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(54) **High pressure generating equipment.**

(57) A high pressure generating equipment comprises a fluid injection pump (1,2) and a pipe (4) connected with and fixed at the discharge outlet of the fluid injection pump (1,2). The pipe (4) is formed in such manner that the sectional area of the pipe is reduced from the inlet to the outlet of the pipe, so that the fluid pressure is increased at the outlet of the pipe (4) by increasing the flow velocity and the pressure of the fluid passing through the pipe.

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HIGH PRESSURE GENERATING EQUIPMENT

The present invention relates to a high pressure generating equipment for liquid, gas, etc., for example for the fuel injection system of an engine.

Conventionally, a jerk type injection pump consisting of a plunger and a bypass port is used in the fuel injection system of an engine, especially, in the fuel injection system for Diesel engine. An injection pipe is connected, and fuel is supplied to an automatic valve with nozzle, mounted on the engine cylinder, to inject the fuel. In an engine of this type, the elimination of exhaust fumes is now a serious problem. As one of the corrective measures, a high pressure injection method is now being considered, in which fuel is compressed to a pressure far higher than that of the existing fuel injection system. For this purpose, a method to generate high pressure without changing the existing fuel injection system or a fuel injection system with a booster piston to boost the pressure by utilizing the difference of the area of the piston have been proposed. There were the difficulties, however, in these methods because of fuel leakage from sliding parts or of a complicated structure.

The object of the present invention is to provide a system with fewer moving parts and simpler construction, by which it is possible to avoid a complicated structure of the fuel injection system and fluid leakage at sliding parts, and to perform injection at a pressure far higher than the pressure inside the injection pump.

The present invention provides a high pressure generating equipment, in which it is possible to reduce the sectional area of pipe from inlet to outlet of the pipe, to increase the flow velocity and the pressure of the fluid by utilizing the inertia of the fluid, and to dynamically increase the pressure fluctuation.

The most important embodiment of this invention is a fuel injection system for a Diesel engine. Normally, as shown in the embodiment of Figure 1, a jerk type injection pump consisting of a plunger and a bypass port is used for this type of equipment. Fuel is supplied to an automatic valve with nozzle, to which an injection pipe is connected and which is mounted on the engine cylinder. For this type of engine, the elimination of exhaust fumes is now a serious problem. As one of the corrective measures, a high pressure injection method is now being considered, in which fuel is compressed to a pressure far higher than the pressure in the existing fuel injection system. Several new methods have been proposed, such as a method to provide high pressure without changing the existing fuel injection system, or a method to incorporate a booster piston in the fuel injection system to obtain

high pressure by the difference of piston area. However, there are difficulties in these methods because of fuel leakage from the sliding parts or complicated structure. If an adequately designed pipe is used instead of the conventional injection pipe for the high pressure generating equipment of this invention, it is possible to inject fuel at high pressure without moving parts such as the booster piston system. This makes it possible to reduce complicated structure and fuel leakage and to improve reliability and reduce the manufacturing cost.

In addition, if this invention is applied to a fuel injection system which is used for a gasoline injection engine or other combustion equipment, it is possible to operate the fuel injection pump at a pressure considerably lower than the injection pressure. This will have the same advantage as in the case of a fuel injection system for a Diesel engine as described above.

Also, the invention is not limited to a fuel injection system but may be applied to a high pressure generating equipment for other liquids, gases, etc.

The invention is illustrated by way of example in the accompanying drawings, in which:

Figure 1 is a sectional view of a first embodiment of the invention applied to a fuel injection system.

Figure 2 is a diagram illustrating the sectional variation of the flow velocity and the pressure wave-form before and after the compression waves pass through the system of Figure 1,

Figure 3 summarizes the results of the calculation of the pressure changes over time, showing that the pressure change at one end of the pipe in the arrangement of this invention is increased at the other end,

Figure 4 is a sectional view showing another embodiment of high pressure generating equipment according to this invention, and

Figure 5 is a sectional view of still another embodiment of high pressure generating equipment of this invention.

Referring to Figure 1, a pipe 4 is formed in such manner that the sectional area of the pipe is continuously reduced from the pipe inlet to the outlet. The pipe 4 is connected to the outlet of a fuel pump, consisting of a cylinder 1 and a plunger 2. An automatic valve 7 consisting of a needle valve 5 and a spring 6 is mounted at the tip of the pipe 4. The cylinder 1 is provided with a bypass port 3, and an additional space 8 is furnished at the inlet of the automatic valve 7. The pipe 4 plays a role in converting the flow from the fuel pump to provide a pressure increase and to increase the

pressure within the automatic valve 7. The additional space 8 is to accumulate the high pressure condition, and it may be furnished at the outlet of the pipe 4 or within the automatic valve 7.

The operation of the equipment according to this invention is described below in connection with the embodiment of Figure 1.

With the fuel filled in this injection system, the fluid fuel is compressed when the plunger 2 is moved to the right and the bypass port 3 is closed by the plunger 2. Compression waves then advance to the right from the left-hand end of the pipe 4 at the speed of sound. Because the sectional area of the pipe is reduced as the compression waves advance, the peak pressure of the compression waves increase as they advance.

If it is assumed that the flow velocity at the left-hand end of the pipe is rapidly increased from zero and is kept at constant level after the bypass port 3 is closed by the plunger 2, it is presumed from the theory of movement of a wave with micro-amplitude as follows:

When the sectional area of the pipe 4 is constant, the discontinuous surface of the flow velocity and the compression wave of pressure are propagated to the right at the speed of sound and the flow velocity and the pressure are kept at constant value. However, as shown by P in Figure 2, when the sectional area of the pipe is reduced at a certain point of the pipe 4a, the condition shown at X occurs before the compression wave, i.e. the discontinuous surface of the flow velocity and the pressure passes there, whereas the reflection wave moving to the left, reducing the flow velocity and increasing the pressure, occurs according to the degree of the change of sectional area as shown by Y after it passes there. At the same time, the flow velocity and the pressure are increased because the fluid is compressed at the discontinuous surface of the compression wave moving to the right due to the inertia of the fluid.

As the result of the repeated pressure increase, when the compression wave reaches the right-hand end, the pressure becomes higher than that of the left-hand end. In other words, the rapid increase of pressure occurring at the pipe inlet can be augmented by the reduction of the sectional area of the pipe.

For this reason, it is possible to generate far higher pressure at the injection nozzle 7 than the pressure in the injection pump according to the degree of reduction of the injection time if the above pipe 4 is used in the fuel injection system.

Figure 3 is a diagram showing the relation between the pressure and the time. The sectional area of the pipe is reduced at a constant ratio in proportion to the distance. At the inlet of the pipe 4 where the ratio of the inlet sectional area to the

outlet sectional area is 100:1, the fluid is passed at a constant velocity for a certain period of time. The changes of the inlet pressure A and the outlet pressure B are calculated theoretically, and these are shown on the diagram in relation to the time. In the calculation, however, it is assumed that the total length of the pipe 4 is 1.5 m, that the additional space 8 accounts for 8.6% of the total volume of the pipe, and that the automatic valve 7 is always closed. As it is evident from the diagram, B rises up later than A according to the time of the advancement of the compression wave, but it reaches a pressure far higher than A. Then, B is decreased because of the reciprocal movement of the pressure wave.

The pressure value attained by B varies not only according to the relation between the sectional area of the pipe and the distance but also according to the opening of the automatic valve or the additional space. Under the proper condition, however, an outlet pressure can be generated, which is far higher than the inlet pressure as shown in this calculation example. Because the time to maintain such high pressure depends upon the parameters such as the pipe length, the relation between sectional area of the pipe and the distance, the additional space 8 at the outlet of the pipe 4, the opening of the automatic valve 7, etc., the time to maintain high pressure can be increased if these parameters are adequately combined.

In actual cases, however, the liquid pressure far higher than the discharge pressure of the fuel pump can be momentarily generated if this principle is used although the increase of the pressure change is lower because of the time required for the change of flow velocity at the inlet or of the influence of viscosity. Accordingly, if an automatic valve 7 is used as in the Embodiment of Fig. 1, the liquid fuel can be injected from the nozzle at a pressure far higher than the discharge pressure of the pump, and the well-atomized fuel spray can be generated.

Fig. 4 shows another embodiment of the high pressure generating equipment of this invention. In this embodiment, the sectional area of the pipe 4 is reduced at two or more points. Also, a nozzle unit 9 is connected to the pipe 4 instead of the automatic valve 7, and the pressurized fluid is injected from the nozzle 9a having an opening with a constant area. A check valve may be used instead of the nozzle unit 9.

Fig. 5 gives still another embodiment of this invention. In this embodiment, the pipe 4a is provided, where the sectional area of the pipe is continuously reduced from the inlet of the pipe 4 to the middle point, and a pipe 4b having constant sectional area is formed and communicated with the pipe 4a.

The essential prerequisite for the high pressure generating equipment of this invention is the fluid injection pump and the above pipe 4 connected with it. The additional space, the automatic valve, the nozzle unit and the check valve as explained in the above embodiments are used incidentally when the invention is applied for various applications.

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Claims

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1. A high pressure generating equipment, comprising a fluid injection pump, and a pipe connected to and fixed at the discharge outlet of the fluid injection pump, characterized in that said pipe is formed in such manner that the sectional area of the pipe is reduced from the inlet to the outlet of the pipe, and that the fluid pressure is increased at the outlet of the pipe by increasing the flow velocity and the pressure of the fluid flowing in the pipe.

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2. A high pressure generating equipment as set forth in Claim 1, wherein the sectional area of said pipe is reduced at two or more points of said pipe.

3. A high pressure generating equipment as set forth in Claim 1, wherein the sectional area of said pipe is continuously reduced.

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4. A high pressure generating equipment as set forth in Claim 1, wherein said pipe comprises a pipe with sectional area continuously reduced and a pipe with constant sectional area.

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5. A high pressure generating equipment as set forth in Claim 1, wherein a nozzle unit is connected to said pipe.

6. A high pressure generating equipment as set forth in Claim 5, wherein an additional space is furnished at the outlet of the pipe or in the nozzle unit.

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7. A high pressure generating equipment as set forth in Claim 5 or 6, wherein said fluid injection pump is a fuel injection pump, and said nozzle unit is furnished on a Diesel engine.

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8. A high pressure generating equipment as set forth in Claim 5 or 6, wherein said nozzle unit is an automatic valve.

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9. A high pressure generating equipment as set forth in Claim 5 or 6, wherein said nozzle unit has an opening with a constant area.

10. A high pressure generating equipment as set forth in Claim 5 or 6, wherein said nozzle unit is a check valve.

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FIG. 1

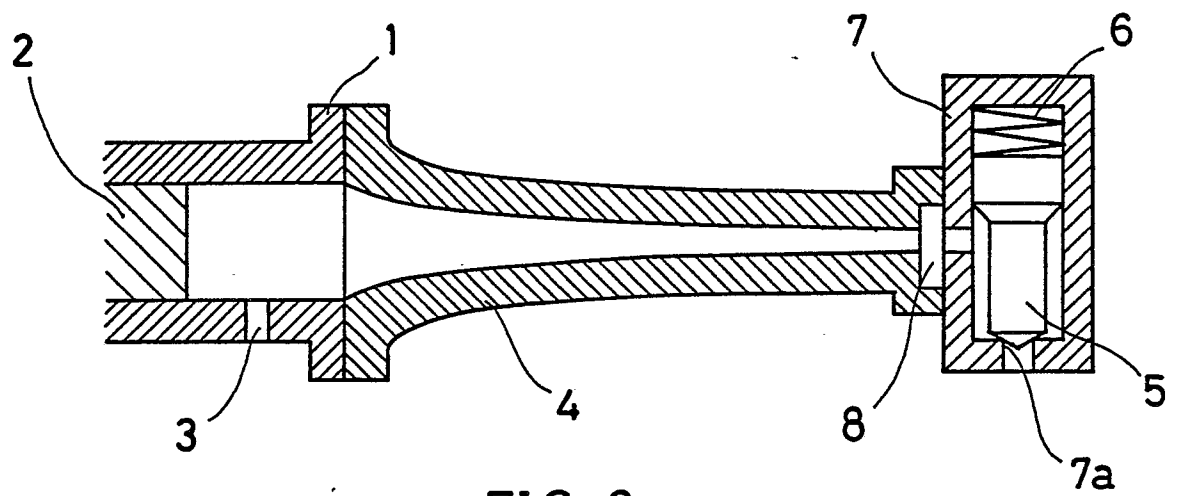


FIG. 2

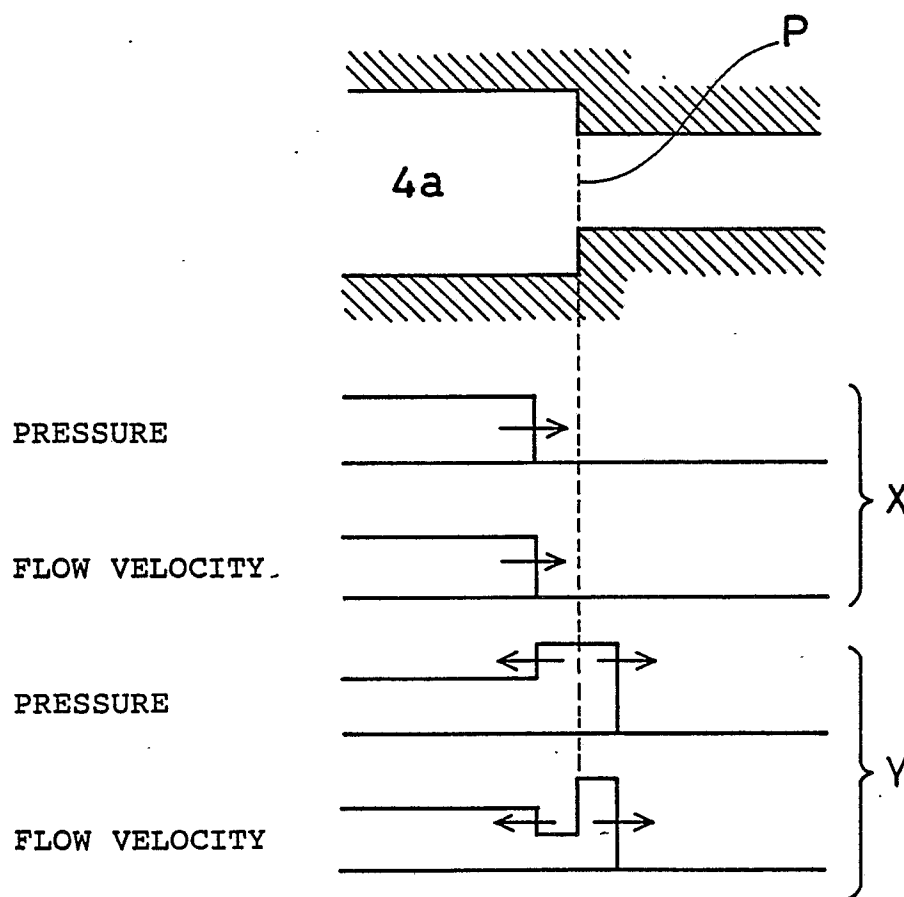


FIG. 3

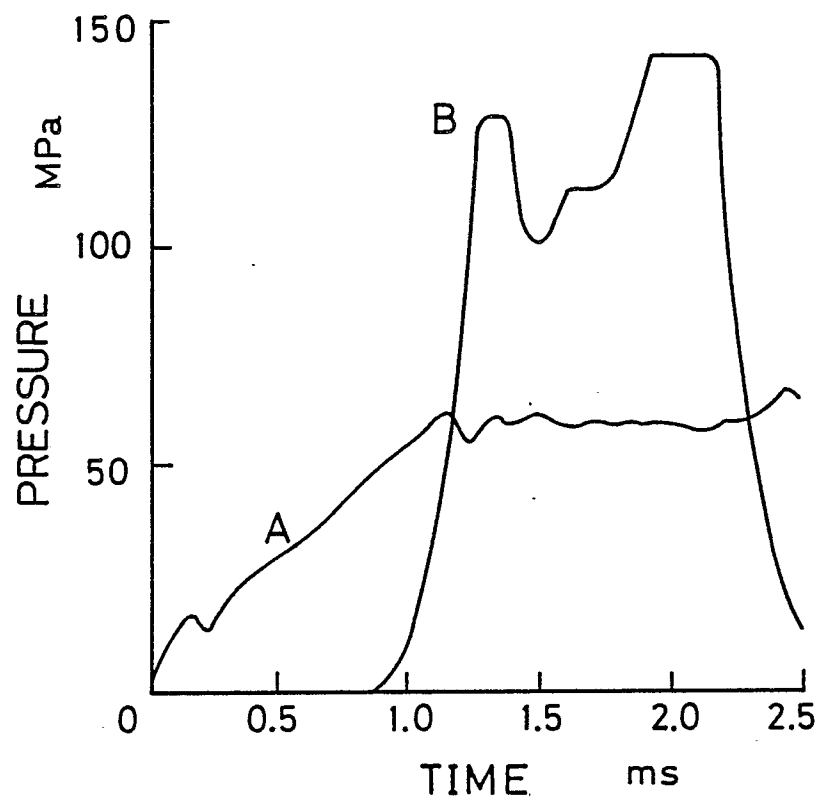


FIG. 4

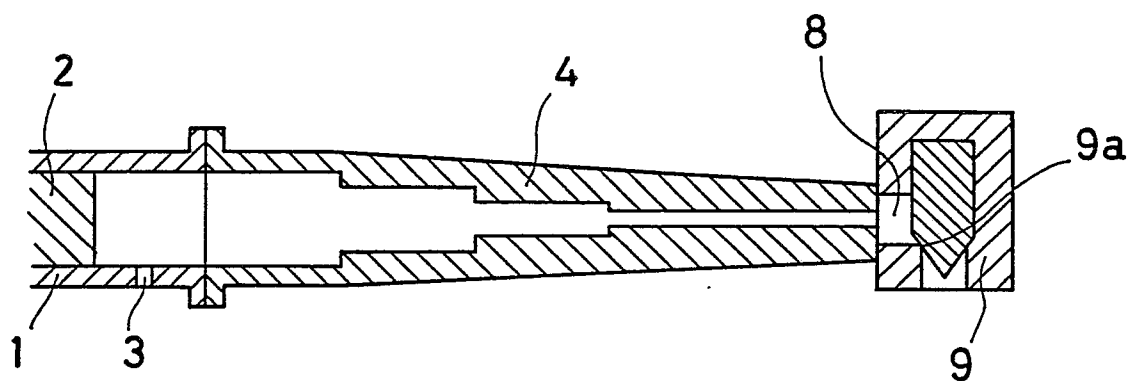
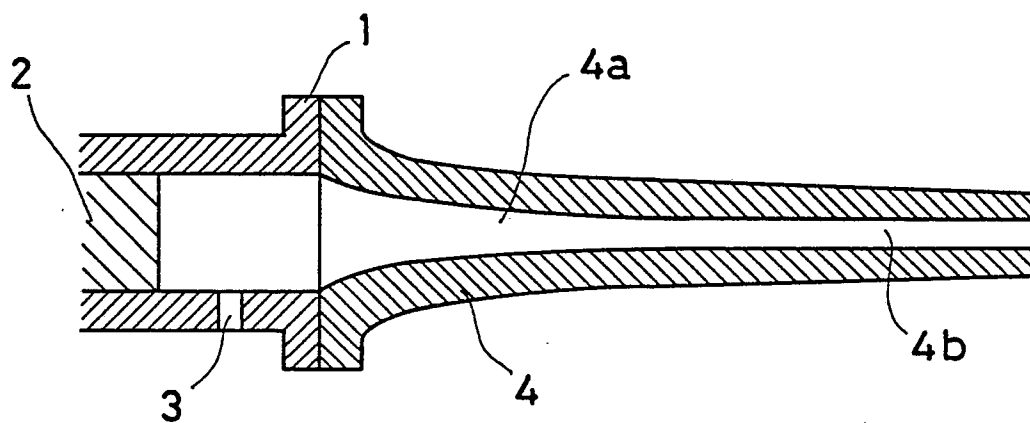


FIG. 5





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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-88937 (MITSUBISHI JUKOGYO KABUSHIKI KAISHA) * the whole document *	1-5, 7	F02M55/02
X	WO-A-8400792 (ROBERT BOSCH GMBH) * the whole document *	1-3, 5, 7	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F02M
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 24 JANUARY 1990	Examiner HAKHVERDI M.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			