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A. T. BREMSER

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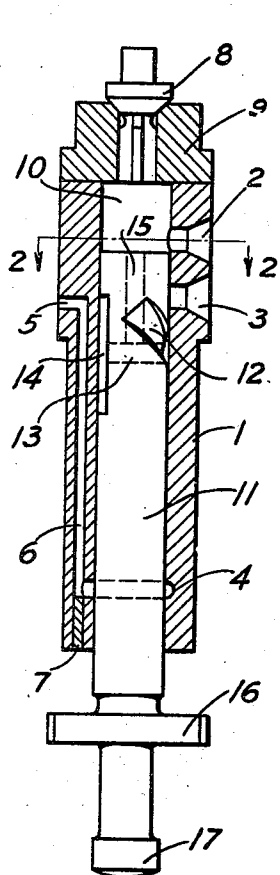


FIG. 1

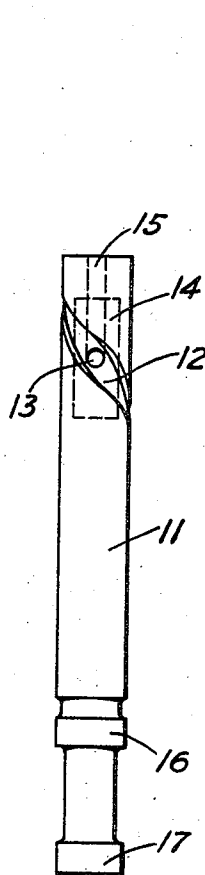


FIG. 3

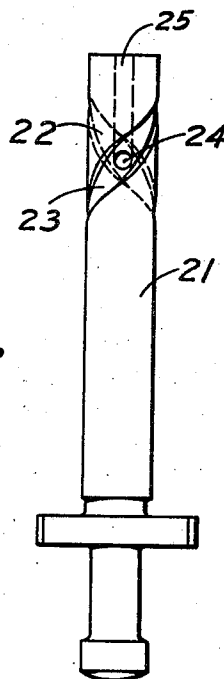


FIG. 4

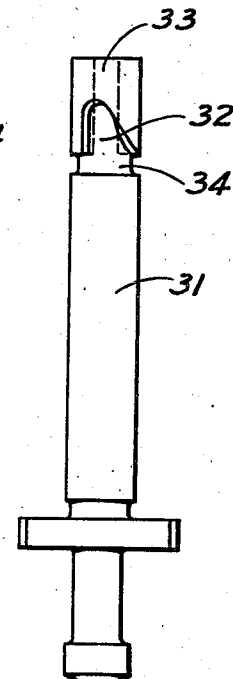


FIG. 5

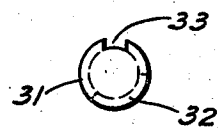


FIG. 6

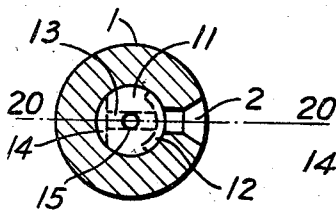


FIG. 2

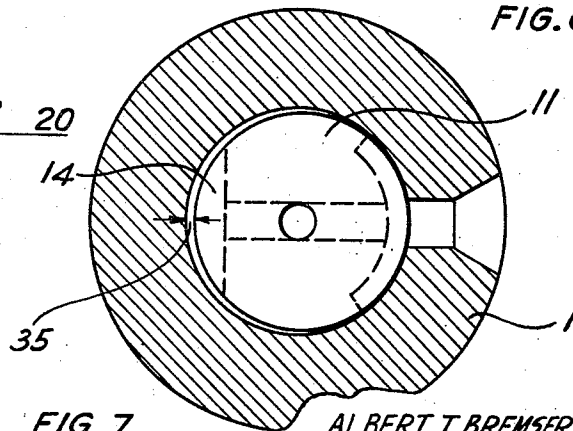


FIG. 7

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8 Claims. (Cl. 103-41)

This invention relates to improvements in fuel injection pumps and more particularly to port controlled pumps in which the plunger is used as a slide valve. Pumps of this kind are used to inject fuel into the combustion chamber or manifold of internal combustion engines.

In port controlled pumps the sealing quality is a function of the clearance between the pump cylinder and the plunger and the leakage is a function of pressure, sealing distance, time, viscosity and clearance. All pumps of this type show more leakage at slow speeds than at high speeds, therefore, the amount of fuel pumped per stroke with a fixed position of the control is less at slow speeds so that the engine power drops at slow speeds and the fuel consumption rises. By improving the seal between the plunger and the cylinder the pumping characteristics can be improved and the engine power increased.

One of the objects of the present invention is to provide novel fuel injection apparatus for fuel injection engines.

Another object of the present invention is to provide a novel plunger pump for injecting variable amounts of fuel into the combustion space of engines.

A further object of the invention is to provide a novel port controlled pump.

A still further object of the invention is to provide a superior seal between the pump plunger and cylinder during the effective pumping stroke in order to obtain greater engine power at slow speeds.

Another object of the invention is to provide novel means to improve the idling of the engines.

A further object of the invention is to reduce the fuel consumption obtained with similar pumps but which do not have the superior sealing characteristics of this pump.

A still further object of the invention is to provide a pressure cavity and a metering cavity on a novel plunger.

These and other objects will appear more fully from the detailed description of the invention which follows. Although several embodiments of the present invention are described and illustrated in the accompanying drawing, it is to be expressly understood that the drawing is for the purpose of illustration only and is not to be construed as a limitation of the scope of the invention, reference being had for this purpose to the appended claims.

In the drawing wherein like reference characters indicate like parts throughout the several views:

Fig. 1 is an end elevation partly in section and with parts broken away of a portion of a fuel pump showing one form of the present invention.

Fig. 2 is a section view taken substantially through line 2-2 of Fig. 1.

Fig. 3 is another view of the plunger shown in Fig. 1.

Fig. 4 represents a modification of the plunger.

Fig. 5 represents a further modification of the fuel pump plunger.

Fig. 6 is a top view of the plunger shown in Fig. 5 showing the relation of the grooves to each other.

Fig. 7 is an enlarged view of Fig. 2 and accentuating the clearance of the piston with the pump cylinder during the effective pumping stroke.

Referring now to Figs. 1 to 3 of the drawing, the cylinder 1 of the pump has near its upper end two ports 2 and 3 substantially on the same vertical centerline as can be seen in Fig. 2. The port 2 is the inlet port and port 3 is the by-pass port. Both ports open into a chamber surrounding the upper portion of cylinder 1. This chamber can be of usual design and has been omitted from the drawing. An annular groove 4 in the cylinder collects any oil that might leak down the sides of the cylinder. This annular groove 4 is connected to drillings 5 and 6 in the cylinder. A plug 7 is placed in the end of the drilling 6.

The delivery valve 8 seats in the retainer 9 and is held in its seat by means of a spring. The valve retainer 9 is held tightly on the cylinder 1 by means of a collar or other device not shown.

The plunger or piston 11 has a metering groove 12 in the form of a helix extending at least partly around the plunger and a cavity or groove 14 arranged substantially opposite groove 12. Passage 13 interconnects groove 12 and cavity 14 and passage 15 extends from passage 13 through the upper face of plunger 11. Thus passages 13 and 15 form a continuous communication between the pumping chamber 10 and the groove 12 and cavity 14. Cavity 14 is termed a pressure cavity or groove and it is so dimensioned and arranged relative to groove 12 that the fuel pressure in cavity 14 will cause the plunger to slide on that portion of its surface which carries the metering groove 12. The pressure cavity 14 may be rectangular as best shown in Fig. 3. A cross member 16 is made integral with or attached to the lower end of plunger 11 for the purpose of

rotating the plunger 11 to regulate the effective stroke of the plunger in the usual manner.

Fig. 4 shows a preferred embodiment of the invention. The plunger 21 is similar to the plunger 11 except that instead of a rectangular pressure cavity it has a helical pressure groove 22 which is substantially diametrically opposite the helical metering groove 23. The two grooves are connected by means of a passage 24 which in turn is connected by a passage 25 to the top of the plunger. The pressure groove 22 has a larger area than the metering groove 23. The advantage of this plunger is the fact that it can be machined in one set-up and the area of the pressure groove 22 can be readily increased by simply increasing the width.

Referring now to Fig. 5 of the drawing, the plunger 31 has a metering groove 32 the upper edge of which is in the form of a helix. Substantially diametrically opposite the metering groove is a pressure groove 33 cut in the side of the plunger 31. An annular groove 34 connects the metering groove 32 to the pressure groove 33. Pressure groove 33 also serves as communicating passage between the pressure chamber 10 and the grooves 34 and 32, if this plunger is used in place of plunger 11.

Operation

Plunger 11 is shown in the lower position and fuel has entered into the pressure chamber 10 through port 2. The plunger is moved upward, by means of a cam arrangement not shown, and the upper edge of the plunger which has an unbroken circumference closes port 2. Pressure is then built up in the pressure chamber 10, passages 15 and 13, and in the metering groove 12 and in the pressure cavity 14. This pressure causes the delivery valve 8 to open.

Delivery of fuel through valve 8 continues until the upper edge of the metering groove 12 registers with the lower edge of the by-pass port 3. Opening of the by-pass port 3 by the groove 12 will cause by-passing of fuel out of the pressure chamber 10 through passages 15 and 13, groove 12 and out of the cylinder into the suction chamber, not shown. The portion of the plunger stroke during which both the suction port 2 and the by-pass port 3 are fully covered by the plunger surface is called effective stroke. If the plunger is rotated so that the upper portion of the metering groove 12 will register with port 3 during most of the upstroke of plunger 11 then the effective stroke is short and the amount of overlap of the ports 2 and 3 by the plunger surface is small. This relative position between port 3 and groove 12 will cause a fuel quantity delivered through valve 8 corresponding to idling or light load condition of an engine to which the pump delivers the fuel.

If the plunger is rotated into the position shown in Figs. 1 and 2 then the effective stroke and the overlap of the ports 2 and 3 by plunger 11 are greater than in the first described position. The effective stroke and overlap will increase if the plunger is rotated further. The longest effective stroke will give a delivered fuel quantity corresponding to about full load condition of an engine.

Since the pump described has to pump pressures of 2000 to 7000 pounds per square inch and higher, the amount of overlap of the ports 2 and 3 and the seal produced thereby are very important. In order to produce an efficient seal the plunger surface overlapping ports 2 and 3 must

be firmly pressed against the cylinder surface surrounding ports 2 and 3. This is accomplished by dimensioning and arranging grooves 12 and 14 relative to each other so that the side pressure exerted on the plunger by fuel in groove 12 is substantially less than the side pressure caused by fuel in the pressure groove 14. Therefore, the fuel film separating the plunger and cylinder surfaces on the metering side of the plunger is put under a pressure substantially in excess of the fuel pressure in the chamber 10 and groove 12, thereby preventing or materially reducing leakage past the plunger into ports 2 and 3. In Fig. 2 line 20—20 is the centerline of the ports 2 and 3 and the plunger is shown in a position in which the side pressure exerted by pressure groove 14 is in the general direction of line 20—20. It is evident that if the direction of the side pressure coincides with the centerline of the ports 2 and 3 the best possible sealing condition is obtained. It has been explained that plunger 11 is shown in a position relative to ports 2 and 3 corresponding to about half load condition of an engine. It is evident that when pressure groove 14 of Fig. 2 is rotated with respect to the metering groove 12 the direction of side pressure will be changed. Therefore, by changing the angular arrangement of groove 14 with respect to groove 12 the best sealing condition can be obtained for any one portion of the helical metering groove 12. The seal obtained for the other portions of the metering groove 12 is also far superior to the seal obtained in usual pumps since the radii of the cylinder surface and plunger surface are equal within a few millionths of an inch.

It is also evident that ports 2 and 3 can be arranged angularly with respect to each other without materially impairing the sealing quality of the pump.

During the effective stroke of the piston, as has been stated heretofore, it is forced towards the ported side of the pump cylinder so that the clearance on the side carrying the pressure cavity is increased. This clearance indicated at 35 in Fig. 7 is largest directly opposite the pressure cavity 14 whereas it slowly decreases towards the metering groove. It is evident that the fluid pressure in the pressure cavity 14 is the same as the pumping pressure built up in chamber 10 whereas the pressures in the gradually diminishing clearance spaces on each side of the pressure cavity are pressure gradients beginning with the full pumping pressure near the pressure cavity and gradually decreasing substantially towards the metering cavity. Therefore, the total side pressure exerted on account of the pressure groove is composed of pressure exerted by fluid in the pressure groove and by fluid in the clearance spaces in the vicinity of the pressure groove.

It is realized that a reduction in clearance between the plunger and cylinder on one side will cause an increase in clearance on the other side. This, however, is immaterial for practical purposes since the distance of the lower edge of groove 14 to the leakage groove 4 is long enough so that the resistance against leakage is great despite increased radial clearance.

When the pressure is relieved the valve 8 will seat and the plunger is forced downward in a known manner by a spring. While the plunger is on its downward stroke a vacuum is created in the pressure chamber 10 and as soon as the top of the plunger 11 overlaps the top portion of the inlet port 2, fuel is drawn into the pressure chamber.

The plungers shown in Figures 4 and 5 may be placed in the same type of cylinder as shown in Fig. 1 and they will function in the identical manner as the plunger 11.

While several embodiments of the invention have been described and illustrated in the drawing, it will be apparent to those skilled in the art that the invention is capable of a wide variety of mechanical expressions, while changes may be made in the form, details and proportions of the parts without departing from the spirit of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What I claim is:

1. In a fuel injection pump having a cylinder and a piston movable therein, suction and by-pass ports in the cylinder, a helical metering groove on said piston, the piston cooperating with said ports, and a rectangular cavity opposite said metering groove, said cavity having a larger area than the metering groove and said groove and cavity having constant communication with the pressure chamber of the pump.
2. In a fuel injection pump, a cylinder having a piston movable therein, said cylinder having inlet and by-pass ports, a metering groove on said piston and a pressure groove substantially opposite said metering groove, said ports being substantially on the same vertical centerline, the metering groove cooperating with said by-pass port, and a conduit connecting said grooves, a second conduit connecting the first conduit with the top of the piston, and the top of said piston cooperating with said inlet port, the relative areas of said grooves being such that the resultant of radial components of pressures acting on said plunger during each pressure stroke thereof acts in the direction of said ports.
3. In a fuel pump of the class described, a cylinder, having a suction port and a by-pass port on substantially the same vertical centerline, a piston plunger movable therein and cooperating therewith, a helical metering groove in communication with a second helical groove, said helical grooves being in communication with the working chamber of the pump cylinder, the second helical groove being of a larger area than the helical metering groove and being substantially opposite the helical metering groove, the pressure transmitted from the working chamber to said helical grooves being such that the pressure exerted on the metering edge of the metering helical groove is substantially greater than the pressure exerted on the edge of the other helical groove.
4. A piston for a fuel injection pump having a metering cavity, an annular groove in communication with said metering cavity, and a longitudinal groove substantially diametrically opposite said metering cavity in communication with said annular groove and extending to the top of the piston, said longitudinal groove having a larger area than the metering cavity.

5. A fuel pump consisting of a delivery valve, a cylinder, a piston movable therein, said cylinder having an inlet port and a by-pass port, substantially on the same vertical centerline, said piston having a helical metering groove adapted to cooperate with said by-pass port to control the pump output, a second helical groove substantially diametrically opposite to the metering groove, communicating means connecting the first helical groove with the second helical groove, and a second communicating means connecting the working chamber of the pump to the said first communicating means, the area of the second helical groove being larger than the said first helical groove whereby the side pressure exerted on the piston by the fuel contained in the said second helical groove will force the piston against the portion of the cylinder wall opposite said second helical groove, said by-pass port and inlet port being located in said portion of the cylinder wall.

6. In a fuel injection pump, a cylinder having an inlet port and an outlet port on the same side thereof, a plunger reciprocable in said cylinder, said plunger having a metering groove in one side thereof adapted to cooperate with said outlet port, a pressure groove in the other side thereof having constant communication with the pressure chamber of the pump and with said metering groove, said pressure groove having a greater area than said metering groove whereby the resultant of radially directed pressures acting on said plunger during each pressure stroke of the latter is slight and effective to press said plunger toward said ports.

7. In a fuel injection pump, a cylinder having an inlet port and an outlet port on the same side thereof, a plunger reciprocable in the said cylinder, the upper end of said plunger being adapted to cover and uncover said inlet port, said plunger having a metering groove in one side thereof adapted to cooperate with said outlet port and a pressure groove in the other side thereof, said grooves having constant communication with the pressure chamber of the pump and said pressure groove having a greater area than said metering groove whereby the resultant of the radial components of pressures acting on said plunger during each pressure stroke of the latter is effective to press said plunger toward said ports.

8. In a fuel injection pump, a cylinder having an inlet port and an outlet port on the same side thereof, a plunger reciprocable in said cylinder, said plunger having a metering groove in one side thereof adapted to cooperate with said outlet port and a pressure groove in the other side thereof, said grooves having constant communication with the pressure chamber of the pump, the relative areas of said grooves being such that the resultant of radial components of pressures acting on said plunger during each pressure stroke thereof tends to press said plunger toward said ports.

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