Jan. 13, 1953 I. E. COFFEY 2,625,114

FUEL PUMP

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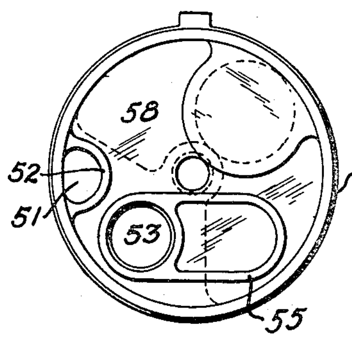

FIG. 3.

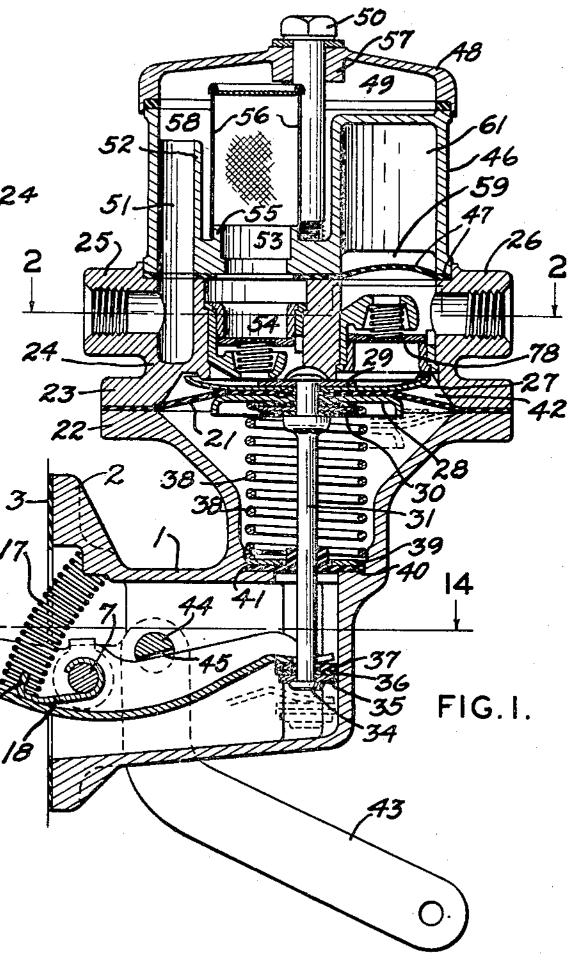

FIG. 1.

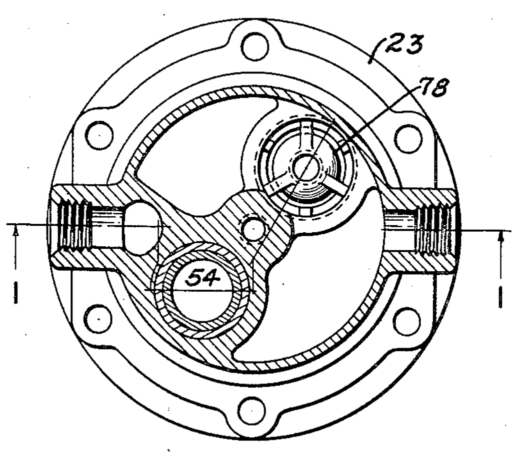

FIG. 2.

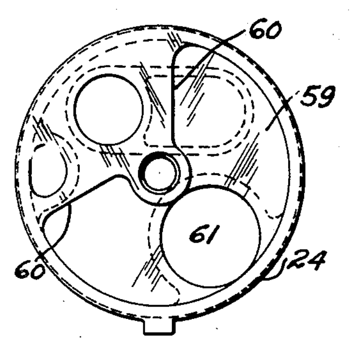

FIG. 4.

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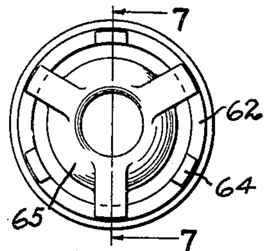

FIG. 5.

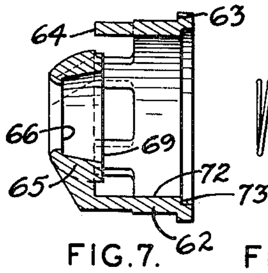

FIG. 7.

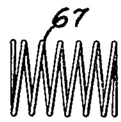

FIG. 8.

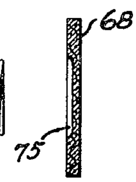

FIG. 9.

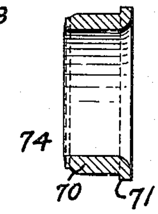

FIG. 10.

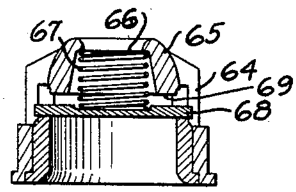

FIG. 6.

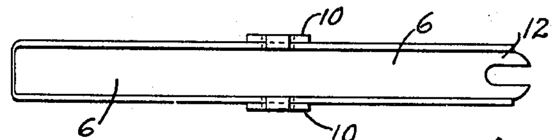

FIG. 11.

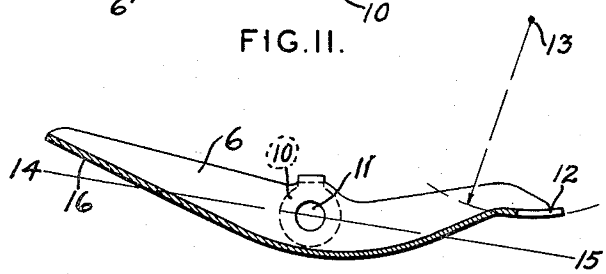

FIG. 12.

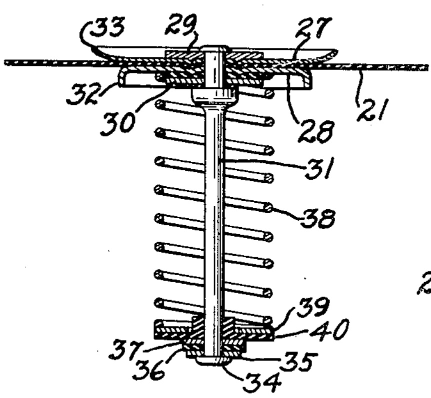

FIG. 13.

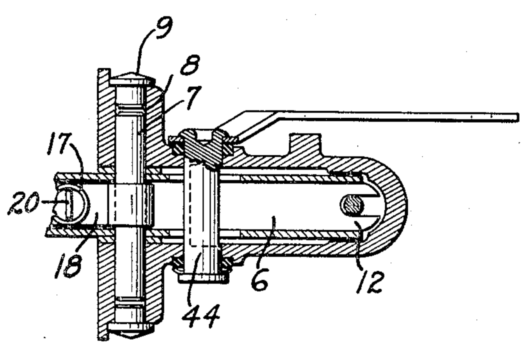

FIG. 14.

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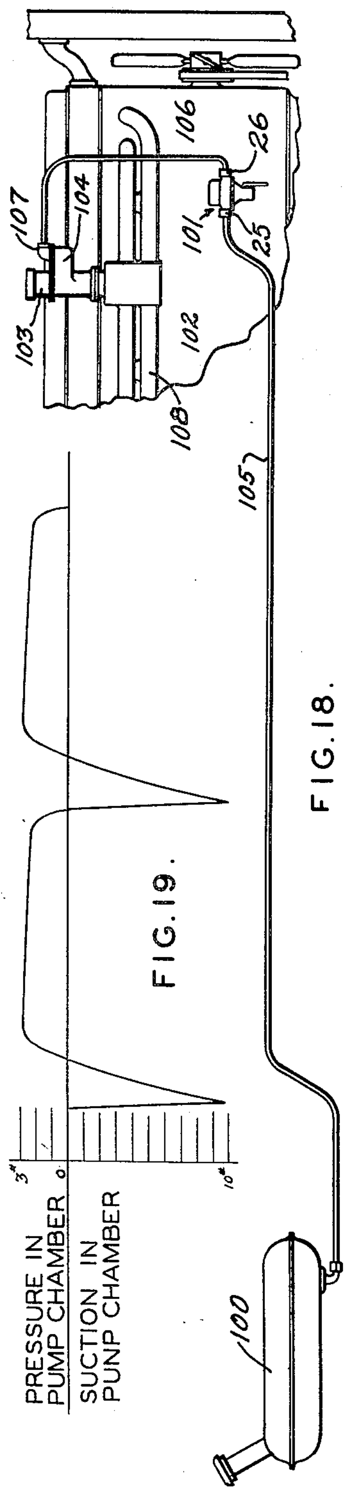

FIG. 18.

FIG. 19.

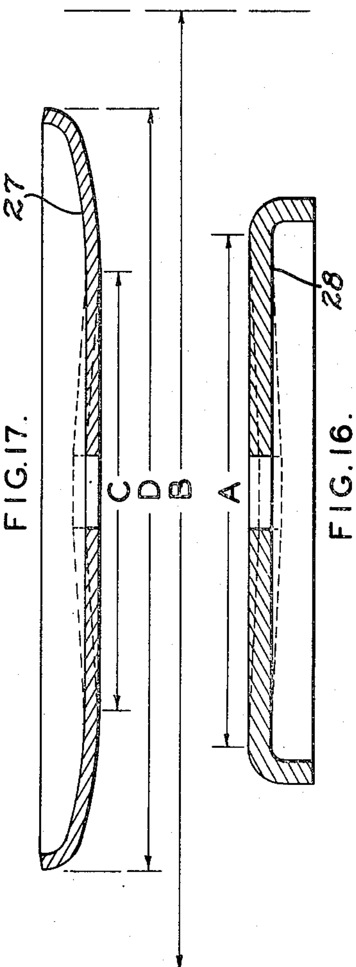

FIG. 17.

FIG. 16.

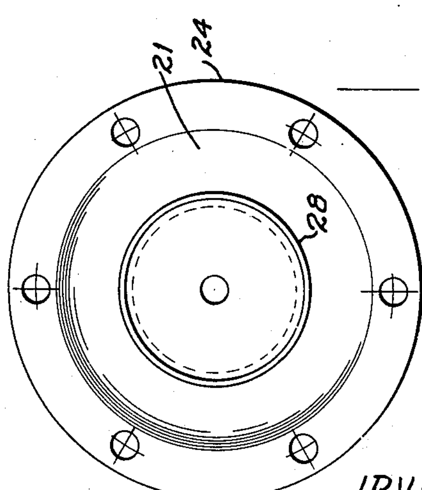

FIG. 15.

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FUEL PUMP

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FIG. 20.

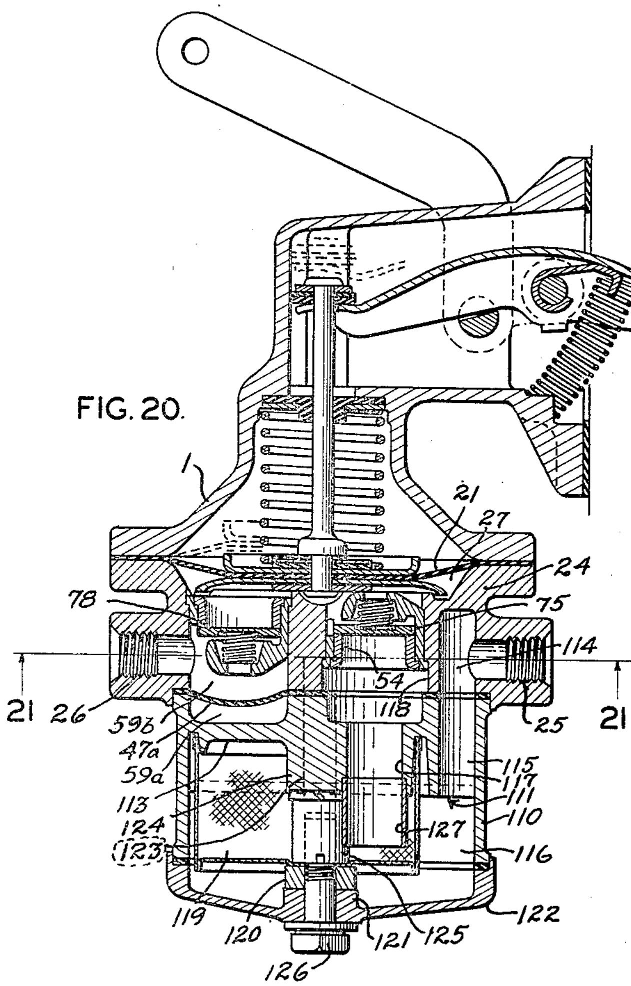
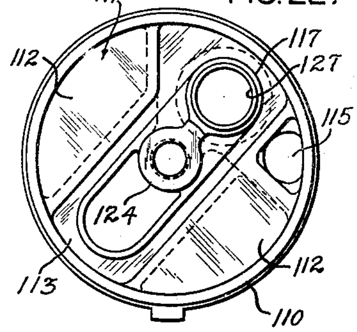


FIG. 22.



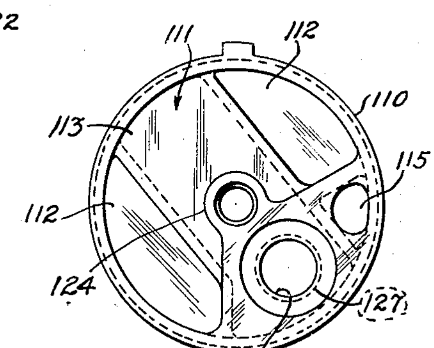


FIG. 23.

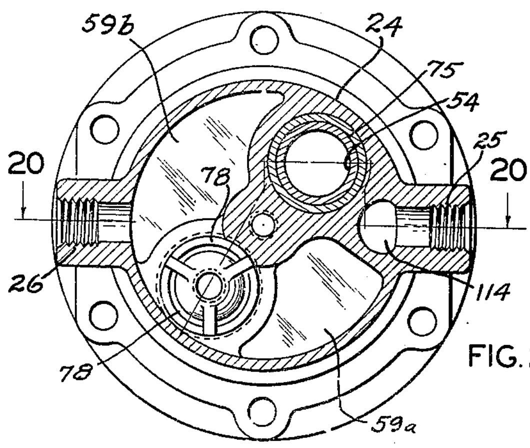


FIG. 21.

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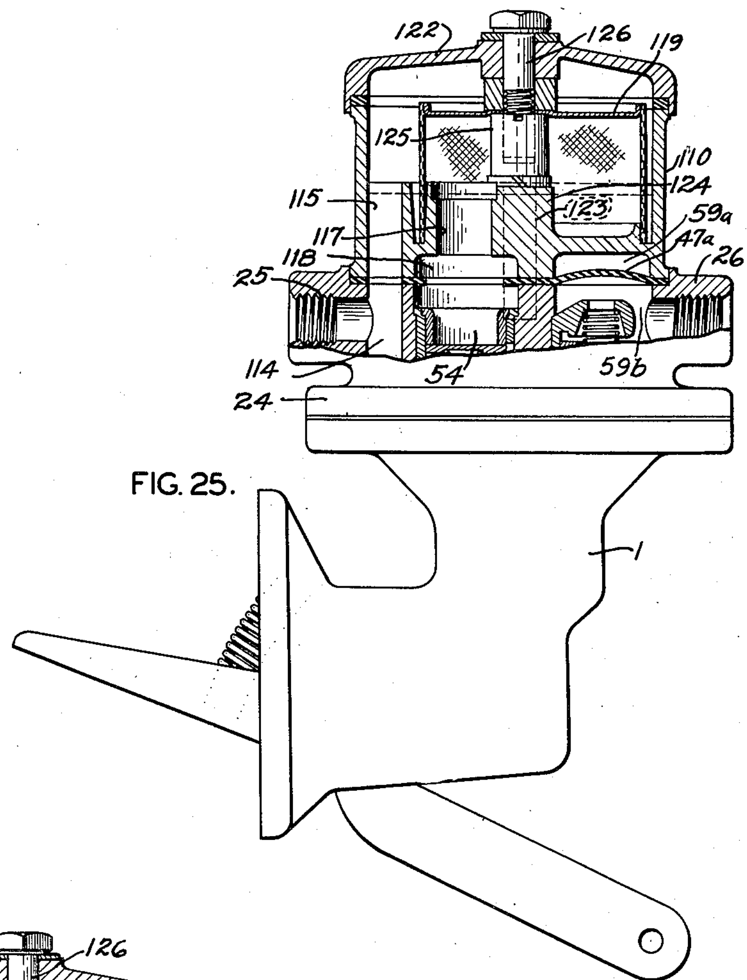

FIG. 25.

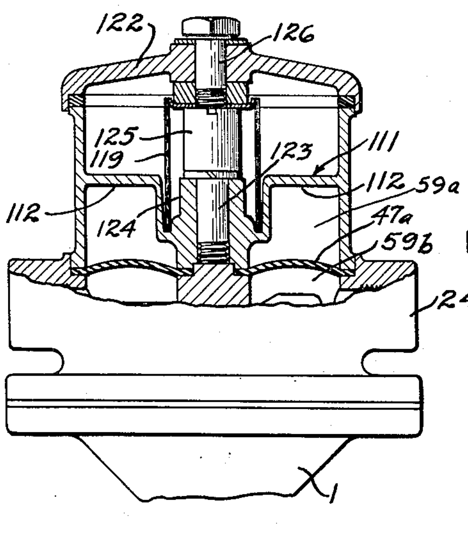

FIG. 24.

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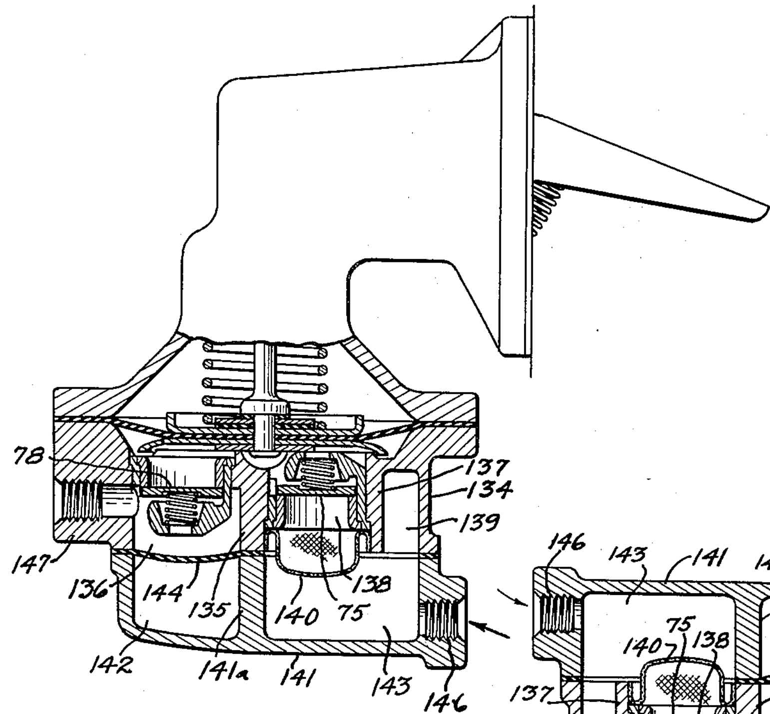

FIG. 26.

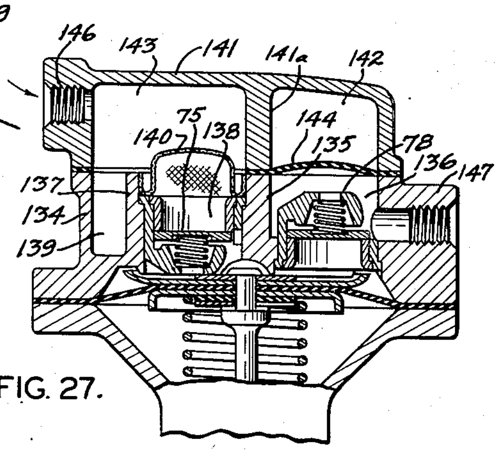

FIG. 27.

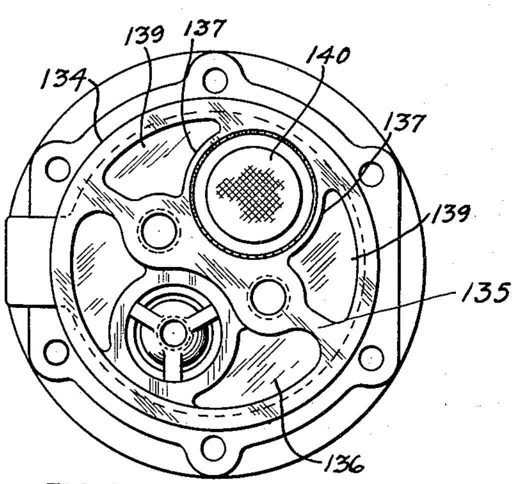

FIG. 28.

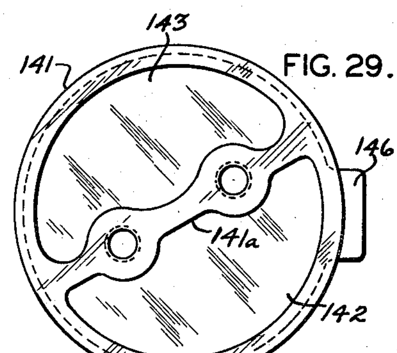

FIG. 29.

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Patented Jan. 13, 1953

2,625,114

UNITED STATES PATENT OFFICE

2,625,114

FUEL PUMP

Irven E. Coffey, St. Louis, Mo., assignor to Carter Carburetor Corporation, St. Louis, Mo., a corporation of Delaware

Application February 17, 1947, Serial No. 728,979

21 Claims. (Cl. 103—150)

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This invention relates to pumps and particularly to fuel pumps for automotive engines and the like and is a continuation in part of my copending application, Serial No. 536,162, filed May 18, 1944, now Patent No. 2,426,965, dated September 2, 1947. Pumps previously provided for this purpose have not been entirely satisfactory for a number of reasons, particularly with regard to capacity and the handling of boiling fuel.

Another serious trouble with previous designs has been diaphragm failures and short life of the pump, generally.

A very frequent source of trouble in previous fuel pump designs is the wearing of the valves and valve seats so that the pump will not prime itself at cranking speeds, and will not pump boiling fuel fast enough to run the engine.

Automotive fuel pumps are ordinarily operated by the engine cam shaft and must have a capacity sufficient to prime the pump, fill the carburetor bowl, and supply all the fuel required to start a cold engine at cranking speeds which may be as low as 40 R. P. M. Since the pump is ordinarily driven from the cam shaft, the pump is only operated twenty strokes per minute under these conditions. On the other hand, the pump must be capable of continuous operation at engine speeds of at least 4000 R. P. M. or 2000 strokes of the pump. Such high speed operation results in excessive strains on the diaphragms of pumps of previous designs.

When operating at 2000 cycles per minute, the inlet and outlet valves of the pump have to be opened and closed with great rapidity, and this is especially hard on the inlet valve and seat, because its operation of opening and closing must be accomplished in a very small portion of the cycle, when the pump is operating at normal speed and capacity.

Another difficulty with previous pumps is that they have, in themselves, tended to set up vapor lock or boiling of the fuel by reason of the excessive suction developed in the fuel at the intake connection of the pump and in the line leading back to the tank. In high speed operation of the pump, the fuel column leading to the inlet valve must be started and stopped with great rapidity, the only means preventing the separation or boiling of the fuel being the atmospheric pressure in the fuel tank or wherever it can act on the fuel.

An object of my invention is to produce a new and improved fuel pump capable of lifting and handling volatile fuels.

Another object of my invention is to produce a new and improved fuel pump for internal combustion engines capable of quickly priming itself

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and filling the carburetor bowl under low speed engine cranking conditions.

Another object of my invention is to produce a fuel pump for internal combustion engines in which the fuel in the intake conduit is refrigerated by vaporization of fuel in the pumping chamber.

It is a further object of my invention to produce a diaphragm type fuel pump in which the strains on the diaphragm are minimized by providing for the acceleration and deceleration of only short columns of fuel.

It is a further object of my invention to produce a new and improved fuel pump of the reciprocating type in which the maximum capacity of the pump is limited by a calibrated restriction at or near the intake valve of the pump.

It is another object of my invention to produce a new and improved fuel pump of the reciprocating type in which the fuel inlet column or pipe is interrupted by an air chamber near the inlet valve of the pump and in which the inlet passage between the air chamber and the inlet valve has sufficient capacity to contain at least as much fuel as can be discharged at one stroke of the pump during normal and high speed operation.

Another object of my invention is to produce a fuel pump for automotive engines in which the life of the pump may be definitely expected to exceed the life of any engine or vehicle to which it is likely to be applied.

Another object of my invention is to produce a new and improved valve capable of maintaining high sealing qualities after long use under high speed operating conditions.

Another object of my invention is to provide a new and improved operating lever for high speed operation.

In order to eliminate the faults of previous designs, and to produce a new and improved pump capable of accomplishing the above described and other objects, I have invented the pump described and shown in the following specification and accompanying drawings, referring to which:

Figure 1 is a sectional elevation of a pump according to my invention.

Figure 2 is a sectional plan view taken along the irregular sectional line 2—2 of Figure 1.

Figure 3 is a detailed plan view of the main air dome member.

Figure 4 is an inverted plan view of the main air dome member.

Figure 5 is a plan view of a valve cage.

Figure 6 is a sectional elevation of a valve assembly.

Figure 7 is a sectional view taken along the line 7—7 of Figure 5.

Figure 8 shows the valve spring.

Figure 9 is a sectional view of the valve.

Figure 10 is a sectional view of the valve seat member.

Figure 11 is a plan view of the operating lever or hammer.

Figure 12 is a sectional elevation of the hammer.

Figure 13 is a sectional elevation of the diaphragm assembly.

Figure 14 is a sectional plan view taken along the line 14—14 of Figure 1, parts being broken away.

Figure 15 shows the diaphragm and lower supporting washer.

Figure 16 is a sectional view of the lower supporting washer.

Figure 17 is a sectional view of the upper supporting washer.

Figure 18 is a diagram showing the approximate position of the main fuel tank with respect to the engine and fuel pump in an automotive installation.

Figure 19 is a diagram showing the approximate pressure and suction curve existing in the pumping chamber.

Figure 20 is a section similar to Figure 1, taken on line 20—20 of Figure 21 but showing a modified form of pump.

Figure 21 is a horizontal section taken substantially on line 21—21 of Figure 20.

Figure 22 is a bottom view showing the dome body of the modified pump.

Figure 23 is a top view of the dome body thereof.

Figure 24 is a partial section taken on line 24—24 of Figure 21.

Figure 25 is a side view and section of the pump shown in Figure 20 but slightly modified and inverted.

Figure 26 is a sectional view similar to Figures 1 and 20 but showing another modification.

Figure 27 is a side view in section similar to Figure 26 but showing the pump inverted.

Figure 28 is a bottom view showing the valve body in Figure 26.

Figure 29 is a top view of the dome body in Figure 26.

Referring first to Figure 18, the reference numeral 100 shows a main fuel tank which is normally mounted at a lower level than the pump which is generally indicated by the reference numeral 101. The pump is mounted on and driven by an internal combustion engine 102 having the usual carburetor 103 and float chamber 104, the details of which are not shown but are well understood by those skilled in the art. A fuel conduit 105 of comparatively small diameter and great length leads from the fuel tank to the pump inlet connection 25, and an outlet conduit 106 also of small diameter and considerable length is connected to the fuel pump outlet at 26 and to the carburetor float chamber at 107. It may be noted that the engine is provided with an exhaust manifold 108 which frequently becomes red hot and is likely to cause boiling of the fuel as it passes through the conduit 105 to the pump inlet. It may also be noted that while boiling occurs in the pump chamber and in the outlet, it is not of such great importance as boiling in the inlet. This is because any boiling which occurs posterior to the inlet valve creates its own discharge pressure, while boiling in the inlet conduit prevents induction of fuel into the pump chamber and causes vapor lock.

The reference numeral 1 (Figs. 1–4) shows a main casting having a flange 2, by means of which it is bolted on to the frame of the engine as at 3. It will be understood that while the pump is primarily designed for automotive engines, it is capable of other uses and can be attached to any support 3 so as to be properly positioned with respect to a cam 4 carried by a rotating shaft 5 which preferably turns in a clockwise direction, so that the sweep of the cam will be inward with respect to the hammer or operating lever 6, which is pivotally mounted on the body member 1 by means of the floating pivot shaft 7.

This shaft is mounted in the bore 8 (Fig. 14), the ends of which are closed by sealing plugs or rivets 9 which permit substantial end play of the shaft.

The actuating lever or hammer 6 is formed of a curved and channel-shaped sheet metal member having bent-over lugs 10 having central openings 11 accurately finished to line up with corresponding holes in the sides of the hammer lever to form bearings for shaft 7. One end of the hammer lever rides on the cam, as indicated in Figure 1, and the other is provided with a fork or hammer head 12 which is slightly curved on a radius about the point 13, as indicated in Figure 12.

It will be noted that the floor of the channel is substantially curved about the bearing 11 in such a manner that a diameter of the bearing, produced as indicated by line 14, 15, passes on the same side of the cam contact portion 16 and the hammer head 12, so that a component of the force on the cam necessary to produce the hammer blow is taken in tension and not in pure bending strain. This feature of construction is of importance, because the high speed of operation and the violence of the hammer blow when the hammer encounters the resistance of the diaphragm would otherwise cause crystallization and breakage of the lever.

The lever is yieldably urged in an anti-clockwise direction by the spring 17, which is seated against the flange 2, and a seating member 18 which is mounted on the shaft 7 and provided with a seating fork 19 and an upturned locating member 20, as shown in Figure 1. This detail is covered in my patent No. 2,369,535.

The pump diaphragm 21 is formed of synthetic rubber or the like with a cloth base, and is held in place between the flange 22 on the main actuator casting and a corresponding flange 23 on the valve body 24, which is provided with inlet and outlet connections 25 and 26, respectively. The diaphragm is clamped in position between the flanges, which are held together by any suitable means, such as bolts or rivets (not shown). The center portion of the pump diaphragm is rigidly held in between upper and lower diaphragm washer cups 27 and 28, respectively, which are, in turn, clamped between washers 29 and 30 riveted onto the shaft 31 as indicated in Figure 13.

The shape and curvature of the washers 27 and 28 are important and form a substantial part of my invention. The lower washer 28 has a slightly convex or conical central portion which is pressed flat in the assembly. The diameter of this washer preferably bears a relation to the working diameter of the diaphragm in the order of six to ten. The flat portion of the lower washer is surrounded by a curved flange 32 which has a sectional radius of approximately ⅛ inch.

The upper washer has a central conical portion approximately the same diameter as the oppositely disposed surface of the lower washer. This surface is surrounded by a flange 33 which is curved on a decreasing radius in such a manner that its cross section is a section of a parabola or ellipse. The full diameter of the washer 27 bears a relation to the working diameter of the diaphragm of approximately 8½ to 10, and the short radius of the ellipse which roughly corresponds to the curvature of the flange 33 is approximately one fifth of the full operating stroke of the pump.

Shaft 31 is provided with an upset head 34 at its free end against which is seated a metal washer 35. A thin, cushion washer 36 of shock-dampening material which is only slightly yieldable transversely, is positioned next to the metal washer, the diaphragm material mentioned being satisfactory, and a third washer 37 is made of hard plastic material such as a phenolic condensate product with highly polished surfaces. A discharge spring 38 having sufficient strength to move the diaphragm in one direction is compressed between diaphragm washer 30 and a metallic washer 39 which rests on a sealing washer 40 formed of synthetic rubber or other oil proof sealing material and slidably or snugly fitted to the shaft 31.

The sealing washer 40 is mounted on a seat forming shoulder 41 in the actuator casting. When mounted as shown in Figure 1, spring 38 acting against the diaphragm 21 has sufficient force to produce the pressure in the pumping chamber 42 which the pump is desired to maintain.

An auxiliary operating lever 43 rigidly mounted on a transverse rock shaft 44 having a cam surface 45, as indicated in Figure 1, is provided. The function of the member 43 is to permit the operator to manually rock hammer lever 6 to prime the pump or carburetor when the engine is not in operation.

A main air dome casting 46 is mounted on a diaphragm 47 against a seat in the side of the valve body 24. A cover member 48 containing a portion of the inlet air dome space 49 is held in position by the screw 50 which is threaded into the valve body to clamp the cover and the air dome in place. The inlet passage 51 extends into the valve body and up into the air dome in which it is surrounded by a baffle 52 which extends to a point substantially higher than the passage 53 leading to the inlet valve 54. The passage 53 is provided with an upstanding flange 55 over which is fitted the strainer 56, the latter being held in position by the boss 57 which extends inwardly from the top of the cover 48.

Space 58 above the inlet passage forms part of the inlet air dome. I have discovered that the relative volumes of the air domes and pump stroke have a definite bearing on the life of the diaphragm as well as capacity of the pump, and since these relative volumes form an important part of my invention, the following examples are given for the assistance of those skilled in the art in making and using the invention. If a particular automobile engine requires fuel delivered at the rate of 3 gallons per hour for cold starting when cranked at 40 R. P. M. or 20 pump strokes per minute and a maximum possible delivery of

29 gallons per hour at 4000 R. P. M. or 2000 pump strokes, I have found that satisfactory results can be obtained with the following approximate dimensions and proportions:

Working diameter of pump diaphragm inches	2.47
Maximum stroke of diaphragm ____do____	.25
Diaphragm displacement (full stroke) cc	10
Maximum stroke of diaphragm during high speed operation (2000 R. P. M.) while pumping liquid fuel only ________inches	.03
Discharge spring and exhaust restriction calibration to give diaphragm displacement during high speed operation while pumping liquid fuel only ____________cc	1
Intake air dome volume ______________cc	62
Outlet air dome volume ______________cc	15

The outlet air dome is closed against the admission of fuel by means of diaphragm 47. In order to give this diaphragm substantial working capacity, I form a substantial part of the air dome volume in a low chamber 59 which extends more than halfway around the base of the air dome casting and terminates in walls 60. In order to prevent unrestricted movement of the outlet diaphragm beyond the distance which it can be flexed with safety, I keep the ceiling over the major portion of chamber 59 low, so as to stop the movement of the diaphragm beyond a predetermined limit, and form the remainder of the volume in a chamber 61 which extends upwardly into the inlet dome space, as shown in Figure 1, but which does not have sufficient diameter to permit undue strain on the diaphragm 47. It will be understood that the greatest strain on the diaphragm 47 does not result from the pumping pressure exerted by spring 38, but from the vapor pressure which builds up as a result of heat when the engine is standing idle, just after a run in which the engine has been thoroughly heated up.

The construction of the valves has an important bearing on the life and operation of the pump. The design of the inlet valve according to my invention is more critical than the design of the outlet valve, because it has to operate at a much higher rate of speed, and also because it is required to perform a restricting function which will be described later. For convenience, I have made the exhaust valve identical with the inlet valve.

The valve (Figs. 5–10) comprises a cage 62 having a shoulder 63 which can be seated in corresponding bores formed in the die cast valve body. Struts 64 extend upwardly from the body member, and some or all of these struts are integrally connected with an annular spring seat and stop member 65, as shown in Figures 5 to 7. A shoulder 66 is formed in the member 65 to receive the spring 67 which normally holds the valve 68 in closed position. The stop portion 69 must be accurately and smoothly finished parallel to the valve 68 and also positioned in such a manner as to definitely limit the opening movement of the valve to a position substantially less than that which would be required to fully clear the passageway through the valve. The valve cage 62 is preferably formed of die cast material.

The valve seat member 70 has a shoulder 71 and is press-fitted into the bore 72 of the valve cage and firmly pushed up against the shoulder 73. A seat portion 74 of slightly conical shape, as indicated in Figure 10, is formed at the end of the valve seat member, and this is carefully lapped to a substantial line contact against the valve 68. This valve is preferably formed of phenolic condensate or other hard, plastic material on a cloth base which is very light so as to move with very little inertia and strike the seat 74 and stop 69 with very little kinetic energy.

Disk valves of the general type shown herein have been previously used, but they have not been satisfactory in regard to wearing quality, as well as for other reasons. It has been assumed by pump and valve engineers that such a disk valve lightly seated by a small spring against a metal seat would present minimum possibilities for wear. There appears to be no rubbing between the valve and the seat. Even in high speed operation, the small inertia of the light valve would seem likely to do no conceivable damage to the seat or to the valve stop.

In previous practice, valves have been subject to rapid wear and have actually worn out the seats and cages without any apparent reason. I have discovered that the cause of this is that the valve cage and springs of previous constructions cause or permit the valve to assume a slightly angular position with respect to the seat or stop during its opening or closing movement. If this occurs during the movement of the valve from one position to the other, it does not strike dead and flat, but strikes with a gyrating movement, the same as when a coin is dropped on a table. During this movement, there is a definite rubbing between the valve and seat which is the cause of the surprising amount of wear which has occurred in previous valves of this type. By carefully centering the disk with respect to the valve seat and the spring with respect to the valve, and making the seats and stops absolutely parallel when new, I have eliminated wear on the valves.

A feature of the invention is that the stop 69 is made circular, so that any wear on the valve is distributed on an annular surface. In this way, I avoid throwing the valve slightly out of parallelism with the seat, which would otherwise result from a slight turning of the valve.

I have also found that a previously unsuspected cause of the tendency of previous disk valves to tilt in operation has been caused by location of the pump fluid connections very close to and directly in line with the valves so that the pump fluid strikes the inlet check valve at an angle as it emerges from the inlet connection and leaves the outlet check valve at an angle as it enters the outlet connection. To avoid this cause of valve failure, I have located the inlet connections 25 and 26 with their axes in planes offset substantially from the valve disks. I also shield the inlet check with the inlet baffle tube 52 and inlet passage 53, so that the entering fuel will approach the inlet check in a direct line therewith. Fuel emerges from the outlet valve seat in substantially all directions around the outlet check through ribs 65 and thence passes from the large space below outlet diaphragm 47 to outlet connection 26. Thus, the fuel does not pass immediately from the inlet connection to the inlet check or from the outlet check to the outlet connection and cannot produce the tilting action mentioned.

Another important and unexpected advantage of the limitation of the movement of the inlet valves is increase in fuel delivery. The movement of the valves between the seat and stop in my design is so short that the reverse flow through the valve is negligible. I have discovered that by snubbing or limiting this movement, I am enabled to use a spring far lighter than those ordinarily used for similar purposes. In order to hold the end of the spring 67 in fixed position with respect to the valve to prevent wear, I counterbore the valve, as indicated at 75. This counterbore may be made of such a diameter as to snugly fit the end of the spring, but good results may also be obtained by making the shoulders of the counterbore with a radius or chamfer so as to centralize the spring with respect to the valve.

I have found that the movement of the valve between the seat and stop tends to occur with great violence, and that the valve should be made as light as possible, so that it will strike the seat and stop with minimum inertia. In order to keep the valve flat and straight, it must have a thickness of at least $\frac{3}{64}$'' at the rim, but by counterboring it, as shown, the diameter of the center can be reduced to approximately $\frac{1}{32}$'' or even less. The material used in making the valve should be as light as possible, and I have found that a hard plastic on a cloth base, such as Celleron, Formica, Micarta, or Spauldite, may be used with satisfactory results.

In designing the valve, I have discovered that it is important for a number of reasons to limit the opening movement, and I prefer to make the space between the valve seat and stop approximately $\frac{1}{10}$ of the diameter of the passageway controlled by the valve. The valve will still operate satisfactorily up to an opening movement of $\frac{1}{6}$ of the passage diameter after which further wear occurs very rapidly, resulting in the premature destruction of the valve. When the valve is new, I allow it to open only approximately $\frac{1}{10}$ of the passage diameter. Wear of the valve seat and stop eventually increases the opening to about $\frac{1}{6}$ of the passage diameter during the normal life of the pump, which is greater than the life of any automobile engine to which it is likely to be applied.

In case the wear should be excessive after extreme length of use, it is desirable to provide some means to prevent further wear on the stop. I accomplish this function by making the spring 67 of a sufficient number of turns so that it will go solid when the valve opening reaches approximately $\frac{1}{6}$ of the passage diameter, so that the opening of the valve cannot have become so great as to result in destruction of the valve due to the inertia which it would acquire in opening a substantial distance. It will be understood that the valve is opened by the flow of liquid and that the first part of the liquid flow is comparatively slow and gentle, so that by snubbing the valve movement during this part of the cycle, it is not subjected to the greater acceleration which it would acquire during the latter part of the impulse of fuel flow.

One very important function of the inlet valve is to permit free flow of fuel or vapor into the pump chamber during cranking of the engine, but to restrict the flow of fuel into the pump chamber during the intake stroke, at least during high speed operation, so as to produce a short period of low pressure in the pump chamber to lower the boiling point of the fuel, to cause some boiling in the pump chamber under incipient boiling conditions, whereby the lowered temperature resulting from partial vaporization of fuel in the pump chamber will be transmitted to the walls of the valve body to the fuel entering at the connection 25.

It will be noted that the fuel is led directly into this connection, so as to intimately contact and be cooled by the metal of the valve body before it passes into the dome 58 where it is comparatively insulated from temperature changes. The inlet port, of course, must be sufficiently large to admit the amount of fuel during most rapid operation which is required to operate the engine. Accordingly, I make this port considerably larger than would be necessary if the valve were permitted to open far enough to fully clear the port. As is well known, it is necessary that a check valve travel from its seat a distance of at least ⅓ the diameter of the seat to fully clear the same. By providing a much shorter valve stroke, as described, and larger inlet port I provide suitable capacity together with greatly increased valve life. The short valve stroke has another advantage in that it avoids the possibility of drawing air from the air dome space through the inlet valve in case of violent pumping action. The air and vapors in the inlet dome will lie above the quantity of fuel in inlet passage 53 and since this passage has more than sufficient volume to supply the pump during one inlet stroke, there is little or no possibility of air being drawn from the inlet dome downwardly into the pump chamber.

In operation, the lever 6 is held in the position shown in Figure 1 by means of the spring 17, so that one end rests on the cam 4, which preferably rotates in a clockwise direction. Turning the cam rocks the lever on the pivot shaft 7 which floats in the bearings 8 and 11. Assuming there is no resistance pressure or "choking" in the passage outlet, the spring 38 moves the diaphragm 21 to the position shown in Figure 1 until it is withdrawn by contact of the hammer 12 with the hammer pad or shock absorber 35—36—37.

The first part of the intake stroke of the diaphragm occurs rather slowly, due to the changing movement of the cam, and during this part of the movement, the intake valve 54 is opened to the full extent permitted by the stop 69. As the cam continues in its movement, the diaphragm 21 moves more rapidly, and the valve is firmly held in contact with the stop. This somewhat restricts the movement of the liquid during the central part of the stroke, and produces a sharp pressure drop in the pump chamber as shown in the diagram in Figure 19. The diaphragm or pump chamber 42 is eventually filled due to the dwell at the end of the stroke, and also due to the fact that this chamber is not emptied at each stroke except under very slow speed operating conditions. In other words, the cycle of fuel flow lags slightly behind the cycle of diaphragm operation and some vapor will appear in the pump chamber during incipient boiling conditions. During the next cycle of cam movement, which is somewhat less than 180°, if the rotation of the cam is clockwise, the hammer 12 is out of contact with the hammer pad (except during some cranking or vapor locking conditions), and the spring 38 returns the diaphragm 21 to discharge the fuel and any vapor through the exhaust valve 78. This valve functions in substantially the same way as the intake valve 54, although its movement against the stop does not tend to occur with such great violence, the spring 38 having limited force while the movement of the cam and hammer is substantially positive. The valve also serves as a restriction

on the amount of fuel discharged, so as to limit the gallons per hour which the diaphragm can be called on to pump, but without placing a corresponding limit on the amount of vapor which can be pumped to get rid of a vapor locking condition. The pump diaphragm is accordingly available to pump at least ten times as much volume of vapor as it will of liquid fuel. Of course, this would result in excessive strain and wear of the diaphragm and operating mechanism, except for the fact that vapor lock occurs only occasionally, and vapor does not present great resistance to the movement of the diaphragm.

During the exhaust stroke, the suction in the dome 58 refills the dome with fuel from the inlet 25, or at least brings in enough fuel to supply the next intake stroke of the pump. The exhaust stroke of the pump also displaces the diaphragm 47 evenly towards the top of the low chamber 59 and against the air in the chamber 61 so that the discharge of fuel from the exhaust of the pump can be continuous throughout the cycle. It will be understood that in a pump of this character, both the inlet and exhaust pipe lines are long and of small diameter, and the fuel has comparatively great inertia, so that without continuity of flow at high speeds, the diaphragm and operating mechanism would be subjected to severe stresses.

One of the most important features of the invention is the construction of the inlet 53 and air dome 58 in such a manner that the column of fuel which must be started in motion at the beginning of the intake stroke is of large diameter and very short, but of volume corresponding to a full charge for normal and high speed operation. Modern motor fuels have comparatively high vapor pressure, and the application of any substantial suction by the diaphragm has a great tendency to cause the fuel to separate or vapor lock. This would not be so important, except for the fact that when the fuel is separated, the vapor collects in bubbles which do not disappear as quickly as they form.

By the construction herein shown and described, the column of fuel present in the dome above the inlet valve is not much more than one inch long. Also, it has greater diameter at the surface than in the passage. By this means, the power required to accelerate the fuel column and the internal suction developed within the column, itself, are held to an absolute minimum.

The device according to this invention departs substantially from prior practice in the restriction at the inlet valve and at the exhaust valve The inlet restriction definitely limits or reduces the internal suction which can be placed on the fuel at the inlet side of the valve. The amount of suction on the fuel in the pump chamber on the other side of the restriction is increased, but the formation of vapor in the pumping chamber, if it occurs, does not appear to give any serious trouble, but on the contrary, its formation has a cooling action which is helpful in preventing the development of vapor lock. The diaphragm is capable of discharging the vapor at each stroke and it is not allowed to accumulate. This is because of the selective action of the restricted valve in passing vapor more freely than liquid fuel. Excessive pressure in the inlet air dome 58, 49 will lower the level of liquid in passage 53 and will be relieved eventually by pumping action, without, however, evacuating the inlet air dome because of the short stroke of the inlet check. Since both inlet and exhaust valves have a very selective action in passing a greater volume of vapor than of fuel, it is practically impossible to vapor lock the pump, and yet the diaphragm is not subjected to severe stresses or required to operate through more than a small fraction of its stroke during normal or high speed operation.

In the form shown in Figs. 20–25, inclusive, a modified pump is shown inverted from the position in the previous form with the domes located on the underside of the pumping chamber. The actuator housing 1 and main body 24 mounting inlet check valve 75 and outlet check valve 78 and forming pumping chamber 27 closed on one side by pumping diaphragm 21 are substantially identical with the corresponding parts in the previous form and will not be described in detail here. Dome-forming structure 110 is secured to the underside of main or valve body 24 and is of general cylindrical form with its transverse area extending substantially coextensively with the flexing part of the pumping diaphragm. A horizontal web 111 extends intermediately across the dome structure and has depressed side portions 112 on each side forming therebetween a diametral ridge 113.

Inlet connection 25 on the valve body opens into a cavity 114 aligned with a tubular passage 115 having its lower end opening into the space 116 beneath transverse web 111. A tubular boss 117 formed adjacent passage 115 in the dome structure forms an extension of inlet passage 118 in the main body and port 54 controlled by the inlet check valve. An elongated wire screen 119 is lodged in the diametral recess below central part 113 of the transverse web and between the floor of the same and a washer 120 resting on a boss 121 projecting from removable bottom wall or cap 122 of the dome structure and secured in place thereby. The dome structure itself is secured to the main body by a bolt 123 extending through a central boss 124 and having an internally threaded extremity 125. The lower cap is secured to the threaded end of bolt 123 by a capscrew 126.

Flexible sealing diaphragm 47a is secured between the main or valve body and the dome structure. The diaphragm is apertured to provide for inlet passages 115 and 117, as shown, but otherwise covers the dome structure. The elevated central portion 113 of transverse web 111 is slightly spaced beneath diaphragm 47a to form air space 59a which also extends laterally on both sides above the depressed portions 112 of the transverse web to form the outlet air dome between the web and diaphragm 47a. (See Fig. 24.) Diaphragm 47a, of course, separates the fuel emerging from the outlet port from the outlet dome space. On the other hand, inlet boss 117 projecting below transverse web 111 forms pockets at the sides thereof and above the open lower extremity thereof which traps a quantity of air and vapor to form the cushioning inlet dome between the web and the surface of liquid accumulated in the bottom of the casing 110. A tube 127 is lightly pressed into the lower end of the inlet 117 to form the lower portion of the inlet passage, providing greater dome space. The length of this tube is varied in accordance with the stroke of the pump for the particular engine to which the pump is applied, and both the capacity of the inlet charge chamber and the air dome may be thus regulated. Screen 119 provides for filtering fuel before it enters inlet tube 127 and the pumping chamber.

It should be noted particularly that inlet connection 25 and outlet connection 26 are disposed in both forms of the invention with their axes in planes substantially offset, respectively, from the inlet and outlet check valves. In the case of the inlet connection, this offsetting together with inlet passage 115 and tube 127 insures that the fuel entering the pump approaches the inlet check valve directly in axial alignment therewith so as to avoid any tendency to tilt this valve with attendant excessive wear thereof. In the case of the outlet check, fuel emerges therepast from the pumping chamber evenly in all directions so as to fill space 59b between diaphragm 47a and the outlet check and apply the pump pulsations evenly to the exposed part of the diaphragm. Thus, the pumped fuel does not directly enter outlet connection 26 from the outlet port of the pump so that any tendency to tilt the valve because of an immediate unsymmetrical change of direction of the pumped liquid is avoided. The tendency to tilt is much more serious in case of the inlet check in fuel pumps heretofore known and thus tubular inlet passage 127, 117, 118 is provided in connection therewith to avoid this tendency.

Figs. 24 and 25 show the modified pump inverted; in this figure extension tube 127 or inlet passage 117 is omitted, the inlet air dome forming beneath cap 122 on the dome structure and extending down to the approximate level of the top of the passage 117, the spaces about and at the sides of inlet boss 117 now being filled with liquid.

The modified form in Figs. 26–29, inclusive, is substantially flattened vertically to provide greater clearance for contiguous parts of the engine. Main or valve body 134 has a diametral rib 135 forming a pocket 136 adjacent outlet valve 78 on one side thereof and forming, with curved walls 137 of inlet passage 138, a pair of pockets 139 at the other side thereof. Walls 137 form a tubular inlet boss or passage, the open lower end of which is closed by a screen 140.

Dome-forming cap structure 141 has a transverse, diametral rib 141a which registers with main body rib 135 and forms pockets or recesses 142, beneath pocket 136, and 143 beneath pockets 139 and passage 138. Flexible sealing diaphragm 144, while extending entirely across the main body and dome-forming structure and clamped therebetween by screws (not shown) is cut out adjacent pockets 139 and inlet passage 138. Inlet connection 146 is formed in the dome structure and opens into pocket 143 and outlet connection 147 is formed on the body structure and opens into pocket 136. The axes of these connections are in planes disaligned from the axis of corresponding valves, as in the previous form.

In operation of the third form of invention, fuel entering pocket 143 is guided through screen inlet 140 and inlet passage 138 directly against inlet valve disk 75 and thence passes into the pumping chamber. Fuel is discharged past outlet check 78 into space 136 extending from side to side of the main body where its pressure is applied evenly to the exposed part of sealing diaphragm 144 and thence through outlet connection 147. Space 142 beneath diaphragm 144 and in the dome structure holds cushioning body of air which forms the outlet dome extending the full width of the dome structure. Pockets 139 at the sides of inlet passage 138 provide for trapping air or vapors on the inlet side to form an inlet dome.

This modification will operate in inverted position as in Figure 27, in which case pocket 143 in the dome structure traps cushioning air forming the inlet dome and the spaces 139 at the side of the inlet passage are filled with liquid which feeds the inlet passage and the pump. The outlet dome acts the same as before.

In order to insure similar operation in both positions the volume of the chambers 143 and 142 are equal and are so calculated and disposed with respect to the level and position of the rim of the walls 137 as to insure the maintenance of the same volume of air dome in any position.

In all forms, the pump and its valves operate to provide maximum capacity, vapor elimination, and long wear. Moreover, the form shown in Figures 26 to 28 may be operated in tilted or inverted position, according to the demands of the particular installation, without losing any of the advantages thereof.

The invention may be modified in various respects as will occur to those skilled in the art and the exclusive use of all modifications as come within the scope of the appended claims is contemplated.

I claim:

1. In a fuel pump, a pumping chamber having movable and stationary walls, dome structure formed on said stationary wall opposite said movable wall, an outlet valve mounted in said stationary wall adjacent said dome structure, a flexible diaphragm extending across said dome structure, and a fluid connection in said dome structure, there being an unobstructed path directly between said connection and said valve and the axis of said connection being in a plane offset substantially from the axis of said valve whereby the pumped fluid emerging from said outlet valve is substantially unaffected by the stream of fluid entering said connection from said dome structure.

2. In a fuel pump, a pumping chamber having stationary and movable walls, inlet and outlet check valves mounted in said stationary wall, dome structure formed on said stationary wall opposite said movable wall, a passage member for conducting fluid from said dome structure in line with and into said inlet valve, inlet and outlet connections opening into said dome structure, there being unobstructed paths directly between said connections and said inlet and outlet check valves, respectively, and the axis of each of said connections being substantially disaligned from the axis of the corresponding check valve.

3. Fuel pump structure as described in claim 2 in which said dome structure includes parts forming inlet and outlet domes arranged symmetrically adjacent said inlet and outlet check valves but extending laterally substantially therebeyond.

4. A fuel pump as described in claim 2 in which said dome structure includes partitioning forming separate inlet and outlet domes, both of said domes extending substantially the full diameter of the movable wall of said pump and said outlet dome including a flexible diaphragm.

5. In a fuel pump, a pumping chamber having a diaphragm mounted therein, inlet and outlet check valves mounted opposite said diaphragm, and a dome body mounted opposite said valves from said diaphragm and substantially coextensive in transverse area with said diaphragm, said body including wall structure forming an inlet dome located above said inlet valve and an outlet dome with a portion pocketed into said inlet dome and a portion extending laterally from said outlet valve and pocketed portion and beneath said inlet dome to provide substantial additional outlet dome space.

6. A fuel pump as described in claim 5 further including a flexible diaphragm in said outlet dome intermediate said outlet valve and said wall structure and extending fully across said pocketed and laterally extending portions.

7. In a fuel pump, a main body having a flexible pumping wall and a stationary wall, inlet and outlet check valves mounted in said stationary wall, a dome forming body mounted adjacent said main body, a flexible diaphragm secured between said bodies and on the one side of said stationary wall opposite said flexible wall, registering tubular wall structure in said bodies forming a continuous inlet passage extending from said inlet check downwardly into the lower portion of said dome forming body and through said diaphragm, a transverse web extending across said dome forming body and around said inlet passage and dividing said dome forming body into a lower inlet dome and an upper outlet dome, said inlet dome communicating with said inlet passage and said outlet dome being adjacent and exposed to said diaphragm, means securing together said dome forming body, said diaphragm and said main body, a fuel inlet connection in said main body, passage means in said main and dome-forming bodies connecting said inlet connection to said inlet dome, a fluid outlet connection in said main body communicating with the space between said outlet check valve and said diaphragm, a filter screen in said inlet dome between said inlet connection and said depending inlet passage, a removable bottom wall for said dome forming body, and a means securing said bottom wall and screen to said dome-forming body.

8. In a fuel pump, a main body having a flexible pumping wall and a stationary wall, inlet and outlet check valves mounted in said stationary wall, a dome-forming body mounted on said main body opposite said flexible wall, a transverse web extending intermediately across said dome-forming body, continuous tubular wall structure extending from said inlet check valve through said transverse web, an inlet fuel connection in one of said bodies and communicating with the space in said dome-forming body with which said inlet passage means connects, said transverse web having a diametral depression and raised portions on each side thereof, a removable end wall for said dome-forming body, an elongated screen lodged in said diametral depression and between the same and said removable end wall, and means attaching said end wall to said dome-forming body and thereby securing said screen in position.

9. A fuel pump as described in claim 8 in which said dome-forming body and the dome spaced adjacent said transverse web are substantially coextensive in transverse area with said flexible pumping wall.

10. In an invertible fuel pump, means forming a pumping chamber having a flexible pumping wall and an opposite, stationary wall, inlet and outlet check valves in said stationary wall, an inlet fuel connection communicating with said inlet check valve, means forming an inlet vapor dome adjacent said pumping chamber, and a tubular element detachably secured to said stationary wall and extending from the vicinity of said inlet check into said inlet dome, said tubular element being removable when the pump is

used in inverted position with said element extending upwardly and said tubular element is unnecessary to maintain an inlet dome.

11. A fuel pump as described in claim 10 in which space is provided adjacent said removable tubular element and communicating therewith in the upper part of said dome structure serving to trap a cushioning body of air as an inlet dome.

12. In a fuel pump, means forming a pumping chamber having a flexible pumping wall, inlet and outlet check valves for said chamber, dome-forming structure adjacent said chamber, a transverse wall extending across said dome structure and forming separate inlet and outlet domes, respectively, adjacent said check valves, a pocketed end wall for said dome structure having cavities forming extensions of said inlet and outlet domes, and means securing together said pumping chamber forming means and said end wall structure.

13. In a fuel pump, a main body structure having a flexible pumping wall and inlet and outlet ports controlled by check valves, dome-forming structure beneath an inlet connection in one of said structures, a tubular inlet passage extending from said inlet port into said dome-forming structure, and a substantial pocket at the side of said inlet passage and also communicating with said inlet connection for trapping a volume of vapor and air as an inlet air dome.

14. An invertible fuel pump of the vapor dome type comprising a main body structure having a flexible wall and inlet and outlet ports with controlling check valves, a dome-forming structure adjacent said main body and having pockets located, respectively, opposite said ports, a wall in said dome structure separating said pockets, and a tubular inlet element projecting from said inlet port and opening into one of said pockets, said last-mentioned pocket having substantial portions at the sides of said tubular element and beyond the open end thereof, said portions serving for trapping volumes of dome-forming vapors, respectively, when said dome structure is mounted below or above said main body structure.

15. In a fuel pump, a body structure having a flexible pumping wall and inlet and outlet ports with controlling valves, a dome structure mounted adjacent said body, a flexible diaphragm secured between said body and dome structure, a rib extending across said dome structure and forming separate cavities therein, a tubular inlet passage element extending from said inlet check valve through said diaphragm into one of said cavities, a fluid inlet connection communicating with said last mentioned cavity, the other cavity extending along said diaphragm and forming therewith a cushioning outlet air dome extending in juxtaposition to said outlet valve.

16. In a fuel pump, a main body structure having a flexible pumping wall and an opposite stationary wall, inlet and outlet ports in said stationary wall controlled by check valves, dome-forming structure beneath said main body structure, an inlet connection in one of said structures, a tubular inlet passage on said stationary wall and extending from said inlet port into said dome-forming structure, and a substantial pocket at the side of said inlet passage and also communicating with said inlet connection for trapping a volume of vapor and air as an inlet air dome.

17. In a fuel pump, a main body structure having a flexible pumping wall and a stationary wall, inlet and outlet ports in said stationary wall and check valves for said ports, a dome-forming structure adjacent said main body structure, registering ribs traversing said structures and forming inlet and outlet pockets each open to one of said valved ports, an inlet fuel connection in one of said structures and opening into said inlet pocket, and a tubular inlet passage extending from said main body structure adjacent said inlet port and opening into said inlet pocket, said inlet pocket having portions within said main body structure and at the sides of said inlet passage and also in said dome structure beyond the open end of said passage to form fuel trapping and inlet vapor dome spaces between said inlet port and said inlet connection.

18. A fuel pump as described in claim 17 in which the pump is mounted with said dome structure depending therefrom, said tubular inlet passage extending downwardly into said inlet pocket and the pocket portions in said main body structure at the sides of said passage serving to trap a substantial volume of vapor to form an inlet dome.

19. A fuel pump as described in claim 17 in which the pump is mounted with said dome structure above said body structure, the upper end of said tubular inlet passage opening into the inlet pocket portion in said dome structure and the inlet pocket portion above said open end of said inlet passage serving to trap a volume of vapor to form an inlet dome.

20. A fuel pump as described in claim 17 further including a flexible diaphragm traversing said outlet pocket and received between said main body and dome structures, said diaphragm sealingly trapping a quantity of gaseous fluid in the portion of said outlet pocket opposite said outlet port and forming therewith a resilient outlet dome.

21. A fuel pump as described in claim 17 in which said main body and dome forming structures are of circular section, said registering ribs being substantially diametral so as to form similar spaces on opposite sides thereof for pocketing.

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