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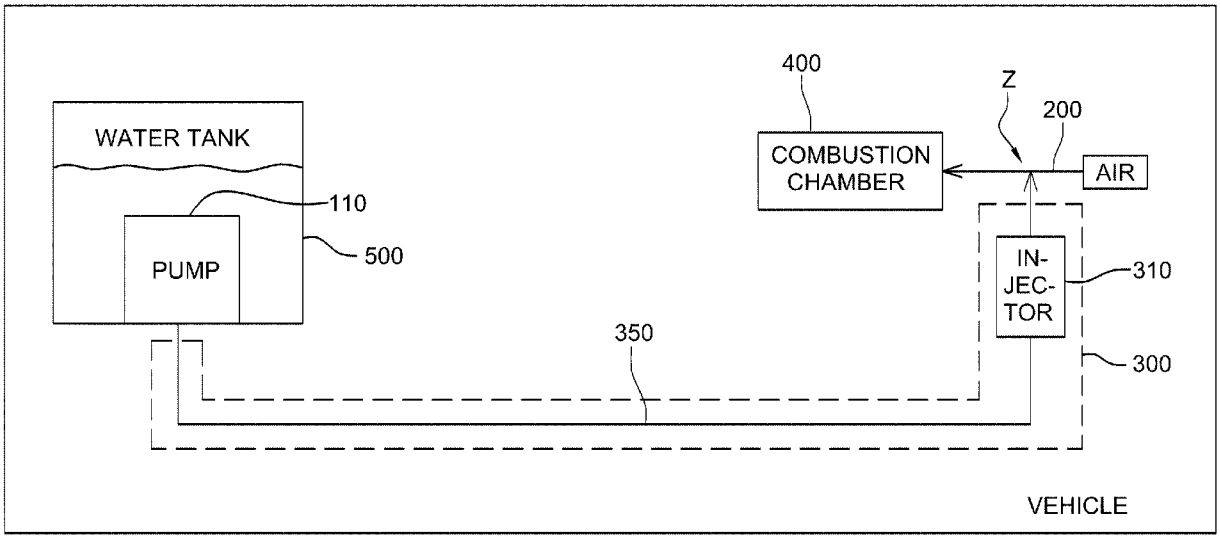

Fig. 1

(57) Abstract: The invention relates to a vehicle system for injecting an aqueous solution in an air intake line upstream of a combustion chamber of an internal combustion engine, or in the combustion chamber of the internal combustion engine. The vehicle system comprises a tank (500) for storing an aqueous solution; a pump unit (110) inside the tank (500); an air intake line (200) upstream of a combustion chamber of an internal combustion engine; an injector (310) configured for injecting aqueous solution in the air intake line or in the combustion chamber; and a feed line (350) for feeding said injector (310) with aqueous solution pumped by the pump unit (110) out of the tank (500).

WO 2018/050894 A1

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System and method for injecting an aqueous solution on-board a vehicle

Field of Invention

The invention relates to a system and method for injecting an aqueous solution, preferably demineralised water, on-board a vehicle, and in particular for injecting an aqueous solution into an air intake upstream of a combustion chamber or directly in the combustion chamber.

Background

It is known to inject water into an air intake upstream of a combustion chamber or directly in the combustion chamber, when the load of the engine of the vehicle is high. By injecting water in the air stream, the air is cooled down, resulting in a higher density and hence more air per volume unit, enhancing the combustion. In that manner more power is obtained, i.e. the performance is boosted.

The water for injection needs to be stored on-board the vehicle, and in view of the limited space on-board a vehicle it is desirable to have a compact water storage and injection system.

Summary

It is a first object of exemplary embodiments of the invention to provide a vehicle system for injecting an aqueous solution in an air intake line upstream of a combustion chamber of an internal combustion engine, or directly in the combustion chamber of the internal combustion engine, which is more compact and requires fewer lines and/or shorter line lengths.

According to a first aspect there is provided a vehicle system for injecting an aqueous solution in an air intake line upstream of a combustion chamber of an internal combustion engine, or in the combustion chamber of the internal combustion engine; said vehicle system comprising:
a tank for storing an aqueous solution; a pump unit, preferably inside the tank; an air intake line upstream of a combustion chamber of an internal combustion engine; an injector configured for injecting aqueous solution in the air intake line or in the combustion chamber; a feed line for feeding said injector with aqueous solution pumped by the pump unit out of the tank.

By arranging the pump unit in the tank, a compact system is obtained. Further only one line (the feed line) is required from the tank (which may be located e.g. in the back of the car) to the injector (which is typically located close to the engine). It is noted that other lines may be provided but this is not required.

According to a second aspect there is vehicle system for injecting an aqueous solution in an air intake line upstream of a combustion chamber of an internal combustion engine, or in the combustion chamber of the internal combustion engine; said vehicle system comprising a tank for storing an aqueous solution; a pump unit; an air intake line upstream of a combustion chamber of an internal combustion engine; an injector configured for injecting aqueous solution in the air intake line or in the combustion chamber; a feed line for feeding said injector with aqueous solution pumped by the pump unit out of the tank; wherein the pump unit is arranged in a module, said module being mounted in a opening in the tank.

By arranging the pump in a module mounted in an opening in the tank a compact system is obtained which can be assembled easily. Further only one line (the feed line) is required from the module (which may be located e.g. in the back of the car) to the injector (which is typically located close to the engine). It is noted that other lines may be provided but this is not required.

Preferably the vehicle system further comprises a return line integrated in the module, said return line connecting the feed line with the interior of the tank. Preferably, the return line is connected to the feed line in the module. This results in a very short return line and hence in an even more compact system.

The module may further comprise any one or more of the following components: a heater, preferably at least an electric heater; a level sensor; a quality sensor; a filter; a bio-decontamination device; an electronic control unit.

Preferably, the pump unit comprises a gear pump.

In an exemplary embodiment the tank has a bottom wall, a top wall and a sidewall connecting the bottom wall with the top wall. In the mounted position of the tank, the bottom wall corresponds with the lowest face of the tank. The opening may be arranged in the bottom wall or in the sidewall, in a lower half of the tank.

In an exemplary embodiment the tank is made of a polyolefin, preferably a polyethylene material or a polypropylene material. The module may be made of a polyolefin, preferably a polyethylene material or a polypropylene material. The module may be welded to the tank.

It is an object of further exemplary embodiments of the invention to provide a vehicle system for injecting an aqueous solution which can be used with various types of aqueous solutions, including water containing bacteria and algae.

In an exemplary embodiment the vehicle system further comprises a decontamination device configured for decontaminating the aqueous solution stored in the tank. In a possible embodiment the decontamination device may be a UV light decontamination device configured for decontaminating the aqueous solution stored in the tank by emitting UV light. By subjecting the aqueous solution to UV light, bacteria and algae can be damaged in order to decontaminate the aqueous solution. In another possible embodiment the decontamination device may be a contact decontamination device configured to decontaminate aqueous solution stored in the tank by contact with a decontaminating material such as copper, zinc or silver.

Preferably, the decontamination device is arranged in the tank.

In an exemplary embodiment, the decontamination device is a UV light decontamination device containing a fluid passage and being configured to emit UV light in said fluid passage, wherein the vehicle system is configured for transferring aqueous solution stored in the tank through said fluid passage. Such a fluid passage may be located inside or outside the tank. The fluid passage may be delimited by a wall made of a UV-resistant material. Also, the tank may be made of a UV-resistant material, e.g. with an outer layer and inner layer made of UV-resistant material.

The decontamination device may be integrated in the module mounted in an opening of the tank.

The decontamination device may be arranged in the return line. The return line may comprise a valve, and the decontamination device may be arranged in the return line, downstream or upstream of the valve.

It is a further object of exemplary embodiments of the invention to provide a vehicle system for injecting liquid with an improved heating system. In an exemplary embodiment the vehicle system further comprises a tubing for transporting a heat exchange fluid, e.g. engine coolant, said tubing extending in the tank and being fixed in the module or integrated in the module; and/or an electrical heater arranged in the tank and/or in the module. Using an electrical heater has the advantage that immediate heater power is available reducing the start-up time at cold temperatures. The tubing may be used for circulating engine coolant. The heater power of tubing will depend on engine heat up speed, and without the electrical heater the start-up time would be much longer. By

suitably combining an electrical heater with a tubing for engine coolant an optimal heating can be achieved fulfilling the start-up requirements whilst at the same time using heat from the engine coolant once the engine is heated up sufficiently.

The vehicle system may further comprise a controller for controlling the electrical heater e.g. in function of the engine temperature or in function of the time during which the engine has been running. In that manner the heating can be adequately controlled and optimized.

In an exemplary embodiment, the electrical heater is arranged in an area surrounding the tubing. In an exemplary embodiment the electrical heater is arranged above a bottom wall of the tank, in a lower half of the tank, wherein, in the mounted position of the tank, the bottom wall corresponds with the lowest face of the tank. The electrical heater may be arranged on the module. Preferably the electrical heater is a flexible electrical heater. This allows the electrical heater to be brought through a rather small opening in the tank, whilst occupying a surface larger than the surface of said opening. The flexible electrical heater may comprise a flexible sheet with integrated electrical tracks. The sheet may extend in an area around the opening in the wall of the tank. The flexible sheet may comprise two flexible films, and the at least one electrical track may be arranged between the two flexible films. The sheet may be a sheet with a central portion extending around the tubing and at least one flap extending from the central portion in the tank, e.g. four flaps extending from the central portion in the tank. The flexible electrical heater may comprise a plurality of flexible tentacles extending freely in the tank. Also, the flexible electrical heater may comprise one or more openings, and one or more components mounted in the tank or on the module may extend through said one or more openings.

In an exemplary embodiment, the vehicle system may comprise a jet pump having a suction inlet, a pressure inlet and an outlet. The pump unit may then be connected for pumping aqueous solution along a jet flow path from the tank through the pump unit, through the pressure inlet of the jet pump to the outlet of the jet pump, wherein said outlet is arranged for returning aqueous solution from the suction inlet and from the pressure inlet to the tank. In an exemplary embodiment, the pump unit is a feed pump unit connected for pumping aqueous solution directly from the tank or from a compartment in fluid communication with aqueous solution in the tank (e.g. a bowl or swirl pot) to a feed outlet for feeding aqueous solution out of the tank or out of the compartment, respectively. The pump unit is also connected for pumping aqueous solution along a flow path from the compartment through the pump unit, through the pressure inlet of the jet pump to the outlet of the jet pump. The outlet is arranged for returning aqueous solution from the suction inlet and from the pressure inlet directly to the tank or to the compartment. In an embodiment with a

compartment in the tank, the suction inlet may be arranged to suck aqueous solution present in the tank into the compartment. In an embodiment with a compartment in the form of a second separate tank, the suction inlet may be arranged to suck liquid from the second tank into the tank associated with the pump unit. Preferably the jet pump is arranged in the same module as the feed pump unit. Preferably, this module is mounted in an opening of a wall of the tank, more preferably the bottom wall of the tank. In alternative embodiments, the jet pump may be provided as a separate module mounted inside or outside of the tank, and e.g. as a separate module mounted in an opening in a wall of the second tank.

Preferably, the aqueous solution contains at least 90% water, more preferably at least 95% water, and most preferably at least 98% water; wherein the aqueous solution is for example demineralized water. For such aqueous solutions a UV light decontamination device will be particularly effective.

The invention is especially advantageous for gasoline cars but may also be useful for diesel cars.

Further preferred embodiments are disclosed in the dependent claims.

Brief description of the figures

The accompanying drawings are used to illustrate presently preferred non-limiting exemplary embodiments of devices of the present invention. The above and other advantages of the features and objects of the invention will become more apparent and the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawings, in which:

Figure 1 illustrates schematically an exemplary embodiment of a vehicle system with a pump inside the tank;

Figures 2 and 2A, illustrate two variants of vehicle systems with a pump integrated in a module mounted in a wall of the tank;

Figure 3 illustrates a section of an exemplary embodiment of a module with a pump mounted in a wall of the tank;

Figure 4 illustrates a perspective view of an exemplary embodiment of a module with a pump and a heater;

Figure 5 illustrates a perspective view of another exemplary embodiment of a module with a pump and a heater;

Figure 6A illustrates schematically an exemplary embodiment of a vehicle system with a UV light decontamination device inside the tank;

Figure 6B illustrates schematically an exemplary embodiment of a vehicle system with a UV light decontamination device outside the tank;

Figure 7 illustrates a further exemplary embodiment of a vehicle system with a UV light decontamination device inside the tank;

Figures 7A, 8 and 8A illustrate further exemplary embodiments of a vehicle system with a UV light decontamination device integrated in a module mounted in an opening in the tank;

Figures 9, 9A and 9B illustrate an exemplary embodiment of a vehicle system with an electrical heater and a heat exchanger;

Figure 10 illustrates another exemplary embodiment of a vehicle system with an electrical heater and a heat exchanger;

Figure 11 illustrates another exemplary embodiment of a vehicle system with an electrical heater and a heat exchanger;

Figures 12A and 12B illustrate a perspective view of an exemplary embodiment of a tank of a vehicle system in which the module of figure 5 is arranged;

Figures 13 and 14 illustrate schematically further exemplary embodiments of vehicle systems; and

Figures 15 and 16 illustrate schematically further exemplary embodiments of vehicle systems comprising a feed pump and a jet pump integrated in a module mounted in an opening in the tank.

Description of embodiments

Figure 1 illustrates a vehicle system for injecting an aqueous solution in an air intake line upstream of a combustion chamber of an internal combustion engine. Alternatively the aqueous solution may be injected directly in the combustion chamber of the internal combustion engine. More generally the aqueous solution may be injected anywhere as long as the injection is such that the air injected in the combustion chamber is cooled. The aqueous solution is preferably a solution containing at least 90% water, more preferably at least 95% water, and most preferably at least 98% water. The aqueous solution is e.g. demineralized water. In other embodiments an amount of methanol may be added to the aqueous solution to lower the freezing point.

The vehicle system of figure 1 comprises a tank 500 for storing the aqueous solution; a pump unit 110 inside tank 500; an air intake line 200 upstream of a combustion chamber 400 of an internal combustion engine; an injection system 300 configured for injecting aqueous solution from the tank 500 in an injection zone (Z) in the vehicle, said injection system 300 comprising an injector 310 configured for injecting aqueous solution in air intake line 200 and a feed line 350 connecting pump unit 110 to said injector 310 such that aqueous solution from the tank 500 can be pumped to the injector 310. By arranging the pump unit 110 in the tank, the injection system (feed line 350 and injector 310) can have a simple configuration. Generally it will be sufficient to have one line

(feed line 350) between tank 500 and injector 310. Indeed, if the pump were to be located close to the injector, typically there will be needed a long return line. If tank 500 is located in the back of the car, by providing pump 110 inside tank 500 there is a significant reduction in required line length compared to prior art solutions where the pump is located in the engine compartment. Alternatively, the vehicle system as shown in figure 1 may comprise a plurality of injectors 310 configured for injecting aqueous solution in the air intake line 200. In this modified embodiment, at least one feed line 350 is arranged for connecting pump unit 110 to said injectors such that aqueous solution from the tank 500 can be pumped to the corresponding injectors.

Figure 2 illustrates an exemplary embodiment similar to the embodiment of figure 1, where pump unit 110 is arranged in a module 100. The module 100 is mounted in an opening 550 in the tank 500. Tank 500 has a bottom wall 510, a top wall 520 and a sidewall 530 connecting the bottom wall 510 with the top wall 520. In the illustrated embodiment the opening 550 is arranged in the bottom wall 510, wherein, in the mounted position of the tank 500, the bottom wall 510 corresponds with the lowest face of the tank 500. In another non-illustrated embodiment the opening 550 may be arranged in the sidewall 530, in a lower half of the tank 500.

In another exemplary embodiment pump unit 110 may be arranged in a module 100, outside the tank, see figure 2A. In this embodiment the module is arranged in sidewall 530, in the lower half of tank 500. In another non-illustrated embodiment module 100 of figure 2A may be arranged in bottom wall 510.

In the exemplary embodiments of figures 2 and 2A, module 100 may further comprise any one or more of the following components (not shown): a heater for heating the aqueous solution in tank 500; a level sensor for sensing the level of the aqueous solution in tank 500; a quality sensor for measuring the quality of the aqueous solution in tank 500; a filter, optionally integrated in pump unit 110 for filtering the aqueous solution before it is transported through feed line 350; a bio-decontamination device configured for decontaminating the aqueous solution in tank 500 e.g. using UV light; a controller for controlling any one or more of the components of the module 100.

In the exemplary embodiments of figures 2 and 2A, the vehicle system further comprises a return line 360 integrated in the module 100. Return line 360 connects the feed line 350 with the interior of the tank 500. Return line 360 is connected to feed line 350 in module 100. Return line 360 comprises a check valve 160 in order to regulate the return flow. Pump unit 110 has an inlet 111 for receiving aqueous solution from the tank and an outlet 112 connected to feed line 350. It is noted that figures 2 and 2A are schematic drawings and that inlet 111 is preferably located as low

as possible in the tank, and more generally below the minimum filling level. Pump unit 110 may comprise e.g. a gear pump.

Figure 3 illustrates a more detailed embodiment of a module 100 adapted for mounting in an opening 550 of bottom wall 510 of tank 500. Module 100 comprises a cylindrical compartment 105, and a pump unit 110 arranged in cylindrical compartment 105. Pump unit 110 comprises a gear pump 113 and a motor 114 (e.g. a BLDC motor). Pump unit 110 has an inlet 111 at the lower end of a cylindrical housing 115 of pump unit 110. In this embodiment a filter 150 is integrated in pump unit 110. The outlet 112 of pump unit 110 is located at a lower end of pump unit 110, below gear pump 113. Outlet 112 is connected to a first portion of feed line 350. This portion of feed line 350 is connected to a return line 360 including a check valve 160. Return line 360 is integrated in module 100 and is located partially below pump unit 110. The outlet of return line 360 is located adjacent to pump unit 110, and returns the aqueous solution into tank 500. A heater 120 is provided adjacent cylindrical compartment 105 of module 100. Heater 120 is preferably an electrical heater. In the illustrated embodiment the heater is a flexible electrical heater 120 with flexible tentacles 121 extending in tank 500. However, it is also possible to provide non-flexible electrical heating elements (not shown), e.g. PTC (Positive Temperature Coefficient) heating elements, adjacent to cylindrical compartment 115, e.g. attached to the inside or the outside of this cylindrical compartment. In the illustrated embodiment cylindrical housing 115 of pump unit 110 contains a separation wall 116 dividing the housing in an upper compartment for motor 114 and a lower compartment for gear pump 113. Aqueous solution enters the lower compartment of cylindrical housing 115 at the bottom thereof, see inlet 111, passes through filter 150 and leaves the lower compartment at outlet 112.

Figure 4 illustrates another detailed embodiment of a module 100 adapted for mounting in an opening 550 of bottom wall 510 of tank 500 in a similar manner as shown in figure 3. Module 100 comprises compartment 105, and a pump unit 110 arranged in compartment 105. Pump unit 110 may comprise a gear pump 113 and a motor 114. Pump unit 110 may have an inlet (not visible) at the lower end of pump unit 110. The outlet (not visible) of pump unit 110 may be located at a lower end of pump unit 110. The module 100 may comprise a portion of feed line and a return line including a check valve, as in the embodiment of figure 3. A heater 120 is provided adjacent compartment 105 of module 100, and may be attached to compartment 105. Heater 120 is preferably an electrical heater. In the illustrated embodiment the heater is a flexible electrical heater 120 with flexible tentacles 121 extending in tank 500. However, it is also possible to provide non-flexible electrical heating elements (not shown), e.g. PTC heating elements, adjacent to compartment 115, e.g. attached to the inside or the outside of this compartment 105. Compartment

105 has an outer wall with a shape which is such that an inner volume is created for receiving the pump unit 110, and a small outer volume 106 for receiving a level sensor 130. The outer wall of compartment 105 surrounds partially level sensor 130 in order to protect the level sensor.

Figure 5 illustrates another detailed embodiment of a module 100 adapted for mounting in an opening 550 of bottom wall 510 of tank 500 in a similar manner as shown in figure 3. Module 100 comprises a compartment 105, and a pump unit 110 arranged in compartment 105. Pump unit (110) may comprise a gear pump 113 and a motor 114. Pump unit 110 may have an inlet (not visible) at the lower end of pump unit 110. The outlet (not visible) of pump unit 110 may be located at a lower end of pump unit 110. The module 100 may comprise a portion of feed line and a return line including a check valve, as in the embodiment of figure 3. A heater 120 is provided adjacent cylindrical compartment 105 of module 100. Heater 120 is preferably an electrical heater. In the illustrated embodiment the heater is a flexible electrical heater 120 comprising a central portion 125 intended for extending parallel to a wall of the tank 500, and four flaps 126 which may be attached to tank portions on the inside of the tank. Central portion 125 is provided with an opening through which compartment 105 protrudes. Compartment 105 has a shape which is such that an inner volume is created for receiving the pump unit 110, and a further volume 106 for receiving a level sensor 130.

In exemplary embodiments of the invention, preferably, the pump unit 110 is configured to be able generate a flow of between 60 and 100 kg/h through the feed line 350. Further, the controller is preferably configured to control pump unit 110 in function of the RPM (Revolutions Per Minute) of the vehicle. When the RPM reaches a predetermined threshold, the pump unit 110 is made to pump with a flow speed within a predetermined range.

Although a gear pump is advantageous for use in exemplary embodiments, also other pumps may be used, e.g. a gerotor pump, a turbine pump, a membrane pump, a piston pump.

Figures 6A and 6B illustrate further exemplary embodiments of a vehicle system for injecting an aqueous solution. The vehicle system comprises a tank 500 for storing an aqueous solution; an injection system 300 configured for injecting aqueous solution from the tank 500 in an injection zone (Z) in the vehicle; and a UV light decontamination device 700 configured for decontaminating the aqueous solution stored in the tank 500 by emitting UV light. In the embodiment of figure 6A, the UV light decontamination device 700 is arranged in the tank 500, and in the embodiment of figure 6B the UV light decontamination device 700 is arranged outside

the tank 500, but in fluid communication with the tank 500 such that aqueous solution runs through the UV light decontamination device 700.

As illustrated in figure 7, the UV light decontamination device 700 may contain a fluid passage 720 and may be configured to emit UV light in said fluid passage. The vehicle system is then configured for transferring aqueous solution stored in the tank 500 through said fluid passage 720, e.g. using a pump which may be the same pump as the pump 110 used for transporting aqueous solution out of the tank to feed line 350, but may also be a different pump. In the embodiment of figure 7A, the same pump 110 is used for pumping fluid to through feed line 350 to an injector 310, and through the UV light decontamination device 700. This may be achieved as illustrated by placing the UV light decontamination device 700 in the return line 360 connecting the feed line 350 with the interior of the tank 500. Here UV light decontamination device 700 is located upstream of valve 160, but this could also be downstream of valve 160. Preferably, the return line 360 is connected to the feed line 350 in the module 100. The skilled person understands that also other configurations are possible wherein the same pump is used for the feeding of aqueous urea solution to the injector and for the feeding of the UV light decontamination device 700. The fluid passage 720 is delimited by a wall 710 made of a UV-resistant material. UV light sources may be integrated in the wall 710.

Figure 8 illustrates an embodiment where the UV light decontamination device 700 is configured to emit UV light in the interior of tank 500. In the embodiment of figure 8 the UV light is emitted upwardly, and in the embodiment of figure 8A the UV light is emitted sideward in the direction of the side wall 530. More in particular, in figure 8A the UV light decontamination device 700 is configured to emit UV light from a central location in the tank 500 to the sidewall 530 of the tank 500. The skilled person understands that also combinations thereof or variations thereof are possible. Also there may be provided suitably positioned reflectors 740 for reflecting the UV-light back in the tank, e.g. on the sidewall 530 as illustrated in figure 8A. In such embodiments the tank 500 is preferably made of a UV-resistant material. The tank 500 may comprise an outer layer and inner layer made of UV-resistant material. As illustrated in figures 7A, 8 and 8A, the UV light decontamination device 700 may be integrated in a module 100 mounted in an opening 550 of the tank 500. Also pump unit 110 and return line 360 may be integrated in this module 100.

In the exemplary embodiments of figures 7A, 8 and 8A, module 100 may further comprise any one or more of the following components (not shown): a heater for heating the aqueous solution in tank 500; a level sensor for sensing the level of the aqueous solution in tank 500; a quality sensor for measuring the quality of the aqueous solution in tank 500; a filter, optionally integrated in pump

unit 110 for filtering the aqueous solution before it is transported through feed line 350; a controller for controlling any one or more of the components of the module 100.

In the exemplary embodiments of figures 7A, 8 and 8A, module 100 is mounted in an opening arranged in the bottom wall 510 of tank 500, wherein, in the mounted position of the tank 500, the bottom wall 510 corresponds with the lowest face of the tank 500. However, it is also possible to mount module 100 in an opening arranged in the sidewall 530, in a lower half of the tank 500.

Figure 9 illustrates a vehicle system for injecting liquid, said vehicle system comprising a tank 500 for storing liquid, a module 100 arranged in a opening 550 in a wall of the tank 500; a tubing 170 for transporting a heat exchange fluid, said tubing extending in the tank 500 and being fixed in said module 100; and an electrical heater 120. Figures 9A and 9B illustrate a detailed view of a possible electrical heater and of a module with tubing 170, respectively. In the illustrated embodiment the electrical heater 120 is attached to the module 100. However, in other embodiments the electrical heater may be arranged against an inner wall of the tank. In the illustrated embodiment the tubing 170 is sealingly fixed in the module 100. However, it is also possible to have a module with an integrated tubing. Preferably, the electrical heater 120 is arranged in an area surrounding the tubing 170. The electrical heater 120 may be arranged above a bottom wall 510 of the tank, in a lower half of the tank, wherein, in the mounted position of the tank 500, the bottom wall 510 corresponds with the lowest face of the tank 500.

Preferably, the electrical heater 120 is a flexible electrical heater comprises a flexible sheet with integrated electrical tracks. Preferably the sheet extends in an area around an opening 550 in the wall, typically bottom wall 510 of the tank 500. The flexible sheet may comprise two flexible films, and wherein at least one electrical track is arranged between the two flexible films. As illustrated in figure 9B the sheet may be a sheet with a central portion 125 extending around the tubing 170 and at least one flap 126 may extend from the central portion 125 in the tank 500. It is noted that there could also be provided a module similar to the module of figure 4, wherein a tubing 170 is added adjacent the pump unit 110. In such an embodiment the flexible electrical heater 120 may comprise a plurality of flexible tentacles 121 extending freely in the tank 500.

Figure 10 illustrates a similar embodiment with a tubing 170 and a flexible electrical heater 120. In this embodiment the flexible electrical heater 120 is provided with a number of openings. Components, such as pump unit 110, level sensor 130, quality sensor 140, may be mounted on the module and may protrude through said openings. As illustrated the tubing 170 may have various shapes. Preferably the tubing has a shape which is such that the module 100 can be mounted in an

opening 550 in the tank 500 from the outside; in other words tubing 170 should fit through the opening 550.

Figure 11 illustrates a further embodiment with a tubing 170 and an electrical heater 120. In this embodiment two modules 100, 100' are provided. Module 100' carries the tubing 170 and is mounted in the sidewall 530, and module 100 carries electrical heater 120 and a pump 110. Module 100 is mounted in the bottom wall 510 of the tank 500. The electrical heater 120 is arranged around the pump unit 110. Module 100 or 100' may further comprise any one or more of the following components: a level sensor, a quality sensor, a filter optionally integrated in pump unit 110, a bio-decontamination device 700 such as a UV light decontamination device.

In the embodiments of figures 9, 10 and 11 using an electrical heater 120 has the advantage that immediate heater power is available reducing the start-up time at cold temperatures. A supply rate of the electrical heater may be between 150 and 350 g/h. The tubing 170 is used for circulating engine coolant. The heater power of tubing 170 will depend on engine heat up speed, and without the electrical heater 120 the start-up time will be much longer. By suitably combining an electrical heater with a tubing for engine coolant an optimal heating can be achieved fulfilling the start-up requirements whilst at the same time using heat from the engine coolant once the engine is heated up sufficiently. The electrical heater may be controlled by a controller in function of the engine temperature, in order to heat more when the engine temperature is too low and less when the engine temperature is increasing.

Figures 12A and 12B illustrate a perspective view of an exemplary embodiment of a tank of a vehicle system in which the module of figure 5 is arranged. The tank 500 comprises a bottom shell 500b and a top shell 500a. A flexible electrical heater 120 is arranged in the bottom shell 500b and extends over the bottom wall and a portion of the side wall 530. The flexible electrical heater 120 surrounds the compartment 105 of module 100. Attachment pads 505 may be arranged against a side wall 530 of the tank 500. Further a controller 180 may be provided to control one or more components of the module 100. The upper shell 500a is provided with a filler pipe 540 for filling the tank 500 with aqueous solution.

Figures 13 and 14 illustrate schematically further exemplary embodiments of vehicle systems. The vehicle system of figure 13 comprises a tank 500 for storing aqueous solution; a module 100 with first pump unit 110; an injector 310 configured for injecting aqueous solution; a feed line 350' connecting pump unit 110 to said injector 310; and a further pump unit 110' in the feed line 350'. Pump unit 110' and/or pump unit 110 allow aqueous solution from the tank 500 to be pumped to

the injector 310. A return line 360' is provided from pump 110' back to the tank 500. This return line 360' comprises a check valve 160'. The module 100 may be embodied according to any one of the above described modules. A heat exchanger 170 for engine coolant may be provided in tank 500 as a separate module or may be included in module 100. Pump unit 110' may be configured to generate the high flows needed when the RPM increases above a certain threshold. Optionally a bio-decontamination device 700, 700' may be provided in the tank 500 and/or in the return line 360'.

The vehicle system of figure 14 comprises a first tank 500 for storing aqueous solution; a module 100 with a first pump unit 110; an injector 310 configured for injecting aqueous solution; a first portion 350a' of a feed line 350' connecting pump unit 110 to a second tank 500' and a second portion 350b' of a feed line 350' connecting second tank 500' to the injector 310; and a further pump unit 110' in the feed line portion 350b'. Pump unit 110' and/or pump unit 110 allow aqueous solution from the tank 500 to be pumped to the injector 310. A return line 360' is provided from second tank 500' back to the tank 500. This return line 360' comprises a check valve 160'. The module 100 may be embodied according to any one of the above described modules. A heat exchanger 170' for engine coolant may be provided in tank 500' as a separate module. Pump unit 110' may be configured to generate the high flows needed when the RPM increases above a certain threshold. Optionally a bio-decontamination device 700, 700' may be provided in the tank 500 and/or in the return line 360' and/or in the tank 500' (not shown). Tank 500 may be located in the back of the car, and tank 500 and pump unit 110' may be located in the engine compartment.

Figure 15 illustrates a vehicle system storing an aqueous solution L. The vehicle system comprises a first compartment 501 for storing aqueous solution L, inside a tank 500 for storing aqueous solution L. The first compartment 501 is a bowl or swirl pot integrated in module 100, such that the bowl is positioned in a lower part of the tank 500. Tank 500 has a bottom wall 510, a top wall 520 and a sidewall 530 connecting the bottom wall 510 with the top wall 520. Module 100 is arranged in an opening in the bottom wall 510 of tank 500. In the mounted position of tank 500, bottom wall 510 corresponds with the lowest face of tank 500. Tank 500 is provided with a filler pipe 540 for filling tank 500, and hence also compartment 501, with aqueous solution L. Module 100 is mounted in the opening in bottom wall 510 of tank 500, e.g. by welding or by any other suitable connection means, e.g. using a ring-nut system screwed onto a thread on tank 500, or using a closure system of the bayonet type. In a preferred embodiment tank 500 and module 100 are made of compatible polyolefin materials allowing module 100 to be welded to the tank material. In another non-illustrated embodiment the opening may be arranged in sidewall 530, in a lower half of the tank 500.

Module 100 comprises a feed pump unit 110 and a jet pump 800. Feed pump unit 110 is connected for pumping aqueous solution L from the first compartment 501 to a feed outlet 351. Feed outlet 351 is connected to a feed line 350 for injecting aqueous solution L by an injector 310, e.g. in an air intake line 200 upstream of a combustion chamber 400 of an internal combustion engine. Alternatively aqueous solution may be injected directly in combustion chamber 400 of the internal combustion engine. More generally, for the described application, the aqueous solution may be injected anywhere as long as the injection is such that the air injected in combustion chamber 400 is cooled.

Jet pump 800 has a suction inlet 810, a pressure inlet 820 and an outlet 830. Pump unit 110 is further connected for pumping aqueous solution along a jet flow path P. The jet flow path P extends from an inlet 111 of feed pump unit 110 to an outlet 112 of feed pump unit 110 through a driving line 190 between outlet 112 and pressure inlet 820 of jet pump 800, to outlet 830 of jet pump 800. Suction inlet 810 is connected to a suction line 290 arranged for receiving aqueous solution from the second compartment 502. Outlet 830 of jet pump 800 is arranged for returning aqueous solution from suction inlet 810 and from pressure inlet 820 to first compartment 501. A non-return valve 160 is included in the jet flow path. Non-return valve 160 avoids that aqueous solution can flow in reverse direction through the path towards outlet 112 of the pump unit 110. The non-return valve 160 is arranged between outlet 112 of the feed pump unit 110 and the pressure inlet 810 of jet pump 800. In that way non-return valve 160 avoids that aqueous solution in jet pump 800 can return to outlet 112 of the feed pump unit 110.

The vehicle system further comprises an electronic control unit 504 configured for controlling feed pump unit 110. Electronic control unit 504 may be configured to pump aqueous solution from the tank 500 through suction line 290 to first compartment 501 when the level of the aqueous solution in first compartment 501 is below a predetermined level. Electronic control unit 504 may be integrated in or mounted on module 100, but the skilled person understands that it may also be located remotely from module 100.

An optional heater, preferably an electric heater (not shown) may be configured and arranged for heating at least said jet flow path.

Figure 16 illustrates another vehicle system storing an aqueous solution L. The vehicle system comprises a first tank 500a for storing aqueous solution L, a second tank 500b for storing an aqueous solution L, and a module 100. The module 100 is arranged in an opening in a wall of first

tank 500a. First tank 500a is provided with a filler pipe 540 for filling first tank 500a, and via an overflow line 210, also second tank 500b, with aqueous solution L. First tank 500a has a bottom wall 510, a top wall 520 and a sidewall 530 connecting bottom wall 510 with top wall 520. An opening is arranged in bottom wall 510. In the mounted position of first tank 500a, bottom wall 510 corresponds with the lowest face of first tank 500a. Module 100 is mounted in the opening in bottom wall 510 of first tank 500a, e.g. by welding or by any other suitable connection means. In another non-illustrated embodiment the opening may be arranged in sidewall 530, in a lower half of the tank 500a.

Module 100 comprises a feed pump unit 110, a jet pump 800, and optionally also a heater (not shown). Feed pump unit 110 is connected for pumping aqueous solution L from the first tank 500a to a feed outlet 351 intended for being connected to a feed line 350 as in the embodiment of figure 15. Jet pump 800 has a suction inlet 810, a pressure inlet 820 and an outlet 830. Feed pump unit 110 is further connected for pumping aqueous solution along a jet flow path. The jet flow path extends from an inlet 111 of feed pump unit 110 to an outlet 112 of feed pump unit 110 through a driving line 190 between outlet 112 and pressure inlet 820 of jet pump 800, to outlet 830 of jet pump 800. Suction inlet 810 is connected to a suction line 290 arranged for receiving aqueous solution from second tank 500b. Outlet 830 of jet pump 800 is arranged for returning aqueous solution from suction inlet 810 and from pressure inlet 820 to first tank 500a. The vehicle system may further comprise a controller (not shown) configured for controlling feed pump unit 110. The controller may be configured to pump aqueous solution from second tank 500b to first tank 500a when the level of the aqueous solution in first tank 500a is below a predetermined level. An optional heater (not shown) may be configured and arranged for heating at least said jet flow path. Further a check valve (not shown) may be included in the jet flow path in a similar manner as described above for figure 15.

First tank 500a may be positioned in a vehicle at a higher level than second tank 500b. In an alternative embodiment first tank 500a and second tank 500b may be positioned at more or less the same height and a filler line 550 may be provided between filler pipe 540 of first tank 500a and second tank 500b.

In alternative embodiments jet pump 800 in the embodiment of figure 16 may be arranged outside of first tank 500a, e.g. in a second module mounted in a wall of second tank 500b. In such embodiments the drive line 190 goes from the first tank 500a to the jet pump 800 of the second module of the second tank 500b, and the outlet 830 is connected to a return line going back from the second tank 500b to the first tank 500a.

Whilst the principles of the invention have been set out above in connection with specific embodiments, it is to be understood that this description is merely made by way of example and not as a limitation of the scope of protection which is determined by the appended claims.

Claims

1. A vehicle system for injecting an aqueous solution in an air intake line upstream of a combustion chamber (400) of an internal combustion engine, or in the combustion chamber of the internal combustion engine; said vehicle system comprising:
   a tank (500) for storing an aqueous solution;
   a pump unit (110);
   an air intake line (200) upstream of a combustion chamber of an internal combustion engine;
   an injector (310) configured for injecting aqueous solution in the air intake line or in the combustion chamber;
   a feed line (350) for feeding said injector (310) with aqueous solution pumped by the pump unit (110); wherein the pump unit (110) is arranged in a module (100), said module (100) being mounted in a opening (550) in the tank (500).

2. The vehicle system of claim 1, wherein the module (100) further comprises any one or more of the following components: a heater (120, 170), a level sensor (130), a quality sensor (140), a filter (150), an electronic control unit (504).

3. The vehicle system of claim 1 or 2, further comprising a return line (360) integrated in the module (100), said return line (360) connecting the feed line (350) with the interior of the tank (500).

4. The vehicle system of the preceding claim, wherein the return line (360) is connected to the feed line (350) in the module (100).

5. The vehicle system of any one of the preceding claims, wherein the tank (500) has a bottom wall (510), a top wall (520) and a sidewall (530) connecting the bottom wall (510) with the top wall (520), wherein the opening (550) is arranged in the bottom wall (510), wherein, in the mounted position of the tank (500), the bottom wall (510) corresponds with the lowest face of the tank (500).

6. The vehicle system of any one of the claims 1-4, wherein the tank (500) has a bottom wall (510), a top wall (520) and a sidewall (530) connecting the bottom wall (510) with the top wall (520), wherein the opening (550) is arranged in the sidewall (530), in a lower half of

the tank (500), wherein, in the mounted position of the tank (500), the bottom wall (510) corresponds with the lowest face of the tank (500).

7. The vehicle system of any one of the preceding claims, wherein the pump unit (110) comprises a gear pump.

8. A vehicle system of any one of the preceding claims, said vehicle system further comprising:

a decontamination device (700) configured for decontaminating the aqueous solution stored in the tank (500).

9. The vehicle system of the preceding claim, wherein the decontamination device (700) is arranged in the tank (500).

10. The vehicle system of claim 8, wherein the decontamination device (700) is arranged in the module (100).

11. The vehicle system of claim 8 and claim 3 or 4, wherein the decontamination device (700) is arranged in the return line (360).

12. The vehicle system of any one of the claims 8-11, wherein the decontamination device is a UV light decontamination device (700).

13. The vehicle system of the preceding claim, wherein the UV light decontamination device contains a fluid passage (720) and is configured to emit UV light in said fluid passage, and wherein the vehicle system is configured for transferring aqueous solution stored in the tank (500) through said fluid passage (720); wherein the fluid passage (720) is arranged such that the pump unit (110) can transfer aqueous solution through said fluid passage.

14. The vehicle system of ant one of the previous claims, wherein the tank is made of a polyolefin, preferably a polyethylene material or a polypropylene material; and/or wherein the module is made of a polyolefin, preferably a polyethylene material or a polypropylene material; and/or wherein the module is welded to the tank.

15. The vehicle system of any preceding claim, further comprising a jet pump (800) having a suction inlet (810), a pressure inlet (820) and an outlet (830), said pump unit (110) being connected for pumping aqueous solution along a jet flow path from the tank through the

pump unit (110), through the pressure inlet (820) of the jet pump to the outlet (830) of the jet pump, said outlet being arranged for returning aqueous solution from the suction inlet and from the pressure inlet to the tank; wherein said suction inlet (810) is connected to a suction line arranged for receiving aqueous solution from one of: a compartment in the tank; a second tank for storing an amount of aqueous solution.

16. A vehicle system for injecting an aqueous solution in an air intake line upstream of a combustion chamber of an internal combustion engine, or in the combustion chamber of the internal combustion engine; said vehicle system comprising:
    a tank (500) for storing an aqueous solution;
    a pump unit (110) inside the tank (500);
    an air intake line (200) upstream of a combustion chamber of an internal combustion engine;
    an injector (310) configured for injecting aqueous solution in the air intake line or in the combustion chamber;
    a feed line (350) for feeding said injector (310) with aqueous solution pumped by the pump unit (110) out of the tank (500);
    a decontamination device (700) configured for decontaminating the aqueous solution stored in the tank (500).

17. The vehicle system of claim 16, wherein the pump unit (110) is arranged in a module (100), said module (100) being mounted in an opening (550) in the tank (500).

18. The vehicle system of claim 17, wherein the decontamination device (700) is arranged in the module.

19. The vehicle system of claim 17 or 18, wherein the module (100) further comprises any one or more of the following components: a heater (120, 170), a level sensor (130), a quality sensor (140), a filter (150), an electronic control unit (504).

20. The vehicle system of any one of the claims 16-19, wherein the pump unit (110) comprises a gear pump.

21. The vehicle system of any one of the claims 19-20, wherein the decontamination device (700) is arranged in the tank (500).

22. The vehicle system of any one of the claims 19-21, wherein the decontamination device is a UV light decontamination device (700).

23. The vehicle system of the preceding claim, wherein the UV light decontamination device contains a fluid passage (720) and is configured to emit UV light in said fluid passage, and wherein the vehicle system is configured for transferring aqueous solution stored in the tank (500) through said fluid passage (720); wherein the fluid passage (720) is arranged such that the pump unit (110) can transfer aqueous solution through said fluid passage.

24. The vehicle system of any one of the claims 16-23, further comprising a return line (360) connecting the feed line (350) with the interior of the tank (500).

25. The vehicle system of the preceding claim, wherein the decontamination device (700) is arranged in the return line.

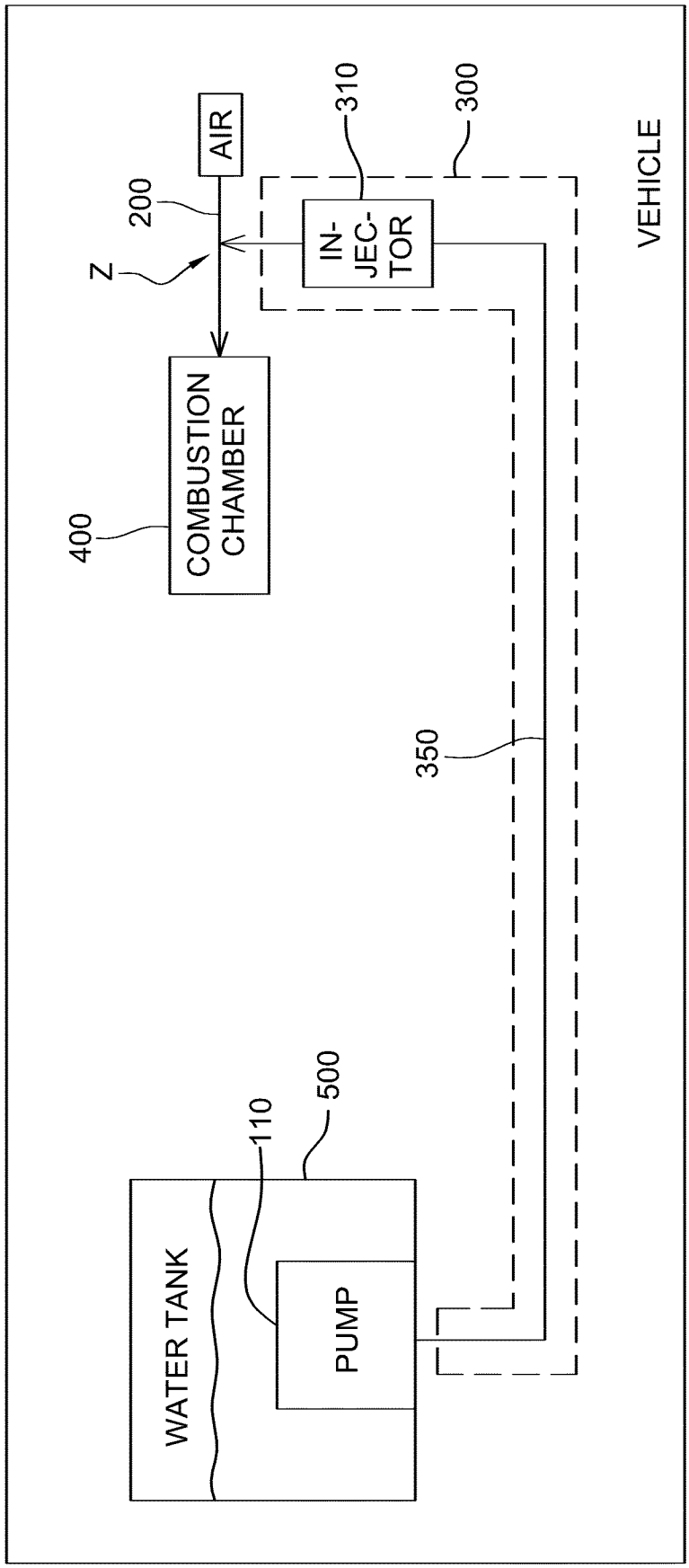
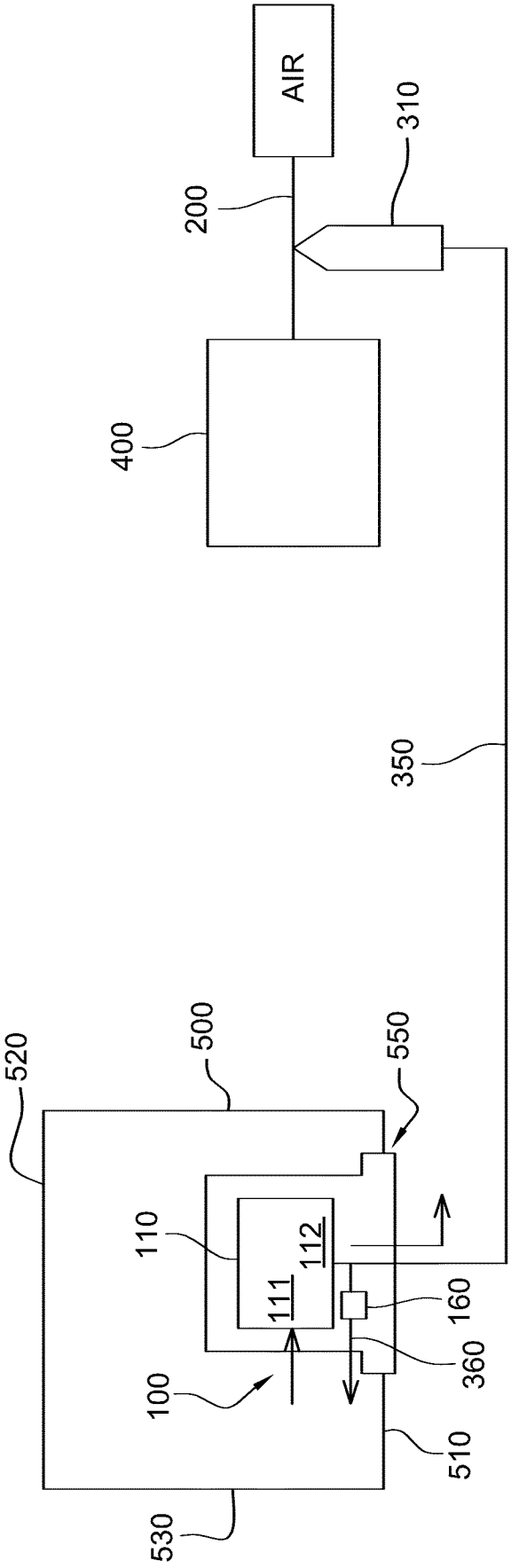

VEHICLE
AIR
310
300
200
Z
IN-
JEC-
TOR
COMBUSTION
CHAMBER
400
350
500
110
WATER TANK
PUMP

Fig. 1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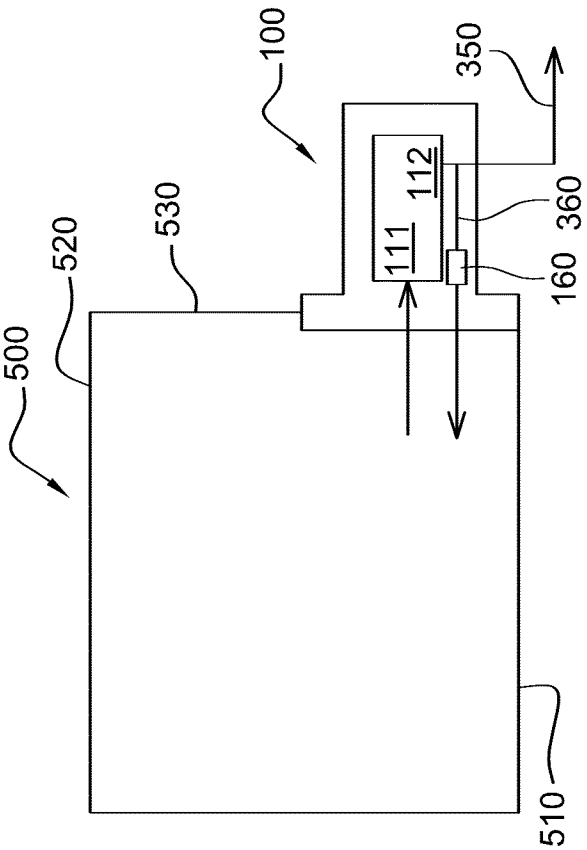
200
400
350
520
500
550
110
112
111
160
360
100
510
530

Fig. 2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350
112
111
360
160
530
520
500
510

Fig. 2A

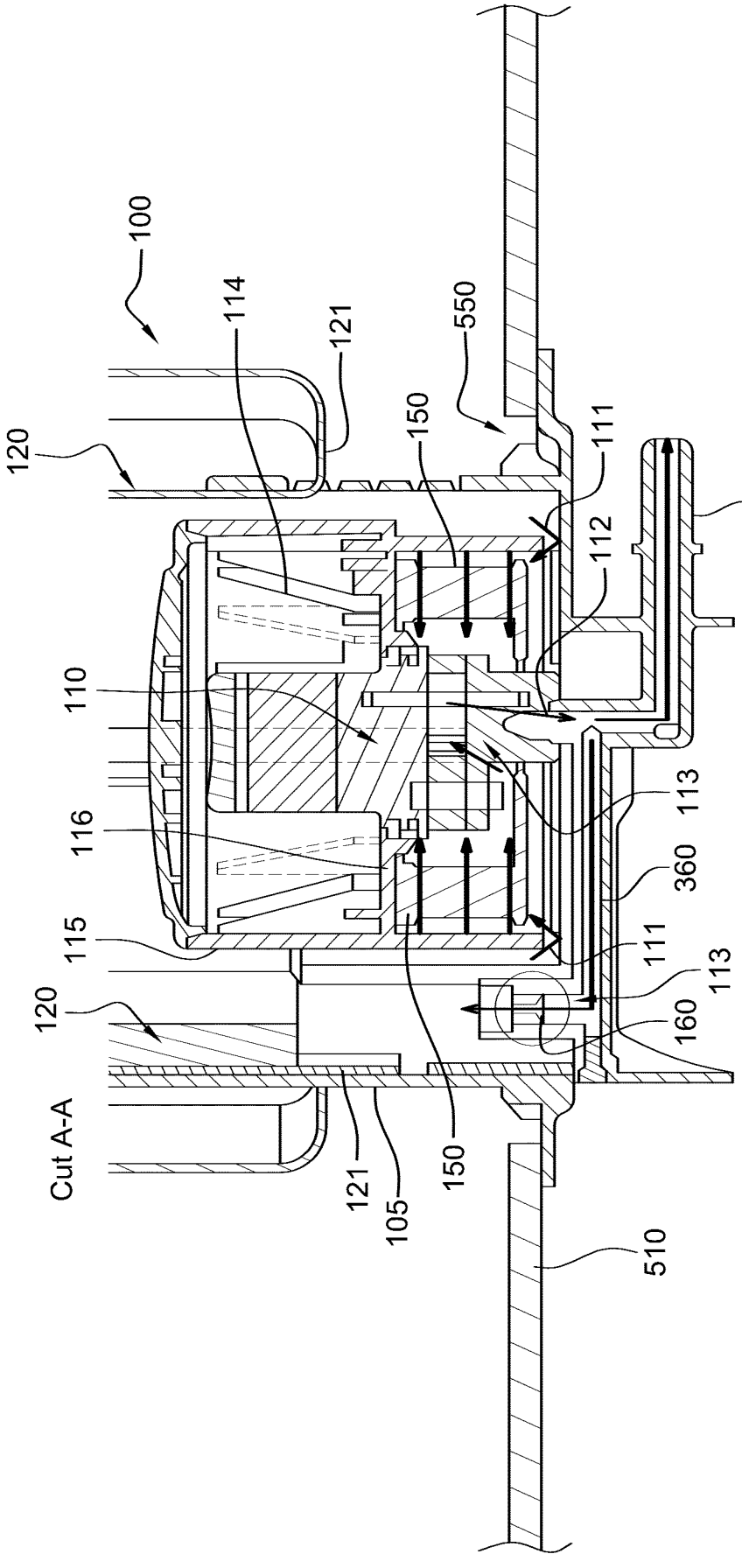
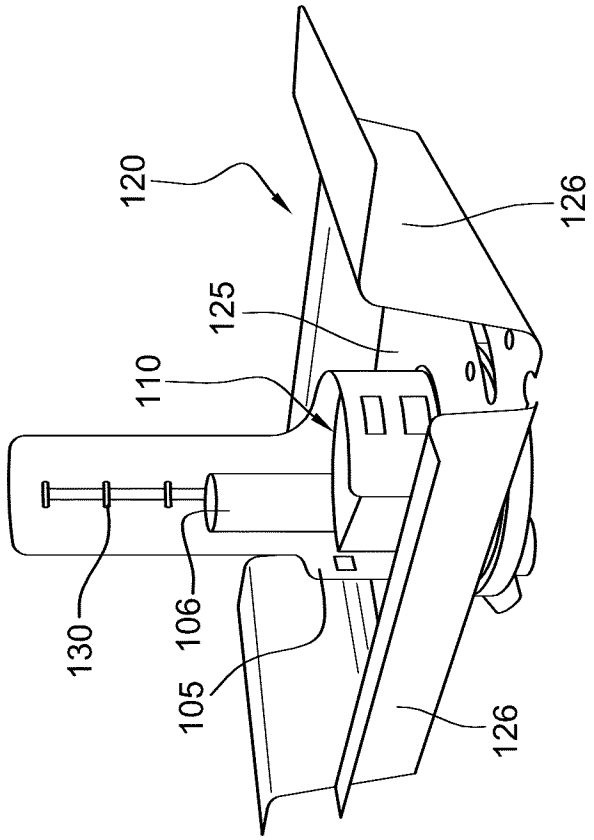

100
114
121
550
150
111
120
350
112
110
113
116
360
115
111
113
120
160
Cut A-A
121
105
150
510

Fig. 3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126
125
110
130
106
105
126

Fig. 5

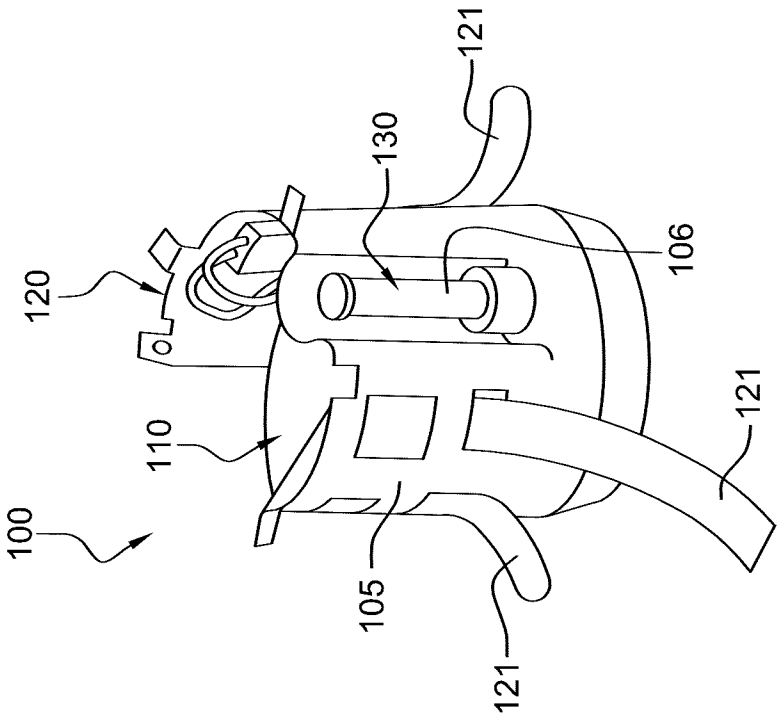

121
130
106
120
110
121
100
105
121

Fig. 4

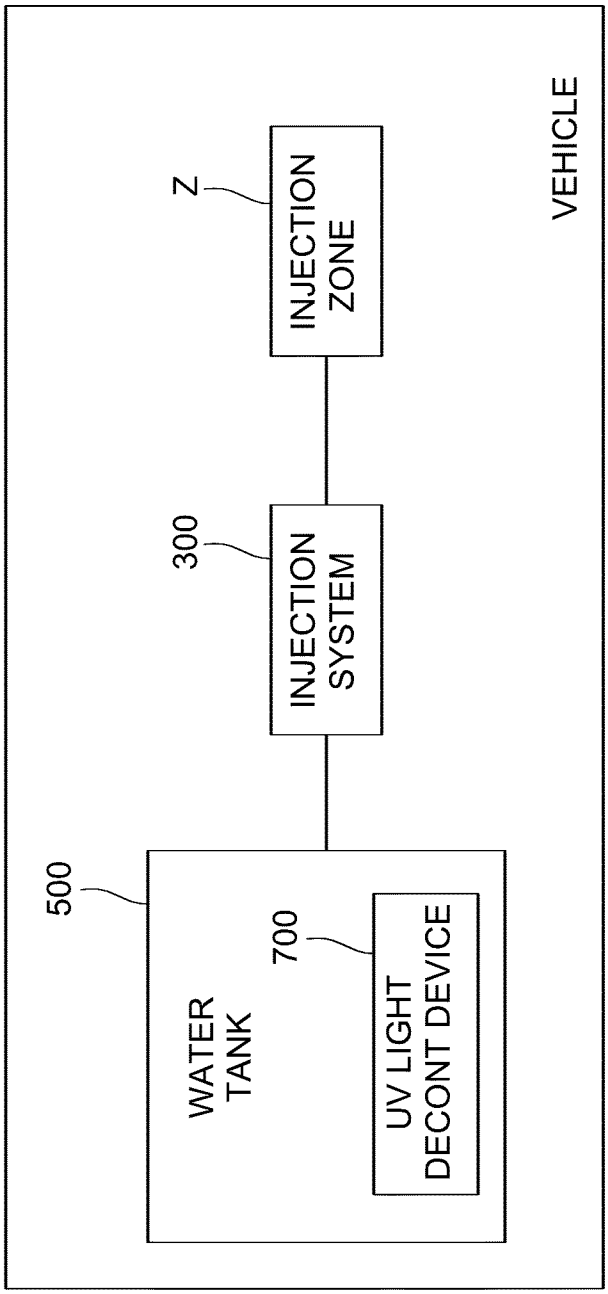

VEHICLE
Z
INJECTION ZONE
300
INJECTION SYSTEM
500
WATER TANK
700
UV LIGHT DECONT DEVICE

Fig. 6A

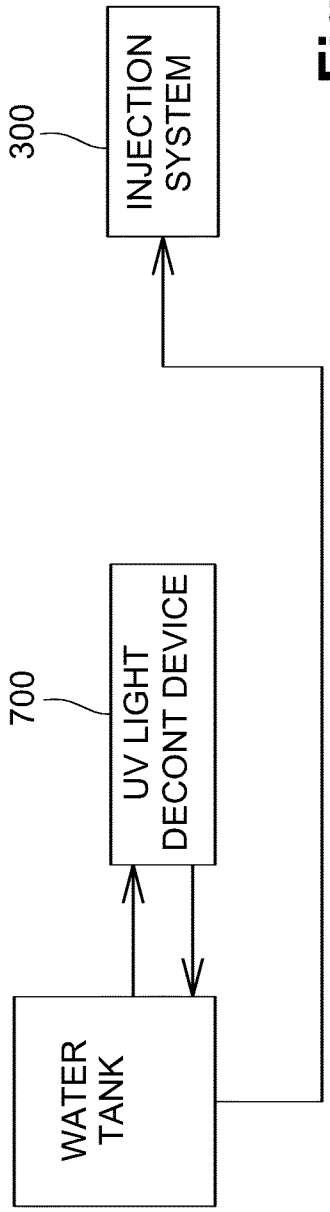

300
INJECTION SYSTEM
700
UV LIGHT DECONT DEVICE
WATER TANK

Fig. 6B

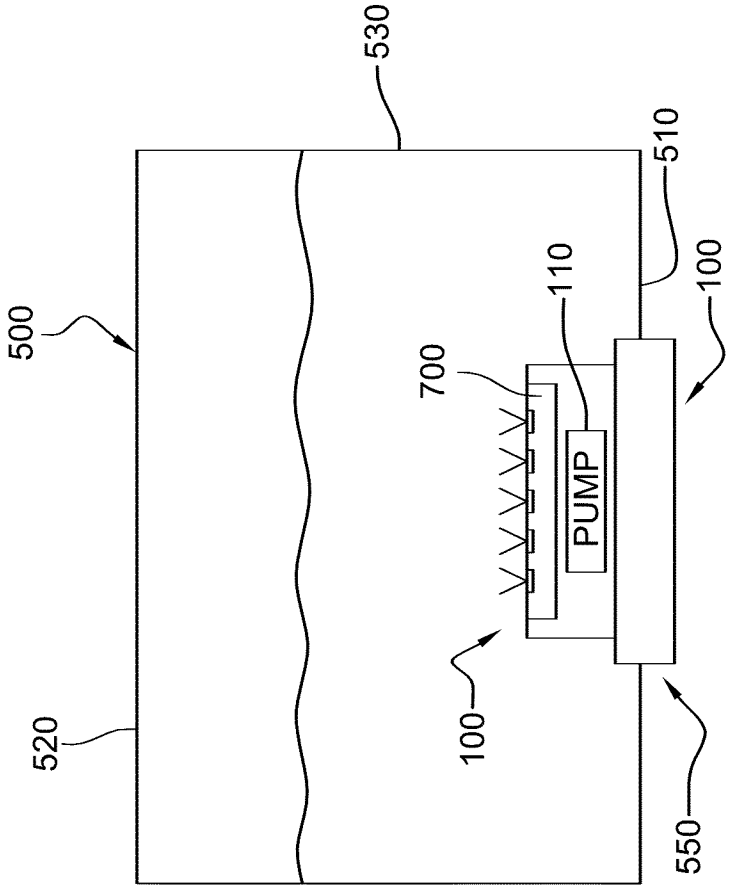


Fig. 8

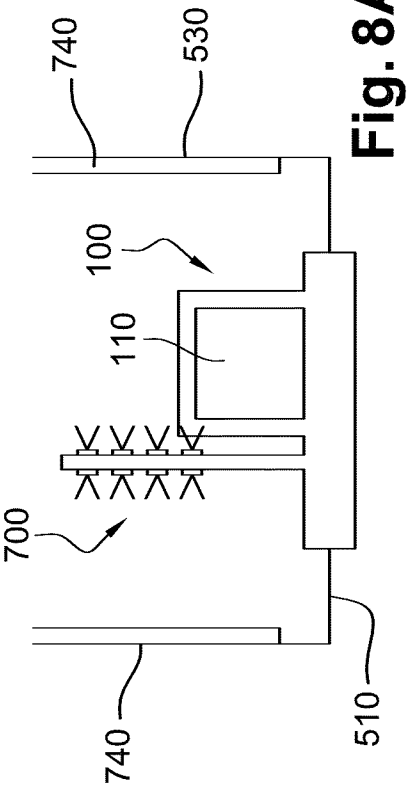


Fig. 8A

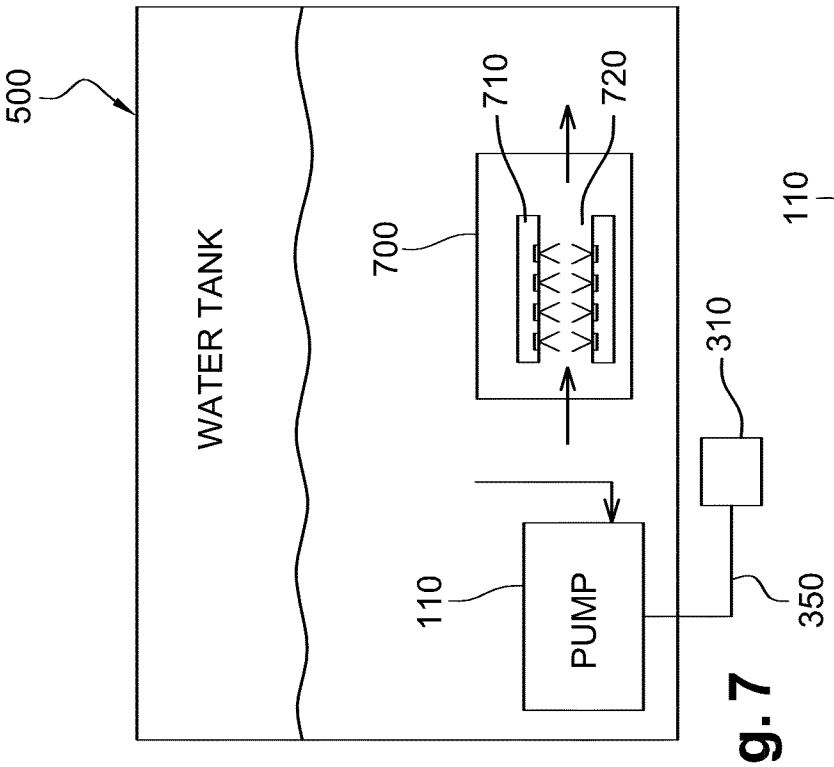


Fig. 7

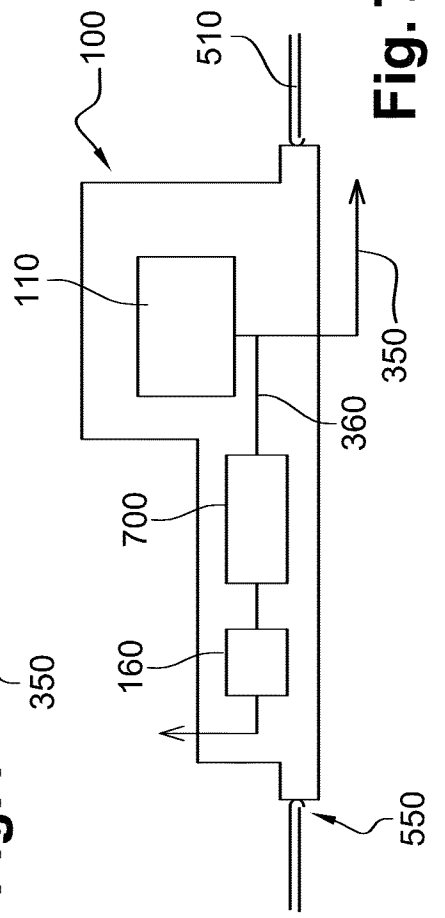


Fig. 7A

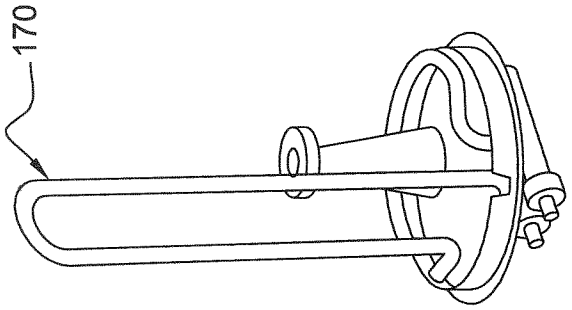


Fig. 9A

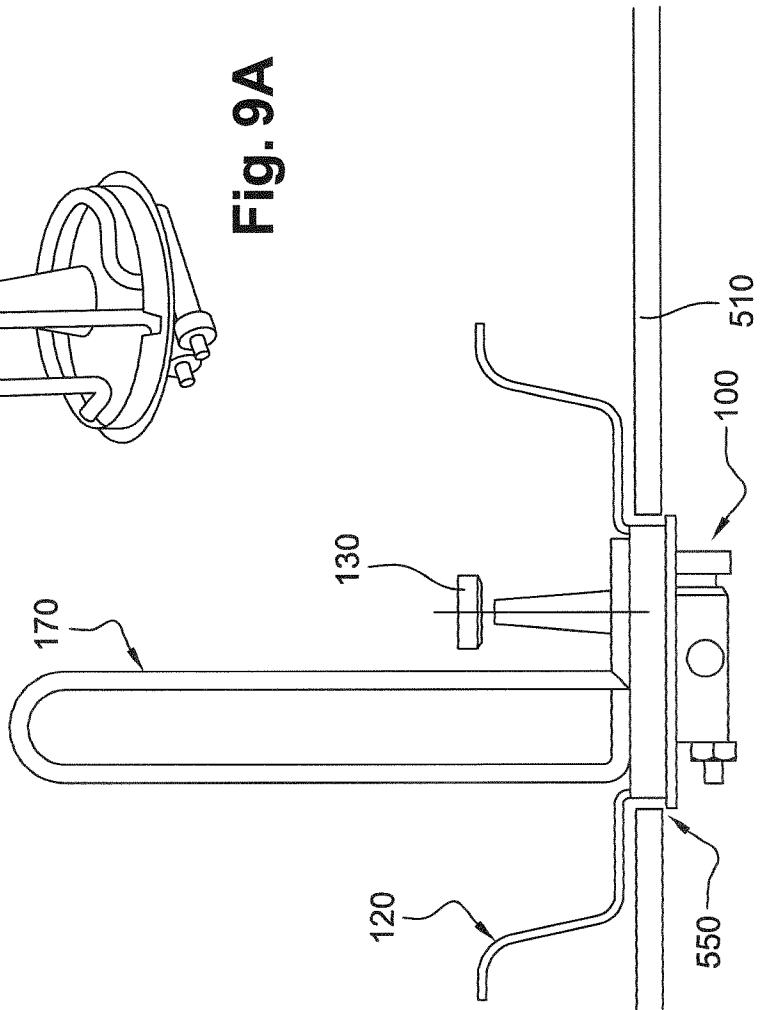


Fig. 9

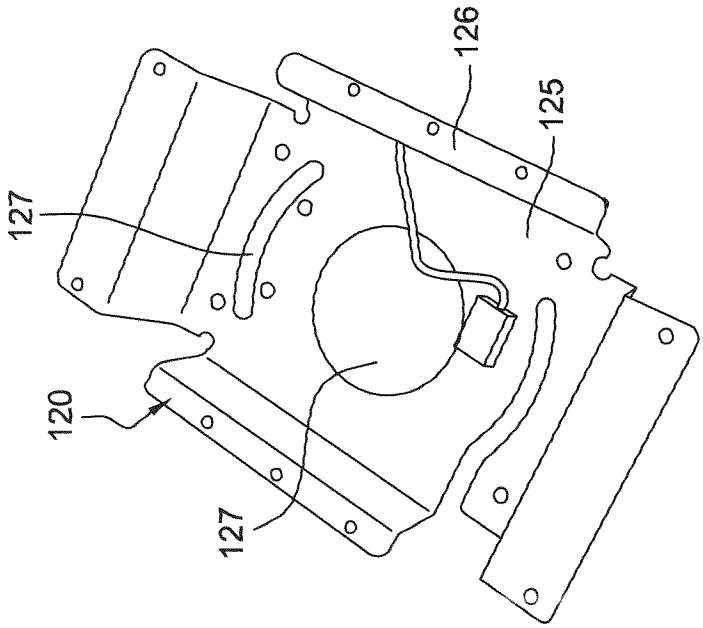


Fig. 9B

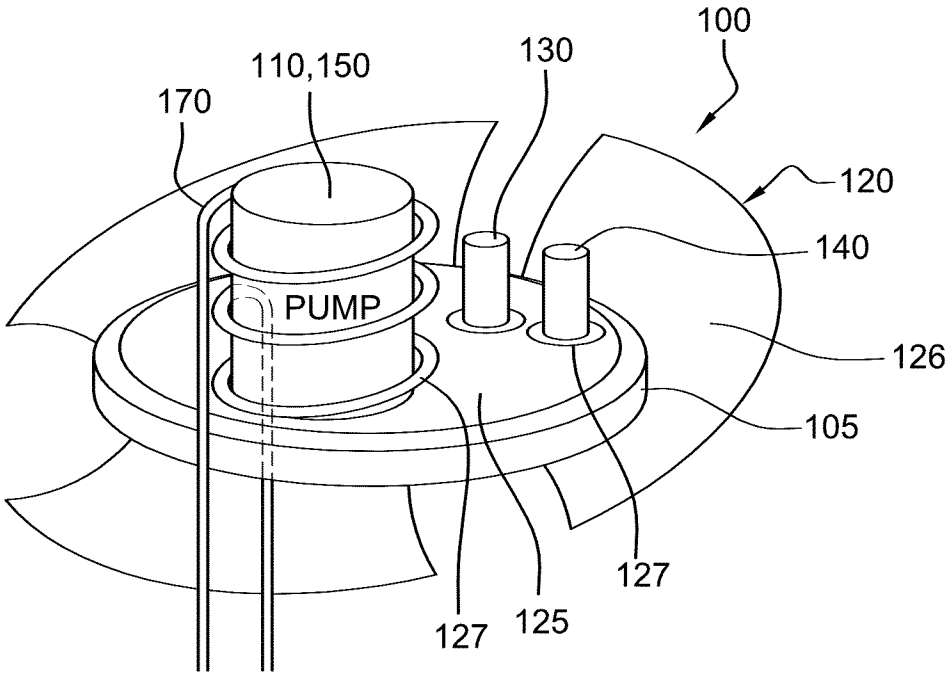

100
110,150
130
170
120
140
PUMP
126
105
127
127
125

Fig. 10

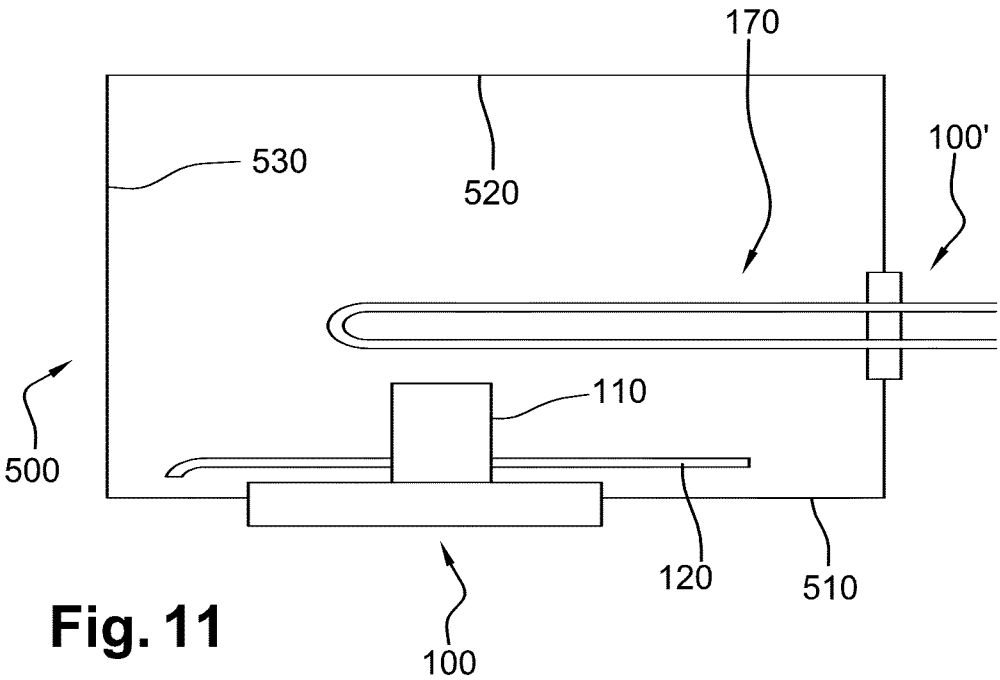

170
530
520
100'
110
500
120
510
100

Fig. 11

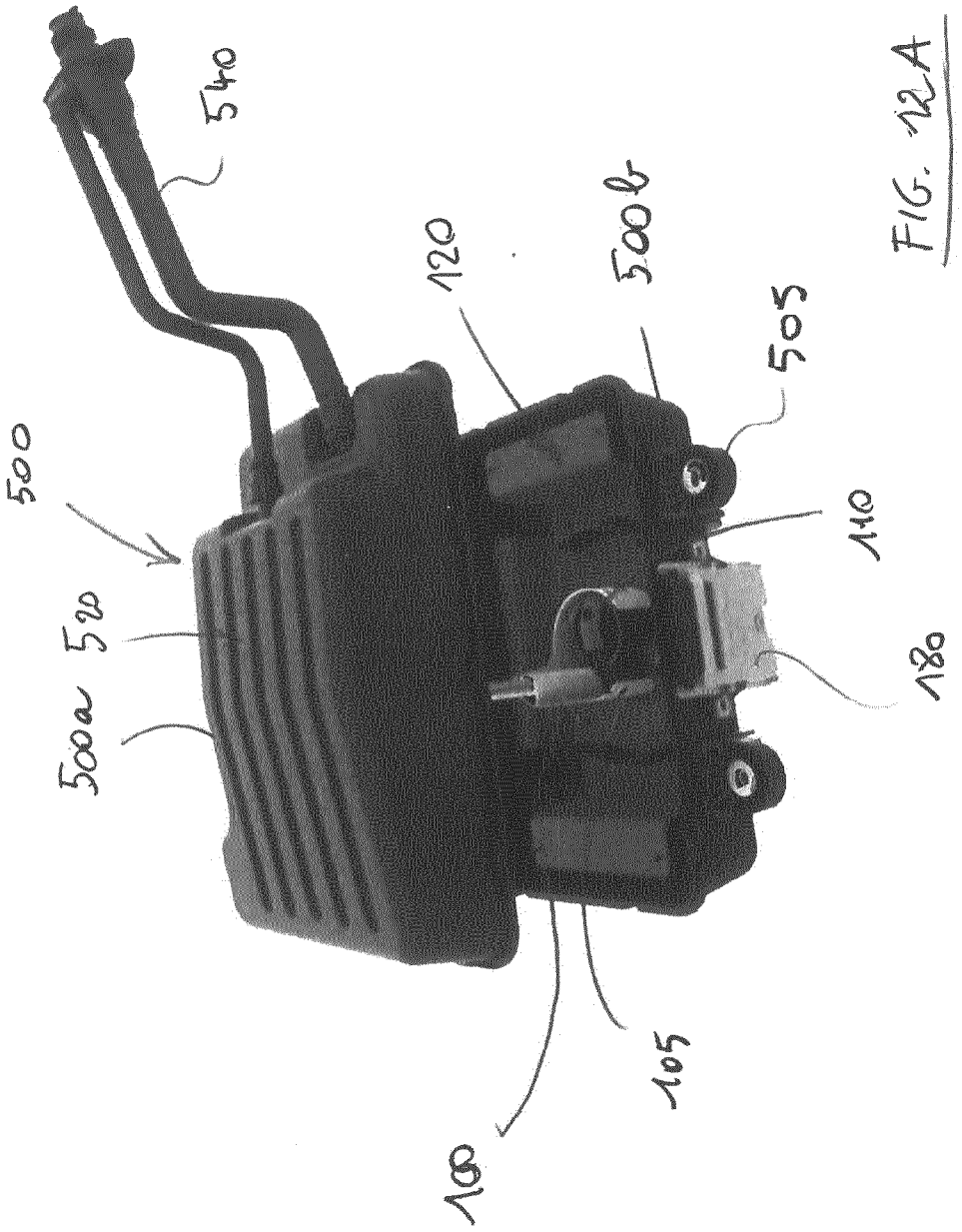


FIG. 12A

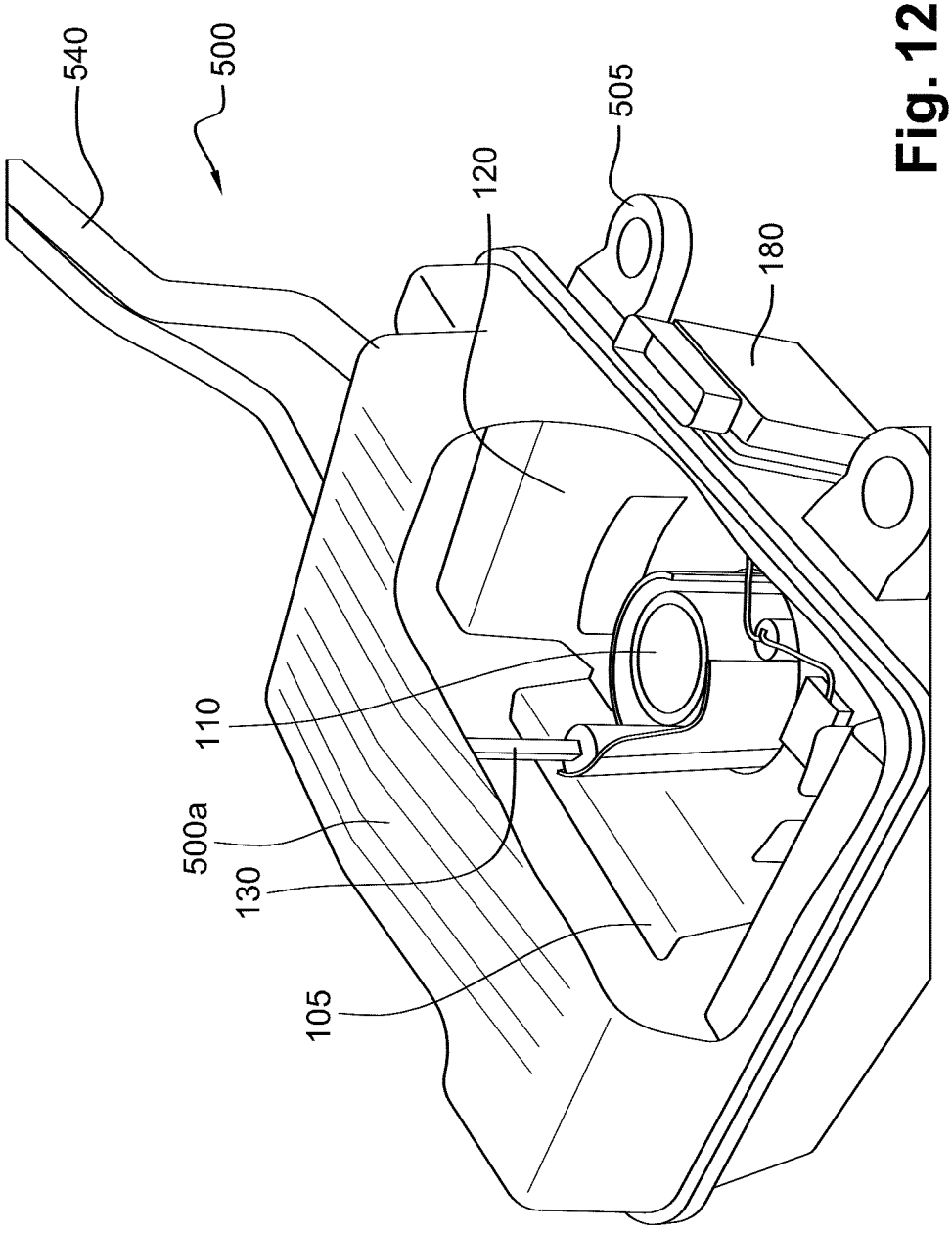


Fig. 12B

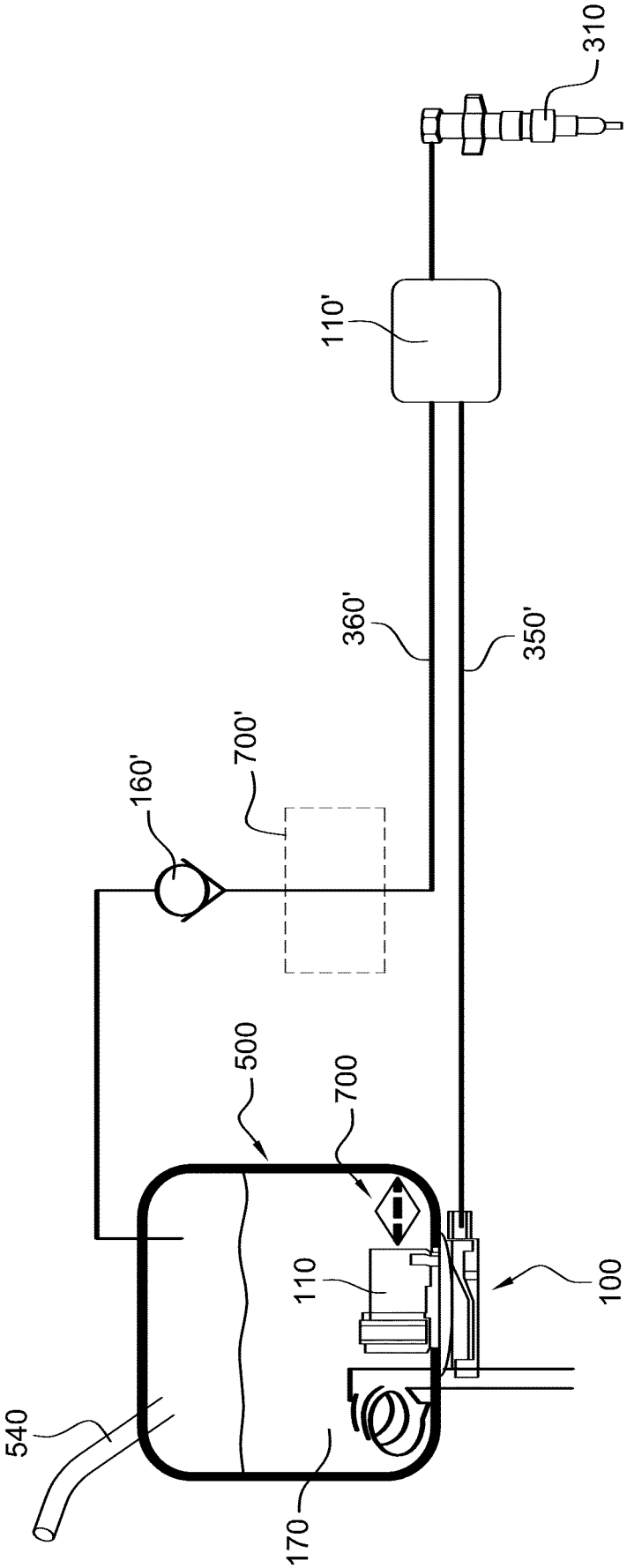


Fig. 13

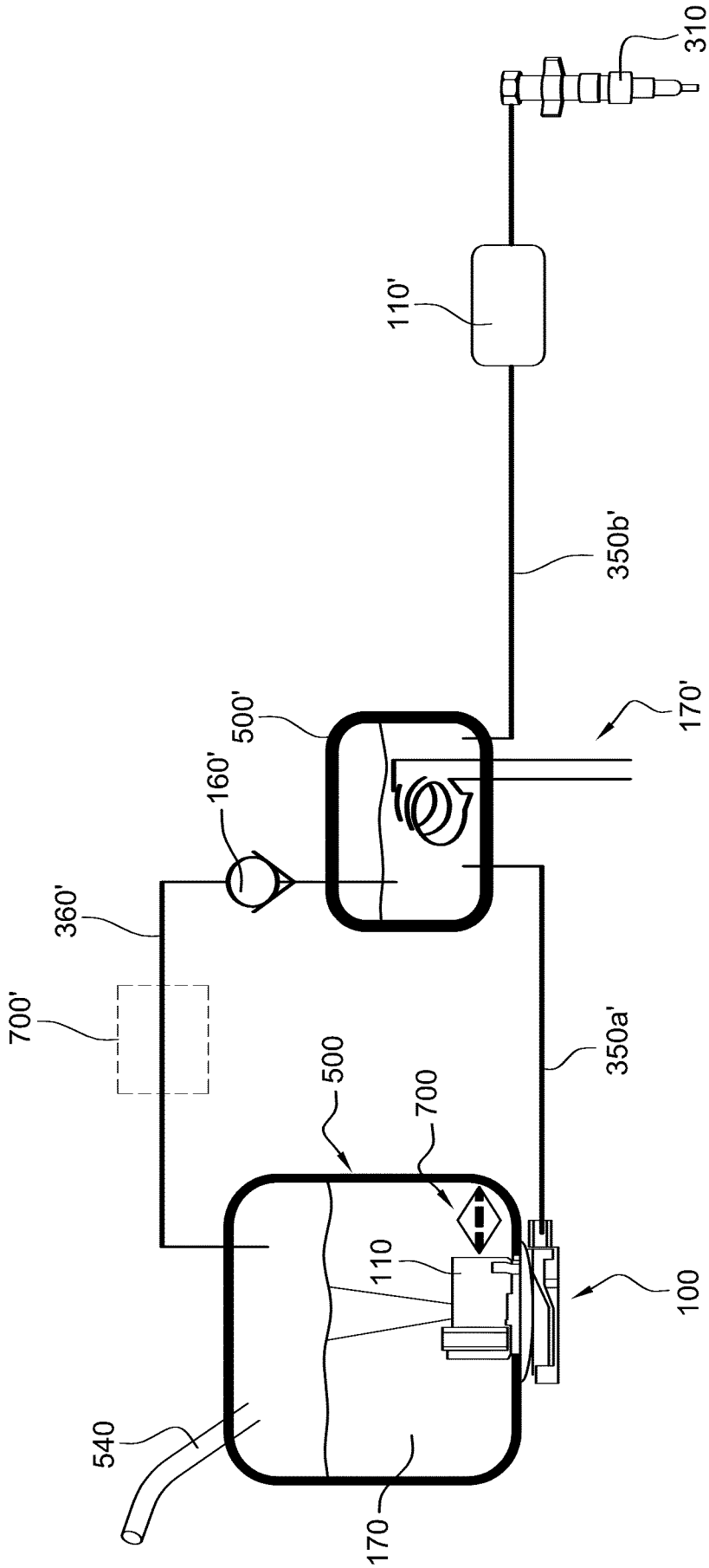


Fig. 14

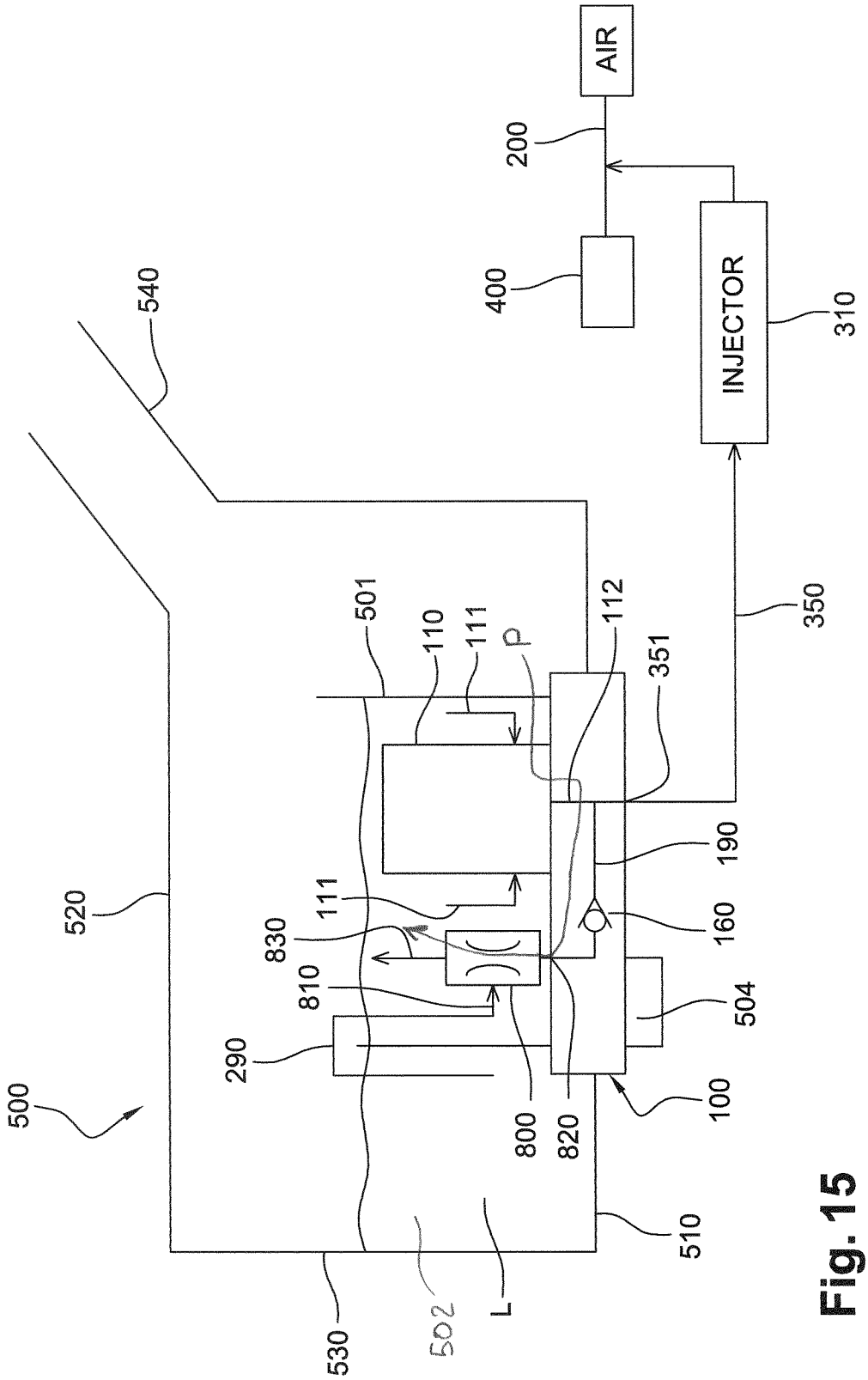
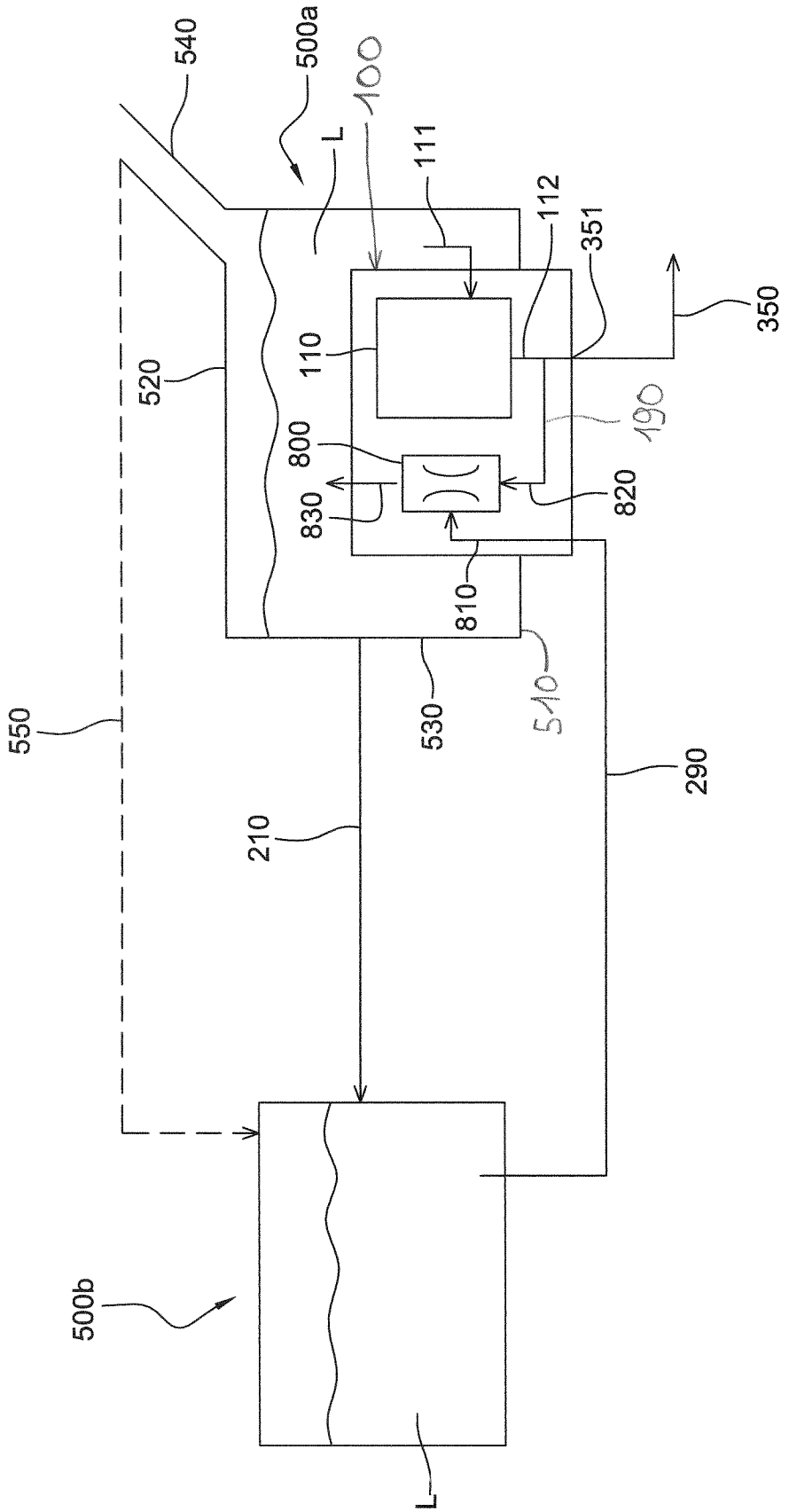

AIR
200
400
INJECTOR
310
540
350
501
110
111
P
112
351
190
520
830
111
160
810
504
290
100
500
800
820
510
530
502
L

Fig. 15


540
500a
100
L
111
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810
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550
290
210
500b
L

Fig. 16

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/073497

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02M25/022 F02M25/028 F02M25/03
ADD. F02M37/02

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)
F02M 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 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	DE 10 2014 222471 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 4 May 2016 (2016-05-04)	1,2, 7-11, 19-21,25
Y	paragraphs [0034] - [0041]; figure 1	1-25
X	EP 3 018 331 A1 (BAYERISCHE MOTOREN WERKE AG [DE]) 11 May 2016 (2016-05-11)	1,2, 7-11,16, 19-21,25
Y	paragraphs [0018] - [0023], [0028]; figure 1	1-25
X	DE 10 2008 015599 A1 (BOSCH GMBH ROBERT [DE]) 1 October 2009 (2009-10-01)	1,2, 7-13,16, 19-23,25
Y	paragraphs [0004], [0017], [0022], [0030], [0031], [0035] - [0039]; figure 1	1-25

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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
31 October 2017	13/11/2017

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	Karstens, Thede

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/073497

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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