April 13, 1954 A. F. UNDERWOOD 2,674,950

FUEL INJECTION PUMP

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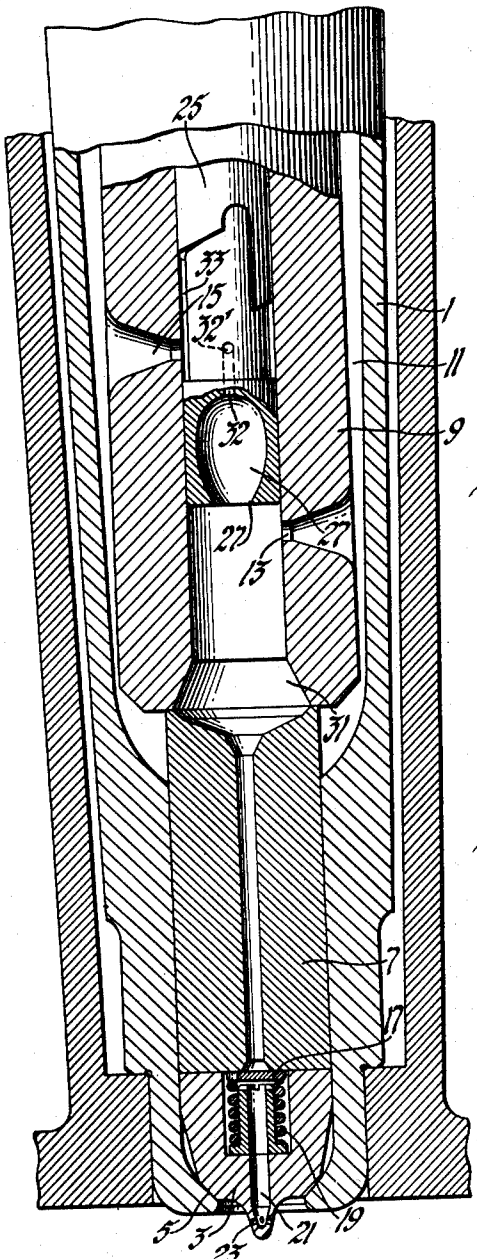

Fig. 1

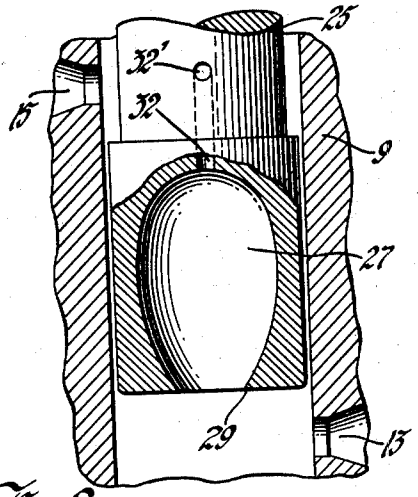

Fig. 2

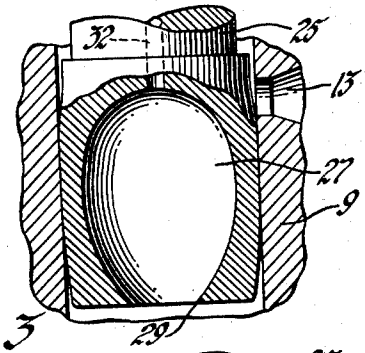

Fig. 3

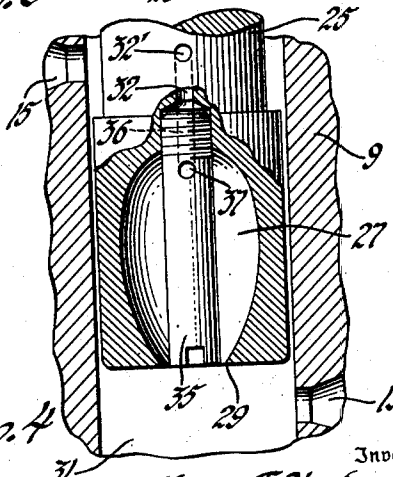

Fig. 4

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FUEL INJECTION PUMP

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12 Claims. (Cl. 103—41)

1

This invention relates to fuel injection pumps and more particularly to improvements in the plungers thereof.

Conventional fuel injection pumps make use of a plunger closely fitted to a cylinder bore to reduce the leakage of fuel between the cylinder and plunger when the latter moves on the fuel pressure discharge stroke. In order to accurately control the clearance between the cylinder and plunger it is necessary that the entire length of the cylinder bore and plunger be made extremely straight and round and by selective fitting of plungers and cylinders the clearance is held to a minimum thereby reducing the fluid lubricating film of fuel oil and fuel leakage therebetween.

The principal object of this invention is to provide a fluid pressure expansible plunger which expands more adjacent the leading edge or the working face to more nearly conform to the cylinder wall in order to reduce the leakage therebetween and to provide a fluid lubricating film of annular wedge shaped section immediately adjacent the leading edge or the working face through which the plunger moves so that the adjacent plunger and cylinder surfaces are maintained concentric and properly lubricated.

The means by which this object and other features of the invention is accomplished will become apparent by reference to the following detailed description of and drawings illustrating a form of the invention which is particularly adapted for high pressure fuel injection pumps for compression ignition internal combustion engines.

Figure 1 is a longitudinal cross section of a fuel injection pump incorporating my improved plunger with parts shown broken away and in section.

Figures 2 and 3 are enlarged views of a portion of Figure 1 with parts shown broken away and in section to illustrate the plunger before and after expansion, Figure 3 illustrating the plunger expanded.

Figure 4 is a view similar to Figures 2 and 3 of a modified form of plunger.

As best illustrated in Figure 1 the fuel discharge portion of a well known type of fuel injection pump is provided with my improved pump plunger. This pump includes a hollow pump body 1 having a fuel spray nozzle 3 seated on an internal flange 5 of the body by means of a hollow spacer 7 held in fluid tight engagement between the end faces of the spray nozzle 3 and a hollow pump cylinder 9 by suitable clamping means, not shown. The space 11 between the body 1 and cylinder sleeve 9 is supplied with fuel

2

and ports 13—15 are provided in the sleeve and communicate with the fuel space 11. The fuel spray nozzle 3 is provided with a recess adjacent the hollow spacer 7 in which a check valve mechanism is located. This mechanism includes a valve disk 17 retained seated on the outer end face of the hollow spacer 7 by a helical compression spring 19. An axial bore 21 leads from the recess in the spray nozzle 3 to fuel discharge openings 23 in the nozzle tip projecting outwardly of the body 1.

A plunger 25 is reciprocal in the hollow cylinder 9 in conventional manner. The plunger is provided with an axial recess 27 in the inner end face 29 of the plunger of substantially ellipsoidal form and forms the inner end of a fuel pumping chamber generally indicated by the character reference 31, the outer end surface of this chamber being formed by the inner face of the valve disk 17 seated on the outer face of the hollow spacer 7. Communicating axial and radial passages 32—32' in the plunger establish communication between the plunger recess 27 and the bottom of an external groove 33 of the plunger 25. The edges of the plunger groove 33 cooperate with the two cylinder ports 13—15 upon reciprocation of the plunger in a well known manner to provide fuel inlet to the pumping chamber 31 upon outward movement of the plunger on the fuel filling stroke and to provide fuel by-pass, pressure discharge and pressure relief from the pumping chamber upon inward movement of the plunger on the fuel discharge stroke, fuel discharge taking place past the valve disk 17 and through the fuel discharge openings 23 in the spray nozzle 3.

It will be evident with the above described structure, upon an increase in the fuel pressure in the pumping chamber 31 by inward movement of the plunger 25 on the fuel discharge stroke, causing closure of both cylinder ports 13—15, that uniform pressure will be applied to the internal surface of the plunger recess 27. As this recess is of substantially ellipsoidal form the wall portions at opposite ends of the recess are reinforced against expansion and by having a thicker wall at the ends with the wall thickness decreasing to a smaller value at a point intermediate the ends to allow greater expansion by pressure so that the outer surface of the wall at this point closely conforms to the internal surface of the cylinder 9, as best shown exaggerated in Figure 3, to reduce the fuel leakage between the plunger and cylinder. It will be noted that the reinforced or thicker wall portions at the end

of the recess expand less than the wall portion intermediate the ends and an annular wedge shaped lubricating film of compressed fuel is formed between the internal surface of the cylinder and outer surface of the plunger adjacent the leading edge or end face 29 through which the plunger moves to provide improved lubrication of these surfaces and to retain the plunger concentric to the cylinder.

As best shown in Figure 4 if it is desired to decrease the volume of the plunger recess 27 a plug 35 is threaded into an enlargement in the axial plunger passage 32 and axial and radial passages 36—37 are provided in the plug for establishing communication with the axial and radial plunger passages 32—32'. The diameter of the plug is less than that of the outer end of the plunger recess 27 so that an annular recess is provided between the ellipsoidal surface of the recess and the outer surface of the plug therein.

It will be evident that the advantages of the plunger structures disclosed may be obtained by providing recesses in the working face of different forms and by reinforcement of the plunger walls adjacent the recesses by other means than by varying the thickness of the wall.

I claim:

1. In a liquid fuel pump, a pump cylinder having a closed end and a pressure discharge passage extending outwardly therethrough, a pump plunger slidable in the cylinder and having a resilient wall formed by an axial recess in the inner end of the plunger, the recess having reduced diameter end portions forming the internal end surfaces of the resilient plunger wall so that the expansion of the thicker end portions of the resilient wall by the fuel pressure in the recess is less than the expansion of the thinner intermediate wall portion in order to reduce leakage of fuel past the plunger and to provide proper lubrication and centering of the plunger by the fuel in the clearance space between the external surface of the plunger immediately adjacent the inner end of the plunger upon inward movement thereof on the pressure discharge stroke.

2. In a fluid pump, a pump cylinder having a closed end and a pressure discharge passage leading outwardly therethrough, a cylindrical pump plunger having a resilient wall formed by an axial recess in the inner end of the plunger of annular form, said resilient wall having a thin intermediate portion and thicker end portions expansible by the pressure in the annular recess to cause the thin wall portion to expand more and more closely conform to the internal surface of the cylinder.

3. In a fluid pump, a pump cylinder having a closed end and a pressure discharge passage extending outwardly therethrough, a cylindrical pump plunger having a resilient wall formed by an annular recess in the inner end of the plunger, said resilient wall having thick end wall portions and a thinner intermediate wall portion expansible by the fluid pressure in the recess to cause expansion of these wall portions inversely with respect to the thickness to reduce the clearance and fluid leakage past the outer surface of the intermediate wall portion and for maintaining the plunger coaxially with the cylinder upon movement of the plunger on the fluid discharge stroke.

4. In a fluid pump, a pump cylinder having a closed end and a fluid pressure discharge passage leading outwardly therefrom, a cylindrical pump plunger having a resilient wall formed by an axial recess in the inner end of the plunger, the inner surface of the resilient wall decreasing in diameter from the outer end of the recess toward the transverse midplane of the recess in order to limit expansion of the wall portion adjacent the inner end of the plunger and to cause the outer surface of the wall to increase in diameter from the inner end of the plunger toward the intermediate portion of the wall by the pressure in the recess.

5. In a fluid pump, a pump cylinder having a closed end and a fluid pressure discharge passage, a pump plunger having an externally cylindrical surface slidably fitting the cylinder and having an axial recess in the inner end of the plunger subjected to fluid pressure, said recess and cylindrical surface cooperating to form an expansible plunger wall of variable expansibility, said wall having a thickened portion surrounding the pressure entrance of said recess to reduce the expansion of said inner end of the plunger relative to remaining portion of said wall.

6. In a fluid pump, a pump cylinder having a closed end and a fluid discharge passage, a pump plunger having an externally cylindrical surface slidably fitting cylinder and having an axial recess of circular cross section in the inner end of the plunger subjected to fluid pressure, said recess and cylindrical surface being in cooperative relation to provide an annular, pressure expansible plunger wall of variable expansibility, said wall having thickened end portions to reduce the expansion of the end portions relative to the portion of the wall intermediate said end portions.

7. In a fluid pump, a pump cylinder having a closed end and a fluid discharge passage, a pump plunger having an externally cylindrical external surface slidably fitting the cylinder and having an axial recess of circular cross section in the inner end of the plunger subjected to fluid pressure, said recess and cylindrical surface being in cooperative relation to provide an annular, pressure expansible plunger wall of variable expansibility, the thickness of said expansible wall being a minimum at a distance inwardly of said recess from said plunger end.

8. In a fluid pump, a pump cylinder having a closed end and a fluid pressure discharge passage, a pump plunger slidable in the cylinder and having an axial recess in the inner end of the plunger subjected to fluid pressure and forming an annular plunger wall of variable expansibility, the internal surface of said plunger wall having an inwardly curved portion surrounding the entrance to the recess to reduce pressure expansion of said wall portion relative that of the plunger wall inwardly of the recess from said portion.

9. In a fluid pump, a pump cylinder having a closed end and a fluid pressure discharge passage extending outwardly therethrough, a plunger slidable in the cylinder and having an axially disposed recess of annular form in the inner end of the plunger subjected to fluid pressure and forming a pressure expansible, annular plunger wall of variable expansibility cooperating with the cylinder wall and a central plunger portion extending axially with respect to said wall, said wall having reinforced end portions adjacent the ends to reduce the expansion by fluid pressure of said end portions relative to the wall portion intermediate said end portions and thereby maintain greater clearance between the cylinder wall and the external surface portions of the plunger

wall adjacent said reinforced end portions thereof than between the cylinder wall and the external surface portion of the plunger wall intermediate said reinforced end portions.

10. In a fluid pump, a cylinder having a closed end and a fluid pressure discharge passage extending outwardly therefrom, a pump plunger slidable in the cylinder and having an annular recess disposed axially in the inner end of the plunger subjected to fluid pressure to form an annular plunger wall of variable expansibility cooperating with the cylinder wall and a plunger portion disposed axially with respect to said plunger wall, the internal surface of said plunger wall having inwardly curved end portions to reinforce said wall and decrease the expansion thereof by pressure relative to the wall portion intermediate the ends and thereby provide an annular wedge shaped clearance space between the cylinder wall and the end portions of the plunger wall and less clearance between the cylinder wall and the portion of the plunger wall intermediate the ends to reduce fluid leakage.

11. In a fluid pump having a pumping cylinder with a side port, a plunger reciprocable in the cylinder having an end subjected to cylinder pressure below said port and an external groove spaced from said end for controlling said port during plunger reciprocation, said plunger having a recess extending into said end and terminating below said groove, said recess being of sufficient depth and transverse dimension that

the transversely surrounding plunger walls will expand under the force of fluid pressure within said recess during the pumping stroke, the walls of said plunger defining said recess being of different thicknesses longitudinally of the plunger axis whereby the rate of said expansion of said walls by fluid pressure varies longitudinally of the plunger axis.

12. The combination set forth in claim 11, together with means for reducing the volume of the recess and extending thereinto coaxially of the plunger axis and spaced from the sides of the recess.

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