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(54) Air-conditioning system for a vehicle and vehicle equipped with such system

(57) Air-conditioning system for a vehicle, comprising:

a main internal combustion engine (1);

characterized by comprising an electric generator unit (9) comprising an auxiliary internal combustion engine (10) and an auxiliary electric generator (11), also suitable for heating the passenger compartment if required, by means of electrical power or the heat generated by the auxiliary engine cooling circuit. The generator unit is also suitable for driving the compressor (3) of a refrigerant circuit (2), to cool the passenger compartment.

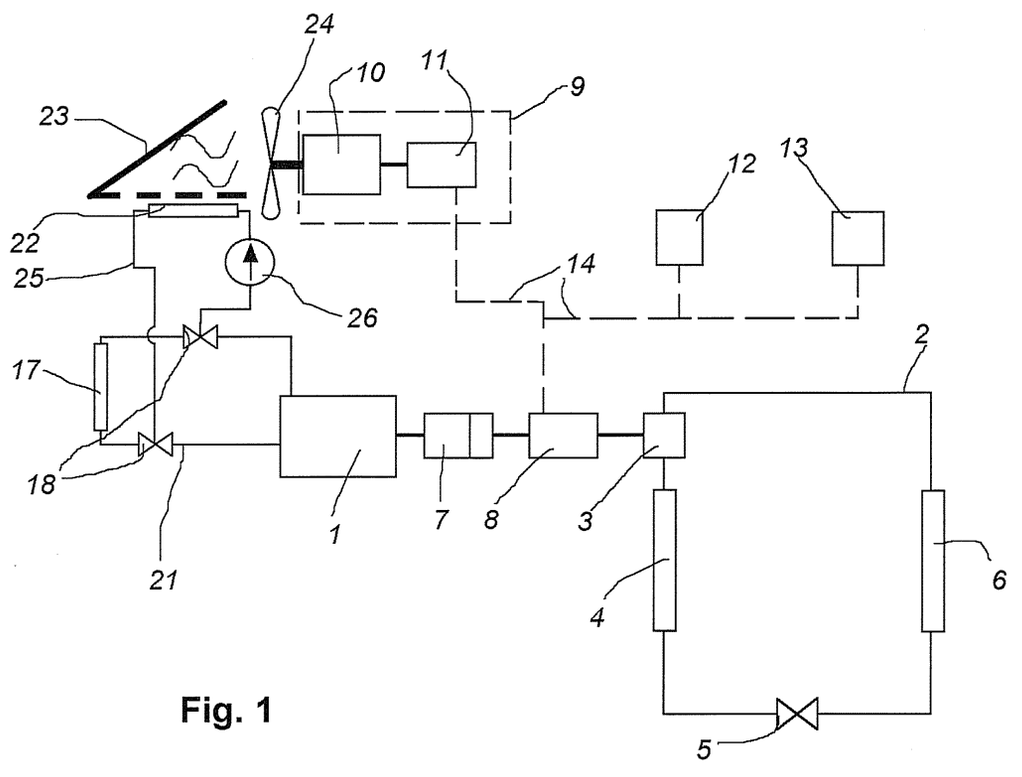

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an air-conditioning system for a vehicle, in particular for an industrial vehicle, that is capable of operating even when the engine is not running.

PRIOR ART

[0002] Air-conditioning systems for vehicles are known in the prior art, that comprise a refrigerant circuit provided with a compressor directly driven by the vehicle's engine. However, such systems cannot operate when the engine is not running, as required in certain applications, such as in the case of industrial vehicles.

[0003] For this reason a number of systems have been developed to cool the passenger compartment even when the engine is not running; one such solution consists of using the cooling circuit to freeze a mass of liquid while the vehicle is running so that, when the vehicle is parked, said frozen mass melts and in doing so removes the heat from the passenger compartment. Among the drawbacks of this solution are the dimensions and additional weight involved.

[0004] Patent IT1308784 suggests providing a conventional air-conditioning system with an electric motor that drives the compressor of the refrigerant circuit, once this has been disconnected from the engine of the vehicle, when the latter is at a standstill, or an auxiliary compressor comprised in said circuit.

[0005] This system, which has the advantage of being compact and integrated with the vehicle's normal air-conditioning system, has the disadvantage that the vehicle's batteries must be used to supply energy to the electric motor. This restricts the amount of power that is actually available for the air-conditioning system and may lead to inadequate cooling. Moreover, even when appropriately oversized batteries are used, the system can only be used for a limited period of time if the engine is not running and, in any case, there is always a risk of running the batteries down, with all the inconvenience that this entails. Therefore, the solutions described above are unsatisfactory and completely inadequate in case of vehicles that are required to stop (when air-conditioning is needed) for several hours, or perhaps even days.

[0006] Another requirement felt in the field of industrial vehicles regards the heating of the passenger compartment, also with the engine turned off, when the heat generated by the engine cooling system cannot be used. In that connection a number of solutions have been developed, such as boilers, that run on the same fuel as that used by the vehicle, installed either inside or outside the passenger compartment. In particular, there are two types of external boilers, neither of which take up space inside the passenger compartment: some heat air that is taken from the passenger compartment and then reintroduce it into the passenger compartment, which involves the use of specific air circulation systems, but allows heating the passenger compartment more rapidly; others heat the water in the vehicle's heating circuit, which is integral with the engine cooling circuit, but this method has the disadvantage of requiring more time to heat the passenger compartment.

[0007] Therefore the need is felt, while the vehicle is not running, to allow the use of different electrical devices, such as lighting appliances or small household appliances.

[0008] Moreover, the need is also felt for an air-conditioning system for the passenger compartment of an industrial vehicle capable of operating for long periods of time with the engine turned off without any of the drawbacks described above. The system should preferably integrate as fully as possible with the air-conditioning system that is used when the vehicle is running. Ideally the system should also be capable of both cooling and heating the passenger compartment when the engine is not running, without any significant increase in the dimensions and complexity of the system.

SUMMARY OF THE INVENTION

[0009] The problems described above have now been solved with an air-conditioning system for a vehicle, preferably for an industrial vehicle, comprising:

a main internal combustion engine;
said system being characterized by comprising a generator unit comprising an auxiliary internal combustion engine and an auxiliary electric generator, suitable for generating the energy to heat the passenger compartment.

[0010] According to a preferred embodiment of this invention, the system also comprises a refrigerant circuit comprising a compressor, suitable for being driven by said main engine, a condenser, expansion means and an evaporator;
an electric motor suitable for being powered by said generator.

[0011] Said main engine is preferably the engine used to drive the vehicle.

[0012] Said electric motor drives said compressor, or an auxiliary compressor that is also part of said refrigerant circuit.

[0013] Said auxiliary generator may be of any known type, for example a dynamo or an alternator, preferably an alternator.

[0014] The invention also relates to a vehicle equipped with a system as described above.

[0015] This invention refers in particular to that set forth in the claims, which are attached hereto.

LIST OF DRAWINGS

[0016] This invention will now be illustrated through a detailed description of the preferred but not exclusive embodiments, provided merely by way of example, with the aid of the figures attached hereto, of which:

figure 1 is a schematic view of the lay-out of an air-conditioning system for a vehicle according to a possible embodiment of this invention;
figure 2 is a schematic view of the lay-out of an air-conditioning system according to a possible alternative embodiment of the solution in figure 1;
figure 3 is a schematic view of the lay-out of an air-conditioning system for a vehicle according to another possible embodiment of this invention;
figure 4 is a schematic view of the lay-out of an air-conditioning system for a vehicle according to another possible embodiment of this invention;

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0017] Figure 1 is a schematic view of the lay-out of an air-conditioning system according to a possible embodiment of this invention.

[0018] The system comprises a main internal combustion engine 1, which may be a diesel engine, and is the engine that drives the vehicle.

[0019] The system according to the present invention comprises a generator unit 9, comprising an auxiliary engine 10, preferably an internal combustion engine.

[0020] According to a preferred embodiment of the invention, the auxiliary engine runs on the same fuel as the main engine. The generating set comprises an auxiliary electric generator 11, that may, according to a preferred embodiment, be an alternator. Said auxiliary generator supplies power to the vehicle's various electrical systems, such as the electric motor 8 that drives a compressor 3, that is part of a refrigerant circuit 2, to cool down the passenger compartment, when the main engine 1 is not running and cannot drive the compressor 3. The auxiliary engine 10 can thus be started when the main engine is not running and electricity or air-conditioning is required in the passenger compartment.

[0021] A first advantage of the present invention is immediately apparent: power can be supplied for as long as necessary without the risk of running the vehicle batteries down. Moreover, according to a preferred embodiment of the invention, the auxiliary generator 11 is also suitable for recharging the batteries 12 of the vehicle and supplying energy to other users as necessary or desirable (means such as fans, to circulate the cooled or, as explained below, heated, to be circulated in the passenger compartment for conditioning it). According to a preferred embodiment of the invention, the auxiliary generator 11 generates current at the same voltage as that generated by generating units that are normally present in the vehicle, such as for example a main generator driven by the main engine 1 when the vehicle is running, as in conventional systems.

[0022] If the auxiliary generator is of a suitable type, for example an alternator, the system may, according to an embodiment of the invention, comprise a transformer 13, powered by the auxiliary generator, in order to supply current at a different voltage to that generated (for example 220 V) to devices that may be used in the vehicle, such as equipment that is often used inside the passenger compartment when the vehicle is parked. The auxiliary generator may be installed in an appropriate position in the vehicle, for example to reduce to a minimum the length of the electric lines (generally indicated by means of the dotted lines 14) operating at the voltage being generated (usually low voltage, for example 12 or 24 V), and thus as close as possible to the electric motor 8, the batteries 12, and the transformer 13, consistently with other construction requirements.

[0023] The generator unit can be used, for example, with the main engine 1 turned off, to supply heat to the passenger compartment, by means of resistors, and/or by means of its own cooling system, as explained below. In that case, of course, no power is supplied to the electric motor 8, which can be disconnected by means of the appropriate means, such as switches. As usual, the passenger compartment can be heated while the vehicle is running by using the cooling system of the main engine.

[0024] The auxiliary engine 10 is preferably provided with cooling means that can comprise, for example, air or water. According to an embodiment of the invention, said cooling means can be used to heat the passenger compartment when required.

[0025] According to a first embodiment of the invention, illustrated in figures 1 and 2, the auxiliary engine is air-cooled and the heat generated by the cooling system can be transferred into the passenger compartment, preferably via a specific heating circuit (usually a circuit through which water or a suitable heat exchange liquid can flow) generally referred to with the reference numeral 25, comprising a heater (usually a heat exchanger of the radiator type) 17 to heat the air to be circulated inside the passenger compartment if required.

[0026] For example, the heat may be transferred from the air to the cooling circuit of the auxiliary engine 10 to the circuit 15 by means of a heat exchanger 22, through which the cooling air flow is directed, said flow being generated by a specific device 24 (such as a fan). Means 23 for regulating the amount of heat dissipated to the heat exchanger 22 may be foreseen. For example, said means may consist of a deflector 23 capable, depending on its position, of directing the air flow to the heat exchanger 22 (as illustrated) or diverting it to the outside so that it does not enter the heat exchanger 22 (dotted line). It may also be able to assume positions so as to regulate the flow, to control the amount of heat that is sent to the passenger compartment. A series of suitably structured air ducts may complete the system, to

conduct the air diverted by the deflector; said series of ducts may be implemented according to the specific requirements and expertise of the person skilled in the art. Other methods of controlling the amount of heat dissipated into the air in the passenger compartment may also be conceived, such as the controlled switching off and switching on of the auxiliary engine 10, provided there are no requests by other devices.

[0027] According to an embodiment of the invention, illustrated in figure 1, the heating circuit 25 is connected to the cooling circuit 21 so that the two circuits share the heater 17 of the passenger compartment. The heater may be connected alternatively to one of the two circuits by means of the appropriate means, such as the three-way valves 18 (that may be appropriately controlled solenoid valves). The rest of the cooling circuit 21 may be of a known type, and comprise flow regulating means, liquid circulation means (pump), and a radiator, for the heat to be dissipated towards the outside. The heating circuit 25 may preferably have its own liquid circulation means 26, such as a pump, or a pump may be incorporated in the shared part of the engine cooling circuit 21.

[0028] According to another embodiment, illustrated in figure 2, the circuits 25 and 21 are separate. The heating circuit 21 thus has its own circulating means 26; the heater 17 is separate from the heater 17' of the cooling circuit 21, or these may be integrated in a single body, but with separate circuits on the liquid side.

[0029] The use of an air-cooled auxiliary engine, as described above, has some significant advantages. The engine is simpler and more versatile and, given the dimensions involved in the specific case, it is more readily available on the market. Moreover, regulating the flow of heat to the passenger compartment, or to be dispersed, as described above, is achieved much more easily than with a water-cooled auxiliary engine. Moreover, the heating circuit is easier to implement, since it is separate from the actual auxiliary engine and does not require a radiator to dissipate unused heat in correspondence the vehicle's radiator.

[0030] According to a possible alternative embodiment of the invention, illustrated in figure 3, a water-cooled auxiliary engine is used. It has been found that, in this case, the heating circuit 25', that is used to cool the auxiliary engine and, when required, to heat the passenger compartment, should preferably be separate from the cooling circuit 21 of the main engine; the heater 17 is separate from the heater 17' of the cooling circuit 21, or these may be integrated into a single body, but with separate circuits on the liquid side. Separating the circuits enables the temperature inside the passenger compartment to be controlled in an optimal and straightforward manner, to achieve trouble-free operation even during phases when simultaneous operation of the two circuits is desirable, such as immediately after starting the vehicle and the main engine. Moreover, there is a reduced risk of any possible interference between the two circuits, such as overheating, unbalanced circuits or malfunctioning, and maintenance operations, such as filling and emptying the circuits, are made easier.

[0031] The circuit 25' has liquid circulation means 26', and, preferably, a radiator 27. It must be possible to cool the auxiliary engine even when no heat is required inside the passenger compartment, or only a part of the heat is required. Connecting devices, such as the three-way valves 28, distribute the liquid circulating in the auxiliary engine between the heater 17 and the radiator 27, or exclude the flow of said liquid alternatively to one or the other, thus regulating the flow as required. It is evident that the flow may be regulated, if possible, by controlling the switching on and switching off of the auxiliary engine 10.

[0032] According to another embodiment of the invention, illustrated in figure 4, the generator unit 9, the auxiliary engine of which is anyway cooled, powers an electric heater 17", for example via the line 14. In this case the auxiliary engine is preferably air-cooled, for the reasons described above. The electric heater 17" is separate from the heater 17' of the cooling circuit 21, or these may be integrated in a single body. The advantage of this solution is its extremely simple structure, and the possibility of connecting the heater 17" easily even in positions in which it is difficult to install a heat exchanger.

[0033] In any case, with the engine running, if heating is required in the passenger compartment, a portion of the liquid in the cooling system of the main engine 1 can be picked up and sent to the heat exchanger 17' (using the same method that is commonly used in vehicles).

[0034] According to a preferred embodiment, as mentioned above, the system may also be used to cool the passenger compartment when the vehicle is parked. With reference to the drawings, there may be a refrigerant circuit, of a known type, comprising a compressor 3, a condenser 4, connected to the outlet of the compressor 3, a refrigerant expansion device, such as a common expansion valve 5, an evaporator 6, connected to the compressor intake, to close the circuit.

[0035] A liquid refrigerant can flow through the circuit; the evaporator 6 is suitable to remove heat from the passenger compartment of the vehicle by evaporation of said liquid refrigerant. For example, the evaporator may cool the air in the passenger compartment, or a stream of air supplied to the passenger compartment, as in conventional systems.

[0036] The compressor 3 may be driven by the engine 1 by means of the transmission means 7. Said transmission means are preferably disengageable, so that the compressor 3 can freely turn when the engine 1 is not running. They may comprise, for example, a belt drive connected to a pulley which can be coupled to a shaft of the compressor 3 by means of an electromagnetic clutch, as described in patent IT1308784 with reference to the diagram in figure 2 of said document, or they may be of any other known type. According to a preferred embodiment of the invention, the compressor 3 can be adapted to be driven by the electric motor 8. According

to another embodiment of the invention the electric motor 8 can drive an auxiliary compressor (not illustrated), that may be included in the refrigerant circuit 2, for example in parallel with the compressor 3 (which in that case may be permanently connected to the main engine 1), for replacing the latter when the engine is turned off, in order to operate the refrigerant circuit, according to the diagram (appropriately modified) in figure 1 of patent IT1308784.

[0037] An advantage of the system described above is that, when the engine is turned off during vehicle stops, the passenger compartment can be both cooled or heated using the same heat exchange means (evaporator 6 and heat exchanger 17) that are used when the engine 1 is running, and as a consequence the system also uses the same air circulation systems that are normally present in the passenger compartment (fans, ducts, vents...).

[0038] The system can advantageously be used to heat the passenger compartment by means of its cooling system, while at the same time generating electricity for the various devices. Moreover, a portion of the electric current can be used to heat the passenger compartment more quickly, for example by means of suitable resistors that may be set in the air circuits of the passenger compartment or by means of electric heaters, thus eliminating the drawback due to the typical slowness of conventional heating systems (heaters) that use the engine cooling circuit to transfer heat.

[0039] The system according to the present invention is a valid solution to the problem of air-conditioning in the passenger compartment of a vehicle, when the engine is not running during vehicle stops; unlike conventional systems it can also be used to cool the passenger compartment for an unlimited period of time, without running the vehicle batteries down, but using the same fuel that is used to drive the vehicle. It enables the integration of the winter and summer air-conditioning systems, without the use of heaters or other devices that take up additional space. Moreover, if suitably dimensioned it enables generating electricity for other users, also at the normal supply voltage, which is an advantage on long journeys during which the driver must sleep in the passenger compartment, which is a common occurrence in case of industrial vehicles.

[0040] Merely by way of example, a generator unit capable of generating 2.2 kW of electricity can be installed in an industrial vehicle. Of said 2.2 kW, with the vehicle at a standstill and the generator running to cool the passenger compartment, approximately 1.5 can be used by the electric motor, to supply 1 kW of mechanical power to the compressor, in order to remove approximately 2 kW of heat from the passenger compartment, a result that is generally considered adequate, with the vehicle at a standstill. The electric power that is not used by the electric motor can be used to charge the batteries and by other users, also at the voltage used by the normal distribution networks (for example lighting, televisions, microwave ovens...used in the passenger compartment).

[0041] If the system is used to heat the vehicle, the auxiliary engine is capable of supplying approximately 3 kW of heat via the cooling system. Moreover, the electric power that is generated and not used by other users, when the electric motor 8 is disconnected, can be used, as described above, via the resistors, for heated blankets and other such devices.

[0042] It is evident that the various components need to be dimensioned according to the size of the vehicle and other specific requirements.

Claims

1. Air-conditioning system for a vehicle, comprising:

   a main internal combustion engine (1);

   characterized by comprising a generator unit (9) comprising an auxiliary internal combustion engine (10) and an auxiliary electric generator (11), suitable for generating power to heat the passenger compartment of the vehicle.

2. System according to claim 1, **characterized by** comprising a refrigerant circuit (2) comprising a compressor (3), suitable for being driven by said main engine, a condenser (4), expansion means (5) and an evaporator (6);
   an electric motor (8) powered by said generator unit.

3. System according to any of the previous claims, **characterized in that** said auxiliary engine is air-cooled.

4. System according to claim 3, **characterized by** comprising a heating circuit (circuit for a heat exchange liquid) (25), comprising a heater (17) suitable for heating the passenger compartment and a heat exchanger (22) suitable for receiving heat from the air in the auxiliary engine cooling circuit.

5. System according to claim 4, **characterized by** comprising means (23) for regulating the amount of heat that is transferred to the heat exchanger (22).

6. System according to claim 5, **characterized in that** said means is a deflector (23).

7. System according to any of the claims from 4 to 6, **characterized in that** said heating circuit is connected to a cooling circuit (21) of the main engine and said heater (17) is common to both circuits.

8. System according to any of the claims from 4 to 6,

characterized in that said heating circuit is separate from the cooling circuit (21) of the main engine.

9. System according to claim 1 or 2, **characterized in that** said auxiliary engine is water-cooled by means of a heating circuit (for heat exchange liquid) (25') comprising a heater (17) suitable for heating the passenger compartment of the vehicle, said heating circuit being separate from the cooling circuit (21) of the main engine.

10. System according to claim 9, **characterized in that** said heating circuit comprises a radiator (27) to dissipate heat to the outside, and means (28) for distributing the flow of liquid between said radiator and said heater.

11. System according to any of the claims from 1 to 3, **characterized by** comprising an electric heater (17") suitable for heating the passenger compartment, that may be powered by said generator unit.

12. System according to any of the previous claims, **characterized in that** said main engine is used to drive the vehicle.

13. System according to any of the previous claims, **characterized in that** said main engine and said auxiliary engine run on the same fuel.

14. System according to any of the previous claims, **characterized in that** said main engine is a diesel engine.

15. System according to claim 2, **characterized in that** said electric motor is suitable for driving said compressor.

16. System according to any of the claims from 1 to 14, **characterized in that** said electric motor is suitable for driving an auxiliary compressor that is also part of said refrigerant circuit.

17. System according to any of the previous claims, **characterized in that** said auxiliary generator is an alternator.

18. System according to any of the previous claims, **characterized by** comprising a transformer (13).

19. System according to any of the previous claims, **characterized in that** said auxiliary generator is suitable for charging the vehicle's batteries (12).

20. Vehicle **characterized by** comprising a system according to any of the previous claims.

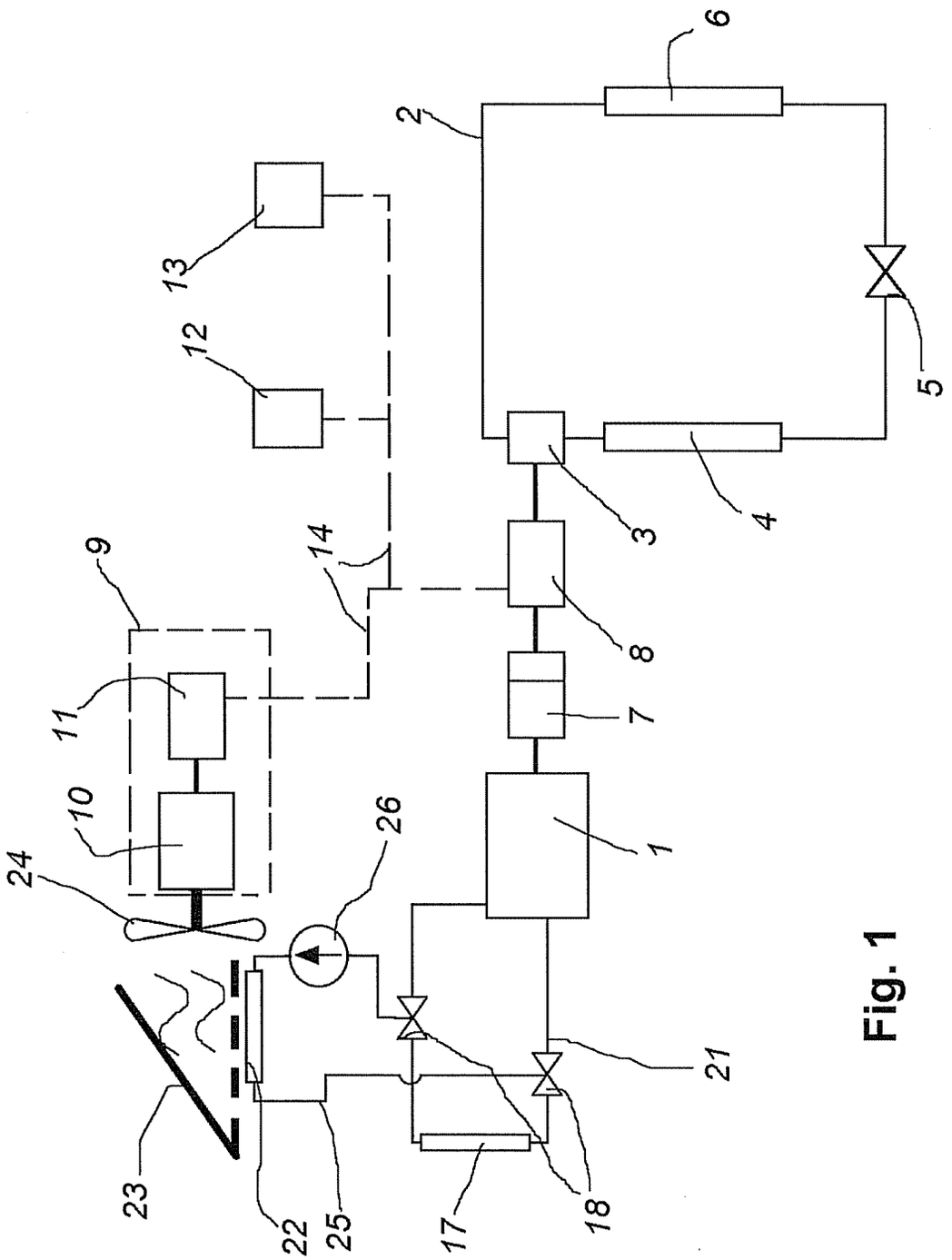

Fig. 1

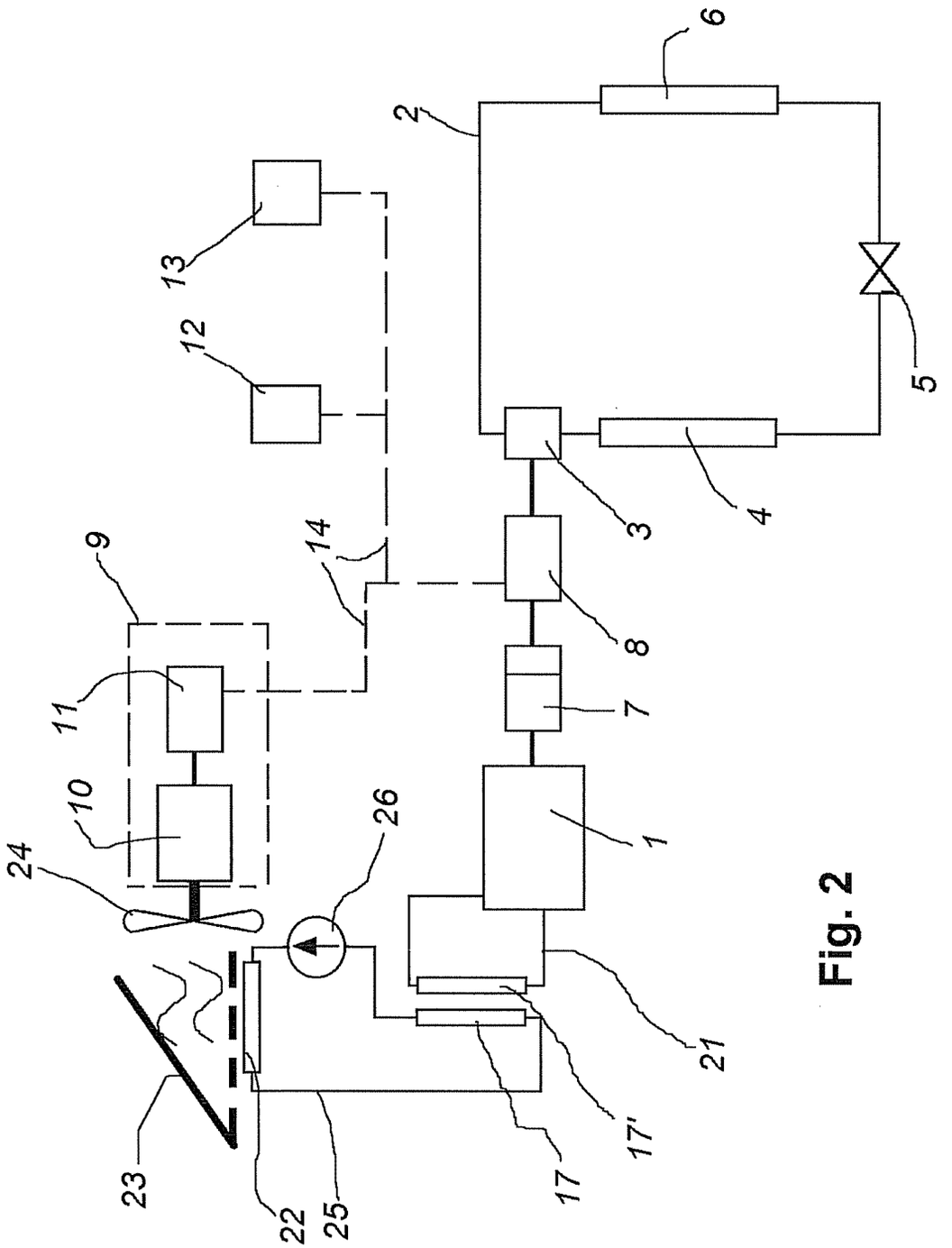

Fig. 2

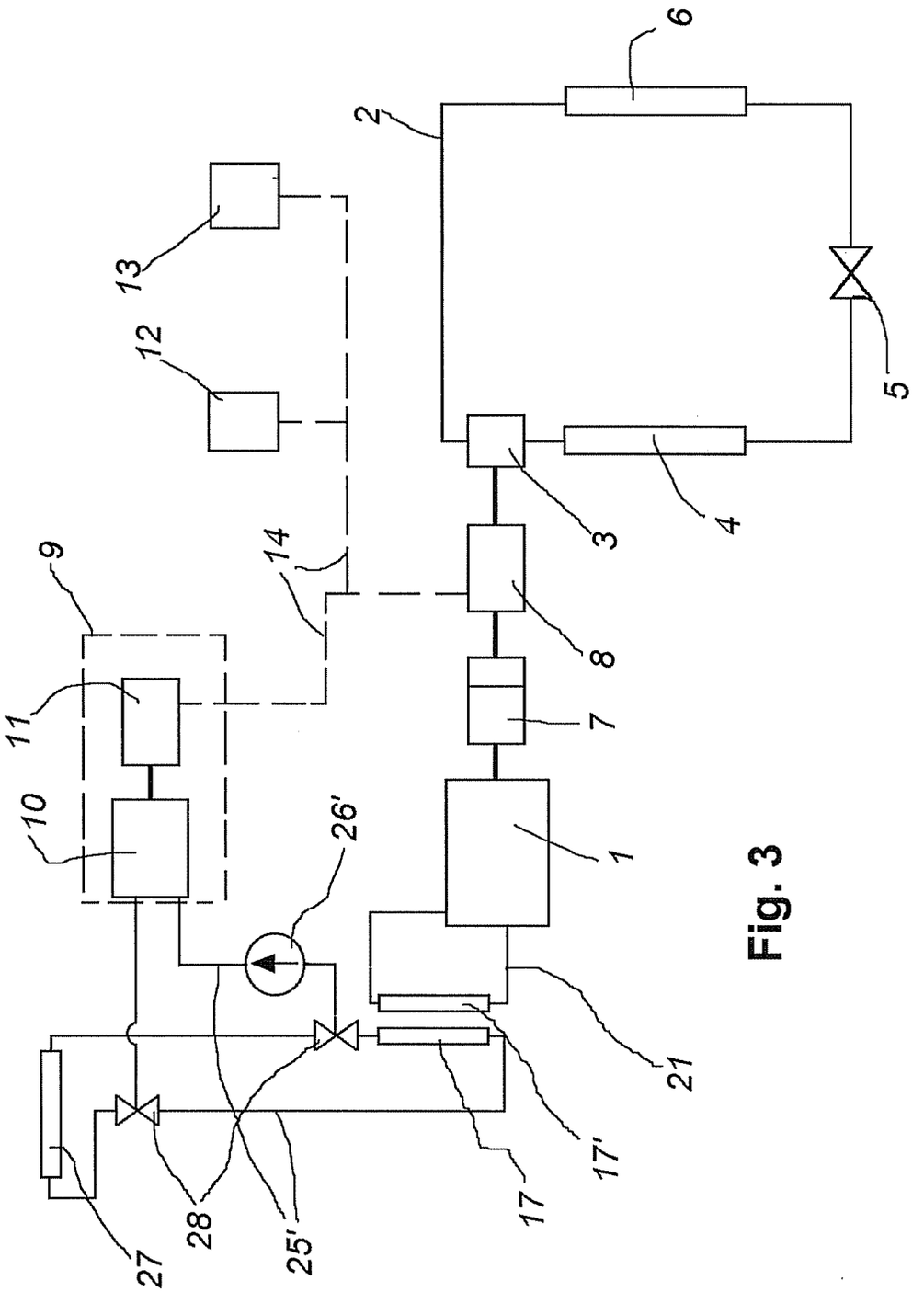

Fig. 3

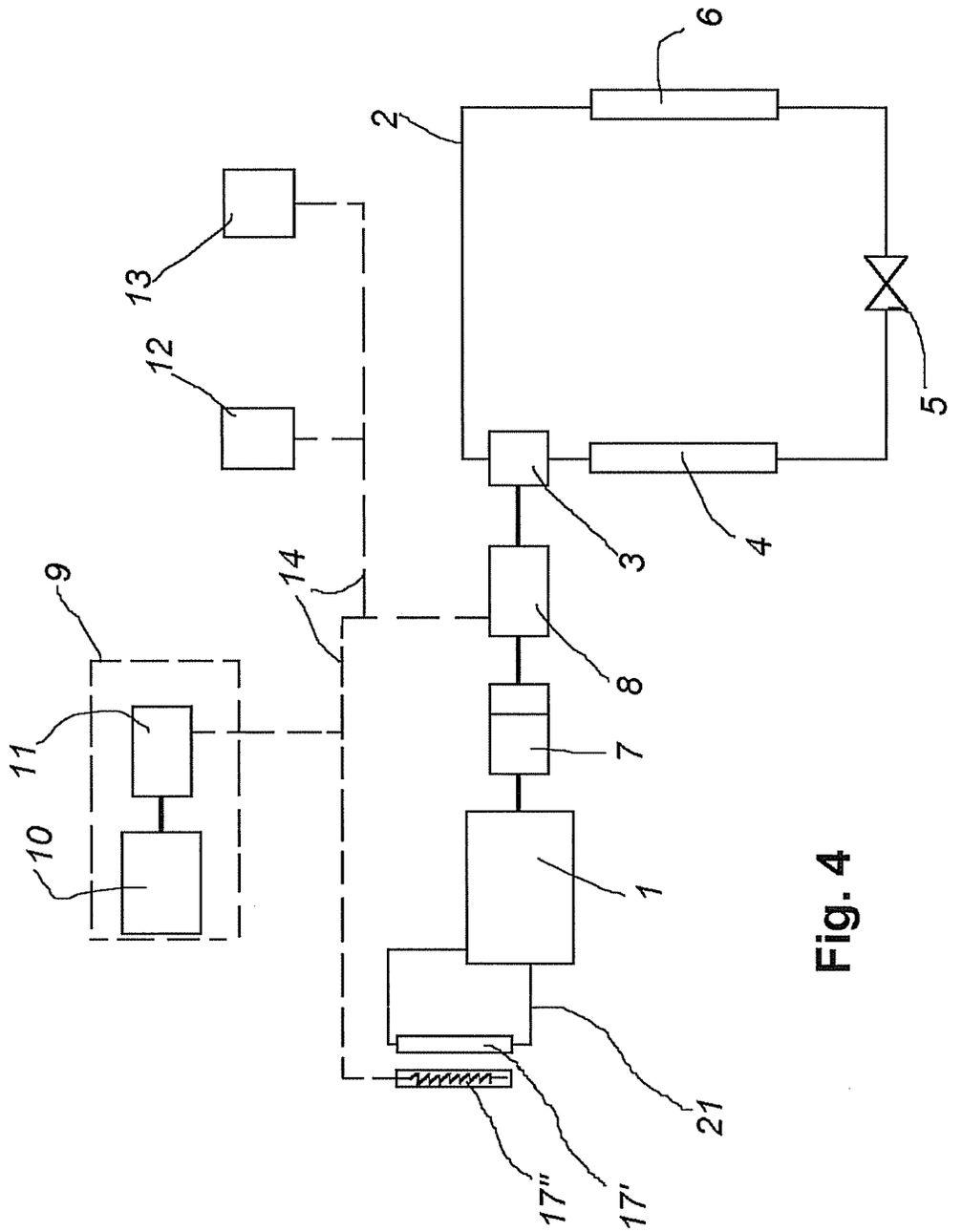

Fig. 4

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	3 August 2005	Kooijman, F

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

Application Number
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