

Dec. 22, 1959

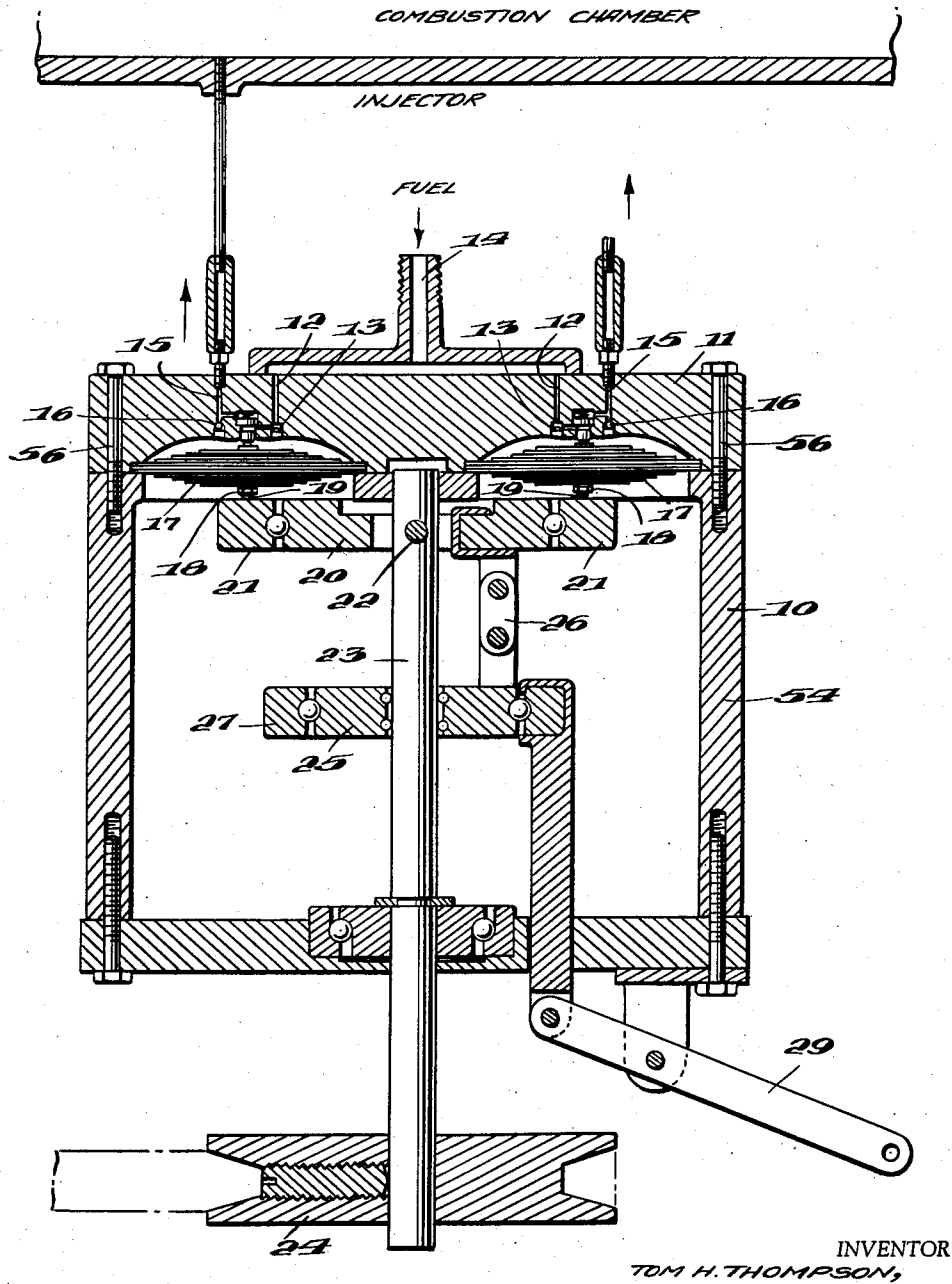
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2,918,008

FUEL PUMP WITH DIAPHRAGM SPRING

Filed Sept. 17, 1954

4 Sheets-Sheet 1



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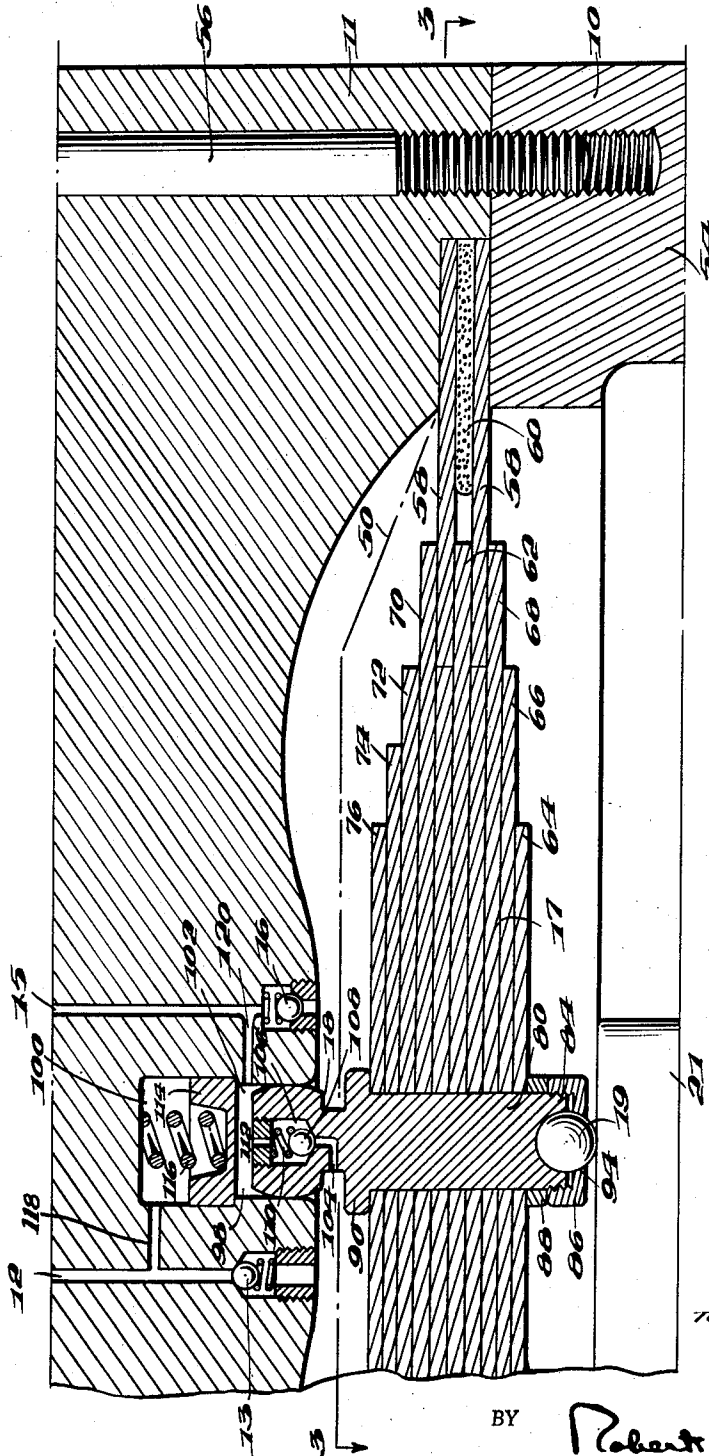


Fig. 2.

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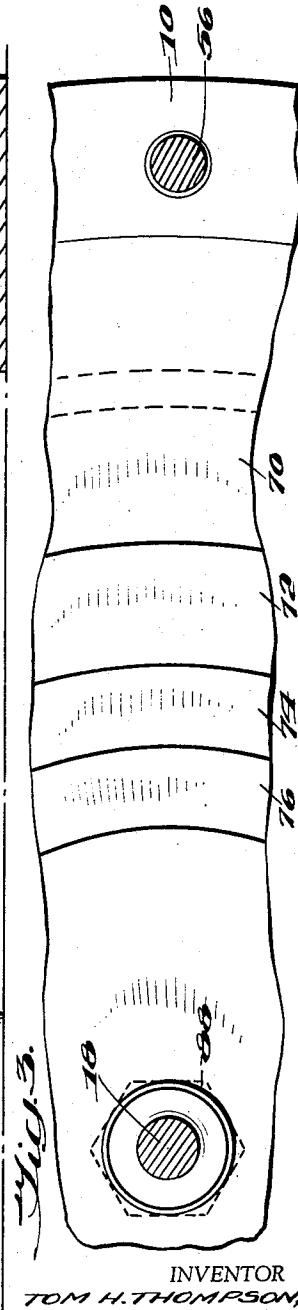
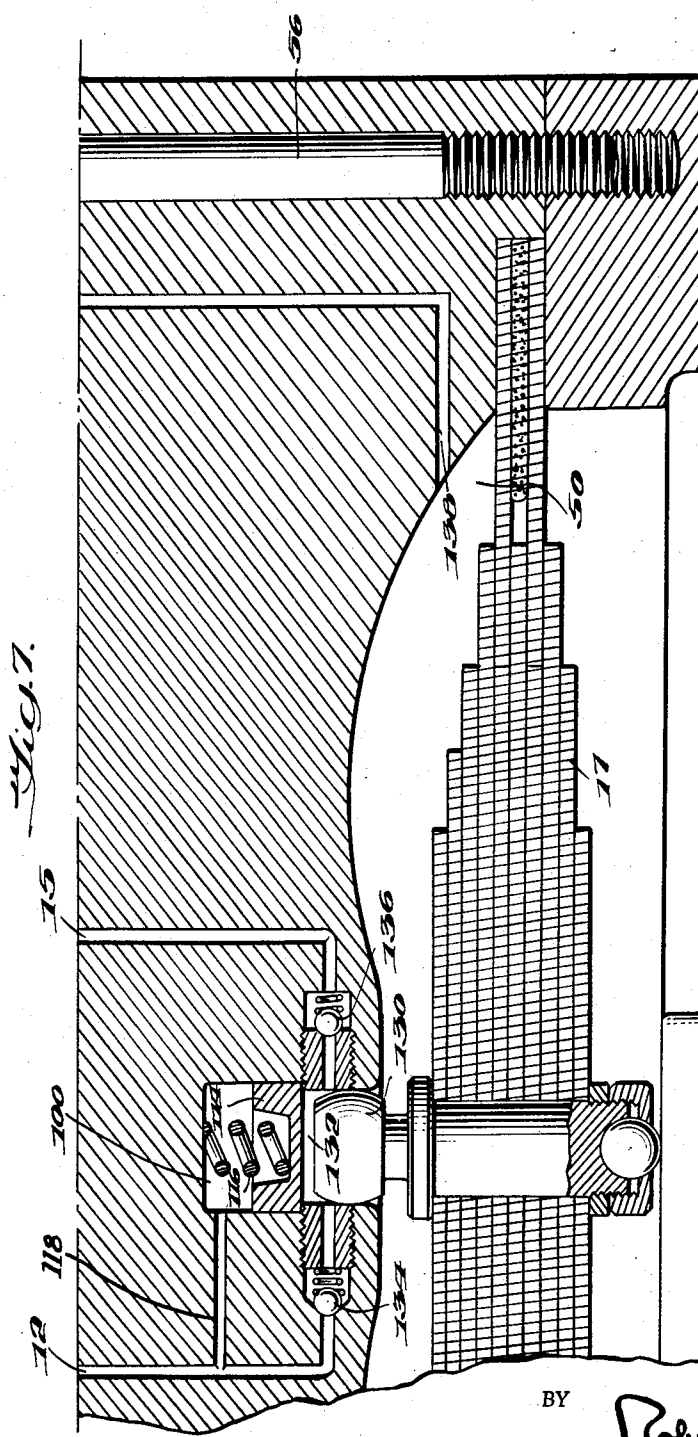
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Fig. 4.

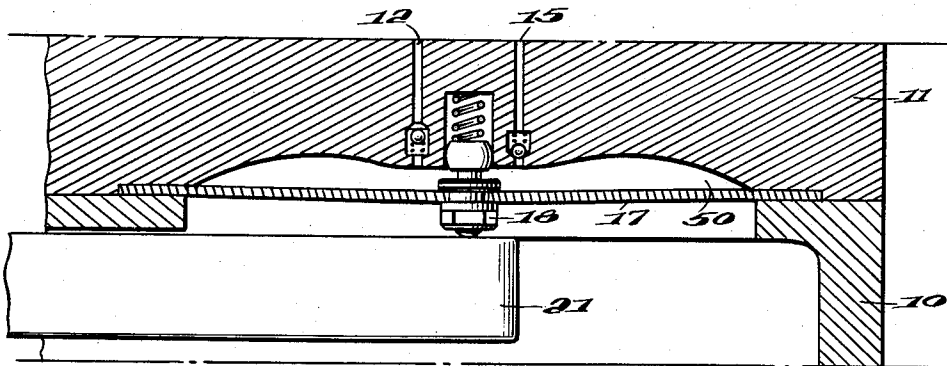


Fig. 5.

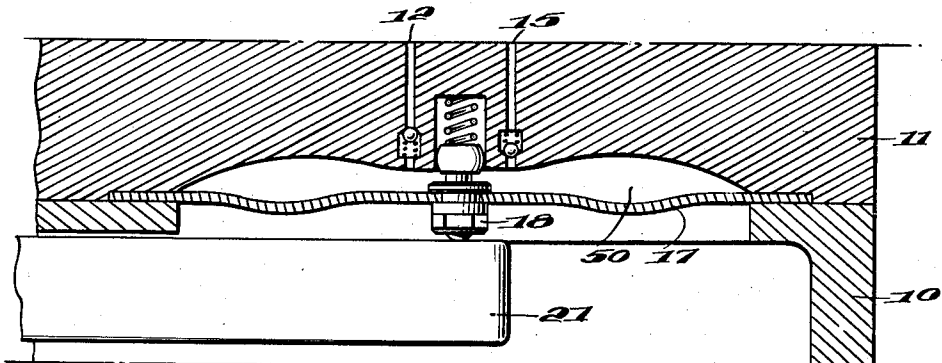
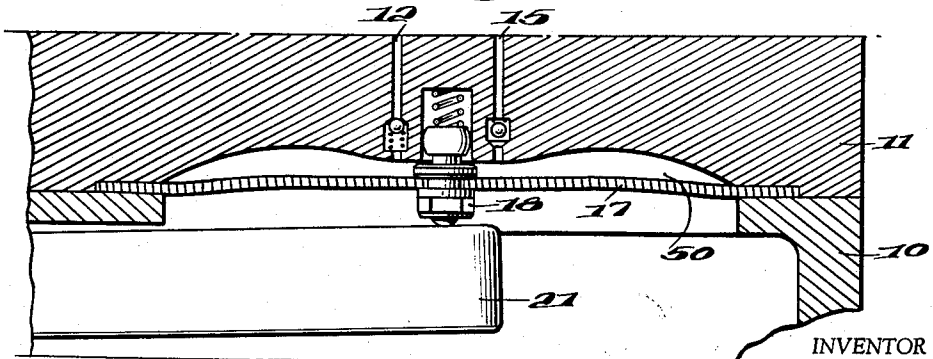


Fig. 6.



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FUEL PUMP WITH DIAPHRAGM SPRING

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Application September 17, 1954, Serial No. 456,708

5 Claims. (Cl. 103—4)

This application is copending with application Serial No. 383,538, filed October 1, 1953, now Patent No. 2,809,868. This invention relates to a fuel pump for a vehicle having a fuel injection system, and more particularly the invention relates to a novel diaphragm spring arrangement which forms a fundamental part of the present fuel pump.

In certain known fuel pumps, the chamber which contains the fuel immediately prior to injection into the engine is comprised partly of a Sylphon bellows. The Sylphon bellows has the ability to distend as fuel is taken into the bellows and to contract under the pressure of a wobble plate to force fuel into the engine through an injection nozzle. Such a fuel pump is shown in Fig. 1 of the above mentioned patent. Fig. 12 of that patent shows the first embodiment of a new type of fuel pump of which the invention in the present application is an improvement.

The Sylphon bellows type pump is disadvantageous for the reason that the pump is quite expensive and because it does not have the characteristics of simplicity and sturdiness which are required in a pump which undergoes its cycles many hundreds of thousands of times during the life of the car.

To overcome the disadvantages of the Sylphon bellows, I have designed a fuel pump in which the Sylphon bellows is replaced by a simple diaphragm. Each fuel inlet and outlet chamber is covered by such a diaphragm and the quantity of fuel to be delivered to each cylinder is measured by the degree to which the diaphragm is flexed. The flexing of the diaphragm is effected by the action of a wobble plate which engages the diaphragm and is connected to operate in synchronism with the engine. In certain cases, when flexed the diaphragm operates to deliver the fuel in much the same manner as the bottom of an oil can.

I have also designed several inlet and outlet valve arrangements which cooperate with the diaphragm to control the flow of fuel.

It is an object of the present invention to eliminate the Sylphon bellows portion of the fuel pump and to replace that portion of the fuel pump with a laminated diaphragm which is simple, sturdy, and has many other advantages as will be demonstrated in the description below.

It is another object of the invention to provide a fuel metering arrangement in the pump which will deliver a predetermined quantity of fuel, for idling purposes, which quantity of fuel will never vary while the engine is idling regardless of any variations in the stroke of the fuel pump.

It is a further object of my invention to provide a fuel pump in which the fuel is pumped directly by a small piston mounted in a cylinder and engaged by the wobble plate. In this arrangement, the diaphragm's primary function is a spring loading for the piston.

It is still a further object of my invention to utilize a thin diaphragm for pumping fuel in which the diaphragm has a snap action known as "oil canning."

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These and other objects of the invention will become more readily apparent from a consideration of the following specification taken in conjunction with the drawings, in which:

Fig. 1 is a cross-sectional view of a fuel pump embodying my invention;

Fig. 2 is an enlarged cross-sectional view of one chamber of the fuel pump;

Fig. 3 is a cross-sectional view taken along lines 3—3 of Fig. 2;

Figs. 4, 5 and 6 are diagrammatic cross-sectional views of one chamber of a pump showing the operation of an alternative embodiment of the pump; and

Fig. 7 is a cross-sectional view of one chamber of the pump showing a further alternative embodiment.

The most desirable characteristic for a fuel injection system is to have the fuel blasted into the cylinder of the engine at the predetermined time and to have that blast cut off sharply at the end of the predetermined time. In known injection systems, the fuel has a tendency to dribble in at the beginning of the injection and to taper off with a dribble of fuel at the end of the injection cycle. In the system developed in my co-pending application referred to above, it was possible to attain the desired sharp blast of fuel injection, and in the present application, it is possible to attain the same desirable sharp blast.

The blast of fuel is effected by the cooperation between a nozzle biased with a Belleville spring as taught in my co-pending application and a fuel pump in which energy is stored by the spring action of one of the fuel pump members. The pump of the present invention is designed to provide the storage of energy for proper fuel injection.

The pump is shown in section in Fig. 1 and comprises a pump casing 10, one end wall 11 of which contains inlets 12 provided with one way ball check valves 13 receiving liquid fuel from an inlet manifold 14 connected to a fuel supply (not shown). Each inlet 12 is paired with an outlet passage 15 provided with a one-way ball check valve 16. The inner ends of each pair of inlet and outlet passages communicate with a closed pumping chamber formed by one of a plurality of diaphragm springs.

The outer edge of the diaphragm 17 is clamped in the pump in a manner to be described below. In the center of the spring is mounted a piston 18 which has mounted at the lower end thereof a reaction ball 19. The ball 19 engages a wobble plate 20 having an outer ball bearing race 21.

The wobble plate 20 is pinned at 22 to a rotatable shaft 23 adapted to be driven by a pulley wheel 24 or by any equivalent driving means such as a gear, etc.

Slidably mounted about shaft 23 is a control plate 25 which is connected by a pivoted linkage 26 to wobble plate 20. Mounted about control plate 25 is a control race 27 to which is attached a control arm 28 passing through the pump housing to lever arm 29 which may be operated by any suitable control such as a throttle lever, pedal, etc.

Referring now to Fig. 2, which shows the invention in detail, each cylinder of the engine has associated therewith a chamber 50 as shown in Fig. 2. This chamber is bound by the end wall 11 of the fuel pump and the diaphragm spring arrangement 17. The diaphragm spring is anchored between the end wall 11 and the housing side walls 54 and clamped in place by bolts 56. The diaphragm 17 is supported by two or three rings 58 separated by a neoprene ring 60 and mounted in the fuel pump housing as described above. (In this embodiment, only two rings are shown.)

A central spring disk 62 is mounted between the two rings 58. Additional spring disks 64, 66, 68, 70, 72, 74

and 76 are stacked concentrically with the center disk 62 to form the complete diaphragm assembly. Each spring disk has a small center hole through which passes a shank 80 of the idler piston 18. At the lower end of the shank 80 is a threaded portion 84 to which is threaded a nut 86 and a neoprene grommet 88. The stack of spring disks are held securely in place between a shoulder 90 and the grommet and nut arrangement 86, 88.

The nut 86 has a small hole 94. A ball bearing 19 of a larger diameter than the hole 94 is captured between the nut 86 and the shank 80 and engages the fuel pump wobble plate bearing race 21.

The idler piston 18 is barrel-shaped and is fitted in a cylindrical extension 98 of chamber 50. The cylinder 98 has an upper portion 100 and a lower portion 102. The piston 18 normally rides in the lower chamber 102 for the injection of idling fuel. The piston 18 is formed with an intake passage 104 fitted with a one-way check valve 106 consisting of a ball 108, a spring 110, and a threaded member 112. The spring 110 has less resistance to compression than the spring which biases check ball 16 for reasons which will be apparent from the description of the idler piston operation.

The upper chamber 100 is fitted with a chamber head 114 which is loaded by a spring 116. The upper chamber, above the chamber head, has a passageway 118 communicating with the fuel intake passage 12. The lower chamber 98 has a passageway 120 communicating with the outlet passage 15 which goes directly to the injector nozzle.

Operation of the diaphragm and idler piston

When the throttle is opened the wobble plate causes the diaphragm 17 and piston 18 to move up and down. The downward movement of the diaphragm causes a vacuum forcing fuel past check valve 13 into chamber 50 until it is full. The upward stroke forces fuel past check balls 108 and 16 into the passageway 15 connected to the injector nozzle.

With appropriate design of the diaphragm and sufficient pressure to overcome in the nozzle the diaphragm will elastically deform slightly, storing energy. This energy will be released upon release of the pressure in the nozzle, forcing a blast of fuel through the nozzle into the combustion cylinder.

When the throttle is set for idling speed, the wobble plate 20 moves the piston 18 with comparatively short strokes, just sufficient to move the top of the piston past the passageway 120. After the wobble plate passes its uppermost position, the diaphragm spring arrangement 17 pulls the idler piston down to the position shown in Fig. 2, causing fuel to be drawn into the chamber through the intake passageway 13. The fuel coming in fills the chamber 50 and the lower cylinder 98 through the passageway 104 and check valve 108.

On the next upward stroke of piston 82 caused by the wobble plate 18, the small amount of fuel in the lower cylinder 98 is forced through the passageway 120 and to the injector by way of passageway 15.

The fuel moves through the passageways 104 and 120 in preference to going by check valve 16 because of the lesser resistance to compression of spring 110.

When the movement of the idler piston is greater than the idle meter amount, the excess movement will cause the piston to engage the chamber head 114, thus displacing this spring loaded chamber head upwardly. The chamber head is permitted to move by reason of the passageway 118 which forms a communication between the upper chamber 100 and the intake passage 13.

If it were not for the idler piston arrangement, the idling fuel would have to be supplied from the movement of the whole disk spring assembly, forcing fuel through the outlet passageway in a manner such as that shown in the device of my copending application. With such an arrangement, variations in the delivery of the

fuel are caused by a variation in the movement of the spring arrangement or even because of variations in the material of the spring. To ensure uniform injection during idling, the piston is provided with a direct connection to the bearing race 19 which, as can be seen from the drawing, provides a positive movement of the fuel into the injection nozzle. The fuel delivering function of the diaphragm, at least during the idling, is completely bypassed. Thus, with my arrangement, considerable variation can be permitted in the diaphragm spring, but as long as there is movement of the idler piston, there will always be a uniform idling of the engine.

Diaphragm constructed for "oil canning"

If the diaphragm is made thin enough, as shown in Figs. 4 to 6, the spring will act in a manner similar to that of the bottom of an oil can. In other words, as the bearing race 19 forces the diaphragm to its uppermost position, the diaphragm snaps upwardly forcing fuel into the engine with a surge.

Figs. 4 to 6 show how this action takes place. For the purpose of clarity and simplicity, the idle metering engagement has been omitted from these figures. The principle of operation with a piston having an idler arrangement is the same. The lowermost position of the diaphragm spring 17 is shown in Fig. 3. At this position, the fuel pump chamber has been filled with fuel ready for injection into the engine through an injector nozzle. As the wobble plate 18 begins to move the piston 18 upwardly, the flow of fuel out of the chamber 50 is resisted by the Belleville spring in the injection nozzle. Consequently, a compound curve is formed in the diaphragm spring 17 as shown in Fig. 4.

When the Belleville spring of the injection nozzle has reached its no-rate position, all of the fuel is permitted to flow through the passageway and the nozzle and is forced through the nozzle by the energy stored in the flexing of the spring disks. The spring disks will then straighten out somewhat as shown in Fig. 5. The movement from Fig. 4 to Fig. 5 is accompanied by a snapping of the diaphragms from the position shown in Fig. 4 to the position shown in Fig. 5 in much the same manner as the bottom of an oil can snaps from one position to another when it is loaded. Hence, the term "oil canning."

The "oil canning" effect is actually a spring action which takes place in a disk which is fixed at its circumference and which has its center moved in a direction transverse to the plane of the disk. The center of the disk moves in the transverse direction a short distance forming a compound curve in the disk. As the center of the disk is moved further in the transverse direction, the compound curve snaps out with a sort of spring action releasing energy. In the case of an oil can, this release of energy is accompanied by a spurt of oil out of the can.

In the embodiment shown in Fig. 7, the fuel does not flow into chamber 50, but is controlled by a piston 130 reciprocating in a cylindrical chamber 132. Inlet 12 communicates with chamber 132 through a one-way valve 134 and outlet 15 is connected to chamber 132 through one-way valve 136.

The pump is formed with upper chamber 100, having head 114 loaded by a spring 116 as in the embodiment shown in Fig. 2.

The chamber 50 is provided with a port 138 communicating to atmosphere. This port permits the chamber to "breathe" so that the piston and diaphragm spring can move freely without compressing air or creating a vacuum in chamber 50. Further, the port permits any fuel which leaks past piston 130 into chamber 50, to be forced out of the fuel pump. Thus the chamber 50 cannot become filled with fuel to cause a jamming of the pump operation or to cause a leakage through the diaphragm to the wobble plate assembly.

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In operation, a downward stroke of piston 130 (to the position shown in Fig. 7) creates a vacuum, drawing in fuel to cylindrical chamber 132 through check valve 134. On the upward stroke, the fuel will be urged to pass through outlet 15 to the injector nozzle. If the nozzle has a spring biased valve such as is shown in my co-pending application Serial No. 383,538, the fuel will not pass through the outlet until the force on the fuel is sufficiently great to overcome the bias on the injector valve. Until this occurs, the fuel will move head 114 upwardly against the action of spring 116. As soon as the bias on the nozzle valve is overcome the spring 116, together with the action of piston 130 will force the fuel to the nozzle with a blast.

The advantage of the device of Fig. 7 is that it permits a positive control of the fuel metering, and a more positive drive of the fuel to the injector nozzle than the arrangements in which the fuel is diaphragm controlled. While the positive control is permitted, no fuel can leak into the wobble plate system because of the diaphragm and port arrangement.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of my invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the accompanying claims.

I claim:

1. A fuel pump comprising a chamber having a fuel inlet and a fuel outlet, said inlet and said outlet having check valves for controlling the flow of fuel, a spring diaphragm forming the bottom of said chamber, an extension in the upper portion of said chamber forming a cylinder, a piston mounted on the center of said diaphragm and having its upper end reciprocable in said cylinder, check valve means in said piston for permitting the flow of fuel from said chamber to said cylinder, a passage connecting said cylinder and said fuel outlet, a

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movable head disposed in the upper portion of said cylinder, spring means resiliently urging said head towards said piston, and means for imparting reciprocatory motion to said diaphragm and said piston.

2. A fuel pump comprising a chamber having a fuel inlet and a fuel outlet, a diaphragm forming the bottom of said chamber, an extension in the upper portion of said chamber forming a cylinder, a piston mounted on said diaphragm and having its upper end reciprocable in said cylinder, a passageway connecting said cylinder and said fuel outlet, means in said piston for permitting the flow of fuel from said chamber to said cylinder, a movable head disposed in the upper portion of said cylinder and resiliently urged toward said piston, and means for imparting reciprocatory motion to said piston and said diaphragm.

3. A fuel pump according to claim 2 wherein said diaphragm is thin and forms a compound curve when urged against the fuel in said chamber whereby when the pressure of the fuel is released said curve will snap out forcing fuel through said outlet with a sudden surge.

4. A fuel pump according to claim 2 wherein said diaphragm comprises a plurality of thin discs having a central hole for mounting said piston, said discs having graduated diameter and being stacked to form a stepped leaf-spring configuration.

5. A fuel pump according to claim 2 wherein said cylinder has a shoulder against which said movable head is normally seated, said shoulder being spaced from the top of said piston.

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