

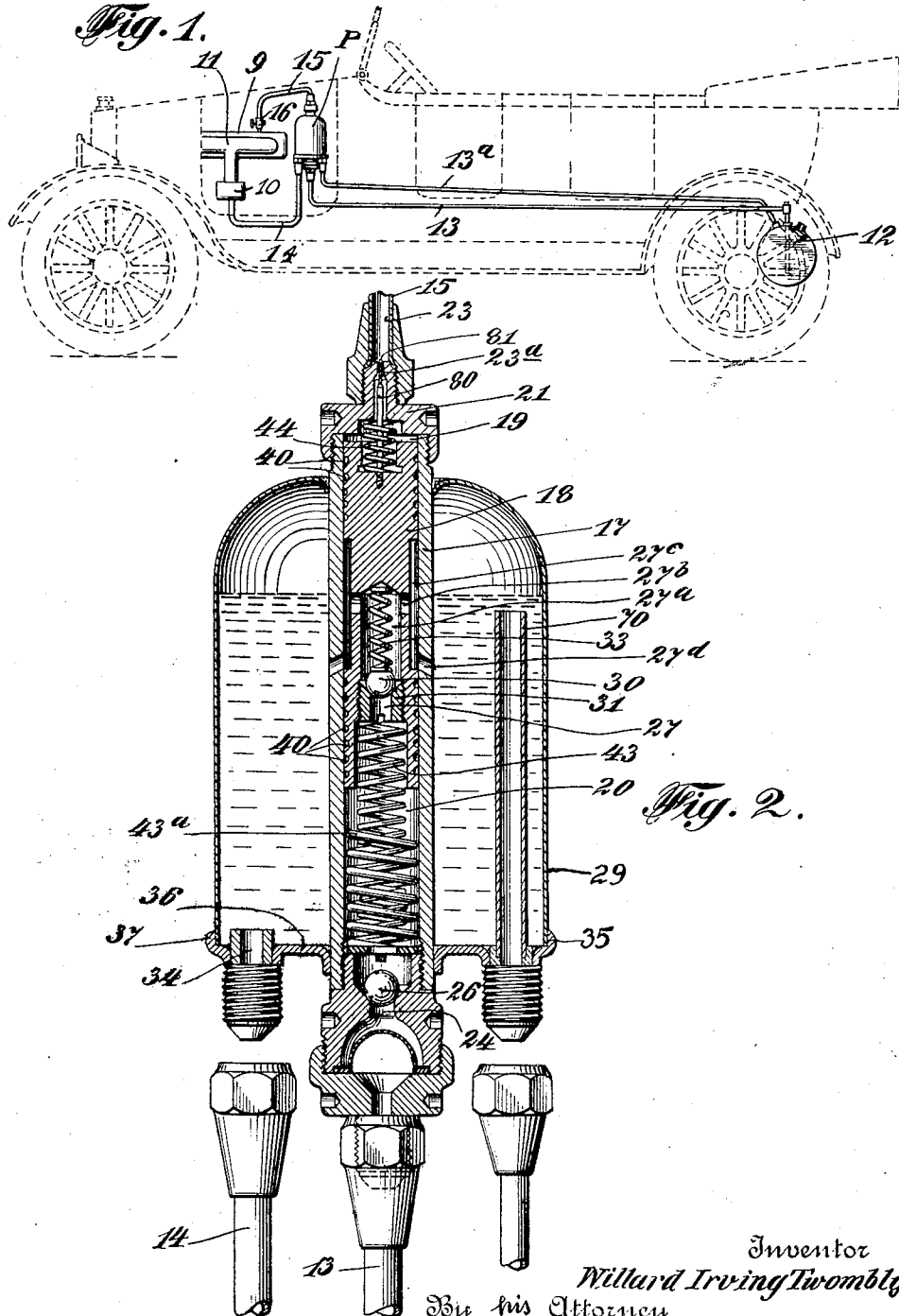
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LIQUID FEEDING MEANS AND METHOD.

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LIQUID-FEEDING MEANS AND METHOD.

Application filed March 27, 1920, Serial No. 369,380. Renewed July 10, 1922. Serial No. 573,925.

To all whom it may concern:

Be it known that I, WILLARD I. TWOMBLY, a citizen of the United States, and resident of Newark, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Liquid-Feeding Means and Methods, of which the following is a specification.

This invention relates to means for feeding liquid, as for instance, liquid fuel or gasoline, from a source of supply to a reservoir and to the intake of an engine such as the carbureter of an internal combustion engine.

The device, as shown herein, is adapted for the same general purposes, and embodies, in a new way, certain of the features of construction and operation set forth in my prior application, Serial No. 197,589, filed October 20th, 1917.

The general purpose of the invention is to provide improved liquid pumping means operable from the movements of the engines, which means are simple and cheap in construction and efficient in operation.

Heretofore, in apparatus of this character, it has been the practice to connect a reservoir to the intake manifold of an engine and to utilize the suction of the piston of the engine to apply a vacuum directly to the surface of the fuel in the reservoir. There have also been attempts to employ a diaphragm pump directly connected but such attempts have been practical failures for many reasons which will become evident from a consideration of my practical, fool-proof device herein disclosed.

One object of this invention is to provide a pump having a pump element operable by a wide range of varying pressures and speeds of the engine; and an important feature is employing as the pumping element, a projectile or freely movable, spring returned piston.

The pump is preferably associated with a reservoir having the pump located therein and preferably extending therethrough. Preferably the reservoir is cylindrical and has the pump cylinder axially disposed therein, the pump cylinder is vertically arranged, preferably the intake for the liquid opens upwardly into the lower end of the

cylinder; the outlet into the reservoir is through the lateral wall of said cylinder; and the inlet for application of pressure from the combustion chamber of the engine, is through a constriction at the upper end of said cylinder. Preferably the pump cylinder is rigidly secured water-tight, through the bottom of the reservoir and the upper end of the pump projects through and serves as securing means for clamping the cover or closure on said vessel.

Several important features of the invention relate to making it successfully operative under certain conditions likely to arise in practical operation of the device, as for instance, when there is no liquid in the supply line because the tank has become empty, or the pump valves have leaked. To meet such conditions, it is important the pump be able to act effectively as an air pump to vacuumize the line and draw up the liquid, and, for subsequent successful operation at high speeds of the engine, it is necessary that the last remnants of air be expelled from the pump cavity so that the piston will act on an incompressible body of fluid, namely, all liquid, without any trapped air or gas.

For effective air pumping the inlet valve into the pump chamber is preferably an upwardly-opening, gravity-seated ball, and, in order to avoid trapping air, the inlet passage opens upwardly.

The port through which the liquid is expelled from the pump cavity and the outlet valve therefor have certain peculiarities particularly adapting them to serve both the above purposes. The outlet port opens upwardly from the topmost portion of the pump cavity which, in this case, is the pump face of the piston, so that any air or other gas rising to the top of the liquid, will be automatically pumped out and expelled into the reservoir, thus leaving only incompressible liquid for action of the pump at high speeds.

Preferably, the outlet valve is also located in the piston and is arranged to lift and seat in alignment with the reciprocating movements of the piston, so that the inertia of the outlet valve is caused to assist in seating it at the end of each expelling outstroke and

beginning of the lifting return-stroke of the piston, and in unseating it at the end of each lifting stroke and beginning of the expelling stroke.

5 The higher the speed of the piston and the more sudden the starts and stops of the strokes, the more powerful this inertia effect will become. This inertia effect may be very great in the present case because the
10 piston is a projectile or flying piston, the speeds of which are free from control by any rigidly acting driving connection, and the starts and stops must occur as often as 4 or 5 times per second, for idling speeds,
15 up to say 80 to 100 or more times per second, for high speeds. Moreover, the self-seating inertia effect will be greatest when it is most needed, that is, when the engine speeds are highest, and also when the piston
20 is pumping air. The air is relatively inefficient for seating and unseating the valve, but since it affords enormously less resistance to the piston, it promotes higher piston velocities, thereby making inertia more effective in its seating and unseating action.

By making the piston chamber long as compared with the normal or average stroke of the piston, and the springs for returning the piston correspondingly long
30 the pump is rendered automatically self-accommodating for a wide range of engine pressures and speeds.

The several improvements above described result in a pump that is capable of
35 operating at all times under all conditions of use of the engine, from mere cranking to start the engine, up to the highest operating speeds, or lightest to heaviest loads.

As a result, I am able to reduce the
40 size and capacity of the reservoir down to a point where it need be no more than a pressure equalizing chamber to steady the intermittent supply of liquid afforded by the strokes of the continuously operating
45 pump. The pump delivers continuously a supply of liquid greater than the engine can use and the excess is returned to the tank.

In this connection an important feature
50 of my invention consists in hermetically sealing the upper part of the reservoir to establish a continuous internal pressure driving the excess liquid back through the overflow standpipe, to the supply tank.
55 This latter feature of pressure return of the overflow excess is of greatest practical importance since it makes possible the employing of a small inexpensive return pipe, whereas a gravity overflow return would require a much larger, prohibitively expensive pipe. Moreover, the troublesome and expensive floats and control valves are dispensed with as also the vent in the top of the reservoir which so commonly operates
65 to permit escape of gasoline whenever the

float or float controlled valves get out of order.

In the drawings accompanying and forming a part of this specification.

Figure 1 is a diagrammatic view showing 70 an embodiment of my invention applied to a motor vehicle utilized to lift gasoline from a tank and deliver it to the carburetor of an engine, the tank being located at a point below the carburetor;
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Figure 2 is a sectional side elevation of an embodiment of a pumping mechanism combined with a pressure chamber for use in connection with my improved fuel or gasoline feeding means.
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In Figure 1 of the drawings, I have shown an embodiment of my invention applied as a fuel or gasoline feed in connection with a motor vehicle, the motive power of which is the usual variable-throttle, variable-speed internal combustion engine 9 to which is connected a carburetor 10 by a manifold 11. A fuel or gasoline supply tank 12 located at the rear of the vehicle at a point below the carburetor, with my improved means (designated in a general way by P) to draw the fuel from the tank and deliver it to the carburetor of the intake of the engine in position between said tank and carburetor, the tank being connected thereto by a supply pipe 13 and an overflow return pipe 13^a; and the carburetor by a pipe 14. The pump is connected by a pipe 15 to the combustion chamber of the engine, such as the opening for the priming cup for the engine, as shown at 16.
90 100

The means to draw and deliver the fuel from the tank to the carburetor or engine is operable by the varying pressures in the combustion chamber of the engine, such as during the power and compression strokes, or the suction and exhaust strokes, of the engine piston, and in the form thereof shown in Figure 2, includes a reservoir 29.
105

The reservoir 29, is preferably a cylindrical, drawn metal cup, in which the pumping mechanism is axially located, said reservoir having an outlet 34 to which the pipe 14 leading to the carburetor is connected. The reservoir is closed by a bottom piece 36 having an annular flange 37 soldered or brazed to the lower edge 35 of the receptacle. The top and bottom have central openings through which the pump 17 extends and in which it is secured air tight, as by soldering or brazing.
110 115 120

The pump comprises a cylinder 17 in which there is mounted a reciprocable piston 18, said piston separating the cylinder into a motive chamber 19 and a pump chamber 20. The motive chamber has a motive fluid inlet 23 through the removable closure 21 of the cylinder 17 and to the threaded projection of this closure 21, is connected the pipe 15 whereby the motive chamber
125 130

has a conduit connection with the combustion chamber of the engine cylinder. It will be noted that the motive pressure inlet 23 has a constricted portion 23^a of extremely small diameter as compared with that of the pump chamber, say $\frac{1}{8}$ inch for a $\frac{3}{8}$ inch pump chamber. This would make the cross-sectional area of the cylinder 400 times that of the constriction, but it will be understood that this may be varied to suit the conditions and purposes in view.

The pump chamber 20 has an inlet 24, connected through a coupling and pipe 13, with the tank 12, the inlet opening upward into the pump chamber 20 and being normally closed by an upwardly-opening gravity-seated valve 26.

The piston 18 is usually formed to fit the pump cylinder 17 closely enough so that no packing is necessary, an easy sliding fit with a clearance of one to two thousandths of an inch being sufficient to operatively withstand the pressures in the motive chamber, 19. I prefer, however, to employ oil grooves 40 about $\frac{1}{8}$ inch in diameter spaced one-eighth inch apart and if desired, the piston may be provided with a cup leather packing. The piston body is preferably made of great length as compared with its diameter so that there can be no tendency for it to become cocked in the cylinder even when reciprocating most violently.

The pump end of the piston is preferably formed with an outlet 27 for discharge of the pump fluid and the outlet valve 30 is preferably located in the piston for reasons explained above. A convenient way of forming the pump end of the piston is to drill it axially from the lower end to a diameter suitable for the chamber of the outlet valve 30 with sufficient clearance for flow of fluid around the sides of the valve. Then the spring 33 and valve 30, which is preferably a ball, being inserted, a screw bushing 31 formed with a valve seat and port is screwed in behind the ball. Preferably a spring 33 is provided to press the valve 30 toward its seat. The upper portion of the outlet valve chamber 27^a is provided with outlet ports 27^b drilled through the walls of the piston. As these ports are in, and necessarily travel with the piston, a wide annular groove 27^c is formed outside the piston, the width of the groove being such that during normal operation, some portion of it will always register with ports 27^a which are drilled through the wall of the pump cylinder, preferably at a downward slant so that the discharge of the liquid into the reservoir will be downward. By varying the width of groove 27^c, the limit of the piston stroke may be controlled, since movement of the piston to a position where the ports 27^a are covered, cuts off further escape of liquid from the pump cavity.

It will be noted that in this piston, the

pumping or liquid-sucking surface comprises the lower surfaces of piston 18, bushing 31 and ball 30, while the liquid expelling surface is the upper surface of groove 27^c and the top of drilled hole 27^a. Also that similar functions could be served by other constructions affording the necessary relations of liquid sucking and expelling surfaces with interspace containing the pump chamber outlet and outlet valve.

The piston is yieldingly maintained toward the uppermost end of the cylinder 17 by a long spring 43. This spring is compressed by the piston on the compression and explosion strokes of the engine cylinder and serves to return the piston when the pressure in the motive cylinder decreases during the exhaust and suction strokes.

During the pressure strokes of the piston of the engine, the pressure will be transmitted through the connection 15 to the motive chamber 19 of the pump cylinder 17, from the combustion chamber of the engine cylinder, and will be exerted on the end of the piston 17, and through the latter on the fluid in the pump chamber. This will seat the inlet valve 26 and unseat the outlet valve 30 thereby cutting off the tank and opening communication between the pump chamber 20 and the reservoir 29. During the suction strokes of the engine piston with the consequent reduction of the pressure in the connection 15 and in the motive chamber 19, the spring 43 will move the piston toward the upper end of the motive chamber, and, the valve 30 having automatically seated by gravity, inertia and spring 33, the return movement of the piston 18 will create a vacuum in the pump chamber 20, thereby unseating the valve 26 and drawing the fuel from the tank 12, through the connection 13, into the pump chamber. This latter movement of the piston 18 may also be facilitated during the suction stroke of the piston of the engine by the creation of a vacuum in the motive chamber.

Where the speed of operation of the engine is fairly uniform or is not too fast, as for instance, on certain types of stationary engines, the spring may be made strong enough so that the return stroke of the pump piston will always be completed.

For the preferred use on automobile engines, however, the spring 43 is preferably made yielding enough to permit a substantial pumping stroke even when the pressures in the engine cylinder are weak, as for instance, when idling with nearly closed throttle or when the engine is being cranked. Such a spring becomes progressively stiffer when increasing engine pressures give longer outstrokes of the pump piston. I have discovered, however, that this spring may be made more yielding and more sensitive for the light pressures, when employed in con-

junction with a supplemental stiffer spring 43^a which, as will be seen from the drawings, is of substantially shorter length and range of action. With this arrangement, spring 43 may be made only so stiff as is necessary to lift the load of gasoline in the supply line at slow speeds, and spring 43^a need not function at all when the pressures are low and the stroke is short; but when the motive pressures become more violent and the stroke longer, spring 43^a will afford a supplemental increasing resilient restoring power additional to that obtained by the increasing compression of spring 43.

At the motive end of the piston is a bumper spring 44 of shorter length and range than those just described. It is interposed between the piston and the closure end 21 of the motive chamber, to prevent the upper end of the piston from striking against the end of the chamber and making clicking or knocking noises. When it strikes the end of the chamber, it is compressed and its subsequent recoil and expansion assists the next out-stroke.

The reciprocation of the piston 18 synchronizes with the suction and compression strokes of the engine piston, and the stroke of the piston 18 is regulated in accordance with the pressure in the engine cylinder. For instance, should the throttle valve for the fuel intake of the engine be closed with consequent low pressures in the engine cylinder there will be a low pressure in the motive chamber of the cylinder 17 and a short motion or out-stroke of the piston 18, and as the throttle valve for the engine intake is opened with the consequent increase of pressures in the engine cylinder, there will be a corresponding increase of the pressures in the motive chamber of the cylinder 17 and a longer out-stroke imparted to the piston 18.

It will be evident, however, that for use on an automobile engine, springs 43, 43^a which will be yielding enough to permit efficient pumping movement of the piston for the lower and medium pressures and speeds of the engine, will function somewhat differently when the engine is operating at high speed. Such a spring can complete the return stroke if the motive pressure is relatively low so as to give short out-strokes or if the speed of the engine is slow so as to give the spring time to do its work. But where high engine pressure, giving a long out-stroke, is combined with high engine speed giving a short time for the spring to work, there will be only time enough for a portion of the return stroke, the slower final part of said stroke being cut short by a succeeding explosive pressure. Consequently, with increasing pressures and speeds, the piston continues to reciprocate in response to the variations of pressure, and the length of the stroke may be approximately the same

or may be less, but the range of the stroke tends to shift toward the spring to a position where the spring operates under a uniformly increased range of maximum and minimum pressures.

There may be a similar effect due to the above-described constriction of the inlet passage 23^a. This constriction serves to moderate on the pump piston, the violence of the engine explosions, but it also tends to average up the low pressures as well as to average down the high pressures, and this tendency becomes more pronounced with increasing speeds of the engine. Hence, though the pressures in the engine cylinder continue to alternate between pronounced vacuum and high pressure, at high speeds the pressures on the pump piston tend to become pulsating, that is, they are above atmosphere even during the vacuum strokes of the engine. This pulsating excess pressure at high speeds also tends to force the pump piston toward the spring thereby compressing the spring until a position is reached where the spring is under a continuous minimum compression equal to the continuous minimum pressure in the motive chamber.

The piston continues to reciprocate in response to the variations of pressure, and the length of the stroke may be approximately the same or may be less, but the range of the stroke is shifted enough to make the spring return strokes more powerful and therefore quicker acting.

Making the spring 43 of great length and providing a long clearance or pumping space in the cylinder, as shown in the drawings, affords a considerable range for the above described shift of position of the stroke of the piston and corresponding increase of spring stiffness. It is one good method of rendering the device automatically self-accommodating for the wide range of engine speeds and pressures practically necessary in the operation of automobile and similar internal combustion engines. For a considerable range of engine speeds the length of the stroke will be determined by the differences of pressure during each cycle of explosion, exhaust, suction and compression in the engine, changes in the speed being taken care of to a large extent by the automatic shift of the position of the stroke to a position where the spring is quicker acting.

The spring 44 on the opposite end of the piston, is of shorter length and shorter range of action than spring 43. It functions only when conditions are such as to permit complete return stroke of the piston on each suction stroke of the engine and this, as will be evident, is at the lower engine speeds and pressure, particularly at times when the speeds and pressures are low enough for establishing a vacuum, or below-atmosphere, pressure in the motive chamber of the pump

during each suction stroke of the engine. At such times the spring 44 is compressed by the suction stroke of the piston. Then, as soon as the suction is relieved, the expansion of spring 44 initiates and assists the subsequent expansion stroke. In this way the short spring 44 acts during times of alternating suction and pressure on the piston, in a manner somewhat analogous to the action of spring 44 during times of continuous pulsating pressure.

The inlet and its valve and the outlet and its valve have peculiarities which in combination contribute to the efficiency of the pump, especially when used for its preferred purpose as a fuel pump on an automobile engine. The explosion strokes in any one of the cylinders of an automobile engine will vary from say 3 or 4 per second for idling, up to say 40 or 50 or more per second for high speed operation. Obviously, in such operation, any delay, even for a small fraction of a second, in the closing of the inlet valve will permit appreciable slip or backflow of liquid to the tank.

The effectiveness of inertia in seating the outlet valve under such conditions has been explained above. The cooperating inlet valve 26 is a free, gravity-seated ball. It is a simple and very effective means of getting the quick, free, low-resistance opening of the inlet which is very desirable at all times, and particularly so when the supply pipe is empty and the gasoline must be lifted by first pumping air; but the ball form and absence of spring pressure tend to make it slow-closing. Hence the outlet 27 is of smaller diameter and of greater fluid flow resistance, than the supply inlet 24; also the piston outlet valve is forced to closed position by spring 33. The smaller size of the outlet port and the spring pressure on the valve both contribute to making the outlet of higher resistance than the inlet. This gives a back-pressure on the outlet, with the result that the high speed movement of the piston under the explosive pressure from the engine, taking effect on incompressible liquid, piles up a sufficient back-pressure on the inlet valve to force it tight down on its seat at the very beginning of the expelling stroke of the piston.

With the above described perfections of construction, relative arrangement and proportioning of parts, it will be possible for one skilled in the art to attain any desired degree of efficiency in pumping either for intermittent or continuous supply under any and all practically possible conditions. Where the conditions are not exacting, as for instance, where there is reservoir capacity sufficient to bridge over the short periods of inaction of the pump or where the engine is of relatively uniform speed or low speed as for instance a stationary engine

controlled by a hit and miss governor, it will not be necessary to employ any more of my novel features than may be necessary for the purpose in view. An important point, however, is that even though the conditions be extremely exacting, my invention provides means whereby the pump may be made continuously acting. Thus, for instance, on a variable-throttle, variable-speed automobile engine, the pump may be made to operate on merely cranking pressures and suction in the engine and may be made to pump when the supply line is empty so that, at first, air must be pumped in order to apply suction to raise the liquid from the rear tank.

A most important feature of my invention is that having achieved a continuously and adequately operable pump, I utilize it so as to get rid of many causes of trouble and danger commonly found in all prior devices of this type, including the following:

The continuously acting pump renders large reservoir capacity unnecessary and this element of the device may be reduced to a small, inexpensive pressure chamber of such capacity as may be necessary to steady the flow of liquid from the pump to the carbureter. Floats and valves and reservoir vents for controlling the level of the liquid in the reservoir with all the attendant expense, danger of flooding, fire hazards and gasoline waste may be completely eliminated.

While this apparatus, and particularly certain features thereof, are of considerable novelty and importance independently of any special refinements in the method of operation, one of its important advantages is its capability of being proportioned and arranged for operation by a special method involving peculiar advantages.

For instance, the natural way to design the device would be to have the pump designed for pumping only a small surplus above the maximum demands of the carbureter and the overflow return pipe designed for a drainage capacity large enough to drain off this surplus thereby keeping down the liquid substantially to the level of the outlet. Perfect operation by this method requires a large drain pipe which is expensive and cumbersome. On the other hand, if the drain pipe is designed of a size only sufficient for drainage of the average surplus liquid, it will be flooded at times when the over-supply is a maximum and will be empty or only partly filled at other times.

I have discovered, however, that in practice, there are disadvantages in having a drainage pipe which is never filled and a still greater disadvantage in one which is sometimes full and sometimes not. This is particularly true where the apparatus is used to pump from a low level rear tank on an automobile to a higher level pressure chamber on the forward end.

Under such conditions, if the overflow pipe is not filled with a solid column of liquid, the work required of the pump will be widely variable. When the automobile is on a level, the work of the pump will be lifting liquid say 18 inches or perhaps 3 feet at the most. Going up a steep grade, this height may be doubled thereby doubling the work of the pump. Going down hill this height will be much less thereby correspondingly decreasing the work of the pump. It will therefore pump more gasoline at the very time when the gravity drainage pipe has become least efficient because its tank outlet end has been raised. Hence, the liquid will accumulate in the reservoir and will rise above the top of the stand pipe until an internal pressure is developed sufficient to blow the excess out through the return pipe with little or no help from gravity. This variable shifting of the load of the pump from all in the lift pipe to part or all in the drainage pipe is attended with notable variations in level of the liquid in the reservoir as well as variations in the internal pressures of the air trapped in the top of the reservoir. This is at its worst where the automobile is alternately proceeding up and down steep grades, so that the back pressure of the full drainage pipe going down hill is followed by a substantial suction due to a sudden reversal of inclination of the filled overflow pipe upon going up hill and the resulting emptying of said pipe by gravity.

As contrasted with either the small-surplus-ample-drainage method, my invention contemplates making the pump of such large pumping capacity and the overflow return pipe of such small size that under normal average conditions of speed, load and throttle opening, the supply will exceed the maximum demands of the carbureter plus the gravity drainage capacity of the return pipe, and will afford a surplus sufficient to swamp the outlet and keep the return pipe filled with a solid column of the liquid, during normal operation. The over-supply first swamps the outlet and then the liquid goes on rising to a height predetermined by the size of the compression space in the top of the reservoir and by the back pressure due to the under-size of the overflow return pipe. The rising pressure in the top of the reservoir assists gravity in forcing the liquid through the return pipe at increasing speeds thereby increasing the capacity of said return pipe to the extent required. I take care of the over-supply.

By this method, the normal or average condition of operation of the pump and the internal pressures in the reservoir, becomes approximately constant. When the device is at rest, the liquid can drain off to the exact level of the overflow stand-pipe and

any excessive internal pressure or vacuum can be relieved by vent to the atmosphere through the rear tank. Upon starting of the pump, however, the over supply of liquid submerges the outlet and fills the return pipe with a solid column of liquid.

In this situation, the total load on the pump comprises two continuous loads which may be made normally equal if desired. These two loads are the suction load through the lift pipe from the tank, and the back-pressure or force-pump load through the return pipe to the tank. The suction or lift pipe load will be the frictional resistance plus the gravity resistance or static head of the lift column in the supply pipe, while the back-pressure or force-pump load will be friction minus the static head of the drop column through the return pipe. That is to say, the gravity component of the pump load is measured by the difference in the static heads, and when the return pipe is kept full this is merely the vertical distance from the surface of the liquid in the rear tank, up to the level of the return outlet in the top thereof.

This distance is small and is substantially independent of the height of the reservoir above the tank. Hence when the system is used on an ordinary automobile, as indicated in Figure 1, any changes in the inclination in the automobile will not materially change the load on the pump. For instance, if the automobile goes up a steep grade, so that the pump has to lift the liquid against a static head 3 feet greater than before, the return pipe corelatively will have the same increase of static head applying a correspondingly increased suction decreasing the back pressure on the pump.

If, on the other hand, the automobile goes down a steep grade thereby reducing the work of pumping into the reservoir, the equal and opposite change of the static head in the return line will increase the back-pressure load by substantially the same amount that the suction load has been decreased in the supply line.

Thus the continuous force feed return against back pressure, ensuring a normally full return pipe, makes the work of the pump approximately independent of the angle of upward or downward pitch of the car. Moreover, the work of the pump being thus rendered approximately constant, it is a simple matter to proportion the parts so that the pressure in the pressure chamber will be practically constant at say one-half pound to one pound per square inch. This is a desirable pressure to have for supplying the reservoir of a carbureter because it is small enough to be easily controlled by the ordinary valve and float of the carbureter bowl and yet substantial enough to beneficially supplement gravity in promptly supplying

the liquid to said bowl when said float opens said valve.

The liquid level and internal pressures are kept practically constant notwithstanding the action of the gasoline in giving off and absorbing air and gases under varying practical conditions of operation because the overflow return pipe has its outlet into the tank at a point above the highest level of the liquid when the tank is full. This space is kept at atmospheric pressure by a suitable vent in the top of the tank. Hence the hermetically sealed chamber will vent through the tank and can blow-off or such air every time the liquid falls below the open end of the stand-pipe 70. This can occur every time the engine is stopped, and could also occur during running provided the internal pressure got high enough to blow out the liquid through the return pipe faster than the excess accumulates.

In this connection it is to be noted that when the return pipe is kept submerged the pressures accumulating in the sealed space above the liquid have a double regulating effect. They not only act in a forward direction assisting gravity in discharging liquid at an increased rate through the return pipe, but they also work backward imposing a back pressure or load opposing expulsion of the liquid from the pump chamber and hence to that extent counterbalancing the motive pressure in the motive chamber of the pump. Consequently when these internal pressures are made continuous, as by my above described method, they also tend to be self-governing for constant pressure even against considerable variations of operating conditions, but when they are sometimes present and sometimes relieved or even reversed to a vacuum, as they are when not operating according to my said method they become a cause as well as an effect of extreme irregularity in the functioning of the device.

I have found that the above described direct connected pump will operate for long periods of time without clogging of the pressure conduit 15 or the constricted passage 23^a provided there are no leaks in the pipe or its connections such as would permit hot gases from the engine to find their way to the pump connection. However, as shown in Figure 2, I prefer to guard against all possibilities of clogging, by having the constriction 23^a in alignment with the axis of the pump cylinder and providing the piston with an axial projection 80, having a reduced cleaning stud or needle 81, of such length that it will project through the constriction whenever the piston reaches its normal initial position either during its reciprocatory functioning above described or when it comes to rest after the engine stops.

In practical operation, it is important to have the location of the pump cylinder within and in contact with the body of gasoline and to have the normal level of the latter maintained substantially above the level of the pump outlets. Thus designed, the gasoline keeps the pump cool thereby dissipating the unavoidable heat transmitted through the pressure connection with the combustion chamber of the engine which would otherwise tend to vaporize the gasoline in the pump. As it is, the pump chamber is kept flooded and primed with gasoline substantially free from vapor and hence in condition for immediate effective pumping operation.

I claim:

1. In a fluid supply system, an internal combustion engine provided with an intake and carbureter and a fuel supply tank vented to atmosphere, in combination with a closed reservoir having a pipe to feed fuel to the carbureter; a fuel supply pipe and continuously operating pump drawing gasoline from said supply tank and discharging it into said reservoir at a rate sufficient to cause pressures higher than atmosphere in said reservoir; a stand-pipe overflow and a return pipe of smaller cross-section than said supply pipe communicating with said supply tank above the highest level of liquid therein when the tank is full and operating to vent the upper portion of said reservoir through said tank.

2. In a fluid supply system, an internal combustion engine provided with an intake and carbureter and a fuel supply tank vented to atmosphere, in combination with a closed reservoir having a pipe to feed fuel to the carbureter; a fuel supply pipe and continuously operating pump drawing gasoline from said supply tank and discharging it into said reservoir at a rate sufficient to cause pressures higher than atmosphere in said reservoir; and means for periodically venting the compression space in the top of the closed reservoir through the empty portion of said supply tank.

3. An internal combustion engine provided with an intake and carbureter and a fuel supply system therefor including a supply tank vented to atmosphere, in combination with a closed reservoir having a pipe to feed fuel to the carbureter, a supply line and continuously operating pump drawing fuel from said supply tank and discharging it into said reservoir and a stand-pipe having its intake a substantial distance above the level of the pump discharge and a return pipe leading to said supply tank above the highest level of liquid therein when the tank is full.

4. A structure adapted to operate at varying inclinations and having secured thereon, a variable-throttle, variable-speed internal

- combustion engine, a vented fuel supply tank located away from the engine so that its level is varied with reference to the fuel intake of the engine by the varying inclinations of said structure, in combination with a combined reservoir and pump, a conduit leading from below the level of liquid in the tank to the pump and from near the bottom of the reservoir to the fuel intake, a return conduit leading from the reservoir to the tank, discharging into the tank at a point above the level of the liquid therein, said pump having a pumping element, one face of which is directly connected with the pressure chamber of a cylinder of said engine and continuously actuated in one direction by the varying pressures from the cylinder and in the other direction by a spring, the other face of said pump element being in operative relation to a pumping chamber with suitable inlet and outlet passages and valves for drawing liquid from the tank and discharging it into said reservoir, said pump being designed and arranged to pump and expel any gaseous fluids thereby normally to operate on an incompressible body of liquid in the pump chamber, said reservoir being sealed against inlet or escape of liquid except through said conduits, and said pump having at all times a pumping capacity in excess of the combined maximum demands of the carbureter and the gravity outlet capacity of the return pipe thereby continuously operating by pressure to forcibly expel surplus fuel through said return pipe, for the purpose described.
5. A structure adapted to operate at varying inclinations and having secured thereon, a variable-throttle, variable-speed internal combustion engine, a vented fuel supply tank located away from the engine so that its level is varied with reference to the fuel intake of the engine by the varying inclinations of said structure, in combination with a combined reservoir and pump, a conduit leading from below the level of liquid in the tank to the pump and from near the bottom of the reservoir to the fuel intake, a return conduit leading from the reservoir to the tank, said pump having a floating piston, one face of which is connected with the pressure chamber of a cylinder of said engine and continuously actuated in one direction by the varying pressures from the cylinder and in the other direction by a spring, the other face of said pump element being in operative relation to a pumping chamber with suitable inlet and outlet passages and valves for drawing liquid from the tank and discharging it into said reservoir, said pump and piston being designed and arranged to pump and expel any gaseous fluids thereby normally to operate on an incompressible body of liquid in the pump chamber.
6. A structure adapted to operate at varying inclinations and having secured thereon, a variable-throttle, variable-speed internal combustion engine, a vented fuel supply tank located away from the engine so that its level is varied with reference to the fuel intake of the engine by the varying inclinations of said structure, in combination with a combined reservoir and pump, a conduit leading from below the level of liquid in the tank to the pump and from near the bottom of the reservoir to the fuel intake, a return conduit leading from the reservoir to the tank; said combined reservoir and pump including a vessel adapted to be secured in upright position, a closure for said vessel, a tubular member secured in vertical position in said vessel and having inlet passages from the exterior through its upper and lower portions respectively, a combined motor and pump element actuated by pressure applied from said source through the upper passage, the intake of said pump being through said bottom passage and the discharge being through a valved outlet through said piston into said vessel.
7. A structure adapted to operate at varying inclinations and having secured thereon, a variable-throttle, variable-speed internal combustion engine, a vented fuel supply tank located away from the engine so that its level is varied with reference to the fuel intake of the engine by the varying inclinations of said structure, in combination with a combined reservoir and pump, a conduit leading from below the level of liquid in the tank to the pump and from near the bottom of the reservoir to the fuel intake, a return conduit leading from the reservoir to the tank; said combined reservoir and pump including an upright, pressure operated pump including a floating piston having its downward stroke non-positively actuated by pressure variations from the combustion chamber of a cylinder of said engine and its return stroke assisted by a spring, the pump surfaces of said piston constituting the top of the pump chamber; inlet and outlet passages and check valves therefor controlling the flow of fluid; said inlet and inlet valve opening upwardly into the lower part of said pump chamber; said outlet being through said pump surface of the piston and said outlet valve being located in the piston and arranged to move in alignment with the reciprocating movements of the piston, so that the inertia of the valve operates to assist the lifting and seating movements thereof; and a yielding spring pressing downwardly on said outlet valve, for the purpose described.
8. A structure adapted to operate at varying inclinations and having secured thereon, a variable-throttle, variable-speed internal combustion engine, a vented fuel supply tank located away from the engine so that its level is varied with reference to the fuel intake of the engine by the varying inclinations of said structure, in combination with

a combined reservoir and pump, a conduit leading from below the level of liquid in the tank to the pump and from near the bottom of the reservoir to the fuel intake, a return conduit leading from the reservoir to the tank, said pump including a floating piston having a working portion in operative relation to a pump chamber and a motive portion in operative relation to a pressure chamber of a cylinder of the engine; and inlet and non-return valve therefor controlling free, low-resistance flow of fluid into said pump chamber; an outlet and non-return valve controlling a relatively high resistance flow of fluid out of said pump chamber.

9. A structure adapted to operate at varying inclinations and having secured thereon, a variable-throttle, variable-speed internal combustion engine, a vented fuel supply tank located away from the engine so that its level is varied with reference to the fuel intake of the engine by the varying inclinations of said structure, in combination with a combined reservoir and pump, a conduit leading from below the level of liquid in the tank to the pump and from near the bottom of the reservoir to the fuel intake, a return conduit leading from the reservoir to the tank, said pump including a floating piston having a working portion in operative relation to a pump chamber and a motive portion in operative relation to a pressure chamber of a cylinder of the engine; and inlet and non-return valve therefor controlling free, low-resistance flow of fluid into said pump chamber; an outlet and non-return valve controlling a relatively high resistance flow of fluid out of said pump chamber, said pump being designed and arranged to pump and expel any gaseous fluids thereby normally to operate on an incompressible body of liquid in the pump chamber, said reservoir being sealed against inlet or escape of liquid except through said conduits, and said pump having at all times a pumping capacity in excess of the combined maximum demands of the carbureter and the gravity outlet capacity of the return pipe thereby continuously operating by pressure to forcibly expel surplus fuel through said return pipe, for the purpose described.

10. In liquid feeding means for internal combustion engines, the combination with an internal combustion engine and a liquid supply tank, of a conduit and pressure actuated pump interposed between the tank and the intake of the engine; said pump including a cylinder and a piston to reciprocate in said cylinder and separating the cylinder into a pump chamber and a motive chamber; a port and conduit connecting the motive chamber with the engine cylinder; a spring in the pump chamber yieldingly pressing said piston toward said port; said

port being in alignment with the axis of the piston and said piston having a clearing needle adapted to enter said port when the piston is in its rearmost position.

11. In liquid feeding means for internal combustion engines, the combination with an internal combustion engine and a liquid supply tank, of a conduit and pressure actuated pump interposed between the tank and the intake of the engine; said pump including a cylinder and a piston to reciprocate in said cylinder and separating the cylinder into a pump chamber and a motive chamber; a port and conduit connecting the motive chamber with the engine cylinder; a spring in the pump chamber yieldingly pressing said piston toward said port; said port being in alignment with the axis of the piston and said piston having a clearing needle adapted to enter said port when the piston is in its rearmost position, an upwardly opening valve controlled inlet into the pump chamber, from the tank; a pump outlet opening upwardly from the uppermost portion of the pump chamber; and a non-return valve adapted to check reverse flow of liquid through said outlet during the lifting stroke of said piston.

12. The method of maintaining a substantially constant pressure fuel supply to the carbureter of an internal combustion engine from a supply tank of variable level with reference to said carbureter, through a pumping circuit including conduits from below the level of the liquid in the supply tank to a point above the level of said liquid and an intermediate sealed reservoir having a feed connection to the carbureter, which method consists in continuously applying a varying gas pressure of the engine, non-positively forcing through said conduit into said reservoir a supply of fuel greater than the combined withdrawal capacity of the carbureter and the gravity-flow capacity of the return portion of the pumping circuit, thereby maintaining under average conditions a gaseous pressure in said reservoir, operating by back pressure on the pressure actuated pump and by forcing pressure on the return conduit so as to have a self-regulating constant pressure tendency and thereby affording a greater fuel supply and a wider range for abnormal operation under abnormal conditions.

13. The method of maintaining a substantially constant pressure fuel supply to the carbureter of an internal combustion engine from a supply tank of variable level with reference to said carbureter, through a pumping circuit including conduits from below the level of the liquid in the supply tank to a point above the level of said liquid and an intermediate sealed reservoir having a feed connection to the carbureter, which method consists in forcing through said con-

duit into said reservoir a supply of fuel
greater than the average combined with-
drawal capacity of the carbureter and the
gravity flow capacity of the return portion
5 of the pumping circuit, thereby normally
maintaining a solid column of liquid
throughout the pumping circuit and an ap-

proximately constant load on the pump inde-
pendently of the level of the tank with ref-
erence to the carbureter.

Signed at New York city in the county
of New York and State of New York this
18 day of March, A. D. 1920.

WILLARD I. TWOMBLY.