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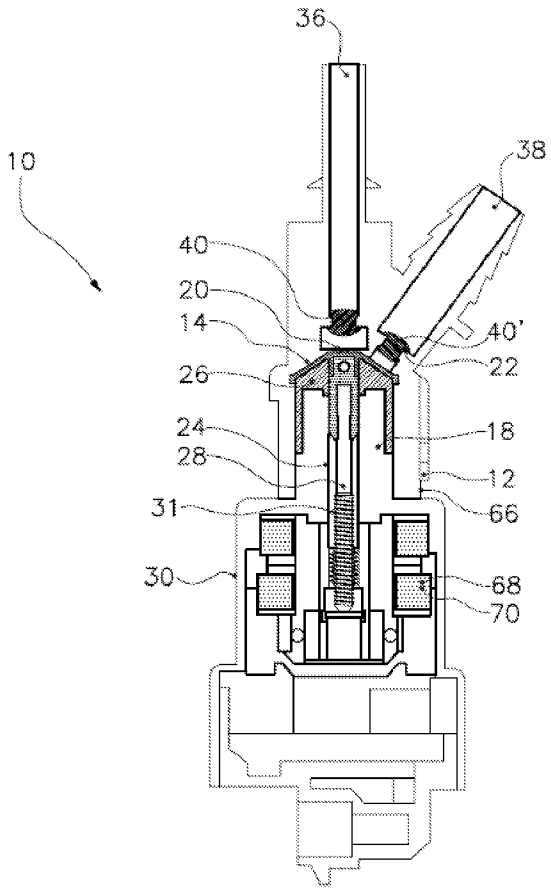
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(54) Title: PROCESS FOR INJECTING A LIQUID ADDITIVE INTO A FUEL TANK



(57) Abstract: Process for injecting a liquid additive in to a fuel tank using a metering pump. The metering pump comprises a metering chamber and an actuating device. The metering chamber is in communication with an inlet port connected to an additive tank and an outlet port connected to the fuel tank. The actuating device comprises an actuator and a piston, the actuator moving the piston between a rest position and a deployed position. The process comprises the steps consisting in : - determining the volume of liquid additive to be injected; - controlling the actuator so as to move the piston of the metering pump in the direction of its deployed position so as to suck a determined volume of liquid additive into the metering chamber; - controlling the actuator so as to move the piston of the metering pump in the direction of its rest position so as to inject the determined volume of liquid additive from the metering chamber into the fuel tank; and - optionally repeating the steps b) and c) until the volume of additive determined in point a) has been injected, and the process moreover comprises the steps consisting in : - determining the temperature of the liquid additive; and - influencing the control of the actuator as a function of the temperature measured.

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Process for injecting a liquid additive into a fuel tank

Introduction

The present invention relates to a process for injecting a liquid additive into a fuel tank using a metering pump of the membrane syringe or piston injector type.

Prior art

Despite its good environmental performance due, in particular, to its low consumption, diesel remains criticized for its releases of soot particles. In order to store the soot particles resulting from the combustion and thus prevent these particles from being emitted into the atmosphere, the particle filter has been developed. With such a filter, the particle emissions can be reduced to the limit of measurability. In order to function correctly, it must be cleaned regularly. The particles stored in the particle filter may be burnt to regenerate the particle filter.

The usual temperature of the exhaust gases is around 150°C. With the so-called "Common-Rail" technique, which allows a subsequent injection and which gives rise to a post-combustion, the temperature of the exhaust gases may be raised to 350°C. The treatment of hydrocarbons in the oxidation catalyst gives rise to a new increase in temperature to 450°C. This temperature is still below the particle combustion temperature of around 550°C.

To enable complete combustion of all the particles, it has been proposed to inject an additive into the fuel so as to lower the combustion temperature of the particles. An additive, such as for example the product EOLYS™, a compound based on cerine and on iron or on iron alone developed by Rhodia, makes it possible to lower the natural combustion temperature of the particles to 450°C, namely around 100°C less than their natural combustion temperature . The particle filter can thus be regenerated in only a few minutes, every 400 to 500 km.

The additive is generally used in an organic solution stored in an additional tank placed in the vicinity of the fuel tank. In order to inject an amount of liquid additive proportional to the volume of fuel introduced during filling, an additivation system with a metering pump has been developed.

Such a metering pump is, for example, described in Patent Application WO 2005/024219 in the name of the Applicant. This pump is a variable volume pump of the membrane syringe type and enables accurate metering of the liquid additive. Such a pump comprises a piston that moves in a cylinder and is controlled by a high resolution linear actuator. The pump moreover comprises a metering chamber, into which the additive may be sucked through an inlet valve. The additive may then be discharged from the chamber through an outlet valve towards the fuel tank.

A metering pump may also be of the injector with piston type. This type of pump enables accurate metering of the liquid additive and comprises a piston that moves in a cylinder and is controlled by a single-acting electromagnet and a return spring.

To ensure the proper functioning of the particle filter regeneration, the fuel must comprise a very precise proportion of additive. It is therefore important to provide a metering pump that allows precise metering of the additive to be injected.

It is therefore important to ensure the proper operation of the metering pump under all conditions. However, it has been noted that the operation of the pump, especially in a low temperature range, is compromised and that precise metering is consequently not guaranteed.

The same type of problem may also be encountered for metering an additive of the fuel detergent type in mainly petrol-type fuels. The actual composition of petrols may sometimes not correspond to the information available on the dispensing pumps. This may result in the malfunctioning of the engines, or even in their deterioration. It is therefore possible to resort to metering a detergent in the petrol so that the detergent acts on the fuel deposits accumulated in a fuel system and/or in an intake system of an internal combustion engine and so that these deposits be reduced, or even eliminated. As explained above, proper operation of the detergent metering pump is important for all operating conditions.

Object of the invention

The object of the present invention is to provide a process for injecting a liquid additive into a fuel tank using a metering pump, with which the proper operation of such a pump is guaranteed.

General description of the invention claimed with its main advantages

According to the invention, the injection process is carried out by a metering pump comprising a metering chamber and an actuating device. The metering chamber is in communication with an inlet port connected to an additive tank and an outlet port connected to the fuel tank. The actuating device comprises an actuator and a piston, the actuator moving the piston between a rest position and a deployed position. The process comprises the steps consisting in :

- a : determining the volume of liquid additive to be injected into the tank;
- b : controlling the actuator so as to move the piston of the metering pump in the direction of its deployed position so as to suck a determined volume of liquid additive into the metering chamber;
- c : controlling the actuator so as to move the piston of the metering pump in the direction of its rest position so as to inject the determined volume of liquid additive from the metering chamber into the fuel tank; and
- d : optionally repeating the steps b) and c) until the determined volume of additive has been injected.

According to one aspect of the invention, the process moreover comprises the steps consisting in determining the temperature of the liquid additive; and influencing the control of the actuator as a function of the temperature measured.

Determination of the temperature of the liquid additive makes it possible to determine the temperature range in which the metering pump should be operated. By knowing the specific problems of various temperature ranges, it is possible to consequently influence the control of the actuator. By adjusting the control of the actuator based on the temperature measured, certain operating parameters may be controlled to thus reduce or even eliminate the compromising effect of a certain temperature range. Thus, the proper operation of the metering pump may be ensured under all the operating conditions.

In one particular form of the process, the pump is of membrane syringe type in which the actuating device consists of an actuating chamber, the pump comprising a membrane arranged in the pump body, the membrane dividing the inside of the pump into the metering chamber and the actuating chamber, the piston being connected to the membrane.

According to one aspect of the process, the displacement rate of the piston is adjusted as a function of the temperature measured. This is because it has been noted that at low temperature the viscosity of the liquid additive is increased and makes it more difficult to suck up the additive. Moreover, the

increased viscosity of the additive causes, in the case of a membrane syringe type pump, an increased deformation of the membrane during the pumping cycle, or in the case of an injector type pump, an increase in the frictional forces of the piston in the pump, which modifies the volume of the metering chamber. The inventors have realized that modification of the volume of the metering chamber may be avoided when the pumping rate is slowed down. This is because a slower suction of the very viscous liquid additive makes it possible to limit, or even eliminate, the membrane deformation effect in the case of a syringe pump or limit, or even eliminate, the effect of the frictional forces in the case of an injector type pump. Moreover, the suction of the additive is facilitated. Due to the elimination of deformation of the membrane in one case, or frictional forces in the other case, the predetermined volume of the metering chamber may be maintained and accurate metering remains possible even in the presence of very viscous liquid additive caused by the low temperature.

According to the invention, it is also or alternatively possible to adjust the force applied by the actuator as a function of the temperature measured. A greater force exerted on the piston makes it possible to facilitate the suction of the additive into the metering chamber and the injection of the additive into the fuel tank. This is particularly advantageous when the metering pump is operated under very low temperature conditions where the additive is very viscous. The precise metering of the liquid additive by the metering pump is therefore guaranteed.

According to the invention, it is also or alternatively possible to adjust the determined volume of additive as a function of the temperature measured. The determined volume may be adjusted as a function of the temperature to take into account either the deformation of the membrane in the case of a membrane syringe type pump, or the increase in the frictional forces in the case of an injector type pump, and an increase in the viscosity of the additive. Thus, a desired volume may be injected into the fuel tank without having to modify the force applied by the actuator or the displacement rate of the piston. The precise metering of the liquid additive by the metering pump is therefore guaranteed.

In order to do this, in practice it is sufficient to establish nomograms that give the volume of liquid injected as a function of the piston stroke and this being done for various temperatures (for example, every 10°C from -40°C to +80°C) and then to store this data in the control unit of the actuator.

Preferably, the step consisting in determining the volume of liquid additive to be injected comprises the determination of the difference in volume of fuel in the fuel tank before and after a fuel tank filling phase. When the start of a filling phase is detected, for example, by opening of the fuel filler flap, the initial level of fuel in the fuel tank is noted. Similarly, when the end of a filling phase is detected, for example, by closure of the fuel filler flap, the final level of fuel in the fuel tank is noted. The difference between the initial level and the final level makes it possible to determine the difference in volume of fuel in the tank. On the basis of this difference, the volume of liquid additive to be injected into the fuel tank may be determined.

The step consisting in determining the temperature of the liquid additive may comprise the measurement of the temperature at the level of the metering pump actuator. Since the liquid additive tank is preferably located very close to the metering pump, the temperature of the additive in the additive tank may be measured by a temperature sensor located on the metering pump actuator. Such a temperature sensor may also be used to detect overheating of the actuator. It is not however excluded to provide a temperature sensor inside the additive tank.

According to another aspect of the process, in the case of a membrane syringe type pump, the actuator is a linear actuator comprising a stepper motor to which a holding current is applied in order to keep the piston in its rest position when the necessary amount of additive has been injected. This makes it possible to prevent, following vibrations, the piston from moving and from causing the unwanted injection of additive into the tank. The expression "rest position" is understood to mean that the piston is at rest against the wall of the metering chamber.

Preferably, the step consisting in influencing the control of the actuator as a function of the temperature measured comprises a step consisting in adapting the intensity of the holding current as a function of the temperature measured. At low temperature, the actuator force is reduced. Furthermore, in view of the increased viscosity of the liquid additive at low temperature, the force needed to displace the piston is higher. By increasing the holding current of the actuator, there is energy dissipation which results in heating of the actuator. Thus, the application of a higher holding current results in restoring the actuator force. Furthermore, heating of the actuator also leads to heating of the liquid additive and therefore to a lower viscosity. Thus, the proper operation of the metering pump may be ensured even in the case of very low temperature. According to

this aspect of the invention, the actuator is controlled both while operating and at reast (when it is not injecting additive).

According to one aspect of the process involving the use of a stepper motor, a possible step loss of the actuator is monitored by control electronics and a higher supply current is applied to the actuator for a predetermined time when such a step loss is detected. Such a step loss is generally due to the fact that the actuator force is insufficient, which, in turn, is generally due to the fact that the actuator is too cold. When a step loss is detected, a higher supply current is applied to heat the actuator and thus guarantee the proper operation of the metering pump.

In another particular form of the process, the pump is of the piston injector type, the actuator comprises a return spring capable of moving the piston from the deployed position to the rest position and an electromagnet equipped with a coil in which a holding current is applied to the coil. The process according to this particular form comprises a step consisting in adapting the intensity of the holding current as a function of the temperature measured. The electromagnet is generally positioned around the body of the pump so that, when the holding current is applied to the coil, this coil heats up and releases the heat which is transmitted to the body of the pump. The holding current therefore consists, in the case of an injector type pump, of a current that gives rise to a release of heat in the coil and that does not provide the control of the piston which is, on the other hand, provided by a current control in the form of square wave current control, for example. In general, the body of the pump is made from a material that conducts heat, preferably a metal, so as to promote the transfer of heat to the liquid additive.

By applying a holding current, it is observed that not only is the viscosity of the liquid additive reduced, but also that the metering at the pump outlet has improved repeatability. In general, the holding current is applied for a few minutes (for example, by subjecting the coil of the electromagnet to a direct voltage generally between 8 and 16 V, for example around 12 V, for around 3 or 4 minutes).

According to this particular form of the process, the electromagnet is generally of the single-acting type so that when it is activated it enables movement of the piston from a rest position to a deployed position. The return spring, which is, for example, positioned inside the piston, ensures the movement of the piston from a rest position to a deployed position so that the action of the

electromagnet and the action of the return spring ensure an alternating movement of the piston from the rest position to the deployed position and *vice versa*.

Preferably, a higher holding current is applied for a predetermined time, for example during a preheating step of the process according to the invention.

The predetermined time may depend on the initial temperature which may be measured on the actuator. The higher holding current may also be applied until a threshold temperature is attained.

Another aspect of the process aims to take into account the fact that the power supply of the actuator may be interrupted during an injection cycle (for example, when the vehicle engine is stopped). The expression "injection cycle" is understood to mean the set of piston strokes needed for the injection of the desired volume of additive. Generally, this comprises a given number of complete strokes and a last incomplete stroke (aiming to adjust the exact amount of additive needed). The process according to this aspect of the invention hence comprises the steps consisting in :

- storing in the memory the total volume of liquid additive to be injected and the volume of liquid additive already injected, or the remaining volume of liquid additive to be injected;
- storing in the memory the number of strokes (suction/injection) already carried out by the piston during the interruption and/or the number of strokes still to be carried out; and
- when the power supply of the actuator is restored, restarting the liquid additive injection cycle at the point where the cycle was interrupted, based on the information stored in the memory.

This is because, after the filling phase, after which the liquid additive injection cycle starts, it could be that the driver only moves his vehicle a few metres to park it and take a break. This is, for example, very often the case when filling up at motorway service areas.

The additive injection cycle preferably starts as soon as the engine is started after the filling phase. The time to park a vehicle generally does not, however, complete the additive injection cycle, which is then interrupted by the engine switching off. To ensure the correct metering of the liquid additive it is therefore important, during the starting of the engine, to restart the additive injection cycle exactly at the point where the cycle was interrupted. Storing in the memory the number of strokes of the piston during the interruption enables the actuator to restart the injection cycle at the precise moment of the

interruption and to complete the injection cycle. The precise metering of the liquid additive into the fuel tank can thus be guaranteed. In this variant, it is therefore advantageous that when the current is cut, the injector comes to rest, in its rest position, so as to inject the total amount of additive sucked up.

According to another aspect of the process, the actuating device is put in contact with the atmosphere during operation of the actuator. In the case of a membrane syringe type pump, the additive tank generally comprises a communication with the atmosphere to allow ventilation of the additive tank. In other words : the metering chamber is generally ventilated (vented to atmospheric pressure). Hence, if the actuating chamber is not also ventilated, an increase in the temperature of the actuator (for example, following an energy dissipation as mentioned previously) will lead to an increase of the pressure in the actuating chamber. This pressure increase may cause, in the case of a membrane syringe type pump, deformation of the membrane which leads to a reduction in the volume of the metering chamber. Putting the actuating chamber in communication with the atmosphere, at least during operation of the actuator, makes it possible to prevent a pressure increase in the actuating chamber and thus makes it possible not to deform the membrane. The precise metering of the liquid additive into the fuel tank can thus be guaranteed.

The various aspects of the invention described above are preferably used in combination. It should however be noted that the various aspects of the injection process may also be used independently and individually to guarantee the precise metering of liquid additive into the fuel tank.

Description with the aid of the figures

The following figures illustrate, by way of example, some advantageous embodiments of a membrane syringe type metering pump (Figs 1 to 6) and of the piston injector type metering pump (Figs 7 to 12) suitable for the process according to the invention.

Fig.1 : a schematic view of an axial cross section through a metering pump suitable for the process according to the invention;

Fig.2 : a schematic view of the part of the metering pump around the pump membrane from Fig.1, in which the piston is illustrated in its deployed position;

Fig.3 : a schematic view of the part of the metering pump around the pump membrane from Fig.1, in which the piston is illustrated in its rest position;

Fig.4 : a schematic view of an axial cross section through a piston according to one aspect of the invention;

Fig.5 : a perspective view of the piston from Fig.4, in which the piston is illustrated in its deployed position; and

Fig.6 : a schematic view of an axial cross section through a non-return valve according to one aspect of the invention;

Figs 7 to 12 : schematic views of an axial cross section through a metering pump also suitable for the process according to the invention and corresponding to various steps of the process according to the invention.

Identical reference signs in the various figures denote identical or similar components.

The membrane syringe type metering pump is described in an overall manner by jointly referring to Figures 1, 2 and 3. The metering pump 10 comprises a hollow pump body 12. A membrane 14 is arranged inside the pump body 12 and divides the inside of the pump into a metering chamber 16 and an actuating chamber 18. The pump body 12 additionally comprises an inlet port 20 and an outlet port 22 in communication with the metering chamber 16. The volume of the metering chamber 16 is variable owing to the displacement of the membrane 14 resulting from the displacement of a piston 24 positioned in the actuating chamber 18.

The piston 24 comprises a piston head 26 connected to the membrane 14 and a rod 28 that extends from the piston head 26 to an actuator 30. The actuator 30 is a linear actuator comprising a stepper motor mounted in the actuating chamber 18 and which causes the rod 28 to move forwards while cooperating with a threaded portion 31 of this rod to thus control the displacement of the piston 26 driving the displacement of the membrane 14 connected to a central part of the piston head 26. The piston 24 can be moved between a rest position and a deployed position. In the rest position, the piston 24 is in a position in which the membrane 14 is sandwiched between the piston head 26 and an end wall 32 of the pump body 12, the end wall 32 comprising the inlet port 20 and the outlet port 22. When the piston 24 is in its rest position, the membrane 14 rests against the end wall 32. Opening of the valves is impossible : the membrane ensures the closure of the hydraulic circuit in addition to the closure of the valves. The volume of the metering chamber 16 – that is to say the volume described by the space between the membrane 14 and

the end wall 32 – is therefore defined by the structure of the metering pump 10. In the rest position, the volume of the metering chamber 16 is consequently always identical. Preferably, the surface area of the end wall 32 and the surface area of the piston head 26 facing the end wall 32 are complementary. Thus, the volume of the metering chamber 16 is substantially zero when the piston 24 is in its rest position. Due to the fact that the volume of the metering chamber is always identical when the piston 24 is in its rest position, the metering pump can therefore only be moved accurately when the additive is sucked up.

When the additive has to be injected into the fuel tank, the actuator exerts a force on the rod 28 of the piston 24 which moves it in the direction of its deployed position. This movement of the piston 24 drives a movement of the membrane 14 connected to the piston head 26. In turn, the movement of the membrane 14 leads to an increase of the volume of the metering pump and to suction of the additive through the inlet port 20 connected to an additive tank (not shown) by an inlet pipe 36. The volume of additive sucked into the metering chamber 16 may be accurately determined as a function of the movement of the piston 24. When the volume of the metering chamber has reached a predetermined volume, the actuator 30 exerts a force on the rod 28 of the piston 24 which moves it to its rest position. The volume of the metering chamber 16 is again reduced and the additive is discharged from the metering chamber 16 through the outlet port 22 connected to a fuel tank (not shown) by an outlet pipe 38. For the correct operation of the metering pump 10, the inlet port 20 and the outlet port 22 are each provided with a non-return valve 40, 40'.

A guiding member 42 that limits rotational movement of the head 26 of the piston 24 about its axis is positioned between the piston head 26 and the side wall 44 of the pump body 12. The stepper motor specifically turns and moves the rod forward as explained previously, whereas the piston, itself, has only to move forwards or move backwards to inject/suck up the additive. The guiding member 42 may be described in detail by referring to Figures 4 and 5. The guiding member 42 comprises at least one longitudinal slider 46, 46' that extends parallel to the axis of the piston 24 from the piston head 26 in the direction of the actuator 30. The slider 46, 46' engages with a guide (not shown) formed on the inner side wall 44 of the pump body 12. The guide may be formed by radial protuberances on the inner side wall 44 of the pump body 12 to receive the slider 46, 46' between two such radial protuberances. Alternatively, the guide may be formed by a groove that receives a radial protuberance formed on at least

one part of the slider 46, 46'. Figure 4 also shows the connection between the piston head 26 and the rod 28 of the piston 24, and also the connection between the membrane 14 and the piston head 26. As illustrated in Figure 4, the head of the rod 28 comprises a lubricated groove (28') which makes it much easier to decouple the piston head 26 and the rod 28 (theoretically, the membrane 14 could, by itself, make it possible to prevent the rotation of the head 26 but with a risk of tearing through fatigue).

A non-return valve 40, 40' is attached to the inlet port 20 and to the outlet port 22 respectively. Such a non-return valve 40 is illustrated schematically in Figure 6. The non-return valve 40 comprises a valve seat 47 that surrounds a passage opening 48 and an umbrella-type valve 50, the valve 50 comprising an axial rod 52 that passes through the passage opening 48 and a stopper 54 connected to an upstream end 55 of the axial rod 52. The stopper 54 comprises, in a peripheral region of the stopper 54, a first protuberance 56 directed towards the valve seat 47 and the valve seat comprises a second protuberance 58 directed towards the stopper 54. The first protuberance 56 and the second protuberance 58 are arranged around the passage opening 48 so as to form a labyrinth-type seal when the stopper 54 rests on the valve seat 47. The valve 50 moreover comprises a travel limiting component 60 connected to a downstream end 62 of the axial rod 52 to prevent the non-return valve 40 from being closed when the rod arrives at the end of its stroke.

The non-return valve illustrated in Figure 6 is the non-return valve 40 associated with the inlet port 20. When the metering pump 10 operates in suction mode, a vacuum is created in the inlet port 20 and the valve 50 is moved into its open position as illustrated in Figure 6. The additive coming from the inlet pipe 36 passes through the passage opening 48 and ends up in the metering chamber 16 through the inlet port 20. On the other hand, when the metering pump 10 operates in injection mode, an overpressure is created in the inlet port 20 and the valve 50 is moved into its closed position in which the first protuberance 56 presses against the valve seat 47 and the second protuberance 58 presses against the stopper 54. The first protuberance 56 and the second protuberance 58 thus form a labyrinth seal preventing leakage paths for the additive. The protuberances 56, 58 are preferably formed from an elastic material. An additional layer 64 made from an elastic material may be deposited on the valve seat 47 to receive the first protuberance 56.

As illustrated in Figure 1, the actuating chamber 18 comprises a pressure-regulating port 66 that provides communication with the atmosphere. The pressure-regulating port 66 makes it possible to keep the actuating chamber 18 at atmospheric pressure to thus prevent a pressure increase in the actuating chamber 18 due to heating up of the actuator 30 and of the environment around the actuator 30.

The metering pump 10 moreover comprises a control unit 68, represented schematically in Figure 1 outside of the metering pump 10. The control unit 68 comprises a connection to a temperature sensor (not shown) for measuring the temperature of the liquid additive and a means (not shown) for controlling the actuator as a function of the temperature measured. The temperature sensor may be located in the additive tank. Preferably, on the other hand, the temperature sensor is positioned on the actuator 30. This is because the proximity of the actuator 30 and the additive tank only results in a minimal temperature difference between the actuator and the additive in the additive tank. Thus, the temperature sensor and the control unit 68 may be integrated into the metering pump 10.

Owing to the control unit 68, the actuator 30 of the metering pump 10 may be controlled as a function of the temperature so as to adjust the displacement rate of the piston 24, to adjust the force applied by the actuator 30 or to adjust a predetermined volume of additive to be injected to thus reduce or even eliminate the compromising effect of a certain temperature range.

The metering pump 10 illustrated comprises an actuator 30 which is a linear actuator comprising a stepper motor which is supplied with supply electric current (to condition the movement of the rod 28) and holding electric current (to keep the piston 24 in its rest position, if necessary, i.e. outside of the injection cycles, when the vehicle engine turns and when vibrations can occur). The control unit 68 comprises at least one temperature sensor for measuring the temperature of the actuator 30 and a means for increasing the holding current when the temperature measured is below a threshold temperature. At low temperature, the force of the actuator 30 is reduced. Furthermore, in view of the increased viscosity of the liquid additive at low temperature, the force needed to displace the piston 24 is higher. By increasing the holding current of the actuator 30, an energy dissipation occurs which results in heating of the actuator 30. Thus, the application of a higher holding current results in restoring the force of the actuator 30. Furthermore, heating of the actuator 30 also leads to heating of the liquid additive and therefore to a lower viscosity. Thus, the proper

operation of the metering pump 10 may be ensured even in the case of very low temperature as the additive is heated when the pump is at rest and is therefore ready to be injected at a good viscosity when an injection cycle has to be started.

The control unit 68 moreover comprises a means for detecting a step loss of the stepper motor and a means for increasing the supply current when a step loss is detected. Such a step loss is generally an indication that the temperature of the actuator is not high enough. When a step loss is detected, the supply current is increased to heat the actuator 30 and thus guarantee the proper operation of the metering pump.

It should be noted that the control unit 68 preferably comprises both the means needed for adjusting the control of the piston and the means needed for adjusting the supply current and holding current. It is not however excluded to separately provide a first control unit comprising the means needed for adjusting the control of the piston and a second control unit comprising the means needed for adjusting the supply current and holding current.

Finally, the metering pump 10 moreover comprises a management unit 70 comprising a means for determining the volume of liquid additive to be injected into the fuel tank. Moreover, the control unit 68 and the management unit 70 preferably form a common unit. A sensor of the fuel level in the fuel tank may be used to measure the fuel level before and after the fuel tank filling phase. Based on the difference in volume thus determined, the management unit 70 determines the volume of additive to be injected into the fuel tank. This determination may be carried out thanks to an algorithm or table stored in the memory. The management unit 70 comprises a means for determining an interruption of a power supply to the actuator and a storage means for storing, in case of such an interruption, information on the volume injected and information on the status of the injection cycle at the time of the interruption. The information on the status of the injection cycle comprises the number of piston strokes at the time of the interruption. The information on the volume injected preferably comprises the volume of liquid additive that remains to be injected. Alternatively, the information on the volume injected may comprise the total volume of liquid additive to be injected and the volume of liquid additive already injected. The management unit 70 enables the metering pump 10 to restart the additive injection cycle at the precise moment of the interruption to thus ensure the correct metering of the additive.

The metering pump described in Figures 7 to 12 corresponds to a piston injection type pump.

Illustrated in Figure 7 is an axial cross section of a pump comprising a pump body 12 inside which a piston 24 is positioned in a rest position. The piston 24 comprises a hollow part 21 which communicates with an inlet port 20 connected to an additive tank (not illustrated) and with an outlet port 22 which communicates with a fuel tank (not illustrated). The pump comprises an actuator 30 of the single-acting electromagnet type, equipped with a coil, the actuator 30 enabling the movement of the piston 24 to a deployed position (which in fact corresponds to a retracted position of the piston 24 in the direction of the inlet port 20 of the pump). The pump moreover comprises a return spring 23 positioned in the hollow part 21 of the piston 24 and capable of bringing the piston 24 back from the deployed position to the rest position.

In the rest position, a ball 25 is held in a position of contact with one end of the piston 24 by means of a spring 25' so that the liquid additive is kept, in a leaktight manner, in the hollow part 21 of the piston 24.

The pump also comprises a non-return valve comprising a non-return ball 27 and a spring 27'. The non-return valve is positioned in the pump body 12, in an extension of the piston 24.

Within the context of the invention, the process comprises the steps consisting in measuring the temperature of the additive and influencing the control of the actuator 30 as a function of the temperature measured. For the pump illustrated in Figure 7, that amounts to making, during a preheating step, a direct current flow in the coil of the electromagnet for a predetermined time so that the coil heats up and transmits the heat released to the additive, thus making it more fluid.

After the preheating step, the electromagnet is controlled by the flow, in the coil, of a control current, for example, in the form of a square wave, so as to move the piston 24 to its deployed position indicated by the arrows in Figure 8, without the control current generating the release of heat in the coil. In this manner, a determined volume of liquid additive is sucked up, through the hollow part 21 in the piston 24, into the metering chamber 16. The ball 25 is then no longer in contact with the end of the piston 24. The spring 25' is sized so that it exerts a force on the ball 25 in such a way that this ball comes into contact with the end of the piston 24 after an amount of liquid additive has been sucked up.

Illustrated in Figure 9 is the situation where the ball 25 is again in contact with the end of the piston 24 after sucking up the liquid additive and where a volume of liquid additive is isolated in the metering chamber 16.

When the electromagnet is no longer supplied with current (Figures 10 and 11), the return spring 23 constrains the piston 24 to its rest position and expels the volume of liquid additive sucked up, the volume of additive exerting a force on the non-return ball 27 so as to clear an exit route towards the outlet port 22 of the pump by moving the non-return ball 27 in the direction of the outlet port 22.

When the volume of additive has been injected, the non-return ball 27 returns to the closed position under the effect of the spring 27', so as to prevent a reflux of liquid additive from the outlet port 22 to the inlet port 20 of the pump 24.

It is additionally possible to measure the temperature of the liquid additive during the steps in the course of which the additive is sucked up and/or injected into the fuel tank.

Reference signs

10	metering pump	44	side wall
12	pump body	46, 46’	slider
14	membrane	47	valve seat
16	metering chamber	48	passage opening
18	actuating chamber	50	valve
20	inlet port	52	axial rod
21	hollow part	54	stopper
22	outlet port	55	upstream end of the axial rod
23	return spring	56	first protuberance
24	piston	58	second protuberance
25	ball	60	travel-limiting component
25’	spring	62	downstream end of the axial rod
26	piston head		
27	non-return ball	64	layer made from elastic material
27’	spring		
28	rod	66	pressure-regulating port
28’	lubricated groove	68	control unit
30	actuator	70	management unit
31	threaded portion		
32	end wall		
36	inlet pipe		
38	outlet pipe		
40	non-return valve		
40'	non-return valve		
42	guiding member		

CLAIMS

1. Process for injecting a liquid additive into a fuel tank using a metering pump comprising a metering chamber and an actuating device arranged in a pump body, the metering chamber being in communication with an inlet port connected to an additive tank and an outlet port connected to the fuel tank; the actuating device comprising an actuator and a piston, the actuator moving the piston between a rest position and a deployed position, the process comprising the steps consisting in :

a) determining the volume of liquid additive to be injected into the fuel tank;

b) controlling the actuator so as to move the piston of the metering pump in the direction of its deployed position so as to suck a determined volume of liquid additive into the metering chamber;

c) controlling the actuator so as to move the piston of the metering pump in the direction of its rest position so as to inject the determined volume of liquid additive from the metering chamber into the fuel tank; and

d) optionally repeating the steps b) and c) until the volume of additive determined in point a) has been injected,

characterized in that the process additionally comprises the steps consisting in :

- determining the temperature of the liquid additive; and
- influencing the control of the actuator as a function of the temperature measured.

2. Process according to Claim 1, in which the pump is of membrane syringe type in which the actuating device consists of an actuating chamber, the pump comprising a membrane arranged in the pump body, the membrane dividing the inside of the pump into the metering chamber and the actuating chamber, the piston being connected to the membrane.

3. Process according to Claim 1 or 2, characterized in that the displacement rate of the piston is adjusted as a function of the temperature measured.

4. Process according to any one of the preceding claims, characterized in that the force applied by the actuator is adjusted as a function of the temperature measured.

5. Process according to any one of the preceding claims, in which the determined volume of additive is adjusted as a function of the temperature measured.

6. Process according to any one of the preceding claims, in which the step consisting in determining the volume of liquid additive to be injected comprises the determination of the difference in volume of fuel before and after a fuel tank filling phase.

7. Process according to any one of the preceding claims, in which the step consisting in determining the temperature of the liquid additive comprises the measurement of the temperature at the level of the metering pump actuator.

8. Process according to any one of the preceding claims, in which the actuator is a linear actuator comprising a stepper motor in which a holding current is applied to the actuator in order to keep the piston in its rest position, the process comprising a step consisting in adapting the intensity of the holding current as a function of the temperature measured.

9. Process according to the preceding claim, in which control electronics monitor the possible appearance of step loss of the actuator and in which, when such a step loss is detected, a higher supply current is applied to the actuator for a predetermined time.

10. Process according to any one of Claims 1 or 3 to 7, in which the pump is of the piston injector type, the actuator comprising a return spring capable of moving the piston from the deployed position to the rest position and an electromagnet equipped with a coil in which a holding current is applied to the coil, the process comprising a step consisting in adapting the intensity of the holding current as a function of the temperature measured.

11. Process according to any one of Claims 8 to 10, in which a higher holding current is applied for a predetermined time.

12. Process according to any one of Claims 8 to 11, in which a higher holding current is applied until a threshold temperature is attained.

13. Process according to any one of the preceding claims, in which the power supply of the actuator may be interrupted, characterized in that the process comprises the steps consisting in :

- storing in the memory the total volume of liquid additive to be injected and the volume of liquid additive already injected, or the remaining volume of liquid additive to be injected;

- storing in the memory the number of strokes already carried out by the piston during the interruption; and

- when the power supply to the actuator is restored, restarting the liquid additive injection cycle at the point where the cycle was interrupted, based on the information stored in the memory.

14. Process according to any one of the preceding claims, in which the actuating device is put in contact with the atmosphere during operation of the actuator.

Fig. 1

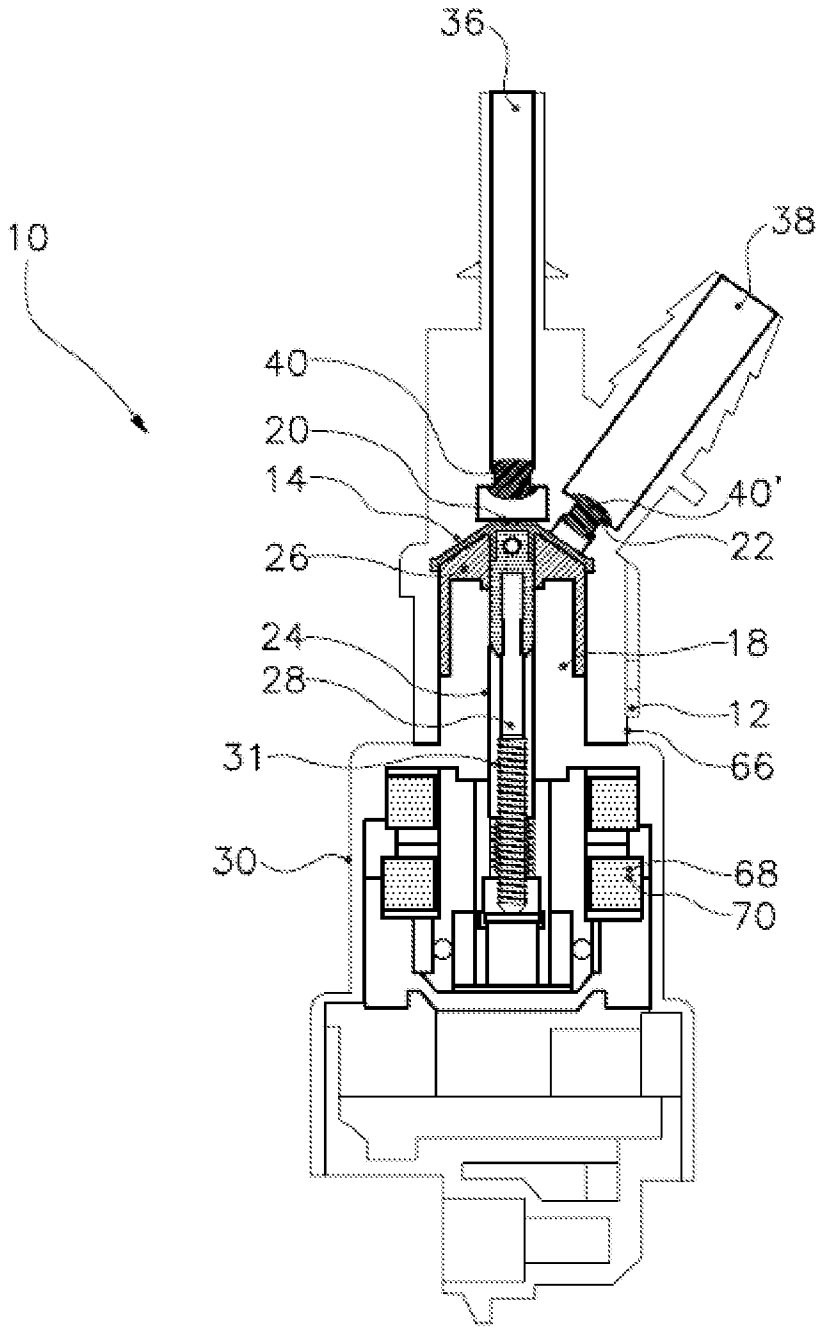


Fig. 2

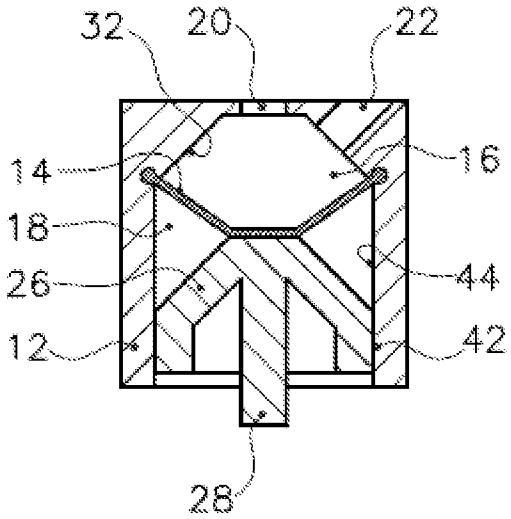


Fig. 3

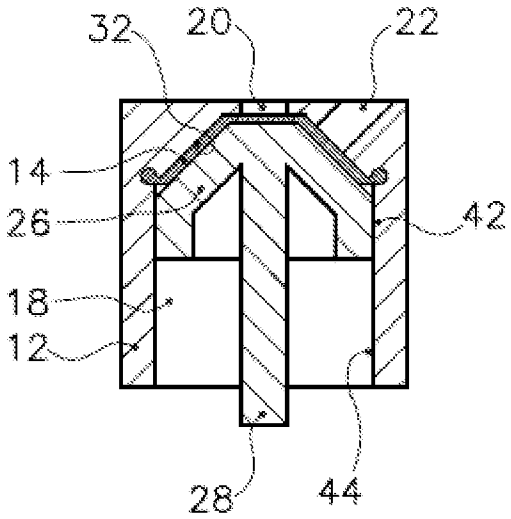


Fig. 4

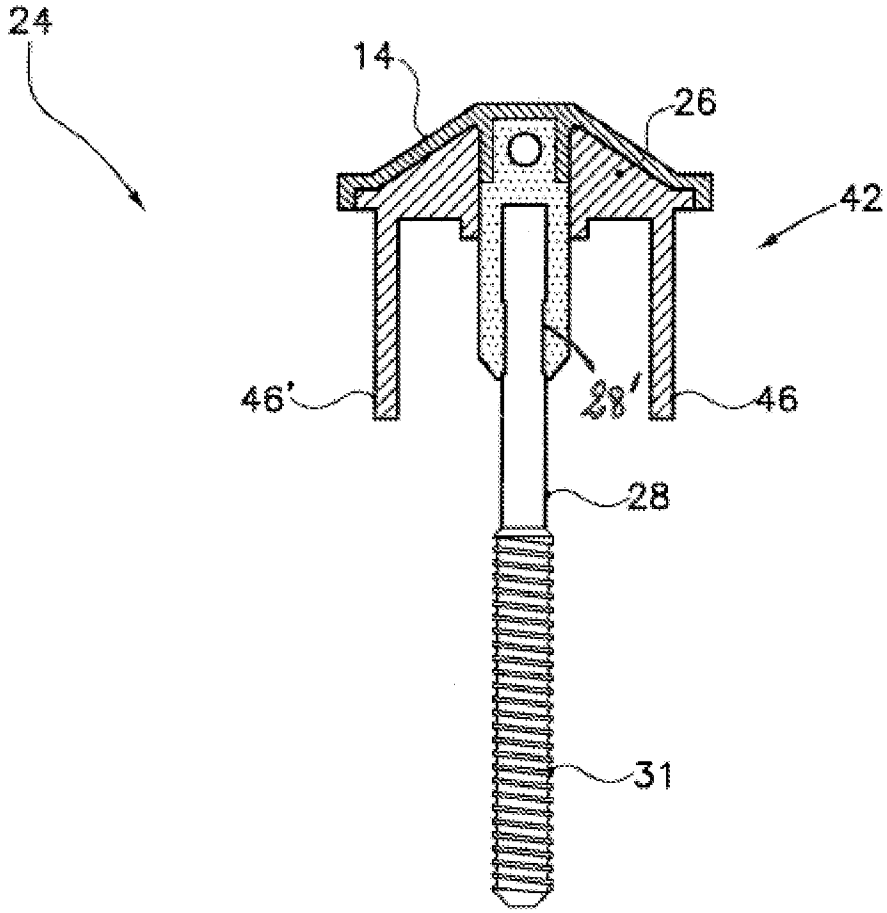


Fig. 5

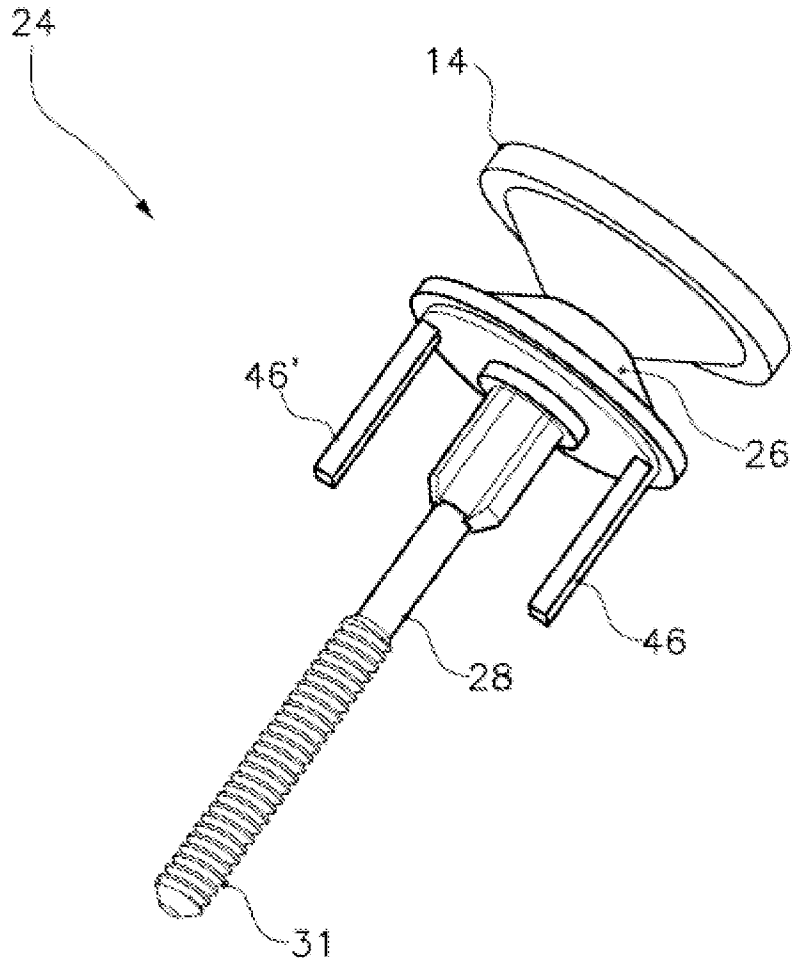
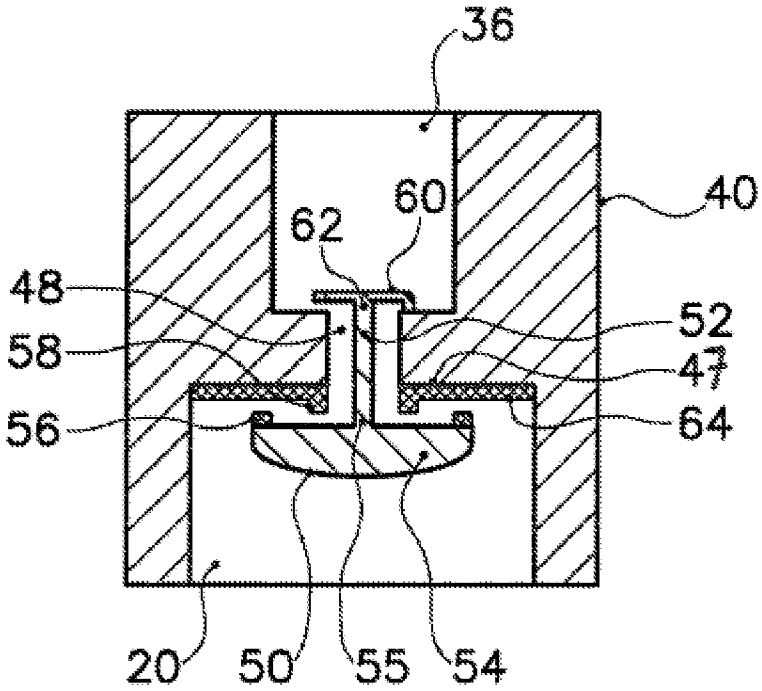


Fig. 6



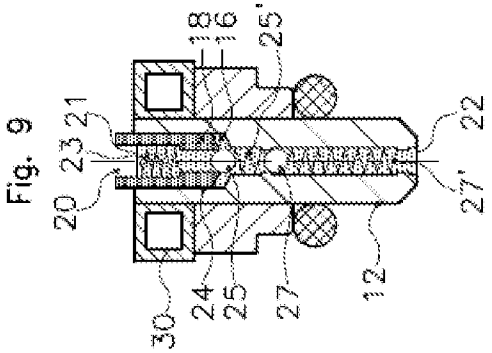


Fig. 9

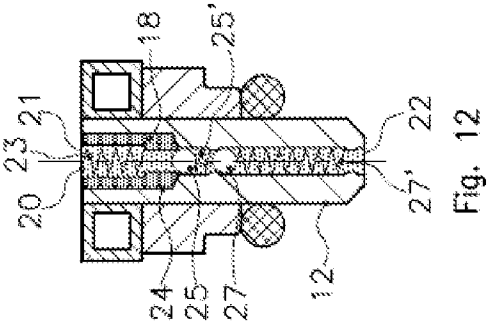


Fig. 12

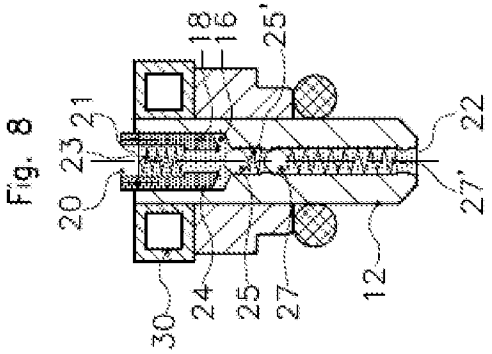


Fig. 8

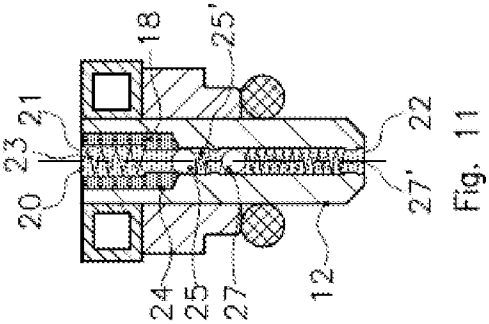


Fig. 11

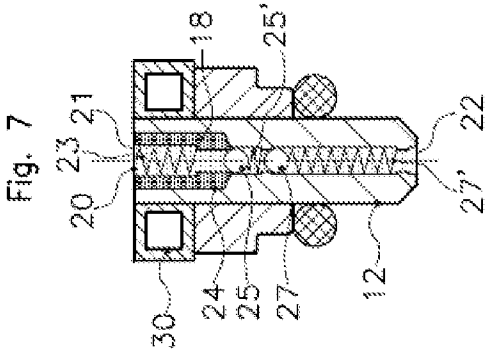


Fig. 7

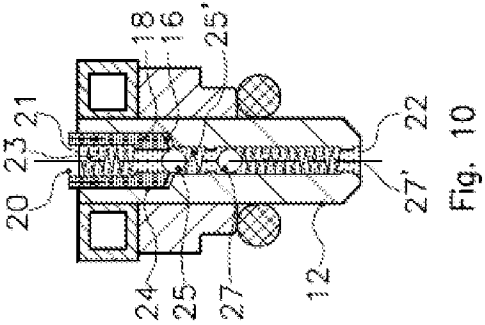


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2008/050675

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04B13/00 F04B43/02 F01N3/029 F01N3/023

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)
F04B F01N

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2005/024219 A (INERGY AUTOMOTIVE SYSTEMS RESEARCH [BE]) 17 March 2005 (2005-03-17) cited in the application page 1, line 1 - page 2, line 8 page 5, line 30 - page 7, line 17 figures 1-4	1-3,5,6, 10
Y	EP 1 031 707 A (PEUGEOT CITROEN AUTOMOBILES SA [FR]) 30 August 2000 (2000-08-30) paragraph [0001] - paragraph [0010] paragraph [0018] - paragraph [0025] paragraph [0044] - paragraph [0047] sentence 56 - sentence 65 figure 1	1-3,5,6, 10

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[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
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"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 March 2008	07/04/2008

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, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gnüchtel, Frank

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2008/050675

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR 2 668 203 A (PEUGEOT CITROEN AUTOMOBILES SA [FR]) 24 April 1992 (1992-04-24) page 1, line 1 - page 2, line 23 page 3, line 12 - page 5, line 25 page 6, line 32 - page 11, line 18 figure 1	1-3,5,6, 10
A	US 4 516 990 A (ERDMANNSDOERFER, HANS; ET AL. [DE]) 14 May 1985 (1985-05-14) column 1, line 7 - line 61 column 3, line 19 - line 54 claim 1 figure 1	1,13
A	EP 1 489 275 A (PEUGEOT CITROEN AUTOMOBILES SA [FR]) 22 December 2004 (2004-12-22) paragraph [0001] - paragraph [0010] paragraph [0014] claim 1 figure 1	1,13
A	FR 2 702 009 A (RHONE POULENC CHIMIE [FR]) 2 September 1994 (1994-09-02) page 1, line 1 - line 20 page 4, line 18 - page 6, line 30 page 9, line 20 - page 10, line 21 claims 1-6 figure 1	1,13
A	US 6 068 672 A (WATSON, CHARLES J.; ET AL. [US]) 30 May 2000 (2000-05-30) abstract figure 1	1,13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2008/050675

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2005024219 A	17-03-2005	AT 386204 T	15-03-2008
		BR PI0414101 A	31-10-2006
		CN 1846053 A	11-10-2006
		EP 1664517 A1	07-06-2006
		JP 2007504392 T	01-03-2007
		KR 20060072133 A	27-06-2006
		US 2007128054 A1	07-06-2007
EP 1031707 A	30-08-2000	AT 230819 T	15-01-2003
		DE 60001122 D1	13-02-2003
		DE 60001122 T2	09-10-2003
		ES 2190395 T3	01-08-2003
		FR 2790223 A1	01-09-2000
FR 2668203 A	24-04-1992	NONE	
US 4516990 A	14-05-1985	BR 8401601 A	18-09-1984
		DE 3325391 A1	24-01-1985
		FR 2549135 A1	18-01-1985
		GB 2145349 A	27-03-1985
EP 1489275 A	22-12-2004	FR 2856425 A1	24-12-2004
FR 2702009 A	02-09-1994	AT 141386 T	15-08-1996
		AU 668456 B2	02-05-1996
		AU 5526594 A	01-09-1994
		BR 9400645 A	27-09-1994
		CA 2115803 A1	24-08-1994
		DE 69400365 D1	19-09-1996
		DE 69400365 T2	20-02-1997
		DK 614002 T3	09-12-1996
		EP 0614002 A1	07-09-1994
		ES 2093492 T3	16-12-1996
		GR 3021471 T3	31-01-1997
		HU 71757 A2	29-01-1996
		JP 2548898 B2	30-10-1996
		JP 6257516 A	13-09-1994
		MX 9401329 A1	31-08-1994
		US 5421295 A	06-06-1995
US 6068672 A	30-05-2000	DE 19805311 A1	20-08-1998
		FR 2759737 A1	21-08-1998