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2 Sheets-Sheet 1

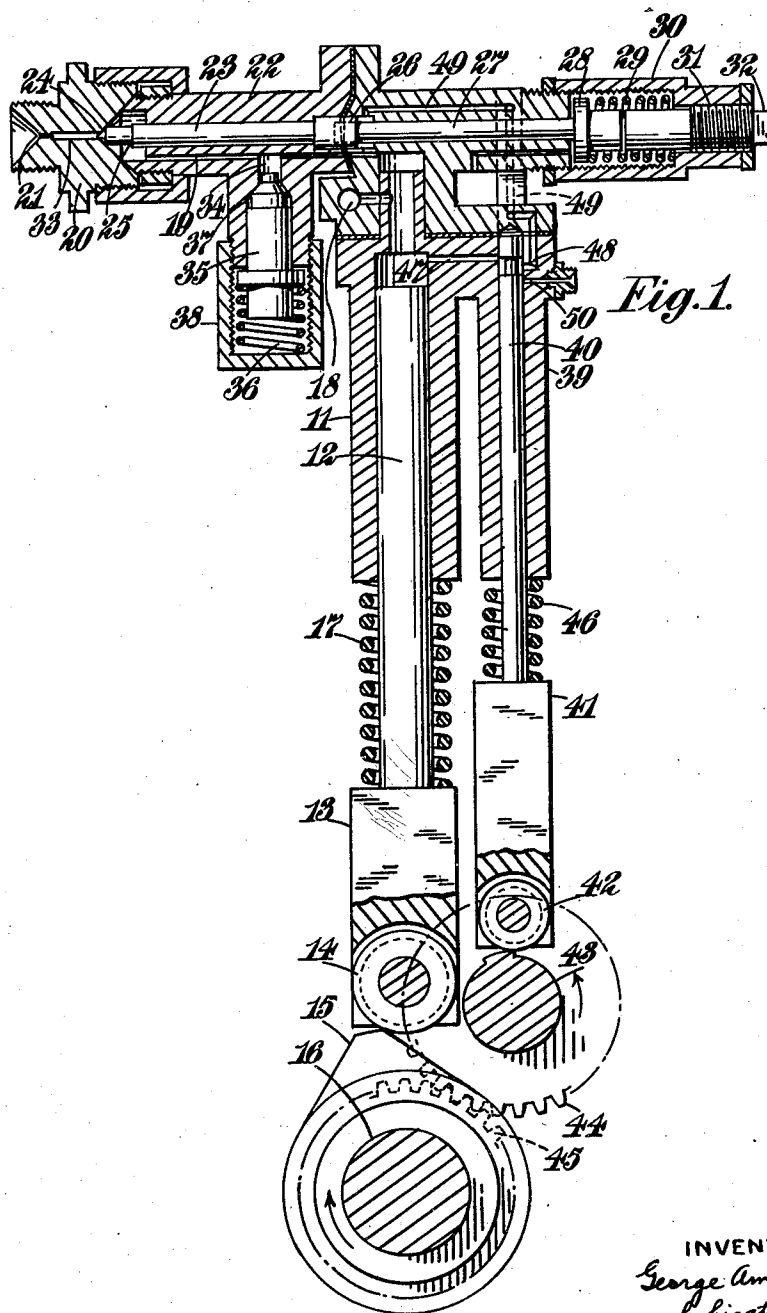


Fig. 1.

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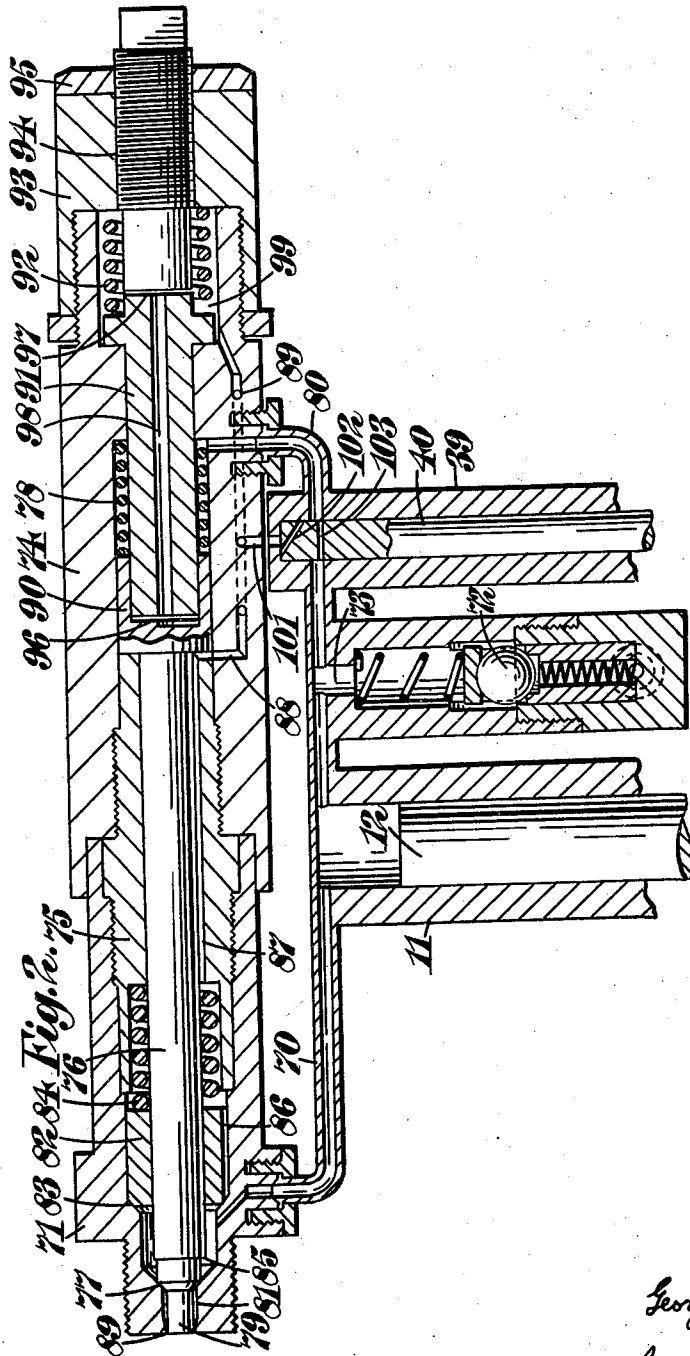
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FUEL INJECTOR FOR INTERNAL-COMBUSTION PRIME-MOVERS

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7 Claims. (Cl. 299-107.2)

This invention comprises improvements in or relating to fuel injectors for internal-combustion prime-movers and has for an object to provide a fuel injection system of an improved type for an internal-combustion engine.

According to one feature of the present invention there is provided in a fuel injection system for an internal-combustion engine the combination of a fuel-pump, a fuel-nozzle through which fuel can be injected into a combustion chamber, a conduit for conveying fuel from the pump to the nozzle, a spring-closed valve for closing said conduit, a piston operatively connected to said valve for opening it under the fuel pressure and a stop for limiting the lift of the valve. By this means, if the stop is adjusted so as to allow a very limited lift atomization takes place at the seating of the valve and a second atomization at the nozzle orifice.

A relief-valve may also be provided for permitting escape of fuel from the conduit after the valve-movement has been terminated by the stop.

The effect of employing a system as just described is that injection commences at a predetermined pressure which is settled by the force required to open the valve under the influence of the piston. When further lift of the valve is prevented by the stop a rise of pressure will take place but the amount of this rise is limited by the relief-valve. Consequently injection commences at a certain pressure and rises to a second pressure at which it is kept. This ensures a more or less gentle start for the ignition followed by a more vigorous period when combustion has well commenced and tends to obviate "knocking".

Fuel pumps are commonly provided on internal-combustion engines of the fuel injection type. Conveniently the parts other than the fuel-pump are according to the present invention combined in a single fuel injection device. The invention accordingly includes in a fuel-injection device for an internal-combustion engine the combination of a nozzle orifice, a fuel-passage leading to the orifice, a valve seating at the back of the fuel-passage, a spring-closed valve therefor, a conduit for conveying fuel under pressure to the valve, a piston subject to the fuel pressure and operatively connected to the valve to lift it from its seating, and a stop for limiting the lift of the valve.

The valve may carry an extension beyond its seating into the fuel-passage leading to the nozzle orifice and the orifice may thus be constituted

by an annular gap around the said extension. The wall of the fuel-passage surrounding the said stem may be made of increasing diameter from the orifice inwardly so that when the valve is lifted the extension moves into a larger portion of the fuel-passage and the area of the orifice is increased. This tends to permit obstruction to be cleared. Moreover, the annular shape of the orifice ensures that it is unlikely the orifice will become even momentarily obstructed over any considerable portion of its area by any accidental solids which may be suspended in the fuel.

The following is a description, by way of example, of certain constructional embodiments of the invention, with reference to the accompanying drawings, in which:—

Figure 1 is a vertical section through a fuel-pump and nozzle, and

Figure 2 illustrates a modified construction.

Referring to Figure 1 a pump-barrel 11 contains a plunger 12 having a head 13 outside the barrel which carries a cam roller 14 actuated by a cam 15 on a shaft 16. The plunger 12 is returned against the action of the cam by a spring 17. It will be appreciated that the drawings are diagrammatic in the sense that well known constructional precautions such as the provision of packing rings or sealing grooves around the plunger are not illustrated. The pump-barrel communicates through a passage 18 with an inlet valve which may be, for example, a spring-closed ball valve of the pattern commonly employed for liquid pumps of small capacity. In addition the plunger is in communication through a permanently open passage 19 with a fuel-nozzle. The fuel-nozzle comprises a nozzle proper 20 having an injection orifice 21 and a body portion 22 which forms a guide for a needle-valve 23. The needle-valve has a conical seating 24 for closing the back of the nozzle aperture, it has an enlargement or shoulder 25 hereinafter referred to and a closing piston 26 at the back of the body 22. Moreover, the stem of the needle-valve 23 is prolonged at 27 and carries outside the back of the body of the fuel-nozzle a head 28 on which bears a closing spring 29 located in a screwed cap 30. By screwing the cap backwards or forwards upon the body of the fuel-nozzle the degree of compression imparted to the spring 29 can be varied. The cap may be locked by a lock-nut 30. The cap 30 furthermore contains a screwed stop 31 having a square 32 on its head for adjustment purposes and adapted to be set so as to limit the degree of opening of the needle-valve 23. Returning to the seating end

of the needle-valve, it will be observed that owing to the action of the stop 31 only a very small lift of the seating 24 from the back of the nozzle 20 is permitted. Between this seating and the fine nozzle-orifice 21 there is a relatively enlarged cylindrical passage 33.

From one side of the permanently open passage 19 between the pump-barrel 11 and the fuel-nozzle there is a branch passage 34 which contains a fuel-pressure relief-valve 35 held down by a spring 36 on a seating 37 by means of an internally screwed and adjustable cap 38.

At one side of the pump-barrel 11 there is a guide 39 for a piston-valve 40, the stem of which carries a head 41 having a roller 42 to engage on a cam 43. The cam 43 is driven by a gear wheel 44 from another gear wheel 45 on the shaft 16, the operative connections being such that the timing of the piston-valve can be varied relatively to the timing of the pump-plunger. The piston-valve constitutes a mechanically-actuated valve for regulating the opening and closing, or at least the closing of the needle-valve 23. The piston-valve is normally kept with its roller 42 pressed against the cam 43 by a spring 46. Into the side of the piston valve chamber there open a port 47 from the pump-barrel 11, and a port 48 leading to a passage 49 which terminates in a chamber in the body 22 of the fuel-nozzle, in which chamber works the closing piston 26. There is, in addition, a port 50 which is open to the atmosphere. Owing to the disposition of the ports through which piston-valve 40 is lowered the passage 49 is connected through the port 50 to the atmosphere, but when the piston-valve is raised connection to the atmosphere is shut off and the port 47 from the pump-barrel is connected to the port 48 and the passage 49. In the operation of this device the cam 15 is so operatively connected to the internal-combustion engine with which it is to operate that the pump-plunger 12 is reciprocated once for each fuel injection which it is required to produce through the nozzle 21; during the suction or down stroke fuel is drawn in through the passage 18 and the timing of the cam is arranged to be such that the subsequent up stroke occurs at the time when injection is required. This produces a rise of pressure in the passage 19, the piston-valve 40 meanwhile being down so that the port 47 is shut. As soon as the pressure is risen to a sufficient value the pressure acting on the shoulder 25 of the injection valve 24 becomes sufficient to lift the valve against the spring 29 and injection commences. There is a preliminary atomization in the narrow conical space between the needle-valve seating 24 and the nozzle 20, this space being set so as to be of the order of a few thousandths of an inch only. Therefore there will be expansion and atomization into the space 33 before the fuel-nozzle proper is reached. Thereafter there is a further expansion through the nozzle proper 21, and highly atomized fuel enters the combustion chamber of the engine. Meanwhile the pump-plunger continues to rise and the injection pressure is kept up but is prevented from rising above a predetermined value by the relief-valve 35 which sets an upper limit to the injection pressure. The spring 29 sets a lower limit and injection must, therefore, take place at a pressure which lies between that set by the spring 29 and that set by the spring 36. If the timing of the cam 43 is delayed sufficiently late the fuel-plunger will come to the end of its stroke and will commence to return.

Shortly after the commencement of the return stroke the fuel in the fuel-nozzle will lose its pressure owing to the flowing of the oil back into the working cylinder, and the spring 29 will close the needle-valve again upon its seating 24. Thus the variations of pressure in the pump-barrel determine the opening and closing of the valve without any interposed valve mechanism. Assuming, however, as will be the case except when the maximum injection period possible is being operated, that the cam 43 comes into operation before the end of the delivery stroke of the pump-plunger, then in that case the piston valve 40 will be raised and oil under pressure will pass through the port 48 and passage 49 to the needle-valve closing piston 26, and as this is of greater area than the shoulder 25 which serves as an opening piston, the needle-valve will be shut, notwithstanding the fact that pressure continues at the seating 24. By arranging that the mechanism which interconnects the shaft 16 with the cam 43 is capable of variable timing, it will be seen that a variable injection period with a short termination is secured in this way without any complication of the valves between the pump-barrel 11 and the nozzle chamber. Such valves are objectionable as they lead to loss of oil pressure and are difficult to maintain in order.

Referring to Fig. 2, this shows a modification of the fuel-pump and injection-nozzle, the barrel 11 and plunger 12, casing 39 and valve 40 being provided and actuated as before. There is a pipe 70 leading to the front end of the injection-nozzle 71 from the pump-barrel and a pipe 80 leading from the valve 40 to a closing piston. Although these pipes are shown in the drawings as quite short it is to be understood that they might be of any desired length and that the same is true of the interconnections shown in Figure 1.

Between the pump-barrel 11 and the casing 39 there is an inlet-valve 72 connected to an inlet-port 73, which port corresponds to the port 18 in Figure 1.

The body of the fuel pump is in two parts 71 and 74 which are screwed together by a nipple 75 between them and both parts of the body are bored through axially to receive a needle-valve 76 which is pressed upon a seating 77 by a spring 78. The needle-valve carries a cylindrical extension 79 beyond the seating 77 and the extension almost fills a nozzle aperture 89 between which and the plug-like extension there is a narrow annular gap which may be only of the order of one or two thousandths of an inch wide or even less. This gap constitutes the effective nozzle-orifice and the extension 79 and the end of the nozzle are arranged to be flush with one another when the nozzle is shut. The nozzle-orifice widens conically as one proceeds backward from the front face of the nozzle, leaving a definite annular passage 81 around the extension 79, and between it and the seating 77. Behind the seating 77 the needle-valve has a shoulder 85 which corresponds to the shoulder 25 of Figure 1. Around the needle-valve, behind the shoulder 85, there is a sleeve-like relief valve 82 which presses on a relief-valve seating 83 and is held up to its work by a spring 84. The relief-valve is grooved longitudinally at 86 to provide a passage for carrying away oil should the valve lift, and this passage is continued by an internal groove 87 in the nipple 75 to a relief-valve passage 88 connected at 89 to the atmosphere by a transverse bore. The passage 75

89 to the atmosphere may, if desired, be provided with a nipple for attachment to a drain pipe instead of opening directly to the atmosphere.

The head 90 of the needle-valve 76 serves as a closing piston as well as receiving the pressure of the spring 78. The head 90 is hollowed out to receive the end of a stem 91 co-axial with it, and the stem 91 is pressed normally forward as far as possible in the nozzle casing 74 by a spring 92 held in place by a cap 93. The cap 93 contains also a screw stop 94 corresponding to the stop 31 of Figure 1. This is secured by a lock-nut 95. It will be observed that the oil passage 80 for closing the needle-valve is connected to a space around the spring 78 so that oil pressure admitted through 80 will bear upon the head 90 of the needle-valve to close it. There is a very small gap 96, not amounting to more than one or two thousandths of an inch or even less between the stem 91 and the head 90, and there is another similar gap 97 between the stem 91 and the stop 94. The stem 91 is hollow, containing a central passage-way 98 which communicates with the space 99 around the spring 92, and is thence connected to the atmospheric outlet 89.

The atmospheric outlet 89 is also connected by a branch 100 to the space at the end of the piston-valve 40, and the piston-valve 40 contains two ports 102, 103. One of these serves, when the valve is raised, to connect the pipe 80 with the oil pressure in the pump-barrel 11 and the other port 102 serves, when the valve is lowered to connect the pipe 80 with the branch 100 and thence to atmosphere.

In the operation of this nozzle, as the pump-plunger 12 rises it causes a rise of oil pressure in the pipe 70 which lifts the needle-valve 76 off its seating 77 owing to the action of the pressure on the shoulder 25. The pressure at which this lifting of the needle-valve occurs is determined by the spring 78 and constitutes the initial injection pressure. The amount of the lift is limited by the amount of the gap 96 and is such that preliminary atomization occurs at the seating 77 followed by expansion in the space 81, and further atomization through the fine annular orifice 89. Any further rise in fuel pressure serves to lift the needle-valve somewhat further off its seating, but the total lift is limited by the stem 91 closing the gap 97 and coming against the stop 94. This total lift is made such as not to prevent atomization at the seating 77, but it will be observed that owing to the conical construction of the nozzle-orifice 89 the increase in area at the seating 77 is accompanied by an increase in area of the nozzle-orifice 89 so that the balance of expansion at the seating and the orifice is maintained. If any further rise of injection pressure occurs it may be sufficient to lift the relief-valve 82 and assist the excess fuel to escape through the passages 86, 87 to the atmosphere at 89. Thus the maximum injection pressure is limited as before. Either by the termination of the movement of the plunger 12 or by the operation of the valve 40 the needle-valve is thereafter closed as already described.

I claim:—

1. A fuel-injection device for an internal-combustion engine comprising in combination a nozzle-orifice, a fuel passage leading to the orifice, a valve seating at the back of the fuel passage, a spring-closed valve therefor, a conduit for conveying fuel under pressure to the valve, a piston subject to the fuel pressure and operatively con-

nected to the valve to lift it from its seating, a stop for limiting the lift of the valve and wherein the valve carries an extension beyond its seating into the fuel-passage leading to the orifice and the orifice is constituted by an annular gap around the said extension and wherein the wall of the fuel-passage surrounding the said extension is made of increasing diameter from the orifice inwardly, for the purpose described.

2. A fuel-injection device for an internal-combustion engine comprising in combination a nozzle-orifice, a fuel passage leading to the orifice, a valve seating at the back of the fuel passage, a spring-closed valve therefor, a conduit for conveying fuel under pressure to the valve, a piston subject to the fuel pressure and operatively connected to the valve to lift it from its seating, a stop for limiting the lift of the valve and wherein a relief-valve is also provided in the form of a sleeve surrounding a stem of the spring-closed valve and is held on its seating by a spring also surrounding said valve stem, said relief-valve being subject to the fuel pressure and communicating when opened with a fuel escape orifice.

3. A fuel-injection device for an internal-combustion engine comprising in combination a nozzle-orifice, a fuel passage leading to the orifice, a valve seating at the back of the fuel passage, a spring-closed valve therefor, a conduit for conveying fuel under pressure to the valve, a piston subject to the fuel pressure and operatively connected to the valve to lift it from its seating, a stop for limiting the lift of the valve and wherein the stop is itself spring-supported and given a limited freedom of movement up to a second stop for the purpose described.

4. A fuel-injection nozzle for an internal-combustion prime-mover comprising a nozzle body and a needle-valve therefor (the nozzle body having an injection orifice into the cylinder and the needle-valve having a seating within the nozzle body which closes a passage leading to the fuel orifice) and a plug on the needle-valve projecting forwardly from the seating into the nozzle-orifice, which plug is of such diameter as to afford between itself and the walls of the nozzle-orifice an annular passage of the area required for the injection opening, and wherein the tip of the plug on the needle-valve is made to coincide at its terminus with the plane of the nozzle face through which the fuel enters the combustion chamber of the prime-mover and the surrounding nozzle-orifice is enlarged behind the face in a stepped or tapered formation so that as the needle-valve moves rearwardly the tip of the plug opens into a wider space.

5. In a fuel injector for an internal-combustion prime mover, the combination of a fuel pump, a fuel nozzle having an orifice through which fuel can be injected into a combustion chamber, a fuel conduit for conveying fuel from the pump to the nozzle, a spring-closed valve for closing said conduit, a fuel passage between the spring-closed valve and the nozzle-orifice, said passage being of greater cross-sectional area than the nozzle-orifice and than the area between the valve and its seating when open, so that fuel is partially atomized at the seating and then again atomized at the nozzle-orifice, a piston subject to the fuel pressure and operatively connected to said valve for opening it under the fuel pressure, a stop for limiting the lift of the valve so set as to ensure the valve contacting with it under the injection pressure and a relief valve connected to the conduit to permit escape of

fuel therefrom, said valve being set to open at normal maximum injection pressure.

6. In a fuel injector for an internal-combustion prime mover, the combination of a fuel pump, a fuel-nozzle through which fuel can be injected into a combustion chamber, a fuel-conduit for conveying fuel from the pump to the nozzle, a spring-closed valve for closing said conduit, a piston subject to the fuel pressure and operatively connected to said valve for opening it under the fuel pressure, a stop for limiting the lift of the valve so set as to ensure the valve contacting with it under the injection pressure and a relief valve (for permitting escape of fuel from the conduit) which is set to open at normal maximum injection pressure, said relief valve having the form of a sleeve surrounding a stem of the spring-closed valve of the nozzle and held on its seating by a spring also surrounding said valve stem.

7. In a fuel injector for an internal-combustion prime mover the combination in one unit of a fuel nozzle through which fuel can be injected into a combustion chamber, a fuel conduit leading to the nozzle, a spring-closed valve for closing said conduit, a piston subject to the fuel pressure and operatively connected to said valve for opening it under the fuel pressure, a stop for limiting the lift of the valve so set as to ensure the valve contacting with it under the injection pressure and a relief valve (for permitting escape of fuel from the conduit) which is set to open at normal maximum injection pressure, said relief valve being in the form of a sleeve surrounding a stem of the spring-closed valve of the nozzle, and held on its seating by a spring also surrounding said valve stem.

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