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(54) **Title**: HEAT EXCHANGE SYSTEM FOR USE ON VEHICLES

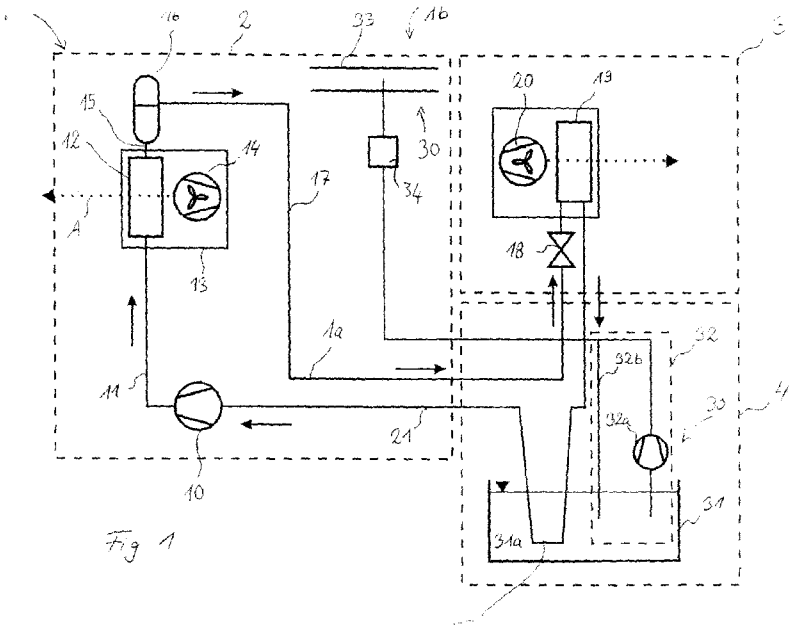


Fig 1

(57) **Abstract**: A heat exchange system (1b) to cool and/or heat at least one fluid on a vehicle having a cooling and/or heating circuit (1a) through which a refrigerant flows. The refrigerant flows in a refrigeration cycle through the circuit (1a) and a portion of the circuit (1a) exchanges heat with said at least one fluid.

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Heat Exchange System for use on Vehicles

This invention relates to a heat exchange system to heat and/or cool fluids on vehicles, in particular on tractors and agricultural machinery.

It is well known to provide a vehicle exhaust gas treatment system in which a urea solution, for example AdBlue® is injected into a catalytic converter located in the exhaust system of an internal combustion engine to reduce the level of exhaust pollutants such as carbon monoxide, nitrogen oxide and particle matter in the exhaust gases.

Problems arise with such treatment systems since if the temperature of the urea solution exceeds 60^0C due to exposure to the sun, or the close proximity of hot components on the vehicle, the urea solution starts to break down into corrosive constituents which can damage the components of the treatment system. It is known to cool various components on a vehicle by providing an air flow. It is also known to use a heat exchanger in which a fluid flow, such as an air or water flow is used to cool down cooling water, oil and fuel on a vehicle. However this is not effective for cooling a large volume of fluid and does not always cool the liquid to a desired temperature.

Problems also arise in low outdoor temperatures since the addition of antifreeze substances to a urea solution can alter the composition of the urea solution and generate undesirable components in the cleaned exhaust gases. For this reason antifreeze is not added to urea solutions. AdBlue®, for example has a freezing point of about -11^0 C.

EP 1698769 discloses a method of heating up a urea solution on a vehicle by using the coolant from a diesel engine.

It is also known to equip modern vehicles with HVAC (Heating, Ventilation and Air Conditioning) systems to cool down, or heat up drivers' cabs to keep the cab at a comfortable temperature despite the ambient temperature

It is an object of the present invention to provide a heat exchange system to cool and/or heat at least one fluid on a vehicle which is cheap and simple to install and use.

According to the invention there is provided a heat exchange system to cool and/or heat at least one liquid on a vehicle on a vehicle, said system comprising a cooling and/or heating circuit through which a refrigerant flows in a refrigeration cycle, the said at least one liquid to be cooled and/or heated being stored in a tank on the vehicle, said tank provided with a liquid outlet and wherein the refrigerant exchanges heat with said at least one liquid
By refrigerant, it is meant here a compound used in a heat cycle that undergoes a phase change from a gas to a liquid and back. By refrigeration cycle it is meant the thermodynamic cycle which is used by both refrigerators and heat pumps.

The cooling and/or heating circuit may be an HVAC circuit. The cooling and/or heating circuit is preferably an HVAC circuit for a vehicle cab.

Preferably, the HVAC circuit comprises a compressor, a condenser, an expansion valve and an evaporator.

Preferably, a portion of the circuit between the evaporator and the condenser exchanges heat with the fluid. More preferably, a portion of the circuit between the evaporator and the compressor exchanges heat with the fluid.

The invention makes use of the fact that an HVAC circuit and refrigerant is usually already installed on a vehicle to cool and/or heat up a driver's cab. It is therefore

relatively cheap and simple to use this HVAC circuit to cool and/or heat fluids on the vehicle and minimal extra space is required on the vehicle for installing the heat exchange system. The HVAC circuits installed on vehicles usually comprise a compressor, a condenser, an expansion valve and an evaporator through which an HVAC refrigerant is pumped. If the HVAC circuit is used as a cooling circuit, the refrigerant is pumped through a vapour-compression cycle. By reversing the flow of the refrigerant through the circuit components, an HVAC cooling circuit can be used as a heat pump to provide heat. An HVAC circuit may be provided with a reversing valve, or other additional means which enables the direction of refrigerant flow to be changed.

For cooling/heating a driver's cab, the evaporator and expansion valve are typically situated in the cab of the vehicle and the remaining components placed in the engine bay. To cool the air in the cab, a fan circulates the hot air in the cab over the evaporator which contains the HVAC refrigerant in a liquid-vapour state. The heat energy from the air is absorbed by the liquid-vapour mixture and causes the liquid part of the refrigerant to evaporate. The absorption of the heat from the cab lowers the temperatures of the cab. The refrigerant is carried along a return line to a compressor and then a condenser where the heat energy is subsequently rejected from the HVAC circuit.

The fluid to be heated or cooled, for example, a urea solution is preferably stored in a tank on the vehicle. The tank is connected to a fluid outlet. The tank may be connected, for example to a dosing module for injecting the solution into the exhaust ducting. In this way the urea solution can be injected into the exhaust gas.

In a first embodiment of the invention, a portion of the HVAC circuit is located in the fluid tank. Preferably, a portion of the circuit between the evaporator and the compressor of the HVAC circuit is located within the tank. When used as a cooling circuit the temperature of the HVAC circuit between the evaporator and the

compressor is approximately between 2-6^{0}C degrees even at very hot ambient temperatures. The section of the HVAC circuit in the fluid tank thus cools down the fluid.

Alternatively, if the HVAC circuit is used as a heat pump, the portion of the HVAC circuit between the evaporator and the compressor can be used to heat the fluid.

A suitable HVAC refrigerant for use in the HVAC circuit is for example, hydrofluorocarbon R134a, or carbon dioxide R744. R744 is most suitable for use in a reversible refrigerant cycle.

In a further embodiment of the invention, the HVAC circuit is provided with a heat exchanger through which the refrigerant and the fluid flows. The first embodiment may also include a heat exchanger. The heat exchanger is preferably provided between the evaporator and the condenser of the HVAC circuit and between the fluid tank and the fluid outlet. An advantage of this arrangement is that a complete length of piping between the fluid tank (which may be located under the cab) and the dosing module (located in the engine bay) can run through the heat exchanger with the return line of the HVAC circuit thus maximising the surface area available for heat exchange and providing the fluid with as much insulation as possible from the heat of the engine bay.

Such an arrangement may also include a further line connecting the fluid tank and the heat exchanger so that fluid in the tank can continuously flow through the heat exchanger and back to the tank. In this respect the fluid in the tank can be continually cooled, or heated allowing the overall temperature of the fluid in the tank to be kept between -15 to 60^{0}C degrees.

In yet a further embodiment of the invention the heat exchange system further comprises a secondary cooling and/or heating circuit carrying a cooling/heating fluid.

In such an arrangement the HVAC refrigerant provides a heat exchange for the fluid in the secondary circuit. The secondary circuit may pass through the evaporator of the HVAC circuit so that the evaporator acts as a heat exchange for the secondary circuit More preferably, a portion of the secondary circuit is located in the fluid tank to heat and/or cool the fluid.

The secondary circuit preferably comprises a pump

More preferably the secondary circuit comprises a storage tank for storing the secondary circuit fluid. The storage tank is preferably insulated. This means that even if engine is stopped the cooling/heating fluid in the storage tank can be circulated to cool, or heat the cab.

Additionally, the secondary circuit may comprise an additional heat core to cool down the fluid, for example, the urea solution even when the engine is not working. In this arrangement the heat core is placed in the secondary circuit so that fluid from the fluid tank can be pumped through it continuously thus maintaining the temperature of the fluid in the tank below 60^0C.

The invention will now be described, by way of example only with reference to the following drawings in which:

Figure 1 is a circuit diagram of a heat exchange system for cooling and/or heating fluids in accordance with the present invention,
Figure 2 is a circuit diagram of a further embodiment of the heat exchange system, in accordance with the invention,
Figure 3 is a circuit diagram of an alternative arrangement of the heat exchange system of figure 2 in accordance with the invention, and
Figure 4 is a circuit diagram of a yet a further embodiment of the heat exchange system which comprises a secondary heating/cooling circuit.

Figure 1 shows a heat exchange system 1b to cool and/or heat fluids on a vehicle, for example, a tractor in accordance with the invention. In this example, the system 1b provides a cooling means for a urea solution for an exhaust gas treatment system 30 on a tractor 1, although the system can also be used for heating and/or cooling other fluids on a vehicle.

As is usual on modern tractors and agricultural machinery with a driver's cab/compartment, an HVAC cooling circuit 1a is installed for providing air conditioning in the driver's cab 3. A refrigerant flows around the HVAC circuit 1a in a refrigeration cycle in the direction indicated by the arrows. The refrigerant may be for example, hydrofluorocarbon R 134a, or carbon dioxide R744. With the refrigerant flowing in the direction shown, the refrigerant undergoes a vapour-compression cycle and is a cooling circuit.

The tractor is shown diagrammatically as being separated into an engine bay 2, a cab 3 and chassis area 4. The evaporator 19, fan 20 and compression valve 18 are located in the cab 3 and the remaining components, compressor 10, condenser 12, accumulator 16 and blower 14 are located in the engine bay 2. The refrigerant enters the compressor 10 as a saturated vapour and is compressed by a compressor 10 resulting in an increase in temperature and pressure. The compressor 10 may be driven by the main belt drive system of the tractor (not shown), or by electric power provided by the supply network of the tractor. The refrigerant exits the compressor 10 as a superheated vapour and is routed through a first pipe 11 into the condenser 12. The condenser 12 is integrated in the cooling arrangement 13 of the tractor 1 and usually comprises one or more tubes, or a coil through which the HVAC refrigerant flows. The tubes, or coil may be cooled down by a water, or air flow. The cooling arrangement 13 may be used as a heat exchanger to cool down other components on the tractor such as cooling water, oil for the gear box or hydraulic circuit, fuel or combustion air.

In figure 1 the cooling arrangement 13 and therefore condenser 12 is cooled by an ambient air stream A which is blown by blower 14 resulting in the HVAC refrigerant cooling and condensing. The refrigerant is then routed via a second pipe 15 to an accumulator 16. The accumulator 16 provides a reservoir for the refrigerant fluid. It contains a granulated material filter which absorbs water droplets in the refrigerant and thus protects the compressor from damage from water such as erosion.

The refrigerant is then routed through a third pipe 17 to an expansions valve 18 which adiabatically decreases the pressure of the refrigerant. The expansion valve 18 can be integrated with the evaporator 19, the next component in the circuit 1a. The rapid drop in pressure results in a huge temperature drop to around 2^{o} C which also cools down the evaporator 19. An air stream from the driver's compartment/cab 3 is fed through the evaporator 19 by an HVAC blower 20, cooled down and then fed back to the driver's compartment/cab 3. The cab air is cooled down by the refrigerant absorbing some of the heat energy from the cab air. The temperature of the refrigerant rises due to the energy absorption but still remains at a low temperature level. The refrigerant is fed back to the compressor 10 via the return pipe 21 and the circuit continues. Following the direction of flow around the circuit the part of the circuit between the compressor 10 and evaporator 19 which carries the warmer refrigerant is known as the high pressure side of the circuit. The part of the circuit between the evaporator 19 and the compressor 10 is known as the low pressure side of the circuit which carries the cooler refrigerant. The return pipe 21 carries the refrigerant at a very low temperature of between 2 to 6^{0}C similar to the temperature inside the evaporator 19. The piping 17, 21, 11, 15 used within the refrigerant circuit is 1a is usually made from steel tubes, or a combination of steel tubes and flexible rubber hoses. The means to control the cooling system and to move the refrigerant through the circuit is well known and therefore not described here.

The urea solution 31a is stored in a urea tank 31 which is situated close to the circuit 1a, below the cab 3 in the chassis area 4. The urea tank 31 is a part of the urea exhaust gas treatment system 30 which also comprises a supply module 32 having a pump 32a and a urea return line 32b, a dosing module 34 and a level indicator (not shown). The dosing module 34 is situated in the engine bay 2 close to the exhaust gas ducting system 33. The pump 32a of supply module 32 can circulate urea solution 31a in the urea exhaust gas treatment system 30. Depending on the exhaust gases emitted by the tractor, the dosing module 34 will inject urea solution by an injector (not shown) into the exhaust gas through the ducting system 33. Urea solution which has been pumped from the tank 31 but which is not injected into the ducting system 33 is returned to the urea tank 31 via the return line 32b.

To prevent the temperature level inside the tank 31 from exceeding the critical level of 60°C, a portion 22 of the return pipe 21 of the HVAC circuit between the evaporator 19 and compressor 10 is placed inside the urea tank 31 and acts as a heat exchanger. Thus the HVAC refrigerant in the pipe 21 and the urea solution 31a in the tank 31 exchange heat and this way the urea can be kept at a desired temperature. . Using portion 22 of the return pipe 21 between the evaporator 19 and compressor 10 as a heat exchanger does not affect the performance of the HVAC circuit.

Figure 2 shows a further embodiment of the heat exchange system 1b in accordance with the invention. Here, the return pipe 21 which carries an HVAC refrigerant from the evaporator 19 to the compressor 10 is equipped with an heat exchanger 35 to cool down the urea solution 31a on its way from tank 31 and supply module 32 to dosing module 34. Since both the return pipe 21 and the urea pipe 36 are routed parallel to one another from cab 3 and/or chassis 4 to engine bay 2, a compact, pipe-in-pipe heat exchanger 35 maximises the heat exchange surface area between the urea solution and the refrigerant but does not require a large amount of installation space. The refrigerant can be fed into the outer piping of the pipe-in-pipe heat exchanger whilst the urea solution is guided through the centre pipe. The use of the heat exchanger 35

further provides insulation of the urea against heat from the engine bay 2, however, since in this arrangement the system 1b is only cooling down the urea solution when it is fed to the dosing module 34, the temperature of the urea solution 31a in the tank 31 is not affected.

In a further arrangement of the system 31b shown in figure 3, the heat exchanger 35 is connected to urea pipe 36 and urea return line 32c which leads back to the tank 31. Pump 32a is constantly pumping urea solution to the dosing module 34. If the dosing module is not injecting urea solution into the exhaust ducting 33, urea solution returns to the tank 31 through return line 32c. With this arrangement the urea solution is pumped through the heat exchanger 35 and returned to the tank 31 ensuring the urea solution 31a in the tank 31 is maintained below a critical temperature. If dosing module 34 is injecting urea solution into the exhaust ducting 33, the pump 32a supplies the dosing module 34 with urea solution from the tank 31 which flows through the heat exchanger 35 and urea pipe 36.

The configuration of pump 32a, tank 31 or dosing module 34 relative to the heat exchanger 35 is variable and can be adapted according to the applicational needs. For example, the heat exchanger could also be installed in the return line 32, or the pump 32a could be installed between dosing module 34 and heat exchanger 35.

By reversing the direction of flow of refrigerant in the circuit, the HVAC circuit 1a can be used as a heat pump to heat fluids. It uses the same basic refrigeration cycle as with the cooling circuit, however when used as a heat pump the evaporator 19 absorbs heat and rejects the heat through the condenser 12. Additional components needed to reverse the circuit are known in the art and are therefore not described.

The heat exchange system 31b described in figures 1 to 3 can only provide HVAC heat exchange when the combustion engine is running and the compressor 10 is driven. If the compressor 10 is driven by electric energy supplied by a battery system,

an HVAC system could be provided for an independent HVAC system working without a running engine. It is common in trucks to provide independent HVAC systems with means for storing a second heating/cooling fluid which can be used for heating/cooling on the vehicle when the main HVAC system is not operated.

It is well known to cool down the injector of the dosing module 34 which heats up due to the hot exhaust gases. The heat exchange circuit 1b may be used to cool down the injector.

Figure 4 shows an HVAC circuit 311a which is not directly connected to the cab 3 but via a secondary circuit 200. The HVAC circuit is similar to those shown in figures 1 to 3 in that the refrigerant is compressed by compressor 10, cooled by condenser 12, fed through accumulator 16 and then expanded by expansion valve 18 and fed into the evaporator 100. The evaporator 100 functions as an heat exchanger to cool down a secondary circuit 200 which does not contain a refrigerant but a cooling fluid similar to standard engine cooling fluids, such as a water glycol mixture. The secondary circuit fluid is pumped to the heat exchanger 202 in the cab 3 to cool down the cab interior similar to the previous mentioned systems. The secondary circuit fluid is then guided into an insulated storage tank 203. Even if the cab 3 does not require cooling down, the secondary circuit fluid can be circulated to cool down and thus cooled fluid is stored inside the storage tank 203. If the vehicle engine is stopped, the secondary circuit fluid in the storage tank 203 cab can still be circulated to cool down the cab which may be necessary in hot climates, for example during a driver's rest period.

In addition, the secondary circuit fluid is guided through the urea tank 301, or connected to the urea circuit 36 by an additional core heater 302 to cool down the urea solution 301a during off operation of the engine.

By reversing the flow of refrigerant around the HVAC circuit 311a, the circuit may be used as a heat pump to heat a fluid (and a cab). A particularly good refrigerant to be

used for this purpose is R744 carbon dioxide. By reversing the circuit, the evaporator 100 of the cooling circuit becomes a condenser and the condenser 100 of the cooling circuit becomes an evaporator. The refrigerant flowing through the heat pump evaporator absorbs heat from the air and the refrigerant is compressed and flows to the heat pump condenser where the heat is rejected. The high pressure and low pressure sides of the circuit are swapped so that a heated refrigerant fluid flows through pipe 21 of the HVAC circuit which can be used to heat a fluid. This means that the secondary circuit 200 shown in figure 4 can also be used to heat the cab 3 and the fluid 301a.

The invention has the advantage that it makes use of an HVAC circuit already installed on a vehicle to heat/ cool a liquid, thus reducing cost and saving space on a vehicle.

Claims

1. A heat exchange system to cool and/or heat at least one liquid on a vehicle, said system comprising a cooling and/or heating circuit through which a refrigerant flows in a refrigeration cycle, the said at least one liquid to be cooled and/or heated being stored in a tank on the vehicle, said tank provided with a liquid outlet and wherein the refrigerant exchanges heat with said at least one liquid.

2. A heat exchange system as claimed in claim 1 wherein the circuit comprises a compressor, a condenser, an expansion valve and an evaporator.

3. A heat exchange system as claimed in any preceding claim wherein the cooling and/or heating circuit is an HVAC circuit for a vehicle cab..

4. A heat exchange system as claimed in claim 2 or claim 3 wherein a portion of the circuit between the evaporator and the condenser exchanges heat with the fluid.

5. A heat exchange system as claimed in any preceding claim wherein a portion of the circuit is located in the fluid tank and exchanges heat with the fluid.

6. A heat exchange system as claimed in any of claims 1 to 4 wherein the circuit comprises a heat exchanger through which the refrigerant and the at least one fluid flow.

7. A heat exchange system as claimed in claim 5 or claim 6 comprising a return connection between the fluid tank and the heat exchanger so that fluid in the fluid tank can flow through the heat exchanger and back to the fluid tank.

8. A heat exchange system as claimed in any preceding claim wherein the heat exchange system further comprises a secondary heating/cooling circuit carrying a secondary circuit heating/cooling fluid.

9. A heat exchange system as claimed in claim 8 wherein the evaporator of the circuit is as a heat exchanger with the secondary circuit

10. A heat exchange system as claimed in claim 8 or claim 9 wherein a portion of the secondary circuit is located in the fluid tank.

11. A heat exchange system as claimed in any of claims 8 to 10 wherein the secondary circuit comprises a storage tank for storing the secondary circuit fluid.

12. A heat exchange system as claimed in any of claims 8 to 11 wherein the secondary circuit comprises a heating core through which the secondary circuit fluid and the at least one fluid flow.

13. As heat exchanger as claimed in any preceding claimed wherein the refrigerant is one of either a hydrofluorocarbon R134A or carbon dioxide R744.

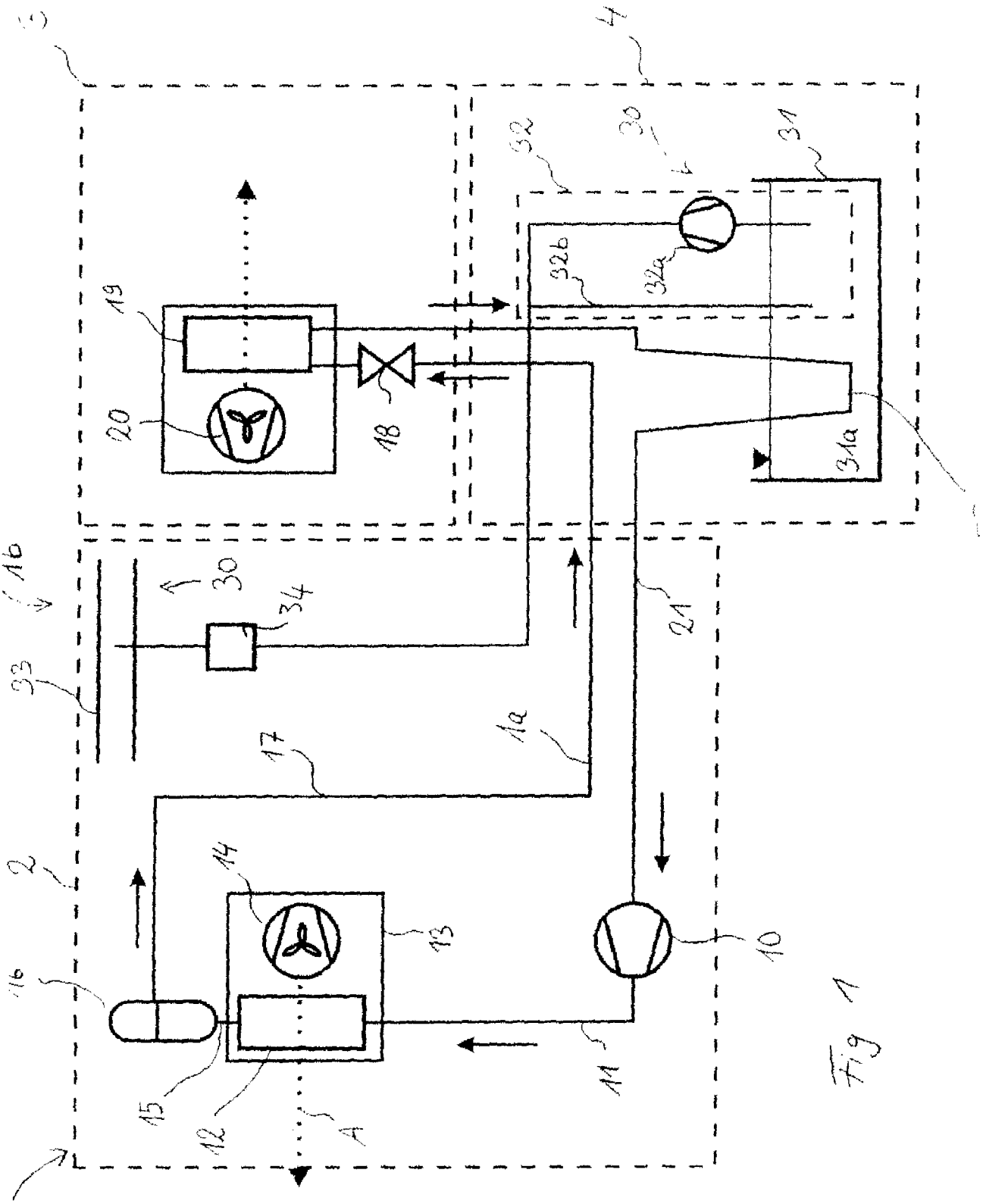

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Fig 1

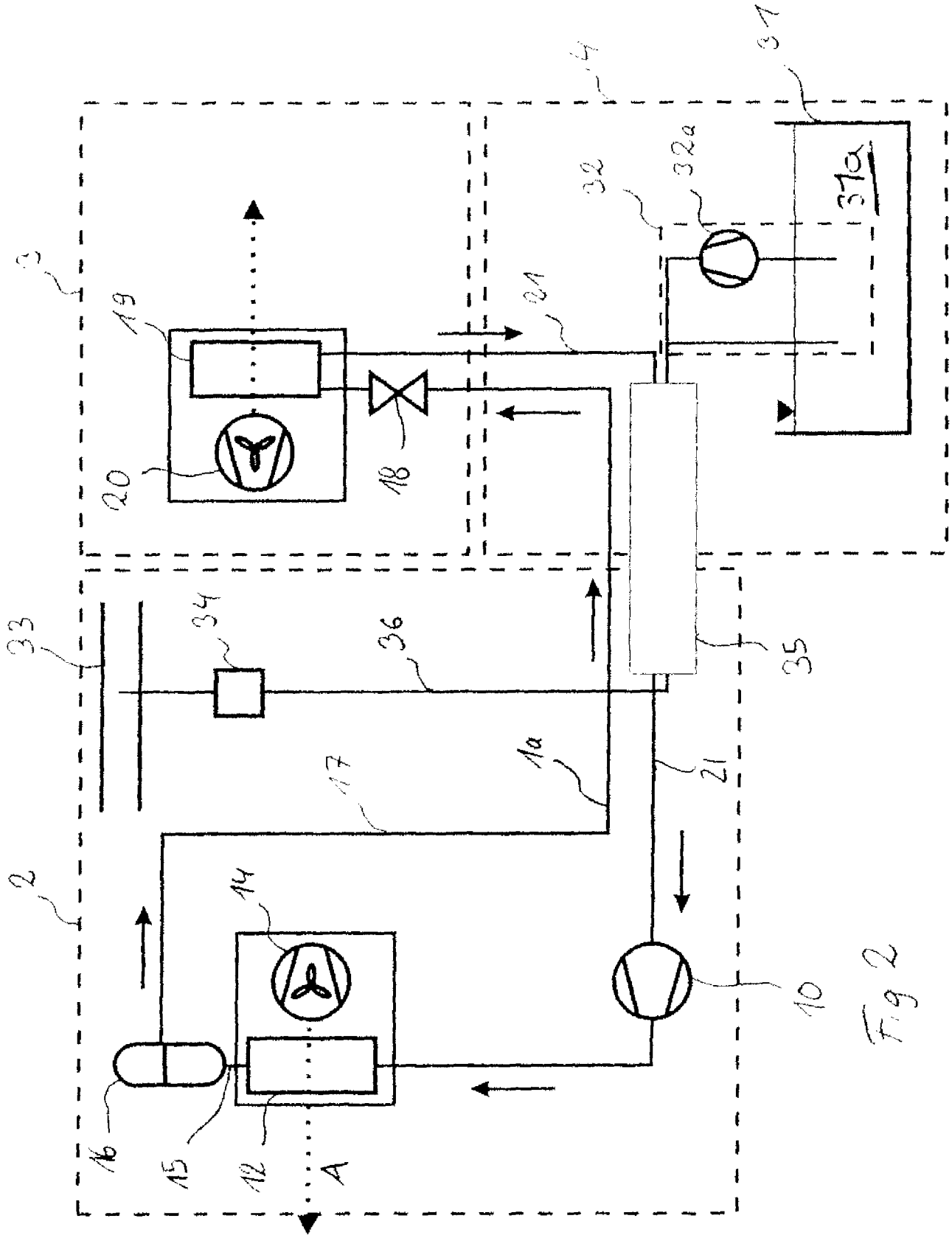


Fig 2

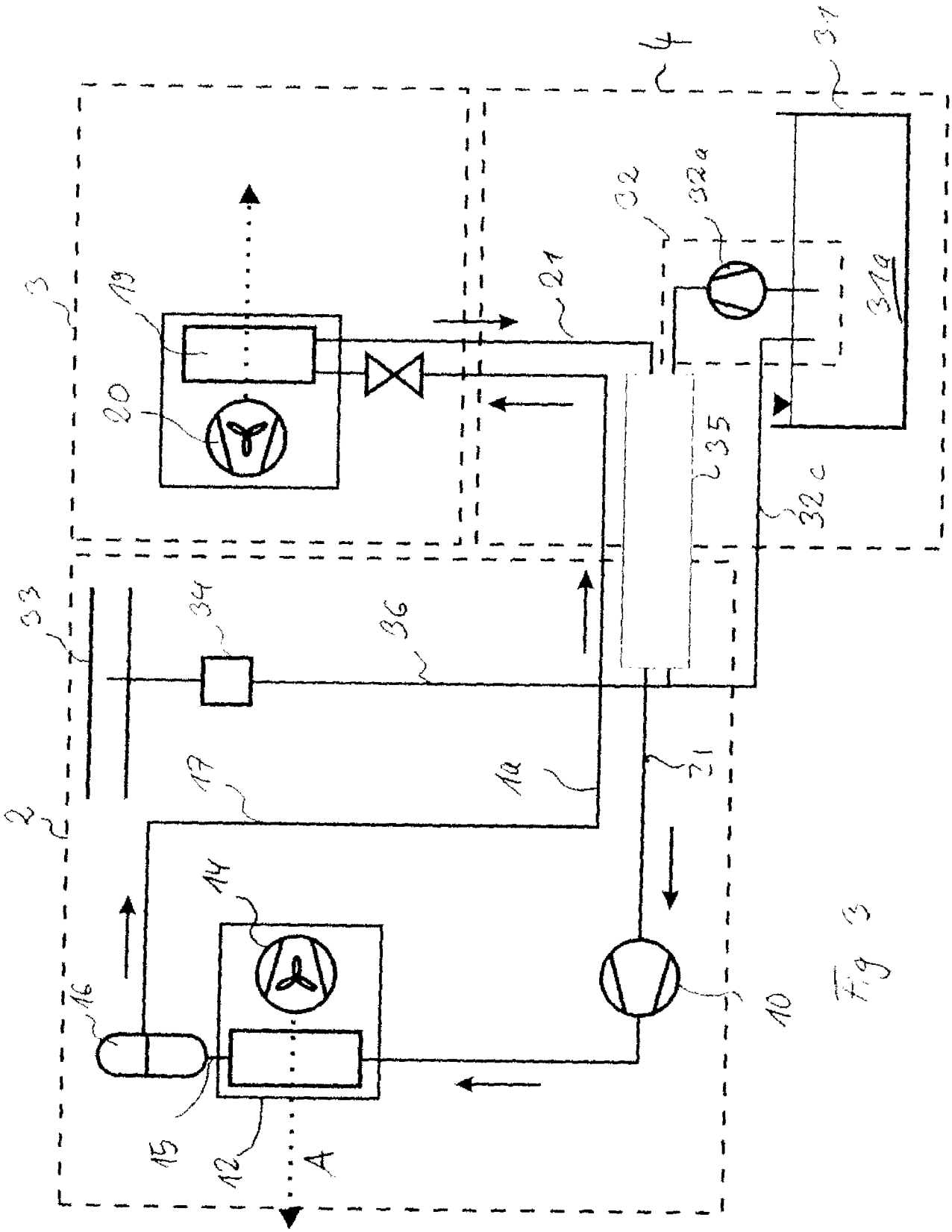


Fig 3

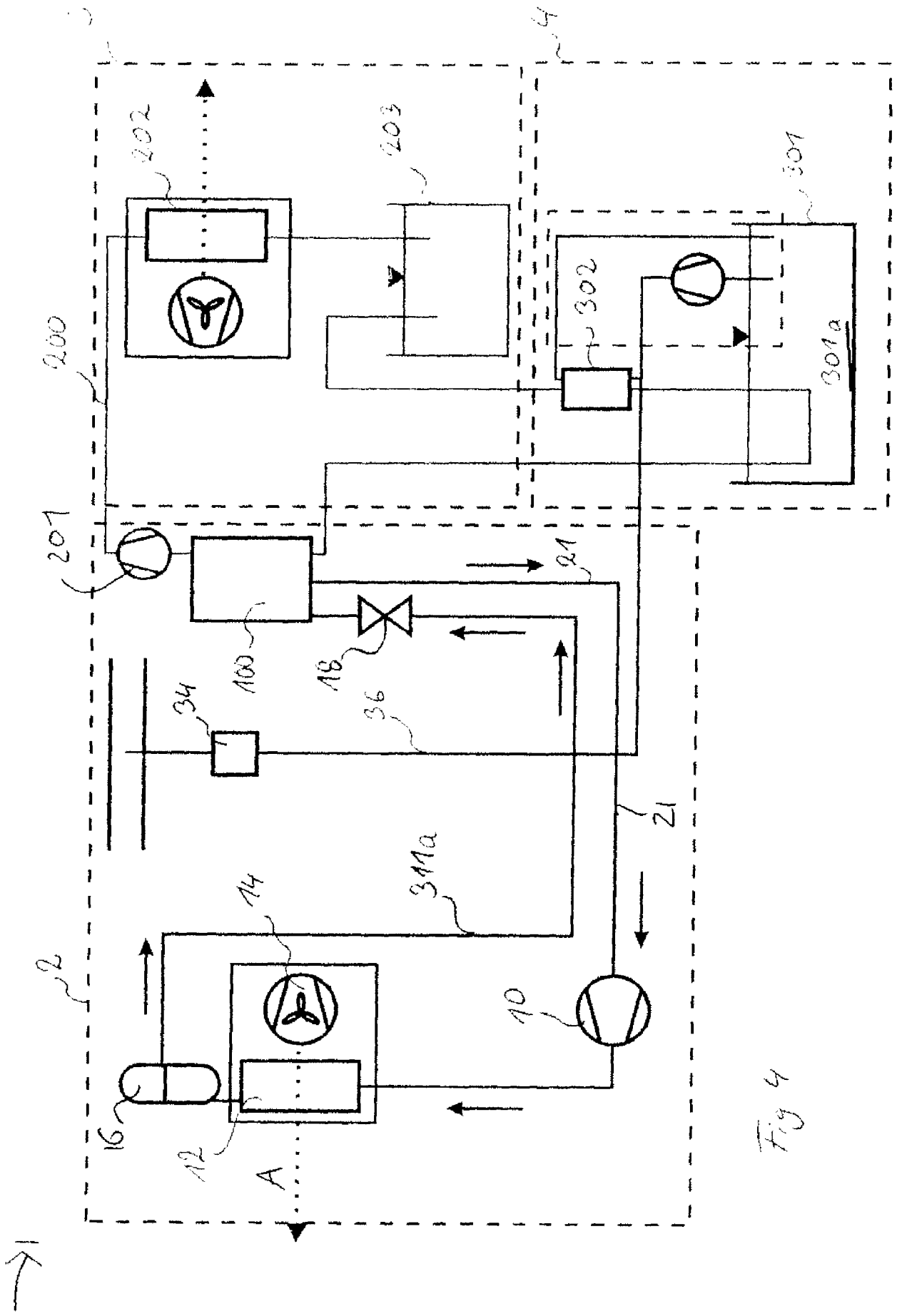


Fig 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2010/059250

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60H1/00 F01N3/20
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60H F01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	WO 2007/067114 A1 (VOLVO LASTVAGNAR AB [SE]; REGNELL HANS [SE]; ADLERSON HANS [SE]; SONDE) 14 June 2007 (2007-06-14) page 1, line 14 - page 2, line 23; figure 1	8-12
X	FR 2 824 388 A1 (ITALINNOVA SAS [IT]) 8 November 2002 (2002-11-08) line 3 - page 4, line 17	1-7,13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 September 2010	01/10/2010

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Fax: (+31–70) 340–3016	Gumbel, Andreas

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2010/059250

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