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(71) Applicant: VOLVO TRUCK CORPORATION [SE/SE]; 405 08 Göteborg (SE).

(72) Inventors: **ANDERSSON, Lennart**; Torpavägen 58, 432 95 Varberg (SE). **LEIDEFELDT, Marcus**; Östra Eriksbergsgatan 84, 417 63 Göteborg (SE). **MAGNUSSON, Ingemar**; Föreningsgatan 8 A, lgh 1702, 411 27 Göteborg (SE).

(74) Agent: VOLVO TECHNOLOGY CORPORATION; Volvo Group Intellectual Property, BF14100, M1.7, 405 08 Göteborg (SE).

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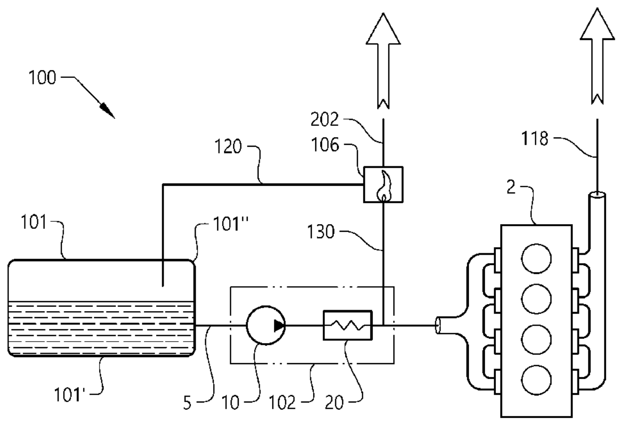

FIG. 2

(57) Abstract: The present invention relates to a gas tank arrangement (100) for an internal combustion engine (2) of a vehicle, the gas tank arrangement (100) comprising a gas tank (101) for containing a combustible gas, a gas converter arrangement (102) arranged to convert liquefied combustible gas to compressed combustible gas for delivery to the internal combustion engine (2), said gas converter arrangement (102) being positioned in downstream fluid communication with said gas tank (101), wherein the gas tank arrangement further comprises a combustible gas burning arrangement (106) for combustion of combustible gas, said combustible gas burning arrangement (106) being positioned in downstream fluid communication with the gas tank (101) via a first conduit (120), and positioned in downstream fluid communication with the gas converter arrangement (102) via a second conduit (130).

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A GAS TANK ARRANGEMENT

TECHNICAL FIELD

The present invention relates to a gas tank arrangement. The invention also relates to a vehicle comprising such a gas tank arrangement. The invention is applicable on vehicles, in particularly low, medium and heavy duty vehicles commonly referred to as trucks. Although the invention will mainly be described in relation to a truck, it may also be applicable for other type of vehicles such as e.g. working machines, buses, boats etc.

BACKGROUND

In relation to propulsion systems for heavy duty vehicles, internal combustion engines are frequently used. These internal combustion engines are most often propelled by a combustible fluid such as e.g. diesel or petrol. However, in order to further reduce engine emissions of the vehicles, alternative propulsion methods and/or fuels are being used, either alone or in combination with the well known combustible fluids. These may include, for example, ethanol or electrical propulsion from an electric machine, etc.

As a further alternative, a combustible gas, such as e.g. compressed natural gas, DME, biogas, etc. has been found a suitable propulsion fuel for vehicles in the form of trucks. The combustible fluids can be used in combination with the combustible gas for propelling the internal combustion engine, in the following also referred to as a dual fuel internal combustion engine. Since the residuals from the combustible gas are relatively environmentally friendly in comparison to e.g. diesel fuel, pollution from the emissions thereof is reduced for these types of engines.

A problem with engines being propelled by the above described combustible gas is that if leakage of gas occurs from e.g. the gas tank or other positions of the system there is a risk of green house gas emission. Unwanted leakage of this kind also has an economical aspect since the fuel consumption will increase.

There is thus a need to provide an improved gas tank arrangement for reducing emission of such gases to the atmosphere.

SUMMARY

It is an object of the present invention to provide a gas tank arrangement which at least partially overcomes the above described deficiencies. This is achieved by a gas tank arrangement according to claim 1.

According to a first aspect of the present invention, there is provided a gas tank arrangement for an internal combustion engine of a vehicle, the gas tank arrangement comprising a gas tank for containing a combustible gas, a gas converter arrangement arranged to convert liquefied combustible gas to compressed combustible gas for delivery to the internal combustion engine, the gas converter arrangement being positioned in downstream fluid communication with the gas tank, wherein the gas tank arrangement further comprises a combustible gas burning arrangement for combustion of combustible gas, the combustible gas burning arrangement being positioned in downstream fluid communication with the gas tank via a first conduit, and positioned in downstream fluid communication with the gas converter arrangement via a second conduit.

The wording “combustible gas” should in the following and throughout the entire description be interpreted as a gas which can be ignited, either self-ignited by compression or be ignited by e.g. a spark plug. The invention should thus not be limited to any specific combustible gas. However, as a non-limiting example, the combustible gas may be natural gas, which is described further below. Other alternatives are of course conceivable such as e.g. DME or biogas, etc. The combustible gas which can be provided in the gas tank can be in liquid phase and in gas phase. Hence, the wording “combustible gas” should be interpreted to include liquefied gas as well as gas in gas phase. Accordingly, a lower portion of the gas tank can be provided with liquefied combustible gas while an upper portion of the gas tank can be provided with combustible gas in gas phase. The combustible gas burning arrangement is thus an arrangement which combusts a combustible gas. Such arrangement may, for example, be a catalytic oxidation burner or a fuel cell burner, etc.

Moreover, the wording “in fluid communication” should be construed as being valid for liquids as well as gases. Hence, fluid communication should be understood to mean that a liquid or gas can be delivered to a specific component. According to the above description, the combustible gas in gas phase may thus have a passage from the gas tank to the combustible gas burning arrangement.

Furthermore, the gas converter arrangement is, as described above, arranged to convert liquefied combustible gas to compressed combustible gas. The combustible gas in the gas tank is provided with relatively low pressure levels, while the combustible gas delivered to the internal combustion engine, or the gas rail of the internal combustion engine, should preferably be provided in gaseous phase at relatively high pressure levels. The gas converter arrangement thus enables for the provision of combustible gas from the gas tank to the internal combustion engine.

An advantage is that a reduction of gases which may be harmful to the environment is reduced. This is due to the fact that the combustible gas burning arrangement is positioned to combust the relatively environmentally harmful combustible gas downstream the gas tank as well as downstream the gas converter arrangement in the event of controlled and/or uncontrolled leakage. The products from the combustible gas are less harmful to the environment after combustion thereof, whereby emissions downstream the combustible gas burning arrangement is preferable. Also, and as will be described further below, using a combustible gas burning arrangement according to the present invention is advantageous as the heat generated therefrom may be used for other components/arrangements of the vehicle, which serves for further benefits thereof.

According to an example embodiment, the gas tank arrangement may further comprise an additional gas tank positioned in upstream fluid communication with the combustible gas burning arrangement.

Hereby, a storage for the combustible gas is provided before delivery to the combustible gas burning arrangement. An advantage is that the combustible gas can be controllably delivered to the combustible gas burning arrangement such that combustible gas is delivered thereto when there is a desire/possibility for the combustible gas burning arrangement to combust the combustible gas. A suitable means, such as a valve, may be arranged between the additional gas tank and the combustible gas burning arrangement for controlling the delivery of combustible gas to the combustible gas burning arrangement. By using a valve, the flow of combustible gas can be controlled such that the amount of gas delivered to the combustible gas burning arrangement can be controlled. Hereby, combustible gas can be delivered to the combustible gas burning arrangement when there is a desire of using the combustible gas burning arrangement.

A further advantage is that the additional gas tank may receive combustible gas from the gas tank in cases when the gas pressure level in the gas tank exceeds a predetermined limit and is in need of venting.

According to an example embodiment, the additional gas tank may be positioned in downstream fluid communication with the gas tank via the first conduit, and positioned in downstream fluid communication with the gas converter arrangement via the second conduit.

Hereby, the additional gas tank can receive combustible gas directly from the gas tank as well as from the gas converter arrangement. In particular, during change of engine load, the injection of combustible gas into the internal combustion engine may be changed from high-pressure injection to low-pressure injection. Hereby, the over-pressure can be delivered to the additional gas tank via the second conduit.

According to an example embodiment, the first conduit may be connected to an upper portion of the gas tank for receiving combustible gas in gas phase from the gas tank.

As described above, this allows for venting of the gas tank when the pressure level of the combustible gas in the gas tank exceeds a predetermined limit.

According to an example embodiment, the gas converter arrangement may comprise a fuel pump and an evaporating unit positioned in fluid communication with the fuel pump.

Hereby, the fuel pump increases the pressure of the combustible gas to pressure levels suitable for the injectors of the internal combustion engine. The evaporating unit on the other hand evaporates the liquid combustible gas such that it can be received and combusted by the internal combustion engine.

According to an example embodiment, the gas tank arrangement may further comprise a valve arrangement, the valve arrangement being arranged in fluid communication between the gas converter arrangement and the combustible gas burning arrangement.

Hereby, the valve arrangement can be arranged to control the delivery of combustible gas to the combustible gas burning arrangement. The valve arrangement may be arranged to control the flow when e.g. the pressure level in the gas tank is too high, or to be controlled to be positioned in the open state when there is a desire to combust combustible gas in the combustible gas burning arrangement.

According to an example embodiment, the valve arrangement may be arranged in fluid communication between the gas converter arrangement and the combustible gas burning arrangement via the additional gas tank.

Hereby, if the additional gas tank is filled up, the valve arrangement can be arranged in a closed state. On the other hand, if the additional gas tank is not filled up, the valve arrangement may receive a signal indicative of positioning the valve arrangement in an open state. The valve arrangement may thus be arranged between the gas converter arrangement and the additional gas tank.

According to an example embodiment, the gas tank arrangement may further comprise a heat exchanger arrangement, the heat exchanger arrangement being positioned in downstream fluid communication with the combustible gas burning arrangement for heating auxiliary components of the vehicle.

The auxiliary components may, for example, include an exhaust aftertreatment system, the cabin, or even the internal combustion engine. Hence, heat from the heat exchanger arrangement may be used for heating the exhaust aftertreatment system and/or the internal combustion engine for reducing cold start emissions, heat the cabin in cold climates, etc. As a further example, the heat exchanger arrangement may be used for generating electricity in combination with a turbine, thermo-electricity or other type of devices. As a still further example, the heat exchanger arrangement may also be used for heating a fluid, such as water used by the evaporating unit.

According to an example embodiment, the heat exchanger arrangement may be arranged in fluid communication with the gas converter arrangement for heating combustible gas provided to the gas converter arrangement from the gas tank.

Hereby, the compressed combustible gas can be heated before being injected into the cylinders of the internal combustion engine. An advantage is that problems associated with cold starts of the internal combustion engine can be reduced.

According to an example embodiment, the gas tank arrangement may further comprise an additional valve arrangement positioned in fluid communication between the combustible gas burning arrangement and the heat exchanger arrangement for controllably delivery of heated combusted gas to the heat exchanger arrangement.

Thus, heat from the combustible gas burning arrangement can be delivered to the heat exchanger arrangement when there is a desire of doing so. The additional valve may also, as will be described below, be able to by-pass the heat exchanger arrangement such that the combustible gas burning arrangement directly heats the auxiliary components of the vehicle. This may be advantageous as heating of the auxiliary components, such as the engine aftertreatment system, may be executed more rapidly. Accordingly, according to an example embodiment, the additional valve arrangement may be arranged to by-pass the heat exchanger arrangement.

According to an example embodiment, the gas tank arrangement may further comprise a cooling arrangement for cooling auxiliary components of the vehicle, the cooling arrangement being connected to a heat source for energization thereof.

As described above, the cooling arrangement may be arranged to e.g. cool the cabin during hot climates, etc. The cooling arrangement may, for example, be an adsorption cooler or an absorption cooler, etc. The cooling arrangement is advantageous as it does not require the use of vehicle electricity for energization thereof as it uses the overflow of heat from the vehicle. Hence, the waste heat from the combustion of the internal combustion engine can be used for energization of the cooling arrangement.

According to an example embodiment, the cooling arrangement may be arranged in downstream fluid communication with the combustible gas burning arrangement.

Hereby, the cooling arrangement is efficiently utilizing the heat generated by the combustible gas burning arrangement.

According to an example embodiment, the cooling arrangement may be connected to an exhaust system of the vehicle upstream an engine exhaust gas aftertreatment system. Hereby, the heat provided to the cooling arrangement is further directed to the exhaust system of the vehicle. Hereby, the engine exhaust gas aftertreatment system is heated thus improving the functionality of the engine exhaust gas aftertreatment system.

According to an example embodiment, the cooling arrangement may be connected to an exhaust system of the vehicle downstream an engine exhaust gas aftertreatment system.

Hereby, the cooling arrangement can be energized/regenerated by the heat from the exhaust gases of the internal combustion engine. Accordingly, the waste heat from the internal combustion engine can be used for cooling purposes of the vehicle during operation of the internal combustion engine.

According to second aspect of the present invention, there is provided a vehicle comprising an internal combustion engine and a gas tank arrangement according to any of the example embodiment described above in relation to the first aspect of the present invention, wherein the internal combustion engine is arranged downstream the gas tank arrangement.

According to an example embodiment, the internal combustion engine may be a dual fuel internal combustion engine.

Effects and features of the second aspect are largely analogous to those described above in relation to the first aspect.

Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following description. The skilled person realize that different features of the present invention may be combined to create embodiments other than those described in the following, without departing from the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of exemplary embodiments of the present invention, wherein:

Fig. 1 is a lateral side view illustrating an example embodiment of a vehicle in the form of a truck;

Fig. 2 is a schematic view illustrating a gas tank arrangement according to an example embodiment of the present invention;

Fig. 3 is a schematic view illustrating a gas tank arrangement according to another example embodiment of the present invention; and

Fig. 4 is a schematic view illustrating a gas tank arrangement according to a further example embodiment of the present invention.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided for thoroughness and completeness. Like reference character refer to like elements throughout the description.

With particular reference to Fig. 1, there is provided a vehicle 1 comprising an internal combustion engine 2. The internal combustion engine 2 may, for example, be a dual fuel internal combustion engine 2 which is connected to a fuel tank, such as e.g. a diesel tank, and to a gas tank arrangement 100, which gas tank arrangement 100 will be described in further detail below. The internal combustion engine 2 may thus be propelled by both conventional fuels such as e.g. diesel or petrol, as well as by a combustible gas such as e.g. compressed natural gas, DME, biogas, etc. The combustible gas may be provided either in a liquid phase i.e. a liquid/liquefied combustible gas, or in a gas phase. The vehicle 1 depicted in Fig. 1 is a heavy duty vehicle 1, here in the form of a truck, for which the inventive gas tank arrangement 100 is particularly suitable for.

Now, with reference to Fig. 2, a schematic view of the gas tank arrangement 100 according to an example embodiment is depicted. As can be seen in Fig. 2, the gas tank arrangement 100 comprises a gas tank 101 provided with a combustible gas. A lower portion 101’ of the gas tank 101 comprises liquefied combustible gas while an upper portion 101’’ of the gas tank 101 comprises combustible gas in gas phase. The combustible gas in the gas tank 101 is thus arranged to supply combustible gas to the internal combustion engine 2 for propulsion thereof. As a non-limiting example, the gas tank may be pressurized between 0 – 16 bar. The exhaust gas from the internal combustion engine 2 is directed through an exhaust system 118 of the vehicle 1.

The gas tank arrangement 100 further comprises a gas converter arrangement 102 positioned downstream the gas tank 101. In more detail, the gas converter arrangement 102 is connected to the lower portion 101’ of the gas tank 101 via a conduit 5. Hereby, liquefied combustible gas is provided to the gas converter arrangement 102. The gas converter arrangement 102 is arranged to pressurize and evaporate the liquefied combustible gas to pressurized combustible gas in gas phase. Such pressurized and evaporated combustible gas is suitable for being provided to the cylinders of the internal combustion engine 2. The gas pressure level of the combustible gas downstream the gas converter arrangement 102 is preferably between 300 – 550 bar. The gas converter arrangement 102 may preferably comprise a fuel pump 10 and an evaporating unit 20, which evaporating unit 20 is arranged downstream the fuel pump 10. The fuel pump 10 may preferably be a high pressure fuel pump 10 arranged to increase the pressure of the liquefied combustible gas to approximately 300 – 550 bar. The internal combustion engine 2 is thus arranged downstream the gas converter arrangement 102 for receiving pressurized combustible gas in gas phase.

Moreover, the gas tank arrangement 100 further comprises a combustible gas burning arrangement 106. The combustible gas burning arrangement 106 is arranged downstream the gas tank 101 via a first conduit 120. In detail, the first conduit 120 is connected to the upper portion 101'' of the gas tank 101 for directing low pressure combustible gas in gas phase to the combustible gas burning arrangement 106. The combustible gas burning arrangement 106 is thus arranged to combust the combustible gas delivered from the gas tank 101 via the first conduit 120. Hereby, when the gas pressure level in the gas tank 101 exceeds a predetermined limit, i.e. when the pressure level in the gas tank 101 is too high, the gas tank 101 can be vented by directing combustible gas in gas phase to the combustible gas burning arrangement 106 for combustion thereof. This is more environmentally friendly in comparison to venting the combustible gas into the atmosphere. Also, the heat generated by combusting the combustible gas in the combustible gas burning arrangement 106 can be used for e.g. heating auxiliary components of the vehicle 1, as will be described further below. A pressure controlled relief valve (not shown) may be positioned in the first conduit 120 for controllably delivery of combustible gas to the combustible gas burning arrangement 106.

Furthermore, the combustible gas burning arrangement 106 is also arranged in downstream fluid communication with the gas converter arrangement 102 via a second conduit 130. Hereby, also pressurized combustible gas in gas phase can be directed to the combustible gas burning arrangement 106. In particular, during change of engine load, the injection into the cylinders of the internal combustion engine 2 may be changed from high-pressure injection to low-pressure injection, whereby an over-pressure can be relieved into the combustible gas burning arrangement 106 via the second conduit 130. The second conduit 130 is thus, as depicted in Fig. 2, connected downstream the gas converter arrangement 102. A valve arrangement (104 in Figs. 3 and 4) can be positioned in the second conduit

130 for controllably delivery of combustible gas to the combustible gas burning arrangement 106.

Reference is now made to Fig. 3 which is a schematic view illustrating the gas tank arrangement 100 according to another example embodiment. As can be seen in Fig. 3, the gas tank arrangement 100 further comprises an additional gas tank 105 arranged downstream the gas tank 101 via the first conduit 120. The additional gas tank 105 is also arranged downstream the gas converter arrangement 102 via the second conduit 130. Hence, the first 120 and second 130 conduits are connected to the additional gas tank 105. The additional gas tank 105 is preferably a low pressure gas tank arranged to contain combustible gas at a pressure level of approximately 5 – 100 bar. Moreover, the additional gas tank 105 is arranged upstream the combustible gas burning arrangement 106. Hereby, the additional gas tank 105 is arranged as a buffer tank for receiving combustible gas, and to further deliver combustible gas to the combustible gas burning arrangement 106. A valve (not shown) may be arranged in fluid communication between the additional gas tank 105 and the combustible gas burning arrangement 106 for controllably delivery of combustible gas to the combustible gas burning arrangement 106. For example, it may be desirable to keep the combustible gas in the additional gas tank 105 when there is no, or low, desire to utilize the combustible gas burning arrangement 106. Hereby, the additional gas tank 105 can be filled up so that there is a sufficient amount available when there is a desire to utilize the combustible gas burning arrangement 106 again.

Furthermore, and as described above, the gas tank arrangement 100 may also comprise a valve arrangement 104 arranged in the second conduit 130. The valve arrangement 104 may be arranged in connection to e.g. the gas pedal of the vehicle, or be controlled in conjunction with the rotational speed variations of the internal combustion engine. Hereby, when there is an overpressure between the valve arrangement 104 and the internal combustion engine 3, the valve arrangement 104 can be positioned in the opened state to lower the pressure between the gas converter arrangement 102 and the internal combustion engine 3. The pressure level is eventually lowered to a level corresponding to the pressure level in the additional gas tank 105, unless the valve arrangement 104 is positioned in a closed state before such pressure level is achieved.

Still further, the gas tank arrangement 100 comprises a heat exchanger arrangement 112 and a cooling arrangement 115 arranged in downstream fluid communication with the combustible gas burning arrangement 106. In the example embodiment depicted in Fig. 3, an additional valve arrangement 111 is arranged downstream the combustible gas burning arrangement 106 for controllably delivery of heat generated in the combustible gas burning arrangement 106 to the heat exchanger arrangement 112, via a conduit 305 and/or the cooling arrangement 115, via a conduit 306. The additional valve arrangement 111 may also be arranged to by-pass the heat exchanger arrangement 112, by means of a conduit 302. Accordingly, the additional valve arrangement 111 may be a three-way valve. It should however be readily understood that the additional valve arrangement 111 may be formed by three separately controlled valves as well. Also, the by-passing of the heat exchanger arrangement 112 may be omitted and the cooling arrangement 115 may be positioned at a different location as depicted in Fig. 4, and thus not arranged in downstream fluid communication with the combustible gas burning arrangement 106.

The heat exchanger arrangement 112 can thus receive heat from the combustible gas burning arrangement 106. Hereby, engine coolant or other type of cooling liquid can be directed through, and heated by the heat exchanger arrangement 112. The heated coolant/liquid can thereafter be delivered downstream the heat exchanger arrangement 112 to the gas converter arrangement 102, via a conduit 308, for heating the pressurized combustible gas. Hereby, the pressurized combustible gas delivered to the internal combustion engine 2 is heated which reduces the problems associated with cold start engines, etc. In particular, this can be achieved by positioning valves (not shown) in an engine coolant circuit (not shown) in a closed position such that the small amount of engine coolant still present in the heat exchanger arrangement 112 can be quickly and efficiently heated. Further, efficiently cooling the evaporating unit 20 enables for the use of a smaller and simpler evaporating unit 20. This will save valuable space in the relatively tight compartment of the gas tank arrangement 100, as well as reducing the overall costs. Furthermore, the heated coolant from the heat exchanger arrangement 112 may also be used for heating the cabin of the vehicle 1, especially during cold climates.

As described above, the cooling arrangement 115 is arranged downstream the combustible gas burning arrangement 106 according to the embodiment depicted in Fig. 3. The cooling arrangement 115 in Fig. 3 is thus energized/regenerated by means of heat from the combustible gas burning arrangement 106. Accordingly, the cooling arrangement 115 uses the heat from the combustible gas burning arrangement 106 to energization/regeneration thereof such that a fluid provided into the cooling arrangement 115 can be cooled. Such a cooling arrangement may be an adsorption cooler or absorption cooler. The cooling arrangement 115 may be arranged in fluid communication with e.g. a refrigerator or the air conditioner system, etc. such that the fluid cooled by the cooling arrangement 115 is used for cooling these arrangements. The heat provided to the cooling arrangement 115 is further directed to the exhaust gas system 118 upstream the engine exhaust gas aftertreatment system 119 after energization/regeneration of the cooling arrangement 115, via a conduit 304. The cooling arrangement 115 may also be connected to exhaust gas system 118 via a conduit 310 for energization of waste heat gases from the internal combustion engine 2.

Moreover, the heat exchanger arrangement 112 may also be by-passed by controlling the additional valve arrangement 111 accordingly. Hereby, heat from the combustible gas burning arrangement 106 can be directed to the exhaust gas system 118 of the vehicle 1. In particular, heat from the combustible gas burning arrangement 106 can be provided to the exhaust gas system 118 upstream the engine exhaust gas aftertreatment system 119 of the vehicle 1 via the conduit 304. Hereby, the functionality of the engine exhaust gas aftertreatment system 119 can be increased as it may function better when being warmer. Moreover, the engine exhaust gas aftertreatment system 119 can be heated more quickly during engine cold start, and heating the engine exhaust gas aftertreatment system 119 even when the internal combustion engine 3 is turned off. Also heat from the heat exchanger arrangement 112 may be provided to the exhaust gas system 118 upstream the engine exhaust gas aftertreatment system 119. As an alternative option, heat from the combustible gas burning arrangement 106 may also be provided to a housing (not shown) of the engine exhaust gas aftertreatment system 119. Such housing may be referred to as a resonance box, etc. Hereby, the engine exhaust gas aftertreatment system 119 is heated and not the exhaust gases delivered into the engine exhaust gas aftertreatment system 119.

In order to describe a further alternative example embodiment, reference is made to Fig. 4. The difference between the embodiments depicted in Fig. 4 in comparison to the embodiment in Fig. 3 is the position of the cooling arrangement 115.

As depicted in Fig. 4, the cooling arrangement 115 is no longer arranged in downstream fluid communication with the combustible gas burning arrangement 106. Hereby, the additional valve arrangement 111 may be a two-way valve instead of the above described three-way valve. Instead of positioning the cooling arrangement 115 in downstream fluid communication with the combustible gas burning arrangement 106, the cooling arrangement 115 is connected to the exhaust gas system 118 downstream the engine exhaust gas aftertreatment system 119. Hereby, the cooling arrangement 115 is arranged to receive heat from the exhaust gases for energization/regeneration thereof, via a conduit 402. The heat provided to the cooling arrangement 115 is further directed to the exhaust gas system downstream the engine exhaust gas aftertreatment system 119 after energization/regeneration of the cooling arrangement 115, via a conduit 404. In order to controllably deliver heat to the cooling arrangement 115, a valve arrangement 420 is arranged in fluid communication between the engine exhaust gas aftertreatment system 119 and the cooling arrangement 115. Hereby, the exhaust gases can be directed to either the cooling arrangement 115 or out through the exhaust gas system 118 to the atmosphere. The valve arrangement 420 may comprise to separate valves or be arranged in the form of a two-way valve. By positioning the cooling arrangement 115 as depicted in Fig. 4, the waste heat in the exhaust system 118 can be used for energization/regeneration of the cooling arrangement 115.

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims. For example, the gas tank arrangement 100 may comprise a variety of valves for controlling flow of combustible gas therein. Such valves may e.g. be controlled mechanically or electrically.

CLAIMS

1. A gas tank arrangement (100) for an internal combustion engine (2) of a vehicle, the gas tank arrangement (100) comprising a gas tank (101) for containing a combustible gas, a gas converter arrangement (102) arranged to convert liquefied combustible gas to compressed combustible gas for delivery to the internal combustion engine (2), said gas converter arrangement (102) being positioned in downstream fluid communication with said gas tank (101), **characterized in that** the gas tank arrangement further comprises a combustible gas burning arrangement (106) for combustion of combustible gas, said combustible gas burning arrangement (106) being positioned in downstream fluid communication with the gas tank (101) via a first conduit (120), and positioned in downstream fluid communication with the gas converter arrangement (102) via a second conduit (130).

2. The gas tank arrangement (100) according to claim 1, wherein the gas tank arrangement (100) further comprises an additional gas tank (105) positioned in upstream fluid communication with the combustible gas burning arrangement (106).

3. The gas tank arrangement (100) according to claim 2, wherein the additional gas tank (105) is positioned in downstream fluid communication with the gas tank (101) via the first conduit (120), and positioned in downstream fluid communication with the gas converter arrangement (102) via the second conduit (130).

4. The gas tank arrangement (100) according to any one of the preceding claims, wherein the first conduit (120) is connected to an upper portion (101'') of the gas tank (101) for receiving combustible gas in gas phase from the gas tank (101).

5. The gas tank arrangement (100) according to any one of the preceding claims, wherein the gas converter arrangement (102) comprises a fuel pump (10) and an evaporating unit (20) positioned in fluid communication with said fuel pump (10).

6. The gas tank arrangement (100) according to any one of the preceding claims, wherein the gas tank arrangement (100) further comprises a valve arrangement (104), said valve arrangement (104) being arranged in fluid communication between the gas converter arrangement (102) and the combustible gas burning arrangement (106).

7. The gas tank arrangement (100) according to claims 2 and 6, wherein the valve arrangement (104) is arranged in fluid communication between the gas converter arrangement (102) and the combustible gas burning arrangement (106) via the additional gas tank (105).

8. The gas tank arrangement (100) according to any one of the preceding claims, wherein the gas tank arrangement (100) further comprises a heat exchanger arrangement (112), said heat exchanger arrangement (112) being positioned in downstream fluid communication with the combustible gas burning arrangement (106) for heating auxiliary components of said vehicle (1).

9. The gas tank arrangement (100) according to claim 8, wherein the heat exchanger arrangement (112) is arranged in fluid communication with the gas converter arrangement (102) for heating combustible gas provided to the gas converter arrangement (102) from the gas tank (101).

10. The gas tank arrangement (100) according to claims 8 or 9, wherein the gas tank arrangement (100) further comprises an additional valve arrangement (111) positioned in fluid communication between the combustible gas burning arrangement (106) and the heat exchanger arrangement (112) for controllably delivery of heated combusted gas to the heat exchanger arrangement (112).

11. The gas tank arrangement (100) according to claim 10, wherein the additional valve arrangement (111) is arranged to by-pass said heat exchanger arrangement (112).

12. The gas tank arrangement (100) according to any one of the preceding claims, the gas tank arrangement (100) further comprising a cooling arrangement (115) for cooling auxiliary components of the vehicle (1), said cooling arrangement (115) being connected to a heat source for energization thereof.

13. The gas tank arrangement (100) according to claim 12, wherein the cooling arrangement (115) is arranged in downstream fluid communication with the combustible gas burning arrangement (106).

14. The gas tank arrangement (100) according to claim 13, wherein the cooling arrangement (115) is connected to an exhaust system (118) of the vehicle upstream an engine exhaust gas aftertreatment system (119).

15. The gas tank arrangement (100) according to claim 12, wherein the cooling arrangement (115) is connected to an exhaust system (118) of the vehicle downstream an engine exhaust gas aftertreatment system (119).

16. A vehicle (1) comprising an internal combustion engine (103) and a gas tank arrangement (100) according to any one of claims 1 - 15, wherein said internal combustion engine (2) is arranged downstream the gas tank arrangement (100).

17. The vehicle (1) according to claim 16, wherein the internal combustion engine (2) is a dual fuel internal combustion engine.

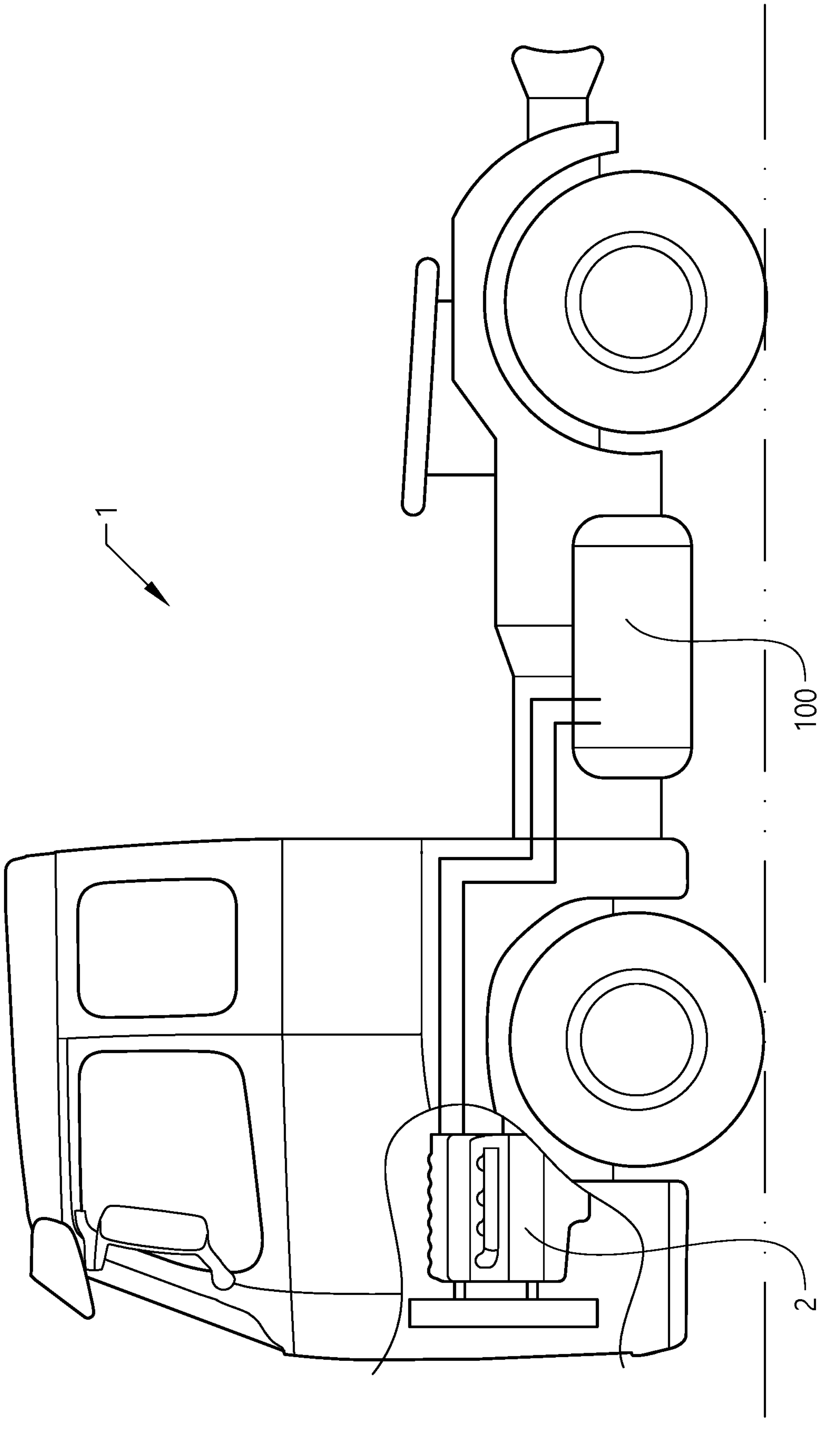


FIG. 1

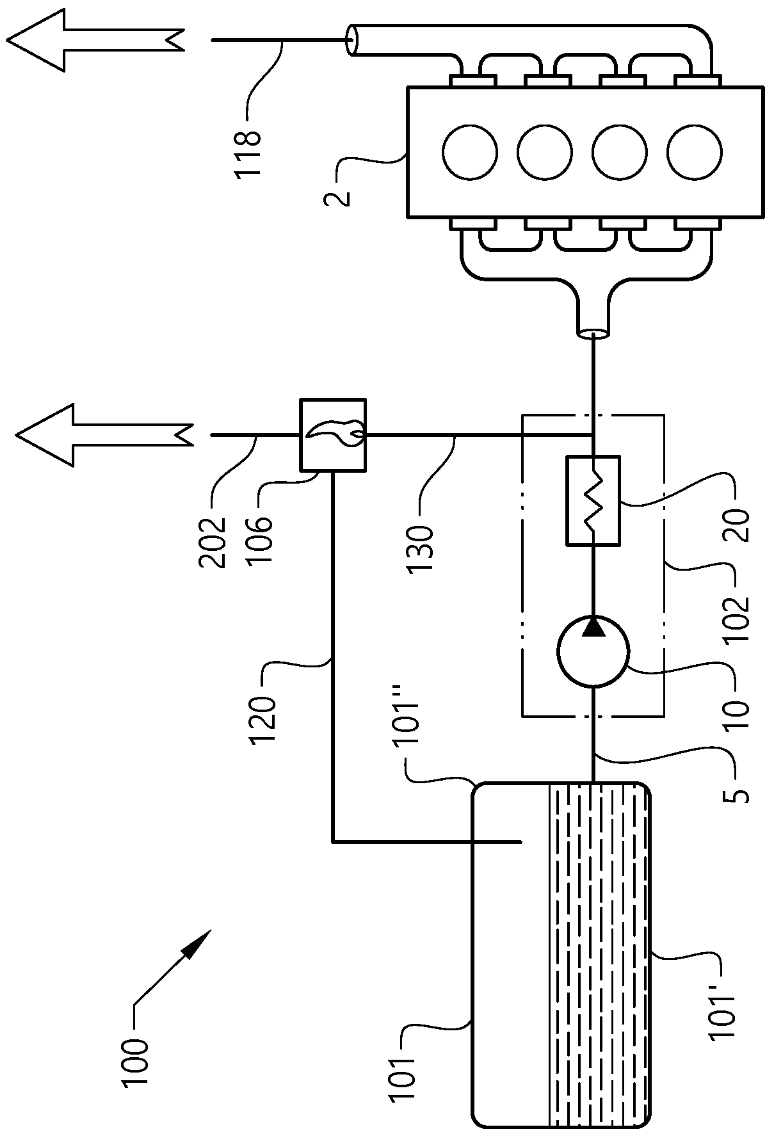
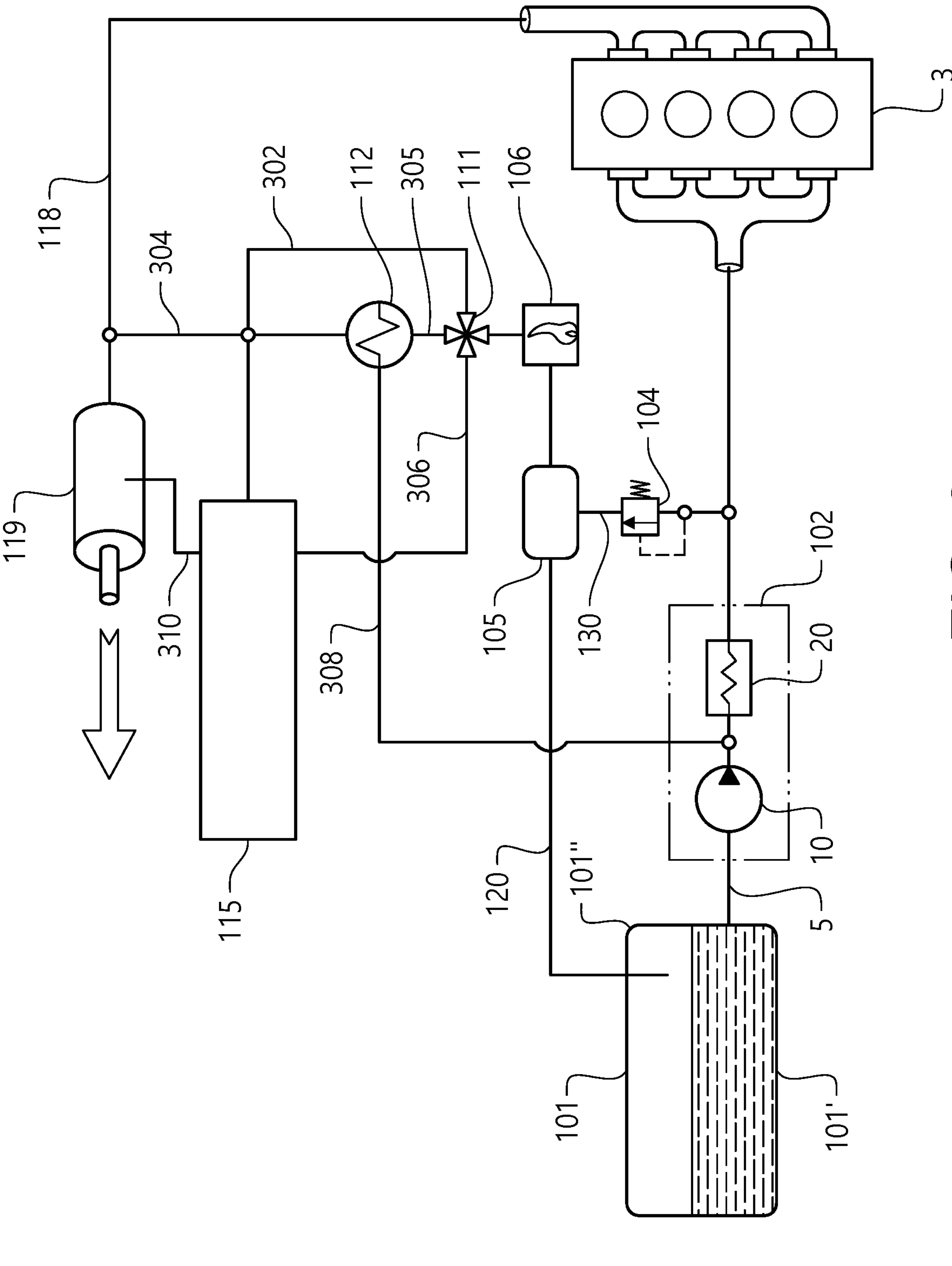


FIG. 2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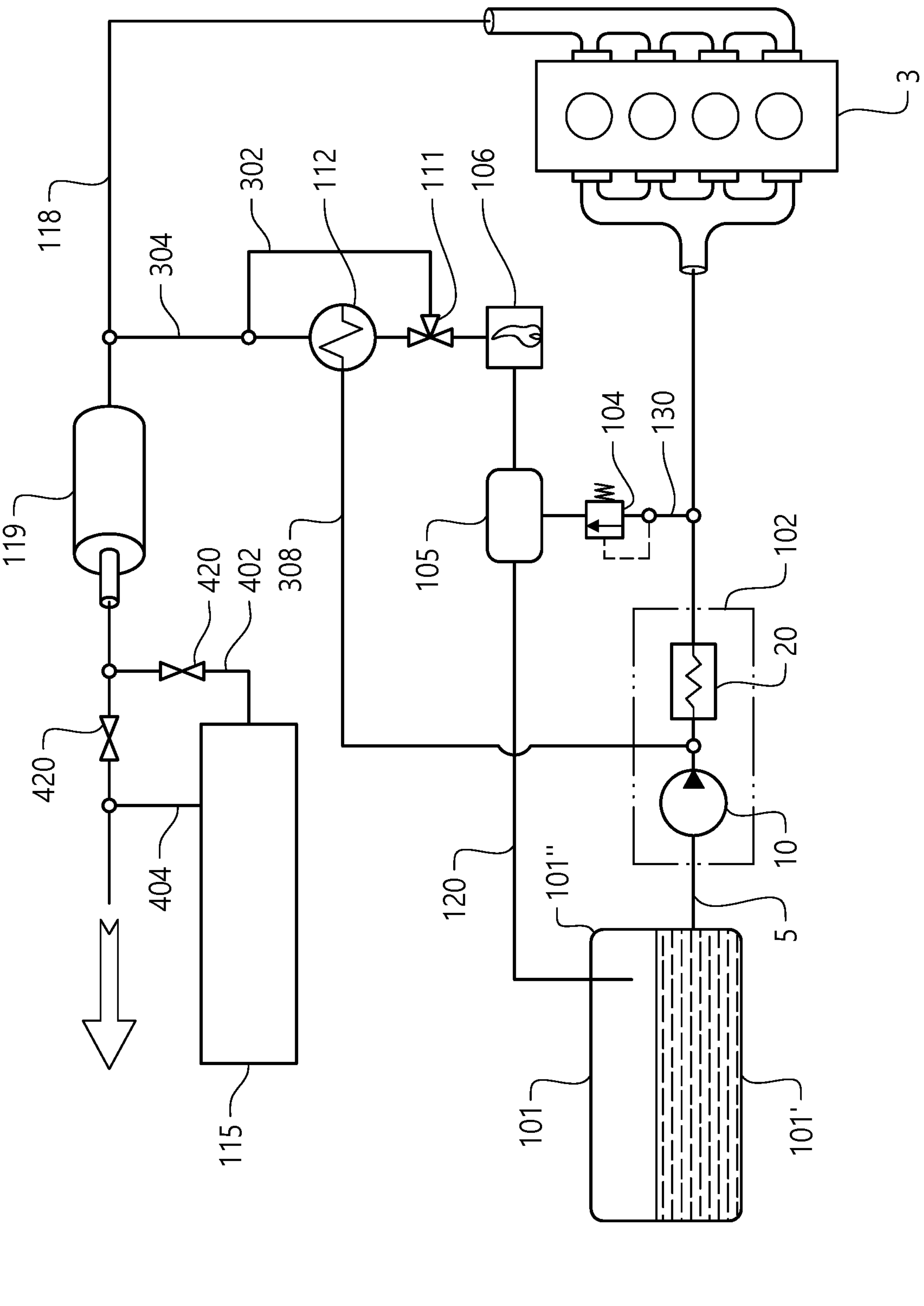
302
112
305
111
106
104
119
310
306
308
105
130
102
20
10
5
115
120
101''
101
101'

FIG. 3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101'

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/079409

A. CLASSIFICATION OF SUBJECT MATTER
INV. F17C7/04
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)
F17C

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 practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012/040835 A1 (WESTPORT POWER INC [CA]; DUNN MARK E [CA]; LEBLANC VALERIE [CA]) 5 April 2012 (2012-04-05) fig.2, 3. (30), (2), (34), (36), (38); [003], [018], [024] -----	1-17
A	US 5 701 928 A (AOKI TAKESHI [JP]) 30 December 1997 (1997-12-30) fig.1, fig.2, (10), (11); columns 3-7 -----	1-17

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

☒ See patent family annex.

* Special categories of cited documents :

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 June 2017	23/06/2017

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	Todor, H

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/079409

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