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(54) **IMPROVED COOLING SYSTEM FOR AN INTERNAL COMBUSTION ENGINE**

(57) Cooling system (1) for cooling an internal combustion engine (2) for a vehicle, the cooling system (1) comprising at least a pump (3), a heat exchanger (4), an engine assembly (2) and at least one operative module (11), the pump (3) comprising a first opening (3a) fluidly connected to heat exchanger (4), engine assembly (2) and at least one operative module (11) each being respectively fluidly connected to heat exchanger (4), pump (3) further comprising a second opening (3b) fluidly connected to respectively engine assembly (2) and at least

one operative module (11), s engine assembly (3) and at least one operative module (11) being placed in parallel one with respect to the other between heat exchanger (4) and pump (3) cooling system (1) further comprising flow control means (12) respectively fluidly interposed between engine assembly (2) and heat exchanger (4) for reducing the flow which may pass between the aforementioned elements between predefined maximum and minimum values.

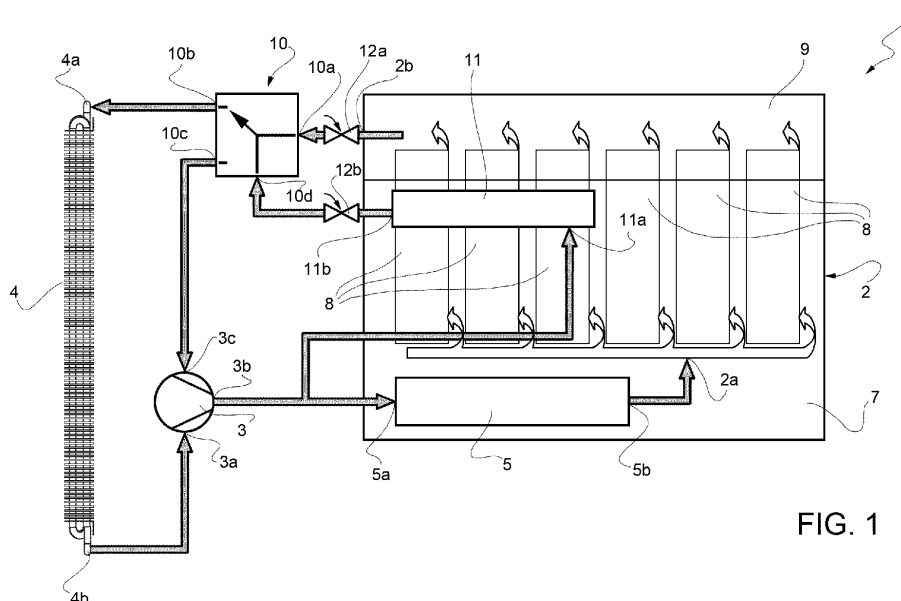


FIG. 1

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims priority from Italian patent application no. 102019000000559 filed on January 14, 2019.

TECHNICAL FIELD

[0002] The present invention concerns a cooling system, in particular an improved cooling system for an internal combustion engine of a vehicle.

BACKGROUND OF THE INVENTION

[0003] The internal combustion engine of a vehicle needs to be cooled for maintaining its temperature in a predetermined allowable range.

[0004] It is known to provide a cooling system configured to circulate a cooling fluid, e.g. water-glycol mixture, though, essentially, an internal combustion engine in which such cooling fluid is heated and a radiator in which the cooling fluid is cooled in a cycle.

[0005] The cooling circuit may be also configured to allow the circulation of the cooling fluid in other modules such as an EGR, i.e. Exhaust Gas Recirculation, Cooler, an oil cooler or an Intarder® (i.e. a hydrodynamic brake cooler).

[0006] The circulation of the cooling fluid in engine and/or other modules is driven by a pump, such as an electric water pump or conventional belt-driven water pump.

[0007] However, the cooling system typically comprises all the aforementioned elements fluidically connected in series one with respect to the other. Therefore, supposing, for sake of example, that EGR cooler is in fluidic series with oil cooler and that only the latter needs high flow of cooling fluid while the EGR cooler simply needs a low flow of cooling fluid, the pump would however supply to both modules the highest needed flow of cooling fluid. In this way, the pump works the most of the time at a high demand level, thereby having a high energy consumption, and increasing fuel consumption of the vehicle/engine.

[0008] At the same time, it is necessary to maintain the pressure level at a predetermined minimum level so as to avoid cavitation phenomenon. Cavitation implies the formation of vapor cavities in a fluid, i.e. bubbles, which may lead to serious damage to the cooling circuit/engine components upon implosion. Engine liners are the most sensible components to such problem due to their particular operative modes. Also EGR cooler is susceptible to problems caused by local boiling in particular when the temperature of the coolant increases sufficiently to cause boiling; in this case, increased coolant flow and increased coolant pressure is necessary to avoid boiling.

[0009] Therefore, the need is felt to reduce the energy

consumption of a cooling circuit for an internal combustion engine while avoiding cavitation phenomenon and other potential problems such as local boiling in the EGR cooler.

[0010] An aim of the present invention is to satisfy the above mentioned needs, in an economic and optimized way.

SUMMARY OF THE INVENTION

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[0011] The aforementioned aim is reached by a cooling system for cooling an internal combustion engine of a vehicle as claimed in the appended set of claims.

BRIEF DESCRIPTION OF DRAWINGS

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[0012] For a better understanding of the present invention, a preferred embodiment is described in the following, by way of a non-limiting example, with reference to the attached drawings wherein:

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- Figure 1 is schematic view of a first embodiment of a cooling system according to a first embodiment of the invention;
- 25 • Figure 2 is a schematic view of a second embodiment of a cooling system according to a second embodiment of the invention;
- Figure 3 is a schematic view of a second embodiment of a cooling system according to a third embodiment of the invention; and
- 30 • Figure 4 is a schematic view of a second embodiment of a cooling system according to a fourth, alternative, embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

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[0013] Figure 1 discloses a schematic view of a cooling system 1 for an internal combustion engine 2 of a vehicle; the cooling system 1 is configured to circulate a cooling fluid, e.g. water-glycol mixture, as described in the following so as to maintain the temperature of engine 2 and/or other modules within a comprised range of temperature.

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[0014] Cooling system 1 essentially comprises a pump 3 configured to increase the pressure of a fluid passing through this latter between a first and a second openings 3a, 3b of this latter and a heat exchanger, such as a radiator 4, configured to cool the cooling fluid flowing through this latter between a first and a second openings 4a, 4b of this latter. According to the exemplary schematized system 1 of figure 1, cooling system 1 further comprises an oil cooler 5 fluidly connected to pump 3 and to engine 2; in particular, pump output 3a is fluidly connected to a first opening 5a of oil cooler 5 and engine 2 is fluidly connected to a second opening 5b of oil cooler 5. Therefore, according to the above, oil cooler 5 and engine 2 are fluidly connected in series, the engine 2 being placed downstream with respect to oil cooler 5. Prefera-

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bly pump 3 is an electric pump.

[0015] In particular, according to all the disclosed embodiments an as known in the art engine 2 comprises essentially a block portion 7, a liner portion 8 and a head portion 9 fluidly connected one between the other in series between a first opening 2a and a second opening 2b for the cooling fluid.

[0016] Therefore, according to the described configuration, second opening 5b of oil cooler 5 is fluidly connected to first opening 2a of engine 2.

[0017] Cooling system 1 preferably further comprises valve means 10 configured to allow the passage of cooling fluid from engine 2 towards either radiator 4 or to pump 3 according to a predefined temperature threshold. Accordingly, valve means 10 may comprise a thermostatic switch valve, which can be controlled electrically or mechanically as known.

[0018] According to the disclosed configuration, valve means 10 comprises a first opening 10a fluidly connected to second opening 2b of engine 2, a second opening 10b fluidly connected to first opening 4a of radiator 4 and a third opening 10c fluidly connected to a third opening 3c of pump 3. Therefore, if temperature of cooling fluid is lower than the preset threshold, this latter will return directly to pump 3 without passing into radiator 4, while, if temperature of cooling fluid is higher than the preset threshold, this latter will pass through radiator 4 to decrease its temperature before returning to pump 3 via openings 4b, 3a.

[0019] Cooling system 1 further comprises at least an operative module, such as in the present case an EGR cooler 11, fluidly interposed in parallel to engine 2 between pump 3 and valve means 10. In particular, according to the disclosed embodiment, EGR cooler 11 is fluidly connected in parallel to the series of oil cooler 5 and engine 2.

[0020] In particular, EGR cooler 11 comprises a first opening 11a fluidly connected to second opening 3b of pump 3 upstream with respect to first opening 5a of oil cooler 5, and a second opening 11b fluidly connected to a fourth opening 10d of valve means 10.

[0021] According to a first aspect of the invention, cooling system 1 comprises flow control means 12 configured to reduce the flow of fluid into valve means 10 coming from engine 2 and/or the remaining operative module, in the present case the EGR cooler 11. Valve means 12 may regulate such flow between predetermined maximum and minimum values, e.g. a total free flow and a zero flow.

[0022] In particular, cooling system 1 comprises flow control means 12a fluidly interposed between second opening 11b of EGR cooler 11 and fourth opening 10d of valve means 10. Further system may further comprise flow control means 12b fluidly interposed between second opening 2b of engine 2 and first opening 10a of valve means 10 and/or Advantageously, flow control means 12 may be realized among any known typology of valves (gate valves, butterfly valves etc..) and may be actuated

mechanically, electrically or hydraulically as known.

[0023] Preferably, flow control means 12 are electrically actuated valves, in particular they may be electrically connected to an electronic control unit (ECU), not shown, comprising elaboration means configured to acquire data related to engine 2 and operative modules 5, 11 operation and to control the status of flow control means 12 accordingly as described in the following. More preferably, such control unit is the ECU of the vehicle.

[0024] The operation of the above described first embodiment is the following.

[0025] Cooling fluid starts its path from second opening 3b of pump 3 and directed partially to EGR cooler 11 and the remaining portion to oil cooler 5. From this latter, the cooling fluid passes through base 7, lines 8 and head 9 of engine 2 and flows out from this latter by second opening 2b. Fluid passing into EGR cooler 11 flows out from this latter by second opening 11b. Both parallel branches of cooling fluid coming from openings 2b, 11b flow to respectively openings 10a, 10d of valve means 10. Here, if flows are merged and if the temperature of merged cooling fluid is lower than a preset temperature, fluid will flow directly to third opening 3c of pump 3, otherwise fluid will, partially or totally, flow to radiator 4. In this latter element cooling fluid is cooled and flows again in pump 3 to close its path.

[0026] According to the invention, if the control unit/user detects, a reduced necessity of flow into engine 2 or EGR cooling module 11, flow control means 12a, 12b will be controlled to reduce the flow of cooling fluid which can pass from opening 2b to opening 10a and/or from opening 11b to opening 10d. In this way, the request of flow of cooling fluid to pump 3 will be reduced, while guaranteeing a correct cooling of the interested module, and, consequently, power consumption of pump 3 will be reduced. The reduced cooling flow necessity may be based on operative information of engine 2 or modules 5, 11 or on it may be based on temperature measures of fluid flowing inside such elements 5, 11 thanks to sensors, not shown, carried by these elements and electrically connected to the electronic control unit.

[0027] Figure 2 discloses a schematic view of a cooling system 1 for an internal combustion engine 2 of a vehicle according to a second embodiment of the invention. Similarly to first embodiment in figure 1, cooling system 1 essentially comprises a pump 3 configured to increase the pressure of a fluid passing through this latter between a first and a second openings 3a, 3b of this latter and a radiator 4 configured to cool the cooling fluid flowing through this latter between a first and a second openings 4a, 4b of this latter.

[0028] In the present embodiment cooling system 1 does not comprise the oil cooler 5 which is substituted by an oil cooler 5 configured as a separate air-to-oil cooler, as known in the art. It has to be noted that An air-to-oil cooler may be feasible, considering reduced oil flows and higher operating oil temperatures on friction-optimized engines.

[0029] According to the embodiment, second opening 3b of pump 3 is fluidly connected to first opening 2a of engine 2.

[0030] Similarly to first embodiment, cooling system 1 further comprises valve means 10 configured to allow the passage of cooling fluid from engine 2 towards either radiator 4 or to pump 3 according to a predefined temperature threshold. Valve means 10 comprises a first opening 10a fluidly connected to second opening 2b of engine 2, a second opening 10b fluidly connected to first opening 4a of radiator 4 and a third opening 10c fluidly connected to a third opening 3c of pump 3.

[0031] Similarly to first embodiment, cooling system 1 further comprises at least an operative module, such as in the present case an EGR cooler 11, fluidly interposed in parallel to engine 2 between pump 3 and valve means 10.

[0032] In particular, EGR cooler 11 comprises a first opening 11a fluidly connected to second opening 3b of pump 3 upstream with respect to first opening 5a of oil cooler 5, and a second opening 11b fluidly connected to a fourth opening 10d of valve means 10.

[0033] According to a further aspect of the invention, cooling system 1 comprises flow control means 12 configured to reduce the flow of fluid into valve means 10 coming from engine 2 and/or the remaining operative module, in the present case the EGR cooler 11, similarly to what described for embodiment of figure 1 and not repeated for sake of brevity.

[0034] Cooling system 1 may comprise a further valve means 13 configured for divide fluid flow between engine 2 and EGR cooler 11, i.e. a branching module placed upstream with respect to engine 2 and EGR cooler 11.

[0035] The operation of the above described second embodiment is the following.

[0036] The operation is substantially the same as the first embodiment except for the fact that the cooling fluid flows directly from second opening 3b of pump 3 directly into engine 2 and oil cooler 5 operates independently as an oil-to air cooler without interfering, i.e. without generating pressure drops due to passage of cooling fluid through this latter in the cooling system. Except for such aspect the operation is the same, i.e. flow control means 12 may be activated, when necessary, to reduce the flow of cooling passing from the respective operative module branch.

[0037] Figure 3 discloses a schematic view of a cooling system 1 for an internal combustion engine 2 of a vehicle according to a third embodiment of the invention. Similarly to embodiments of figure 1 and 2, cooling system 1 essentially comprises a pump 3 configured to increase the pressure of a fluid passing through this latter between a first and a second openings 3a, 3b of this latter and a radiator 4 configured to cool the fluid flowing through this latter between a first and a second opening 4a, 4b of this latter.

[0038] Similarly to first embodiment, cooling system 1 further comprises an oil cooler 5 fluidly connected to

pump 3 and to engine 2, fluidically in series with this latter.

[0039] Always similarly to first and second embodiments, cooling system 1 further comprises valve means 10 configured to allow the passage of cooling fluid towards either radiator 4 or to pump 3 according to a predefined temperature threshold. According to the disclosed configuration, valve means 10 comprises a first opening 10a fluidly connected to an operative module as described in the following, a second opening 10b fluidly connected to first opening 4a of radiator 4 and a third opening 10c fluidly connected to a third opening 3c of pump 3.

[0040] First opening 10a of valve means 10 is not, as in figures 1 and 2 embodiments, directly connected to second opening 2b of engine 2. Indeed, it is fluidly connected to a second opening 14b of an operative module, such as an intarder® 14.

[0041] According to the described configuration, cooling system 1 comprises further flow control means 15, having the same function of valve means 10, i.e. switching a fluid in particular coming from second opening 2b of engine 2 towards intarder 14 or directly towards first opening 10a of valve means 10.

[0042] Accordingly, flow control means 15 comprises a first opening 15a fluidly connected to second opening 2b of engine 2, a second opening 15b fluidly connected to a first opening 14a of intarder 14 and a third opening 15c directly fluidly connected to first opening 10a of valve means 10. Accordingly, oil cooler 5, engine 2 and intarder 14, when fluidly connected to these latter, are fluidically in series each other between pump 3 and valve means 10.

[0043] According to an aspect of the invention, cooling system 1 further comprises at least an operative module, such as in the present case an EGR cooler 11, fluidly interposed in parallel to engine 2 between pump 3 and valve means 10. In particular, according to the disclosed embodiment, EGR cooler 11 is fluidly connected in parallel to the series of engine 2, oil cooler 5 and intarder 14.

[0044] In particular, EGR cooler 11 comprises a first opening 11a fluidly connected to second opening 3b of pump 3 upstream with respect to first opening 5a of oil cooler 5, and a second opening 11b fluidly connected to a first opening 10a of valve means 10.

[0045] According to a further aspect of the invention, cooling system 1 comprises flow control means 12 configured to reduce the flow of fluid into valve means 10 coming from such operative module, in the present case the EGR cooler 11. Valve means 12 operation and typology correspond to what described for embodiment of figures 1 and 2, therefore they are not repeated for sake of brevity.

[0046] The operation of the above described third embodiment is the following.

[0047] The operation is substantially the same as the first embodiment except for the fact that from opening 2b flow of cooling may be divided to flow into intarder 14, if necessary (e.g., during vehicle braking). Except for such

aspect the operation is the same, i.e. flow control means 12 may be activated, when necessary, to reduce the flow of cooling passing from the respective operative module branch.

[0048] Figure 4 discloses a schematic view of a cooling system 1 for an internal combustion engine 2 of a vehicle according to a fourth embodiment of the invention. For sake of brevity, it may be resumed that all the elements described in first embodiments are present except for flow control means 12 which are not present and by an additional pump 3'.

[0049] In particular, pump 3' is a pump similar to pump 3 comprising a first opening 3a' fluidly connected to second opening 4b of radiator 4 and a second opening 3b' fluidly connected to first opening 11a of EGR cooler 11.

[0050] According to the above, first opening 3a of pump 3 is fluidly connected to second opening 5b of radiator 4 and second opening 3b of pump 3 is fluidly connected to only first opening 5a of oil cooler 5.

[0051] In this way, two different pressure sources are provided, in parallel with each other between radiator 4 and valve means 10 to an operative module, e.g. EGR cooler, and engine 2, in particular the series of engine 2 and oil cooler 5.

[0052] The operation of the above described fourth embodiment is the following.

[0053] Cooling fluid starts two independent paths from second opening 3b of pump 3 to oil cooler 5/engine 2 and from second opening 3b' of pump 3' to EGR cooler 11.

[0054] From oil cooler 5, similar to first embodiment, cooling fluid passes through base 7, lines 8 and head 9 of engine 2 and flows out from this latter by second opening 2b.

[0055] Fluid passing into EGR cooler 11 flows out from this latter by second opening 11b. Both parallel independent branches of cooling fluid coming from openings 2b, 11b flows to respectively openings 10a, 10d of valve means 10. Here, if flows are merged and if the temperature of merged cooling fluid is lower than a preset temperature, fluid will flow directly to third opening 10c of valve 10, otherwise fluid will, partially or totally, flow to radiator 4. In this latter element cooling fluid is cooled then flows to pumps 3, 3' proportionally to their suction side.

[0056] In view of the foregoing, the advantages of the cooling system 1 for an internal combustion engine 2 of a vehicle according to the invention are apparent.

[0057] Thanks to the cooling system 1 according to the invention, the fuel consumption of the system decreases and, at the same time, cavitation is reduced in critical components.

[0058] Such main effect is achieved thanks to the use of two separate parallel branches, one passing through at least engine 2 assembly and the remaining passing through at least an operative module, such as EGR cooler 11. The cooling system performance can hence be optimally adapted to the needs of specific components to

reduce the total power required to pump the coolant in the engine. Other components can be isolated as parallel branches in a similar manner if necessary, see e.g. figure 3 embodiment, allowing more flexibility in the delivery of sufficient coolant flow at required pressures to each component or engine sub-system.

[0059] The same effect may be obtained, alternatively as depicted in figure 4 or in combination to the above valves 12, with the use of independent pumps 3, 3' in each of the parallel branches of cooling fluid.

[0060] By replacing oil cooler 5 with a separate element it is possible to reduce further power consumption of pump 3.

[0061] It is clear that modifications can be made to the described cooling system 1 for an internal combustion engine 2 of a vehicle which do not extend beyond the scope of protection defined by the claims.

[0062] For example, it is clear that the described embodiments, e.g. figure 1 and figure 4 or figure 4 and figure 3, may be combined together to defined other possible combination all linked by the idea at the base of the present invention.

[0063] Operative module in parallel to engine 2 assembly may be obviously any module, not specifically EGR cooler 11. Further components can be isolated as separate branches for independent flow control via a separate valve or separate pump.

[0064] Further, other elements, such as interarder 14 or many other known in the art, could be added, in series or in parallel to the cooling circuit 1 as claimed below and radiator 4 may be substituted by any known typology of heat exchanger.

Claims

1. Cooling system (1) for cooling an internal combustion engine (2) for a vehicle, said cooling system (1) comprising at least a pump (3), a heat exchanger (4), an engine assembly (2) and at least one operative module (11), said pump (3) comprising a first opening (3a) fluidly connected to said heat exchanger (4), said engine assembly (2) and said at least one operative module (11) each being respectively fluidly connected to said heat exchanger (4), said pump (3) further comprising a second opening (3b) fluidly connected to respectively said engine assembly (2) and said at least one operative module (11), said engine assembly (3) and said at least one operative module (11) being placed in parallel one with respect to the other between said heat exchanger (4) and said pump (3) wherein said cooling system (1) further comprises flow control means (12) respectively fluidly interposed between said engine assembly (2) and said heat exchanger (4) said flow control means (12) being configured to reduce the flow which may pass between the aforementioned elements between predefined maximum and minimum

values.

2. Cooling system according to claim 1, wherein said cooling system (1) further comprises flow control means (12) between said at least one operative module (11) and said heat exchanger (4). 5
3. Cooling system according to claim 2, further comprising an electronic control unit configured to control the regulation of flow control means (12). 10
4. Cooling system according to claim 1, wherein said cooling system (1) further comprises a first pump (3) fluidly connected to said engine assembly (2) and to said heat exchanger (4) and a second pump (3') fluidly connected to said operative module (11), said first and second pumps (3, 3') being operable independently one with respect to the other. 15
5. Cooling system (1) for cooling an internal combustion engine (2) for a vehicle, said cooling system (1) comprising at least a pump (3), a heat exchanger (4), an engine assembly (2) and at least one operative module (11), said pump (3) comprising a first opening (3a) fluidly connected to said heat exchanger (4), said engine assembly (2) and said at least one operative module (11) each being respectively fluidly connected to said heat exchanger (4), said pump (3) further comprising a second opening (3b) fluidly connected to respectively said engine assembly (2) and said at least one operative module (11), said engine assembly (3) and said at least one operative module (11) being placed in parallel one with respect to the other between said heat exchanger (4) and said pump (3), wherein said cooling system (1) further comprises a first pump (3) fluidly connected to said engine assembly (2) and to said heat exchanger (4) and a second pump (3') fluidly connected to said operative module (11), said first and second pumps (3, 3') being operable independently one with respect to the other. 20
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6. Cooling system according to any of the preceding claims, further comprising valve means (10) fluidly interposed between said heat exchanger (4), said pump (3), said engine assembly (2) and said operative module (11), said valve means (10) being configured to divide the flow, at least partially, coming from said engine assembly (2) and said operative module (11) between said heat exchanger (4) and said pump (3). 45
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7. Cooling system according to claim 6, wherein said valve means (10) comprise a thermostatic valve, said division being made in function of a predetermined temperature threshold. 55
8. Cooling system according to any of the preceding

claims, wherein said pump is an electric pump.

9. Cooling system according to any of the preceding claims, wherein said at least one operative module (11) is a EGR cooler.
10. Cooling system according to any of the preceding claims, wherein said at engine assembly (2) comprises an oil cooler (5) and an engine (2), fluidically in series one with respect the other.
11. Cooling system according to claim 10, wherein said at engine assembly (2) further comprises an intarder (14) selectively fluidically in series with said oil cooler (5) and said engine (2) through flow control means (15). 5
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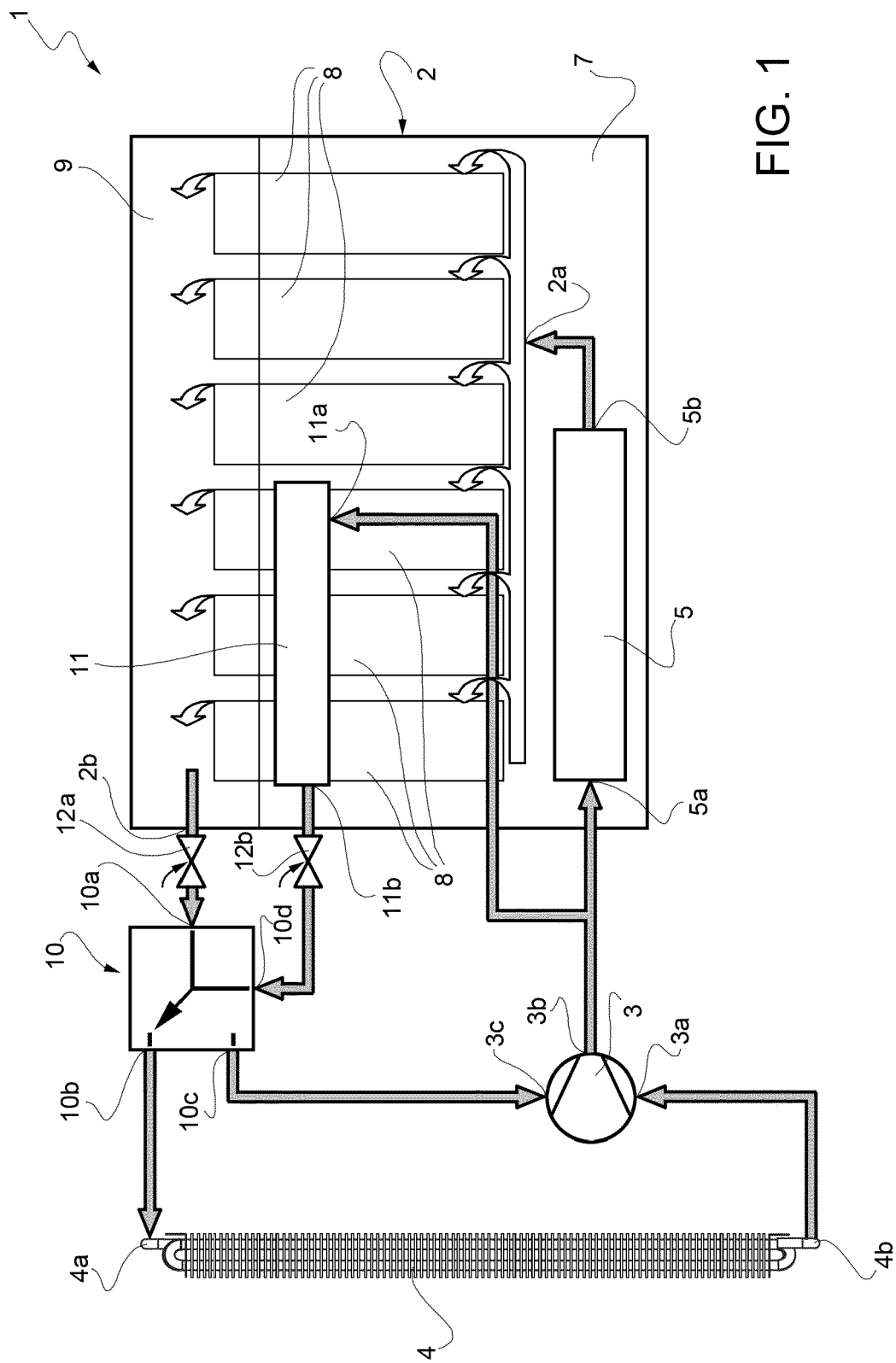


FIG. 1

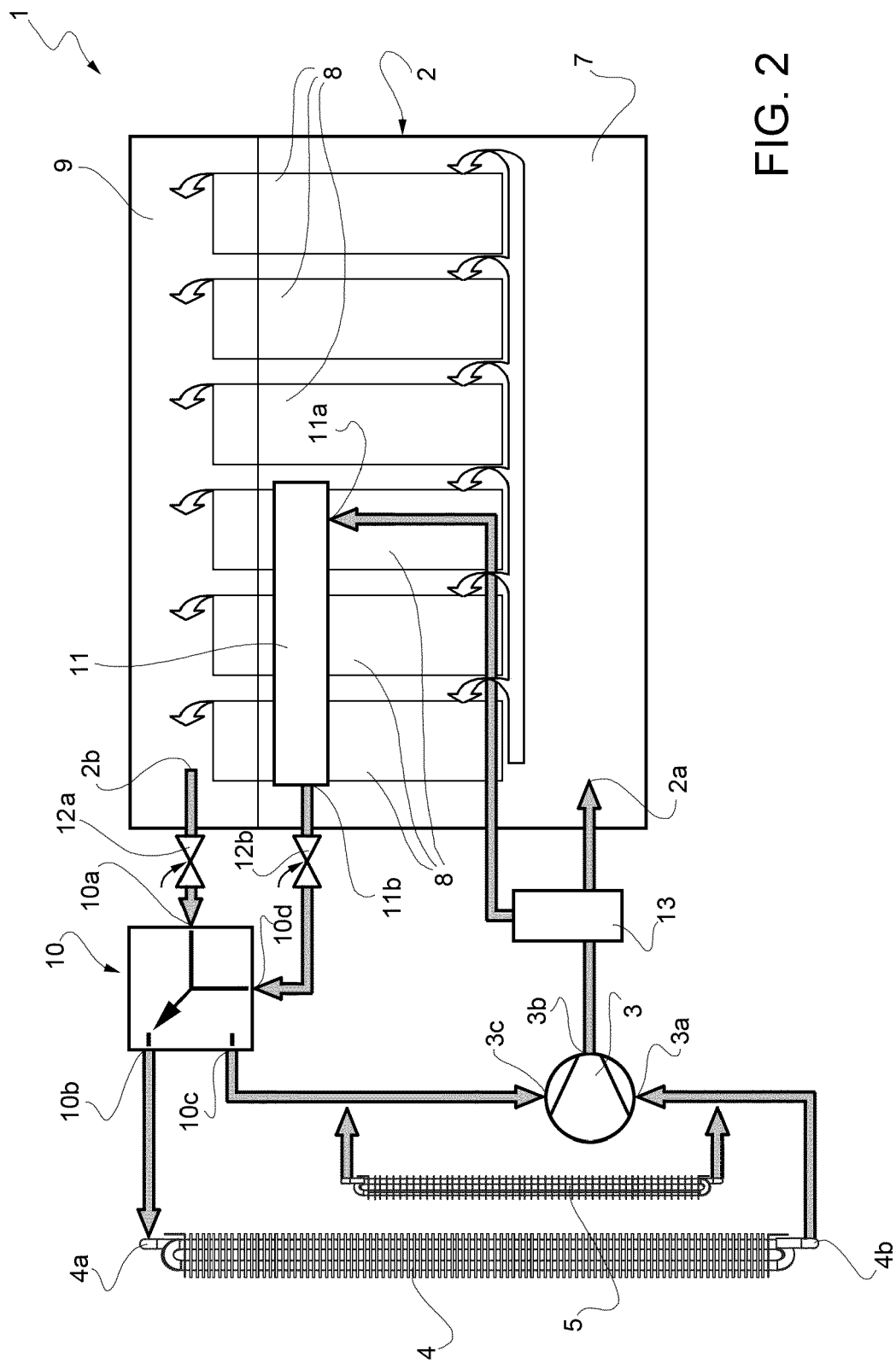
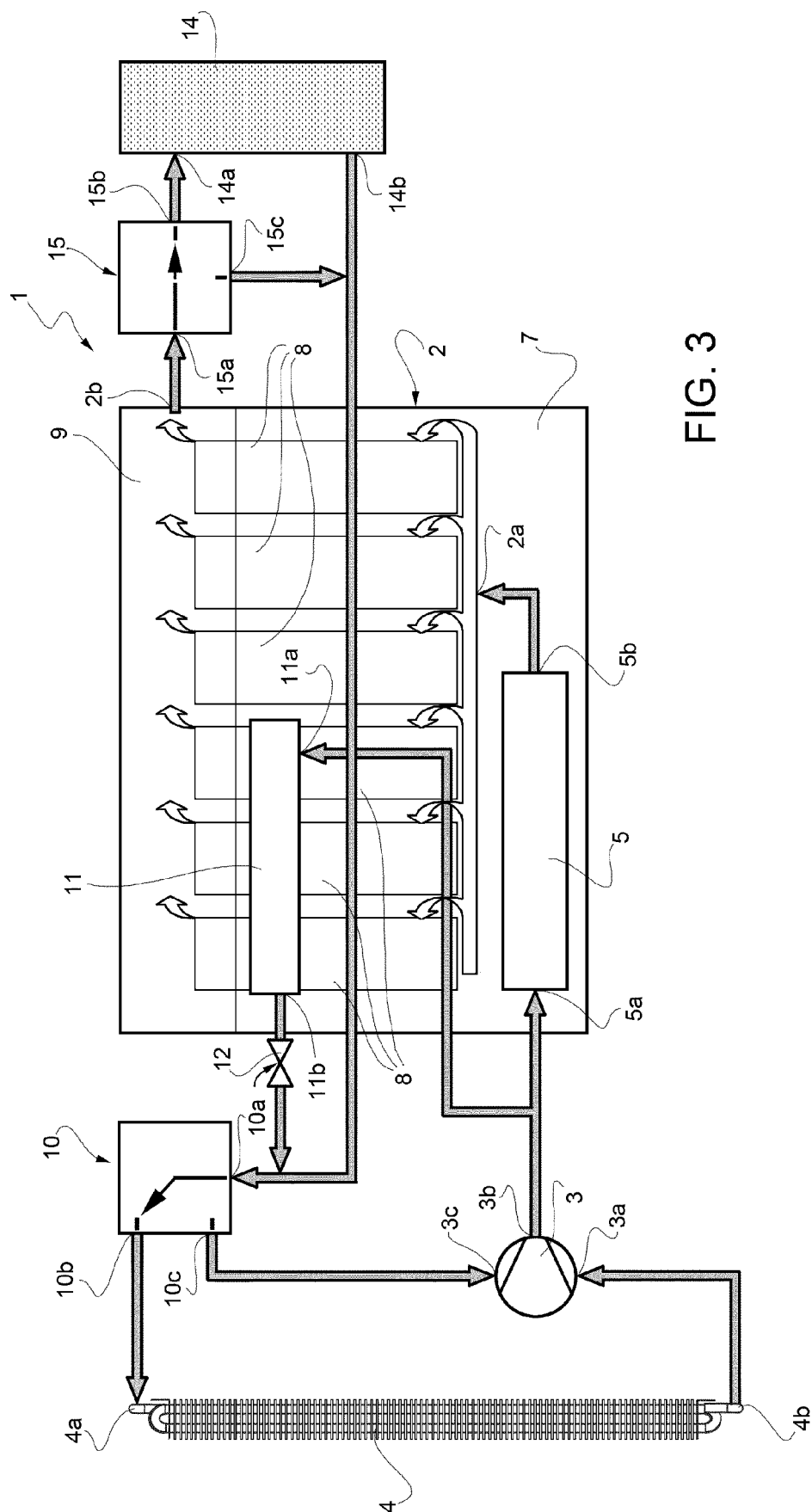


FIG. 2



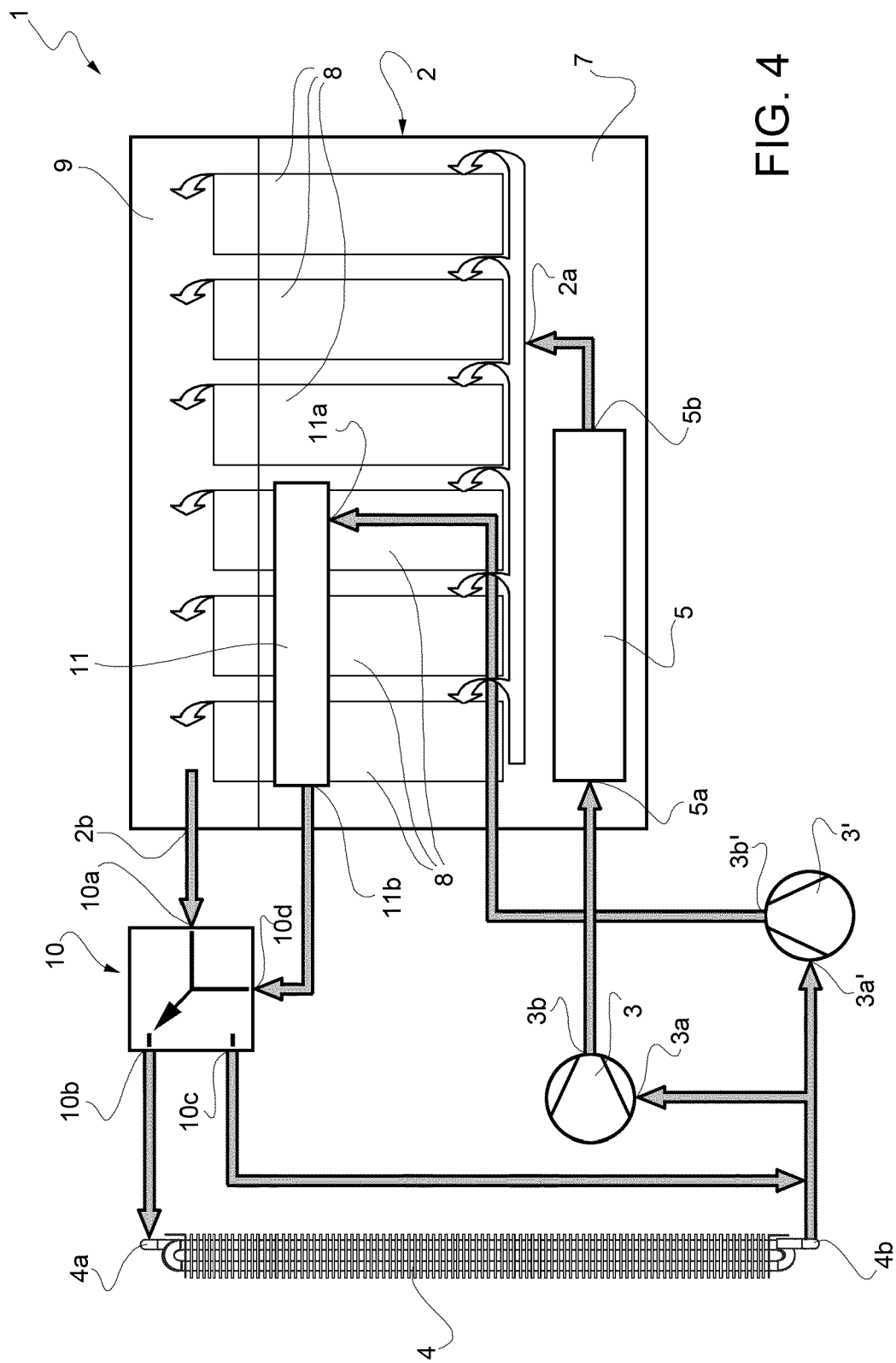


FIG. 4



EUROPEAN SEARCH REPORT

Application Number
EP 20 15 1297

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The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F01P
Place of search		Date of completion of the search	Examiner
Munich		31 January 2020	Luta, Dragos
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

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

EP 20 15 1297

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

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