March 11, 1958 E. A. JOHNSON 2,826,153

PUMP DIAPHRAGM MOUNTING

Filed Nov. 9, 1953 2 Sheets-Sheet 1

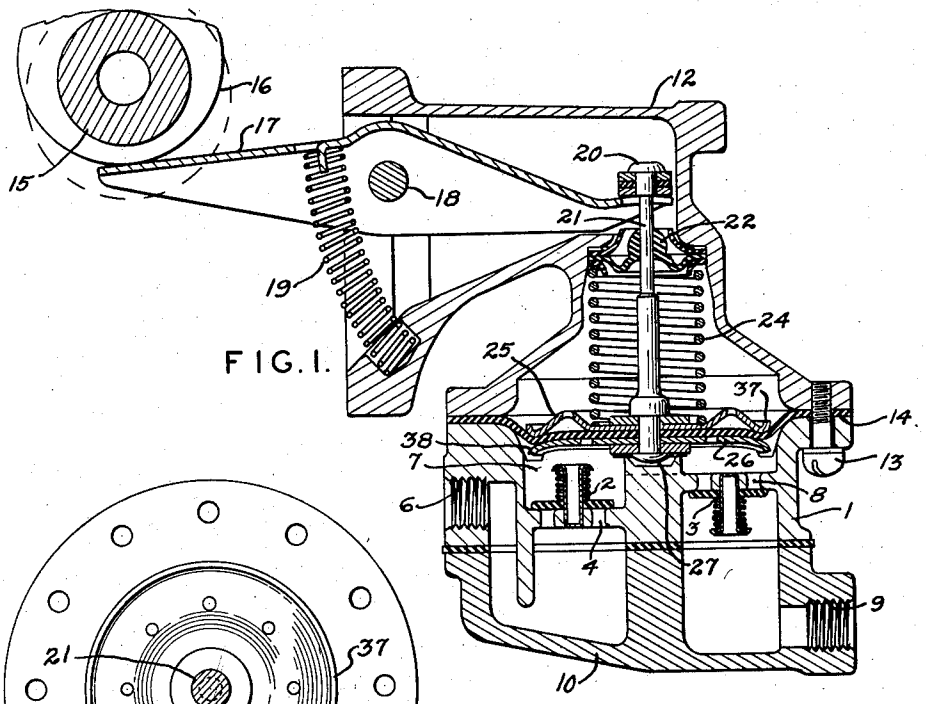


FIG. 1.

FIG. 2.

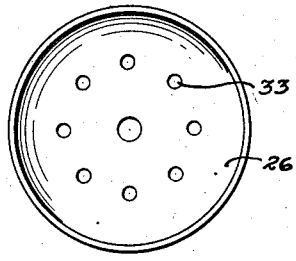


FIG. 3.

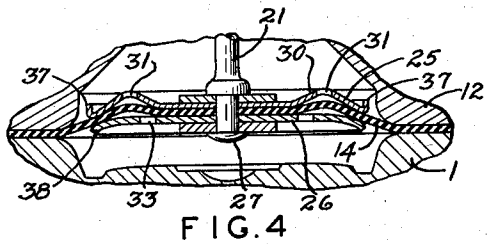
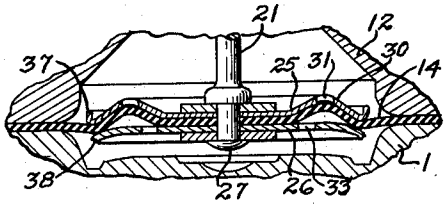


FIG. 4.



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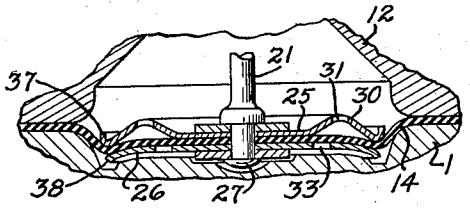

FIG. 6.

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PUMP DIAPHRAGM MOUNTING

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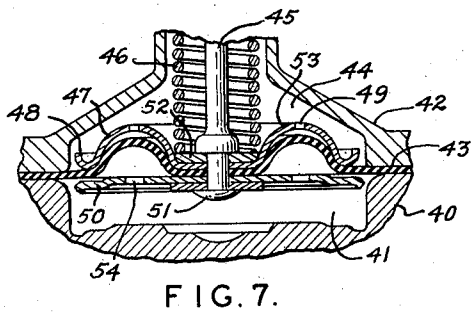

FIG. 7.

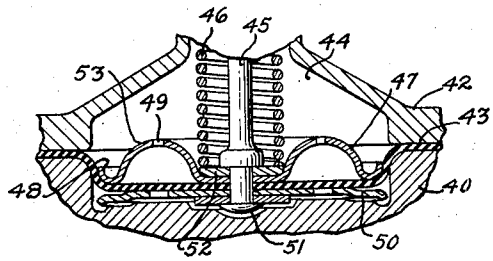

FIG. 8

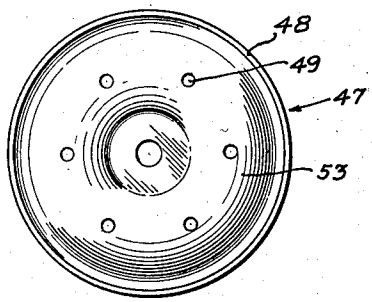

FIG. 9.

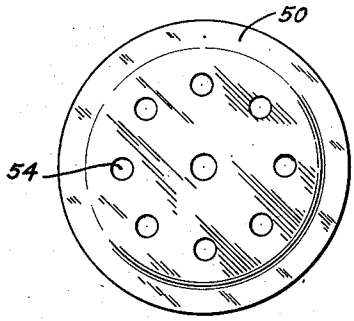

FIG. 10

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PUMP DIAPHRAGM MOUNTING

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Application November 9, 1953, Serial No. 391,008

3 Claims. (Cl. 103—150)

This invention relates to expansible chamber motors and, more specifically, to the type wherein a flexible wall in a chamber forms a seal for a movable piston.

The invention is described and illustrated here as part of a fuel pump of the type used on motor vehicles, for this is the use now contemplated and that wherein its advantages are best known. As this description proceeds, it will become apparent to those skilled in the art of expansible chamber motors that the features and advantages of this invention make many other specific applications readily conceivable.

In most all fuel pumps of this type, a cylindrical pump chamber is divided by a flexible pump diaphragm usually secured in seating relation by clamping its marginal edges between opposed flanges of a pair of body castings containing cavities to form the pump chamber. One or the other of the body castings contains the usual intake and exhaust valves, and that cavity is termed a "valve chamber." The pumping action is by a spring actuated piston having opposed rigid plates in clamping relation with the sealing diaphragm, and the drive is through an actuating stem on which these plates are secured. Since the pumping action is performed in part by the flexing of the sealing diaphragm, the output and performance of such diaphragm pumps is largely affected by the size of these rigid plates as related to the diameter of the pump chamber in which they operate. The average diaphragm is flexible, but will not stretch. Accordingly, the diaphragm and its plates are usually positioned so that one half of the total travel takes place on each side of the plane determined by the sealed circumference of the diaphragm in the pump chamber. It is common practice in installing the diaphragm to position it past the plane a little more than one half of the total travel before clamping the body castings together and sealing the diaphragm in position. This is done to eliminate tension in the diaphragm when it is at either end of its maximum pumping travel. This operation is known as "loop setting."

Because of this manner of assembly, the extra diaphragm material provided by "loop setting" must be gathered in the form of a circumferential wrinkle between the outer edges of the diaphragm plates and the pump chamber at midstroke position. The formation of the loop between the moving parts which is most severe at midstroke, is referred to as "loop interference," and controls the maximum allowable plate diameter. Since the positive displacement depends upon the diameter of the piston, rather than the diaphragm, this limitation on plate diameter effectively limits the maximum output of the pump for any given pump chamber diameter and stroke.

Where the plates are made large for extra capacity, or the stroke lengthened for the same purpose without enlarging the plates, the degree of "loop interference" increases, and the diaphragm offers an unusual amount of resistance which requires a heavier actuating spring

for a given static fuel pressure. This, in turn, introduces another variable in pump output pressure directly dependent on variations in diaphragm thickness and/or flexibility which change the effect of the pump spring. If a spring is designed to produce an initial static pressure, the design must take into account the variations above mentioned. Even if static design pressure is achieved, it is wholly possible for this pressure to increase approximately one pound per square inch after the loop portion of the diaphragm becomes limber through prolonged use. Tests are available which demonstrate the direct effect of diaphragm thickness or hardness on static pressure. Curves plotted from these tests illustrate the adverse effect of these variables on pump performance.

The present invention comprises essentially a means to eliminate diaphragm interference between the rigid backing plates of the piston and the cylinder walls. Applicant has illustrated here one construction for obtaining the desirable result of eliminating "loop interference." However, many structures for obtaining the same result will occur to those skilled in the art from an inspection of the modification disclosed. It is contemplated, therefore, that the invention be limited only by the scope of the appended claims.

In the particular modifications disclosed, the pump piston is formed by inner and outer rigid plates between which the diaphragm is securely clamped at its central portion. Sliding clearance is allowed between the outer edges of the plates, so that the diaphragm may move inwardly as the midstroke position is approached. To accommodate this inward movement of the diaphragm, a circular bead is formed in the outer plate on the side of the piston away from the fuel, and apertures are formed in this bead so as to allow for the escape of any air trapped between the backing plate and the diaphragm. The plate on the fuel side of the piston has a ring of holes which may be, and preferably are, offset inwardly of the apertured bead in the upper plate. In this construction, the sliding clearance for the diaphragm at the plate outer edges, together with the inherent stiffness in the diaphragm, eliminate the "loop interference" between the outer edges of the plates and the cylinder walls. At the extreme ends of the piston stroke, the slack of the diaphragm is substantially taken up, and it conforms substantially completely with the upper surface of the lower plate. At midstroke, the diaphragm loop is formed between the plates of the piston and within the space provided by the circumferential bead in the upper plate. This action is aided to some extent by the pressure of fuel under the piston acting through the offset holes in the lower plate.

An object of this invention is to narrow the effect of physical characteristics of the diaphragm on the action of the pump.

Another object of the invention is to eliminate "loop interference" with pump action, due to the use of larger piston diameters with respect to a cavity of a given size.

Another object of the invention is to increase the volumetric efficiency of the pump by decreasing the clearance volume to a minimum.

In the drawings,

Fig. 1 is an environmental view in vertical section of a fuel pump having the features of the present invention.

Fig. 2 is a top plan view of the pump diaphragm and upper backing plate of the piston.

Fig. 3 is a plan view of the lower side of the opposite backing plate on the fuel side of the piston.

Figs. 4, 5, and 6 illustrate the action of the diaphragm during the pumping stroke.

Figs. 7 and 8 are views in vertical section illustrating the action of a modification of the invention.

Fig. 9 and 10 are detail views of the backing plates.

The pump shown in Fig. 1 has a valve body 1 provided with intake valve 2 and exhaust valve 3. The valve controlled ports 4 provide an entrance for the fuel from the intake passage 6 into the pump chamber 7. Exhaust ports 8 provide for the flow of fuel from the pump chamber 7 to the outlet connection 9 formed in a cap portion 10. The pump actuator housing 12 is secured to the valve body by a series of screws 13, and diaphragm 14 is effectively sealed between the valve body 1 and the actuator housing 12 when the pump is assembled. The engine cam shaft 15 has an eccentric 16 in contact with the pump operating arm 17. Rotation of the eccentric 16 oscillates the arm 17 about a pivot 18. Spring 19 between the housing 12 and the arm 17 maintains the arm in contact with the cam 16. Inner end of arm 17 is forked for engaging a series of washers disposed beneath the headed end 20 of the pump actuating stem 21. Around the upper end of the stem is the usual oil seal 22 maintained in tight seating engagement with a shoulder in actuator housing 12 by spring 24. The opposite end of spring 24 bears directly against the upper backing plate 25 of the pump piston. The lower backing plate 26 is maintained securely on the end of the stem 21 by the headed end 27 which clamps the piston, including the backing plates and diaphragm, against a shoulder on the stem. The center of the diaphragm is held securely, and lips 37 and 38 act as guides for the diaphragm as it moves into and out of the cavity formed between the plates during reciprocation of the piston.

Turning now to Fig. 4, the detail of the piston assembly is clearly shown. Upper plate 25 has a circular bead 30 with a ring of holes 31 in the apex of the bead. The arrangement of holes 31 is clearly shown in Fig. 2. Lower plate 26 is provided with a ring of holes 33 also shown in Fig. 3. The diaphragm 14 has a ring of holes 35 which receive the screws 13 for clamping the casing parts. It will be noted that the ring of holes 33 is similar but offset from the ring of holes 31, and the reason for this will be explained by the operation.

In the operation of the structure above described, at the top of the intake stroke, the diaphragm will have the position with respect to the plates substantially as in Fig. 4. As shown therein, some loop will still be present within the cavity provided between the upper and lower backing plates. This is due to the fact that the diaphragm is set to provide some slack at the end of the pump stroke during the "loop setting" operation performed in assembly of the pump. The loop present at this particular part of the stroke is due probably to the inherent stiffness of the diaphragm, although it may be aided by the friction between the diaphragm and the edges of the backing plates. As the pump reaches midstroke position as shown in Fig. 5, the loop in the diaphragm is formed between the backing plates. This is due to the inherent stiffness of the diaphragm aided by the action of pump pressure through the ring of holes 33 acting below the diaphragm and the venting holes 31 above the diaphragm. In contradistinction to the action of conventional fuel pumps, very little, if any, loop forms outside the periphery of the plates. In any event, there will be no "loop interference" or variations in pressure due to "loop interference."

At the end of the pumping stroke shown in Fig. 6, the diaphragm slack which formed the loop in Fig. 5 has been substantially taken up, and the diaphragm now is held in face-to-face contact with the lower backing plate by the action of the outer peripheral edges of the upper backing plate. This view illustrates very well how the diaphragm outside of the backing plates conforms to the contour of the pumping chamber to eliminate the clearance between the diaphragm and increase the volumetric efficiency.

On the suction stroke of the pump, the action of the diaphragm is substantially the reverse of that above described.

In the structure shown in Figs. 7–10, a pump is illustrated of the type wherein the valves are contained in chambers external of the pump chamber. Only a portion of the pump is illustrated in the drawings, but that mechanism not shown is, of course, similar to that in Fig. 1 above described.

In this modification, the pump body 40 is formed with a pump chamber 41 in communication with intake and outlet valves (not shown). A pump casing 42 is attached to pump body 40 in any suitable manner to secure diaphragm 43 therebetween to seal the joint. Pump actuating spring 46 surrounds a pump actuating stem 45 and is seated at one end on a flange, or the like, formed in the casing 42, as shown in Fig. 1. The opposite end of the spring abuts a washer 52 secured to the pump stem 45. The diaphragm 43 is tightly clamped at its central portion between the upper and lower backing plates 47 and 50 attached to the lower end of the stem 45 between a shoulder and headed end 51. A suitable washer is interposed between the headed end and the lower backing plate.

The upper backing plate, generally indicated as 47, has vent holes 49 located in the crest of bead 53 which forms an annular cavity to accommodate the loop formed in the diaphragm in the position shown in Fig. 7. A peripheral lip 48 is spaced from the lower backing plate 50 a sufficient amount so that the diaphragm 43 may slide in and out of the annular cavity in the upper backing plate 47. The lower backing plate is provided with an annular ring of holes 54 to allow the fuel to fill the cavity formed in the diaphragm when in the looped position shown in Fig. 7.

In this modification, Figs. 7 and 8 illustrate the pump diaphragm at the extreme ends of the pumping stroke. In Fig. 7, the diaphragm and backing plates are in the position corresponding to the end of the intake stroke. In this position, the diaphragm forms a large annular pocket within the cavity 53, which pocket increases the capacity of the pump chamber 41.

In Fig. 8, the diaphragm 43 is tensioned by the downward movement of the backing plates and held closely adjacent the walls of the pump chamber 41 by the lip 48. This mechanism for actuating the diaphragm provides for minimum practical clearance at the end of the pump stroke as illustrated in Fig. 8.

With this particular structure it becomes possible to obtain the same volumetric displacement per stroke as in the conventional diaphragm type of pump, although the stroke in the pump shown in Figs. 7 and 8 is approximately one half of that usually employed.

A structure has been described which will carry out all the objects above recited. In this structure, the loop has been formed in the diaphragm within the piston, because this appears to be the most practical way of carrying the invention into effect. It is contemplated, however, that this action of the diaphragm might be accommodated by a similar design between the flanges of the casings.

I claim:

1. In a fluid pump, a housing having a generally cylindrical pump chamber therein, a pump actuating stem reciprocable within and axially of said chamber during intake and discharge strokes, and a pump piston carried by said reciprocating stem and including inner and outer rigid plates and a diaphragm positioned therebetween and secured to the plates at its central portion, the portion of the diaphragm within the pump chamber being of greater diameter than the diameter of said chamber, said diaphragm having its marginal portion connected to said housing and including an annular intermediate portion adapted to form a loop when said reciprocating stem is intermediate the ends of its stroke, said plates being spaced at their peripheral portions to provide sliding clearance of said diaphragm therebetween, and one of said plates being formed with an outwardly extending

circular bead forming a chamber between the plates for receiving the loop portion of the diaphragm during its inward sliding movement.

2. The structure of claim 1 characterized in that the outwardly extending bead forming a chamber for receiving the loop portion of the diaphragm is located in the outer plate.

3. The structure of claim 1 characterized in that the bead forming the annular chamber for receiving the loop portion of the diaphragm is formed with bleed openings.

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