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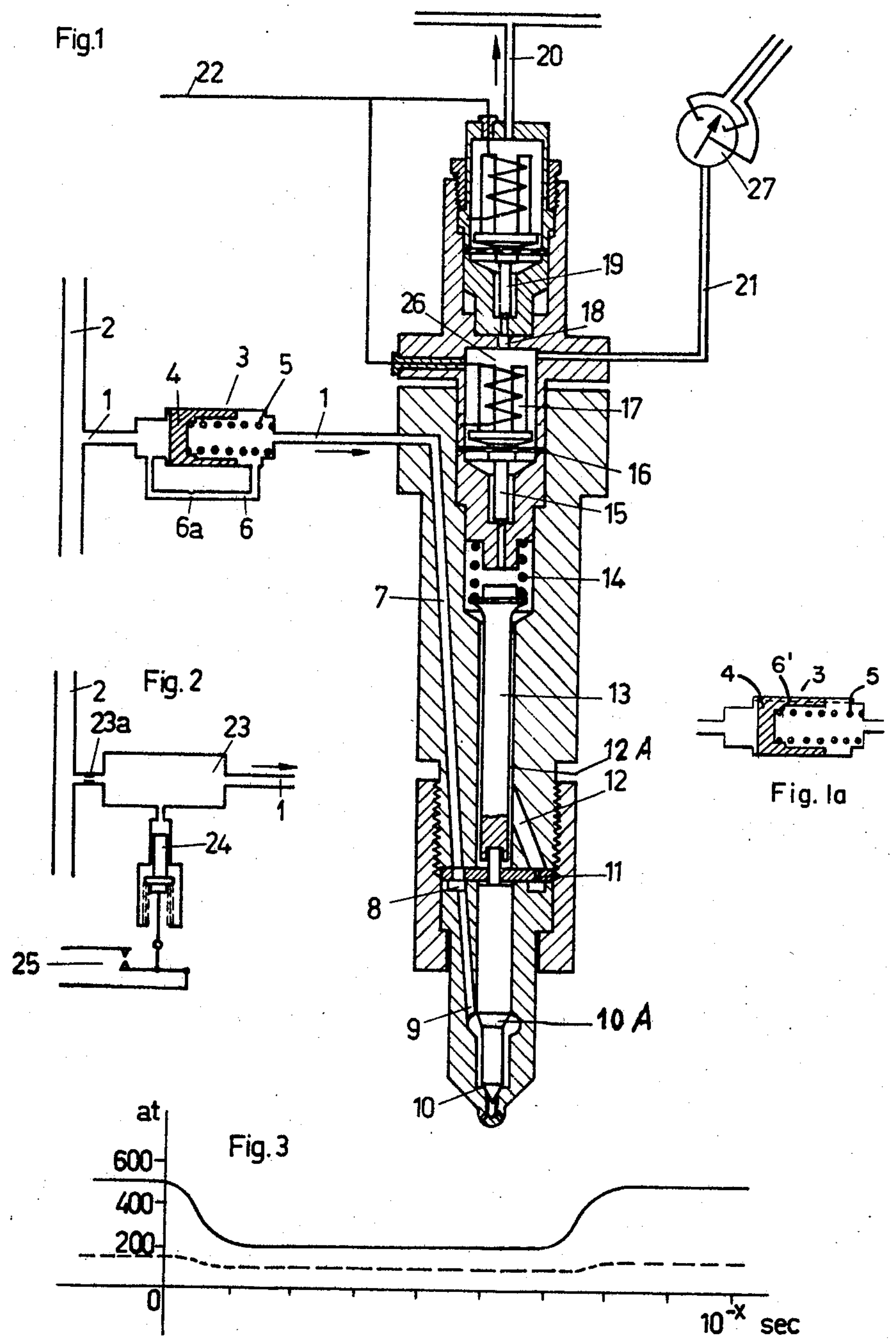

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SAFETY DEVICE FOR ELECTROMAGNETIC FUEL-INJECTION SPRAY NOZZLES FOR INTERNAL COMBUSTION ENGINES

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ABSTRACT OF THE DISCLOSURE

A safety device comprising a piston is located in the fuel-supply as fuel-outlet line of the spray nozzle. Movement of the piston, caused by fall in fuel pressure, shuts off the line. And/or the pressure between two series-connected valves is monitored, for operating a gauge and/or a warning device.

BACKGROUND OF THE INVENTION

The invention relates to safety devices for electromagnetically, operated fuel-injection spray nozzles of internal combustion engines.

Spray nozzles in which the nozzle-valve needle is opened by reducing the pressure in a space behind the needle are known in the prior art. The prior art also discloses controlling the fall in pressure in this space by means of an electromagnetically-operated valve, such that the duration that this valve is open determines the duration of fuel injection and consequently the quantity of fuel that is injected. Spray nozzles of this kind are fed from a common conduit that is under the fuel pressure, which latter is customarily held constant, although it can be varied to suit changed operating conditions.

Fuel-injection spray nozzles of this sort have the disadvantage that, should the nozzle-valve needle stick open or the electromagnetic valve misoperate, an uncontrolled quantity of fuel can enter the cylinder.

SUMMARY OF THE INVENTION

An object of the invention is to limit the amount of fuel that can be injected, even though the nozzle-valve needle is stuck open.

A further object of the invention is to monitor continuously the functioning of the one or more electromagnetic valves, and thereby to prevent faulty operation.

These and other objects of the invention will be apparent from the ensuing detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be described, with reference to the figures of the accompanying drawing, wherein:

FIG. 1 is a longitudinal view in section of a fuel-injection spray nozzle equipped with the safety devices of the invention;

FIG. 1*a* shows a variation of a detail of the arrangement of FIG. 1.

FIG. 2 is a schematic representation of a second embodiment of one safety device of the invention; and

FIG. 3 graphically shows the variation of pressure with time behind the nozzle-valve needle and between the two electromagnetic valves.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

With reference to FIG. 1, the fuel-injection spray nozzle is connected via a fuel-supply line **1** to a common conduit **2**, which is under the injection pressure. The line **1** incorporates a safety device **3**, comprising a piston **4**, a spring **5**, and a bypass **6** or **6'** that incorporates a calibrated aperture which will be referred to again later in the description.

The fuel is urged through the passage **7** into the annular space **8**, from whence it is conveyed, on the one hand, to the front end of a nozzle-valve needle **10** via a passage **9**, and, on the other hand, via a calibrated aperture **11** and a passage **12** into the space **12A** located behind the nozzle-valve needle. A spring-operated push rod **13** and its spring **14** are located in the space **12A**. The upper end of this space is closed off by an electromagnetic valve **15**. A diaphragm spring **16** presses the valve **15** downwardly against its seat, and an electromagnet **17** opens the valve. The chamber in which the valve **15** is located is connected via a passage **18** to a second electromagnetic valve **19** of identical or similar construction. The two valves **15** and **19** have approximately the same cross sectional areas. The chamber housing of this second valve is connected via a fuel-outlet line **20** to a fuel-return conduit. A line **21** connects the space **26**, located between the two electromagnetic valves, to a pressure gauge **27**, which can be an expansible metallic-element gauge, and which can operate an alarm or warning apparatus (not shown) via switching contacts (not shown). The line **21** can also be connected directly to an alarm or warning device. The energizing current for the electromagnetic valves is conducted via a lead **22**.

With reference to FIG. 2, there is shown a variation of the safety device **3**, wherein a reservoir chamber **23** is connected to a spring -loaded piston **24** that controls an electrical switch **25**. This variation will be treated further on in the specification.

With respect to FIG. 3, the upper, solid curve shows the variation in pressure in atmospheres as a function of time in the space **12A**, and the lower, dashed curve that in the space **26**.

The fuel-injection spray nozzle of the invention operates in the following manner. When the nozzle-valve needle **10** is closed, the line **1**, the passages **7**, **9**, and **12**, the annular space **8**, and the calibrated aperture **11** are under the full fuel pressure, whereas the pressure in the space **26** is less than that. An electrical pulse conducted via the lead **22** causes both electromagnetic valves simultaneously to rise off their seats, whereby the fuel escaping past these valves causes the pressure in space **12A** to fall. The cross sectional areas of the calibrated aperture **11** and of the two electromagnetic valves are so chosen that the pressure in the space falls, for example, from 500 to 200 atmospheres.

Since the needle taper **10A**, and that portion of the needle-tip taper lying between the commencement thereof and the beginning of the seat therefor, act to subject an equivalent large part of the cross sectional area of the nozzle-valve needle **10** to the full fuel pressure, which latter tends to move the needle against its spring bias, the needle opens with even a small decline—50 to 100 atmospheres—in the pressure in the space **12A**, and remains open until the electromagnetic valves are closed and the pressure in the space **12A** again rises.

Since both electromagnetic valves have approximately the same cross sectional area and rise simultaneously, the pressure in the space **26** is approximately half that in the space **12A**, and thus measure approximately 100 atmospheres.

The pressure existing between the two electromagnetic valves—that is, in the space **26**—serves as a monitoring pressure, which operates the pressure gauge **27** or an alarm or warning device (not shown). Thus, if the two electromagnetic valves do not have exactly the same time cross sections, the monitoring pressure changes. It rises, for example, if valve **15** is stuck in an open position while valve **19** is closed; and falls if the valve **15** does not open but valve **19** does.

This arrangement of the invention further has the advantage that even should one of the electromagnetic valves remain open the fuel-injection spray nozzle continues to operate, although under slightly changed conditions.

As remarked previously, the time variation in pressure in the space **12A** and the space **26** is respectively shown by the solid and dash lines in FIG. 3.

In accordance with the invention, the time cross sections of the two electromagnetic valves can also be different. The one valve can have amuch larger cross section than the other, as a consequence of which the pressure in the space **26** will be a definite fraction of that in the space **12A**.

Further in accordance with the invention, the two electromagnetic valves can be separately operated. Thus, the valve **15** can be opened prior to the valve **19**, whereby the fuel escaping from the space **12A** into the space **26** causes a momentary fall in pressure in the former that acts briefly to raise the nozzle-valve needle **10** for the purpose of a preinjection of fuel. In this case, the main injection is caused by the opening of the valve **19**.

The invention, as thus far described, does not operate properly, however, when the nozzle-valve needle is stuck open. In order to prevent the injection of an excessive amount of fuel under these conditions, the safety device **3**, in accordance with the invention is built into the fuel-supply line **1**. When the fuel-injection spray nozzle is closed, the piston **4** is seated against the left-hand seat. As soon as the spray nozzle opens the pressure on the right-hand side of the piston falls, and the piston **4** shifts rightwards. Since the volume displaced by the piston until it closes off the bypass **6** is somewhat greater than the maximum permissible volume of fuel that is to be injected by the spray nozzle, the bypass **6** is not closed off until the volume of fuel flowing through the safety device exceeds the said maximum volume by a certain amount, upon which the piston comes to rest against the right-hand side seat, shutting off the bypass. The calibrated aperture **6A** is sufficiently large to ensure that even when the engine is turning over very fast the spring **5** forces the piston back to its original left-hand position during the time between two successive injections. As a variant, shown in FIGURE 1*a*, the bypass **6** can take the form of a narrow passage **6′** incorporated in the piston.

The safety device **3** ensures that, should the nozzle-valve needle **10** remain open, the piston **4**, in consequence of the fall in pressure on its right-hand side, will shift all the way to the right, thereby closing off the bypass **6** or **6′**.

The safety device **3** can also be provided with a warning or alarm device (not shown) that operates when the pressure in the line **1**, between the device **3** and the spray nozzle, falls unduly low while the bypass **6** or **6′** is closed. The safety device can be employed, as in the preceding case when not equipped with a warning device or alarm, with indirectly operated valves as well as with directly electromagnetically-operated valves. Since the quantity of fuel that flows through the electromagnetic valves is proportional to that quantity which is injected, a safety device of the kind **3** can also be connected in the fuel-outlet line **20**. If too much fuel should flow through an electromagnetic valve because of its faulty operation, and, as a consequence, too much fuel be injected, the safety device closes off the line **20**, whereupon the pressure in the space **12A** rises to a valve equal to that of the injections pressure and remains there, thereby preventing the nozzle-valve needle **10** from again opening.

Thus, in accordance with the invention the safety device **3** can be connected in the line **1** and/or in the line **20**.

In the second embodiment of the safety device **3**, illustrated in FIG. 2, the reservoir chamber **23** has a volume such that, with maximum injection, the pressure within the chamber falls, for example, from 500 to 300 atmospheres. If the pressure should fall further, because the nozzle-valve needle **10** is stuck open, the piston **24**, which is spring biased to move towards the chamber **23**, shifts under the effect of the bias and thereby closes the switch **25**, which operates an alarm or a warning signal (not shown), or shuts off the fuel pump. The line **1**, between the chamber **23** and the common conduit **2**, incorporates a calibrated aperture **23*a***, which serves the same purpose as the aperture **6A** of the embodiment illustrated in FIG. 1.

As employed in the claims, the term alarm means shall be construed to cover all devices, usable with the invention, that are suitable for giving an alarm or a warning.

I claim:

1. A safety device for an electromagnetically-operated fuel-injection spray nozzle of an internal combustion engine, including a fuel-supply line and a fuel-outlet line for the spray nozzle, and safety means provided in at least one of said lines which acts to shut off the respective line and/or to turn on an alarm means when the maximum permissible quantity of fuel is exceeded by a given amount.

2. The safety device as defined in claim **1**, wherein said safety means includes a piston movable between a first and a second end position and acted upon, on the one side, by the full fuel pressure, and, on the other side, by the fluid pressure present in said line between the spray nozzle and said safety means, resilient means for loading said piston to return it to said first end position between two successive injections, and a bypass for conveying fuel from one side of said piston to the other side thereof, said piston closes said bypass when the former is in said second end position, during each injection period said piston moves from said first end position towards said second end position through a stroke that is proportional to the quantity of fuel injected, and said piston reaches said second end position and closes said bypass when the quantity of fuel injected exceeds by a given amount the maximum permissable quantity.

3. The safety devices as defined in claim **2**, including a pressure responsive means connected between said safety means and the fuel-injection spray nozzle, said pressure responsive means operating the alarm means when the fluid pressure falls to a predetermined value.

4. The safety device as defined in claim **2**, wherein said safety means is connected in said fuel-supply line.

5. The safety device as defined in claim **2**, wherein said safety means is connected in said fuel-outlet line.

6. The safety device as defined in claim **2**, wherein a respective one of said safety means is connected in said fuel-supply and said fuel-outlet lines.

7. The safety device as defined in claim **2**, wherein said bypass incorporates a calibrated aperture.

8. The safety device as defined in claim **1**, including a calibrated aperature in said fuel-supply line, a chamber located in said fuel-supply line, pressure responsive means connected to said chamber and responsive to the fluid pressure therein, and a switch connected to said pressure responsive means and controlled thereby to close when the fluid pressure in said chamber falls below a given value.

9. The safety device as defined in claim **8**, wherein said switch operates the alarm means.

10. The safety device as defined in claim 8, wherein said switch shuts off the fuel pump of the engine.

11. The safety device as defined in claim 1, wherein the fuel-injection spray nozzle includes two electro-magnetically-operated valves connected in series and separated by a fuel-containing space, and monitoring means for monitoring the fluid pressure in said space.

12. The safety device as defined in claim 11, wherein said monitoring means operates the alarm means.

13. The safety device as defined in claim 12, wherein said monitoring means including a pressure gauge that operates the alarm means.

14. The safety device as defined in claim 11, wherein said two valves control operation of the spray nozzle and are connected upstream of said fuel-out-let line, and wherein that valve upstream of the other acts to initiate

a preinjection of fuel and the other valve acts to initiate the main fuel injection.

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