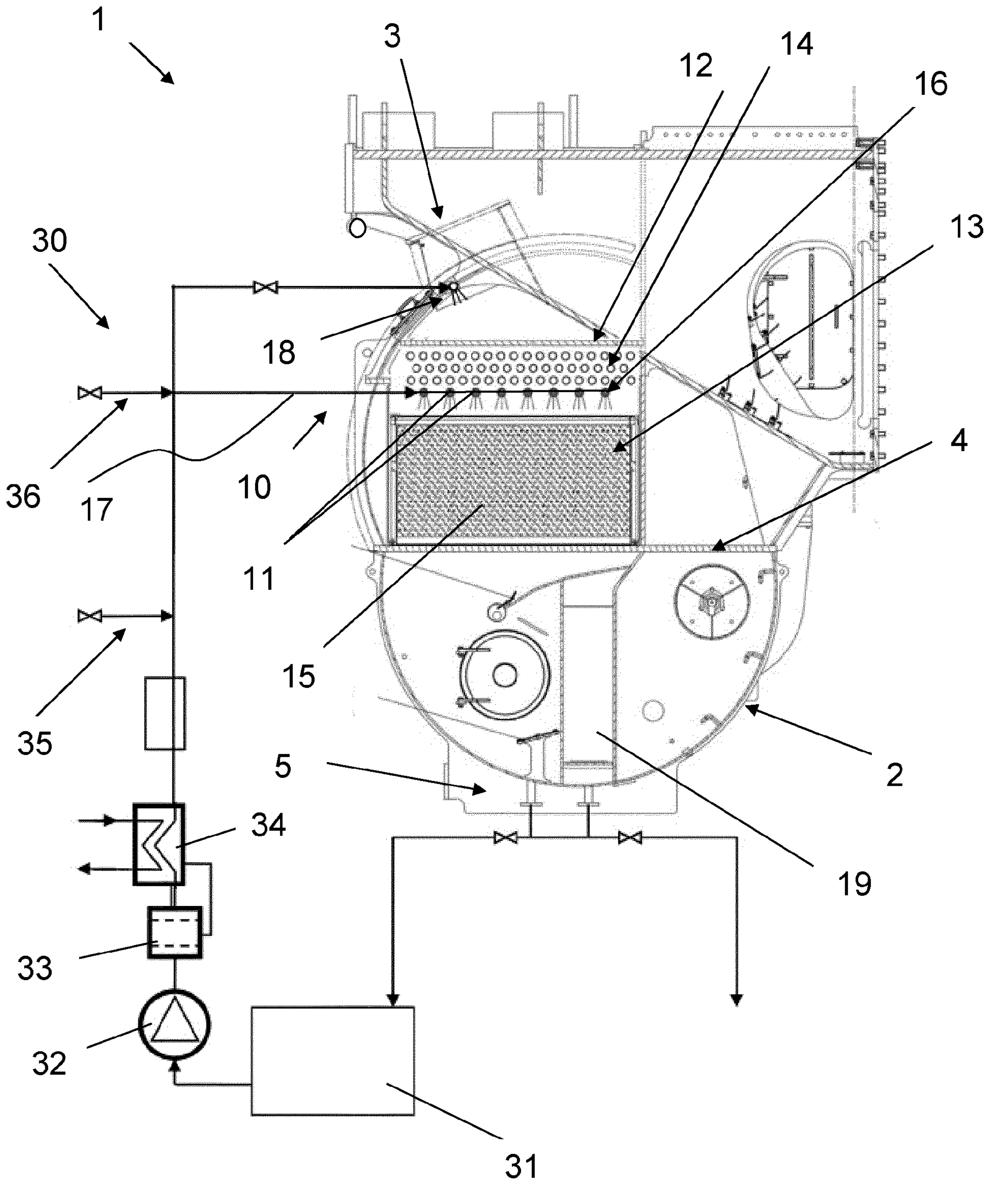

Fig. 2

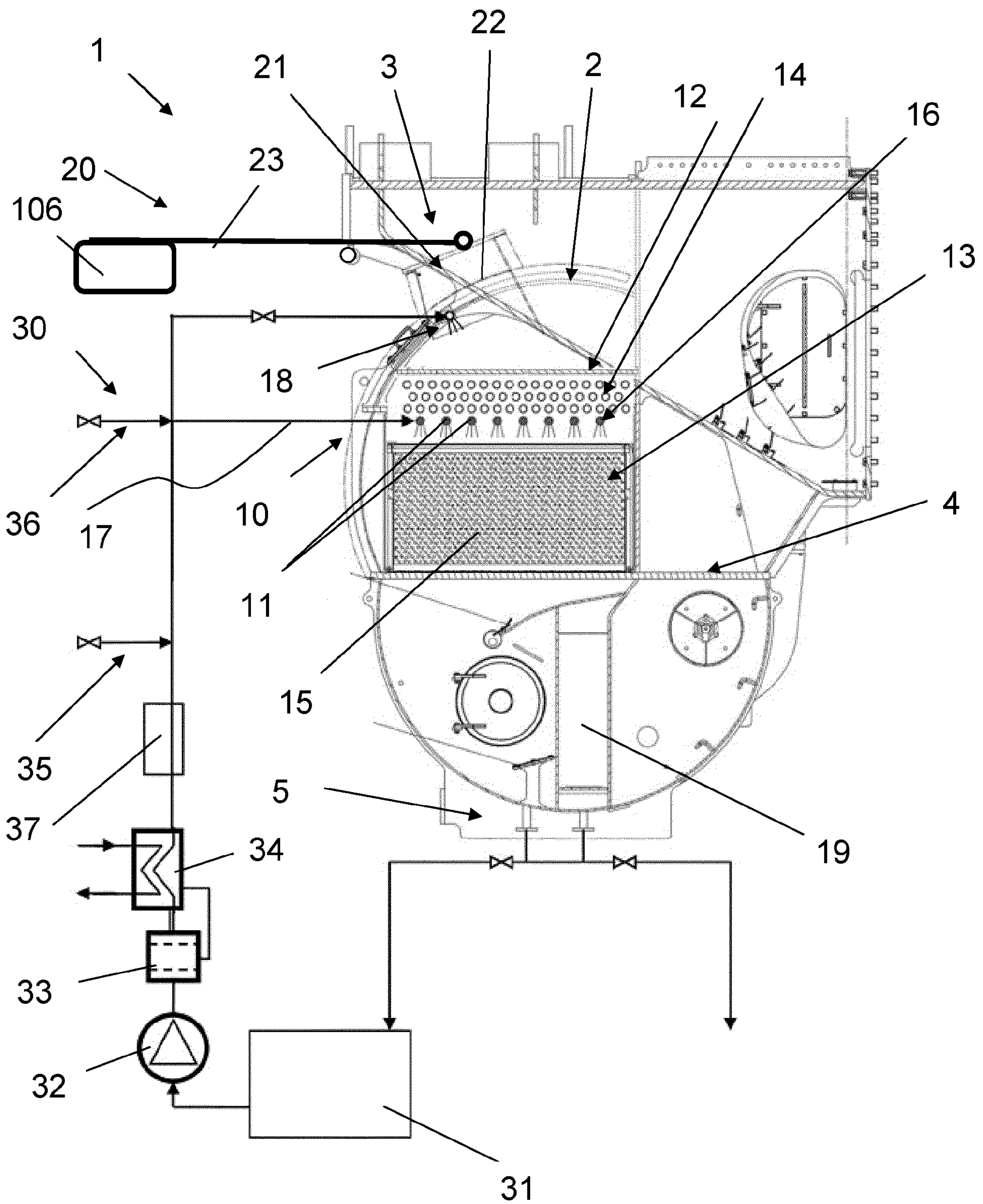
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Fig. 3

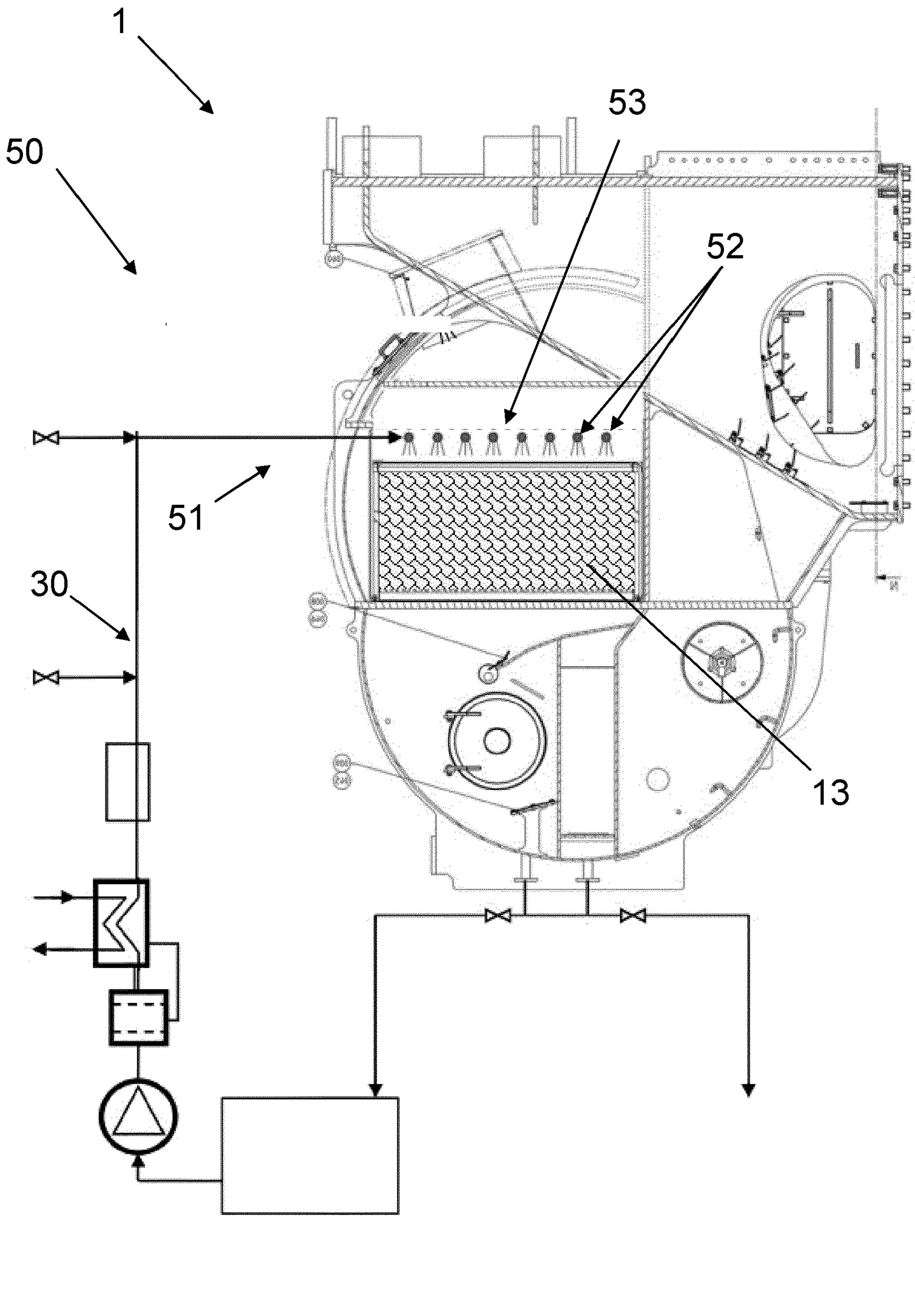

Fig. 4

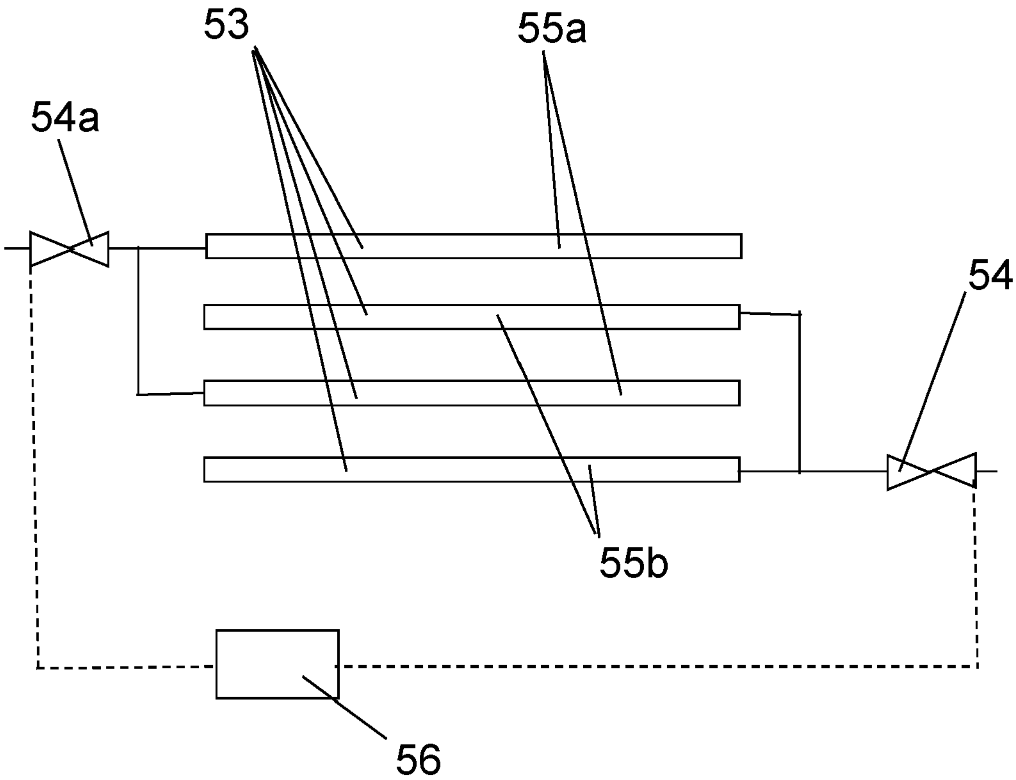

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	2 February 2024	Juvenelle, Cyril

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