

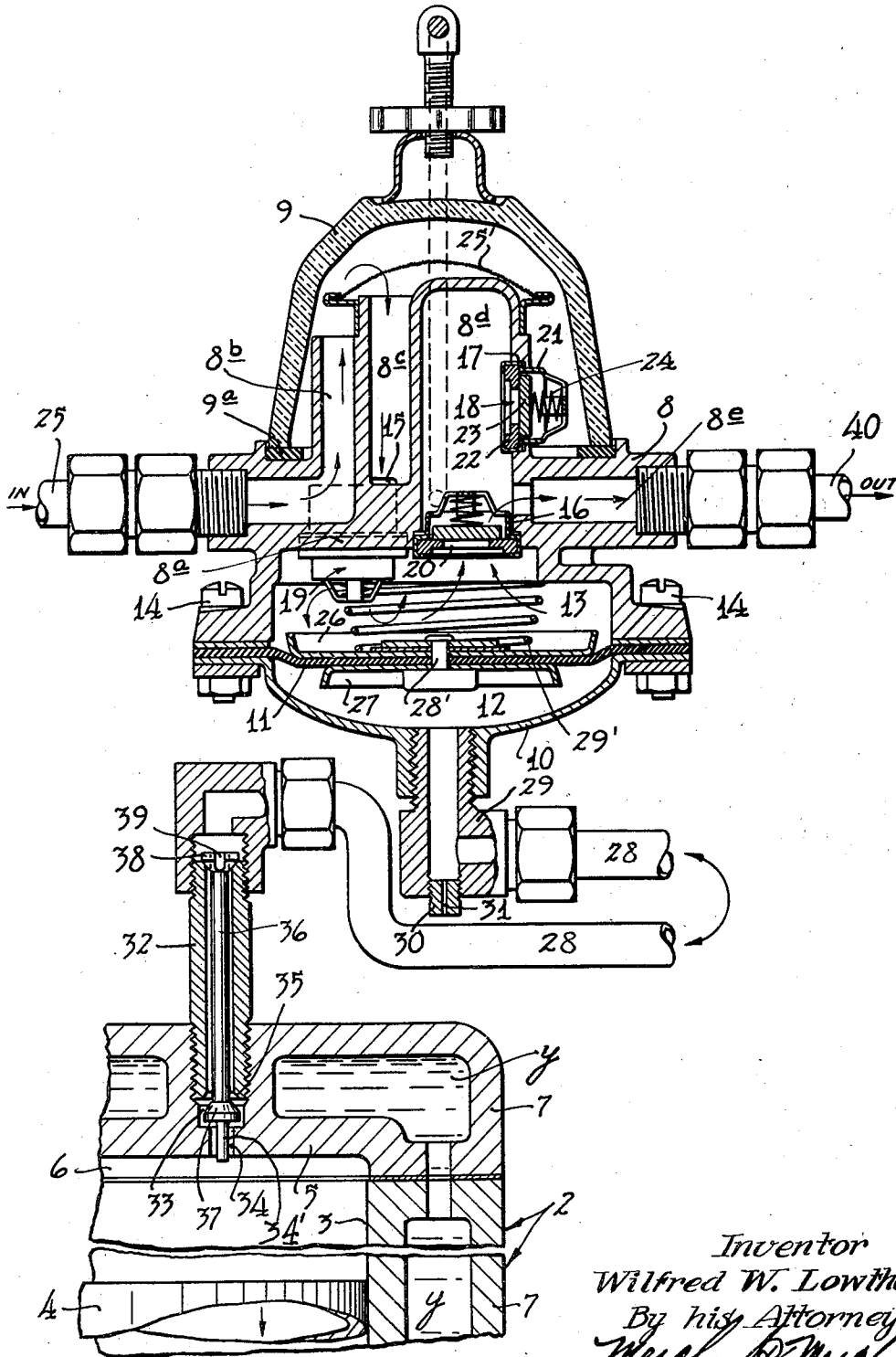
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FUEL PUMP FOR INTERNAL-COMBUSTION ENGINES

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FUEL PUMP FOR INTERNAL-COMBUSTION
ENGINES

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2 Claims. (Cl. 123—139)

My present invention relates to an improved system for feeding fuel to internal combustion engines.

More specifically stated, my present invention may be said to relate to improvements in fuel feeding systems of the general character wherein the pulsating pressure produced in the cylinder of an internal combustion engine is employed as a source of motivating energy for actuating a pumping device.

Heretofore, numerous fuel pumping systems utilizing the varying or pulsating pressure in the cylinder of an internal combustion engine as a source of motivating energy have been proposed, but all these prior art systems have been found objectionable and have failed to meet commercial requirements. Among the most serious objections to prior art devices of this general character was the transmission of such excessively high temperatures from the associated engine cylinder to the pumping device and extending fuel conduits as to cause one or more of the following troubles, to wit: (a) premature breakdown of the pumping mechanism itself, or of its pressure control valve mechanism in cases where the latter were employed; and (b) the heating of liquid fuel to excessive temperatures at critical points in the system, causing inoperativeness of the pumping system due to vapor lock, trouble of this kind being particularly prevalent in engines using highly volatile fuel such as gasoline.

An important objective of the present invention is the provision of an improved liquid fuel feeding system of the kind described in which the heat transfer to the pumping device from the engine cylinder is reduced to a minimum and, in fact, is so low as to cause no serious or objectionable rise in temperature in the pumping device proper or the fuel contained therein or within its extending fuel conduits. To this end I have incorporated, in the preferred embodiment of the invention herein illustrated, the following important features: (a) one of these important features is an improved apparatus wherein the pumping device is operated from cylinder fluid at pressures and temperatures that are relatively lower than have heretofore been generally utilized for this purpose, and which pressures and temperatures are far below the pressures and temperatures obtained during the power strokes or movements of an engine piston. In accordance with my present invention an automatic pressure operated valve controls communication between the engine cylinder and the pumping device and this valve is balanced to automatically

open and establish communication between the engine cylinder and pumping device for intervals of engine operation between power delivery periods and during which intervals the pressures and temperatures in the cylinder and its combustion chamber are relatively very low as compared to the pressures and temperatures resulting from combustion and present during the power delivery period, and said valve is balanced to close and automatically disrupted during the explosion periods and power delivery strokes or movements of the piston, at which times the pressures and temperatures are very high in the cylinder and its combustion chamber.

(b) As another important feature of the preferred embodiment of the invention, I locate the seat of the pressure operated valve within a cooled wall of the engine cylinder so that communication between the engine cylinder and the pumping device operated from the pulsating pressure produced in the engine cylinder is disrupted or broken off during high pressure periods, substantially at the point of opening of the pressure conduit into the engine cylinder, whereby high pressure, high temperature gases that are present in the engine cylinder and combustion chamber portion of the cylinder during the power strokes or movements of the piston thereof are prevented from entering any portion of the connecting pressure conduit outwardly of the engine cylinder or combustion chamber wall. This is considered a highly important step forward in the art in that it prevents high temperature gases present in the combustion chamber during the power strokes or movements of the cylinder piston from entering and thereby heating up any portion of the conduit outwardly of the cooled wall of the cylinder or its combustion chamber to a temperature above the temperature of the cooled cylinder or combustion chamber walls; and, in this connection, it may be stated that the location of this pressure cut-off valve at any point in the pressure conduit outwardly of the combustion chamber or cylinder cooled wall will result in heating up of the pressure conduit at the engine side of the valve to temperatures far above that of the cooled walls of the cylinder and combustion chamber and that this heat will be conducted past the valve and through the opposite side of the pressure conduit to the pumping device through the conduit and the column of gases therein.

(c) Still another important feature of the present invention is the provision of an improved pressure control valve for the purpose specified. The above and other highly important objec-

tives and advantages of the invention will be made apparent from the following specification and claims and the accompanying drawing.

In the single view of the drawing, which illustrates a preferred embodiment of the invention, like characters indicate like parts.

With reference to the drawing the single view thereof is a view in axial section, with some parts broken away and some parts shown in full, of a complete fuel pumping apparatus operatively connected to a piston-equipped cylinder of an internal combustion engine.

The internal combustion engine, only a fragmentary portion of one piston-equipped cylinder of which is illustrated, is indicated as an entirety by the numeral 2 and may, for the purpose of the present example, be assumed to be of the four cycle, gas burning variety. The cylinder of this engine is indicated by the numeral 3 and is provided with the customary reciprocating piston 4. The top of this cylinder 3 is closed by a cylinder head 5 which affords, in the upper end portion of the cylinder 3, a combustion chamber 6. The cylinder side and end walls, which latter are formed by the cylinder head, are surrounded by connected water jackets 7 through which is circulated a cooling fluid or liquid *y* for the purpose of cooling the engine's cylinder walls to a pre-determined temperature.

The main body of this pump, which body forms the intermediate portion of the pump casing, is indicated as an entirety by 8, the cooperating dome-like upper shell or casing section by 9, and a removable bottom shell or casing section by 10. The dome-like upper shell or casing section 9 is illustrated as being of glass or other transparent material permitting inspection of the pump mechanism under operating conditions. The open lower end of this dome-like transparent upper section is seated on the intermediate pump body-forming section 8 through the medium of a suitable gasket 9a against which gasket said section 8 is normally tightly pressed to form a liquid-tight joint by means of a suitable clamping device permitting easy removal of the dome-like upper section 9 for the purpose of repairs and adjustment. Interposed between the intermediate section 8 and the lower bottom-forming shell or casing section 10 is a resilient reciprocable piston-acting diaphragm 11 that divides the lower interior portion of the shell-like pump casing into a motivating pressure chamber 12 below the diaphragm 11, and a liquid containing pump chamber 13 above said diaphragm 11. The casing section 10 is removably anchored to the section 8 and the diaphragm clamped between the sections 8 and 10 by means of suitable nut-equipped bolts 14. The diaphragm 11 is preferably formed of synthetic rubber or synthetic rubber-treated material, such as is now in common use in diaphragm type fuel pumps.

The body-forming intermediate section 8 is formed to afford a partition wall 8a that extends completely across the interior of the pump housing and forms the top of the pump chamber 13, and said intermediate section 8 is further formed to provide a primary fuel intake passage 8b that opens upwardly into the interior of the dome-shaped upper section 9. Still further, the intermediate body-forming section 8 is formed to afford a secondary fuel inlet passage 8c, a fuel pressure chamber 8d, and a final fuel outlet passage 8e. The secondary fuel inlet passage 8c opens downwardly into the pumping chamber 13 through a downwardly opening check-valve-

equipped port 15 in the partition 8a. The final outlet passage 8e is in free communication with the pressure chamber 8d, and said pressure chamber 8d is in one-way communication with the pressure chamber 13 through a check-valve-equipped port 16. The pressure chamber 8d is also provided with a relief port 17 opening into the space within the dome-like upper section 9 and which port 17 is provided with a spring-loaded relief valve 18. The downwardly opening check-valve for port 15 is indicated as an entirety by 19 and the upwardly opening check-valve for the outlet port 16 is indicated as an entirety by 20. The valves 18, 19 and 20 are of identical construction, and each comprise a valve casing 21, an annular valve seat 22, and a disc-valve element 23 that is spring-pressed in the direction of the annular valve seats 22 in a direction opposite to the direction of fluid flow by a coiled compression spring 24. Preferably a fine screen 25' is provided intermediate the primary and secondary fuel inlet passages 8b and 8c. In the preferred arrangement illustrated the central portion of the diaphragm 11 is made rigid by means of opposed reinforcing plates 26 and 27 that are tightly clamped together by means of an axial rivet or the like 28', and the diaphragm is yieldingly biased in a downwardly direction by a coiled compression spring 29'. The primary fuel inlet passage 8b is shown as being in open communication with a fuel delivery conduit 25 that may be assumed to lead from a suitable fuel supply tank or reservoir, such as the gasoline tank of an automotive vehicle, and the final fuel outlet port 8e is shown as being in open communication with a fuel delivery conduit that may be assumed to lead to the fuel distributing device or carburetor of the internal combustion engine 2. The motivating pressure chamber 12 of the pump is shown as being in open communication with a pressure conduit 28 that extends thereto from the combustion chamber-forming portion of the cylinder 3 of the internal combustion engine 2. The conduit 28 is connected to the interior of chamber 12 through the medium of an elbow-like coupling 29 that is screw-threaded into the bottom of the lower section 10 of the pump, and this coupling 29 has an axial bore extending through its bottom which is normally closed, or largely closed, by a plug 30 having a small diameter release passage 31. The plug 30 forms a condensation sump in the bottom of the fitting 29 below the point of opening of conduit 28 thereto. The primary end portion of the conduit 28 is formed by the tubular body of the pressure regulating valve previously referred to and which body is indicated as an entirety by 32. This tubular valve body 32 has its lower end screw-threaded into the cylinder head 5 and communicates with the interior of the engine cylinder 3 through a valve cavity 33 and a somewhat constricted primary passage or port 34 in the cylinder head.

The tubular valve body 32 is provided at its lower end with a valve seat 35 and at its upper end, said tubular body, is formed with a similar seat which does not, however, act as a valve seat. Axially slidably mounted within the tubular valve body 32 is a valve stem 36 that is formed at its lower end with a conical valve head 37, and at its upper end with a conical head 38 that is similar to the valve head 37 but is further formed with circumferentially spaced peripheral notches 39 to permit free passage of fluid thereby when said head 38 is seated upon its cooperating seat.

The valve stem 36 is of such length that the valve head 37 will be spaced downwardly from its cooperating valve seat 35 when the head 38 is seated, and said stem is of considerably less diameter than the internal diameter of the tubular valve body 32, so as to permit free passage of fluid thereby when the valve head 37 is in its open position. Further important to note is the fact that the valve stem 36 is free for lateral wobbling movements within the passage for the purpose of maintaining the passage free of foreign substances which might tend to plug or restrict the same.

Operation

When the engine is in an inoperative condition, the parts of the valve and pump will all be in the position indicated in the drawing. When the engine is set in operation, the mechanism will function as follows:

During the upward fuel compression strokes or movements of the engine piston 4, a positive pressure (meaning a pressure above atmospheric pressure) will be progressively built up in the engine cylinder and combustion chamber, and so long as the valve 36 remains in its open position, shown in the drawing, the fluid pressure motivating chamber 12 of the pump will be in open communication with the engine cylinder. This increased pressure in the motivating chamber 12 of the pump will cause the resilient pump diaphragm 11 to move upwardly against the action of the spring 29'. Preferably the area of the diaphragm 11 and the pressure exerted by the spring 29' will be such that the diaphragm will be moved to its upper position under the influence of a relatively very low pressure, such as might be present in the combustion chamber of the engine during the initial portion of the fuel compression strokes or movements of the piston.

After the diaphragm 11 has been moved to its upper position and during the fuel compression strokes or movements of the engine piston, and well before combustion takes place, the floating valve will respond to the rapidly increasing pressure in the engine cylinder, which latter will rise much more rapidly than will the pressure in the motivating chamber 12 due to the restriction offered by the connecting conduit and valve, by moving to its upper position wherein the valve head 37 will cooperate with the seat 35 to close the conduit to passage of fluid. This disrupted condition of communication between the engine cylinder and pump motivating pressure chamber 12 will be maintained during the balance of the compression stroke, through the combustion or firing period, and throughout the entire power delivery strokes or movements of the piston 4 and during the succeeding exhaust stroke or movement of the engine piston. During these succeeding strokes or movements of the piston, during which the valve 37 is closed, the pressure in the motivating chamber 12 will recede due to outward leakage through the highly restricted vent port 31, but will not ordinarily recede sufficiently to permit more than a slight or partial downward return movement of the diaphragm 11. During intake or suction movement of the engine piston, which follows immediately after the exhaust stroke or movement of the piston, the pressure in the engine cylinder and combustion chamber will recede rapidly from a positive pressure to a negative or sub-atmospheric pressure, and during this intake period, usually during the initial part there-

of, the valve 37 will return under the action of gravity to its open position, so that during the balance of the intake movement of the piston the motivating chamber 12 and diaphragm 11 will be subject to this reduced sub-atmospheric pressure, whereupon the diaphragm 11 will return to its lower position under the combined influence of the spring 29' and suction produced in the engine cylinder. Of course, during each succeeding complete cycle of operation of the engine, the operation just described will be repeated so that the diaphragm 11 will be alternately moved upwardly and downwardly in rapid succession.

With the pump structure illustrated, each upward movement of the diaphragm will cause fluid in the pump chamber 13 to be expelled upwardly and outwardly therefrom through the upwardly opening check valve 20 into the pressure chamber 8b, from which the fluid will be largely expelled through the passage 8c and the outlet pipe 40 to the point of delivery which may be assumed to be the carburetor or other fuel distributing mechanism of the associated internal combustion engine, and each downward movement of the diaphragm 11 will cause fluid to be drawn into the pump chamber 13 through the downwardly opening check valve 19 from a suitable source of fuel supply through the intake pipe 25 and primary and secondary fuel intake passages 8b and 8c. The relief valve 18 will remain closed except when pressure in the outlet pipe 40 is built up beyond a predetermined point, at which times the relief valve 18 will open to permit circulation of the fluid within the pump casing and thereby relieve the pumping mechanism of excessive loads.

Since the pressure cut-off valve 37 and its cooperating seat 35 are located substantially at the cylinder source of pressure and within the confines of the cooled wall of the head of the engine cylinder, and since the valve is closed at this point during intervals of high temperature and pressure resulting from combustion, gases at excessively high temperatures and pressures will not be permitted to enter any part of the conduit outwardly of the cooled wall of the engine cylinder and, of course, the valve elements themselves will be cooled substantially to cylinder wall temperature. With this arrangement, the actual temperature of cylinder gases injected into the pressure conduit 28 to move the diaphragm upwardly is so relatively low and the rate of conductivity through the conduit 28 itself from the engine will be so relatively low that no serious rise in temperature of the pumping mechanism or the fluid contained therein, or the fuel conduits leading thereto and therefrom, will be effected even during prolonged periods of operation. In fact, it is important to note that the temperatures present in the motivating chamber 12 of the pump are so low as to have no deteriorating effect upon the treated fabric diaphragm 11.

The restricted pressure relief port 31 in the conduit 28 is important, first, for the reason that it affords an outlet for condensation that may, at times, collect in the conduit 28; and, secondly, because it permits partial equalization of pressure in the pressure chamber 12 with respect to atmosphere during periods after the diaphragm has moved to either of its extreme positions, thereby permitting more rapid reversal of the diaphragm movements under high speed engine operation.

The pumping mechanism and pressure valve mechanism are herein shown substantially in full

scale but, since the proportions of diameter to weight in the pressure cut-off valve mechanism is rather critical, a specific specification of a particular valve that has been found to work well with a number of recent automotive engines, including several Chrysler built automotive engines of recent manufacture, will herein be set forth just as an aid to those desiring to utilize the invention, but without any attempt to limit the invention. As is well known, the engines referred to are of the common four-cycle gas burning variety employing relatively low cylinder compression pressures, as compared to Diesel engines or other oil burning high pressure injection type engines, and using electric spark ignition. In the experiments I have made, very successful results have been obtained with the pressure regulating valve proportioned substantially as follows:

Diameter of stem 36-----inch--	125
Diameter of bore or orifice in valve body 32-----do-----	200
Diameter of valve head-----do-----	250
Total weight of valve stem unit-----grams--	3

The over-all weight of the valve stem with relation to the diameters above given is particularly important since gravity is relied upon to yieldingly bias the valve in an open direction in the preferred embodiment of the invention described. Of course, it is desirable to hold the weight of the valve stem to a minimum, but if successful operation under all varying engine conditions is to be assured, the relative weight of the valve stem must be sufficient to open the valve even under conditions when the pressure above the valve may be considerably lower than the pressure below the valve which would, of course, have a tendency to hold the valve on its seat. In this respect attention is directed to the fact that the minimum pressure or highest partial vacuum built up in the engine cylinder during intake strokes varies widely under different engine operating conditions, the partial vacuum in the cylinder during suction strokes being greatest during periods of deceleration and being lowest under periods of acceleration. Hence, it will be seen that if the valve 37 is closed immediately after the pressure chamber 12 has been subject to a maximum degree of partial vacuum obtained in the engine cylinder during a suction stroke under conditions of deceleration and the engine is in a condition of acceleration when the next intake or suction stroke takes place, the valve must either become vacuum bound in a closed position and fail to open, at least during that suction

stroke, or must have sufficient weight to open against a considerably greater pressure in the engine cylinder than in the pressure chamber 12 of the pump. Using the above specifications as a basis for experimentation, very little difficulty should be encountered in adapting the invention to almost any internal combustion engine.

Since the pressure cut-off valve is closed during firing strokes of the engine and is only open when the gases in the combustion chamber are relatively fresh and clean, there will be very little tendency to clog the pressure conduit with foreign substances or products of combustion, but as a safeguard against clogging of the passage through the valve, which represents the maximum restriction in the conduit, I permit the stem 36 to wobble throughout its length within the bore of the valve body and thereby keep itself wiped clean and free of any foreign substances that may tend to further restrict the passage.

What I claim is:

1. In a pumping mechanism operated by fluid pressure built up in the piston-equipped cylinder of a gas burning internal combustion engine, said pumping mechanism having a conduit extending to the engine cylinder, and a normally open pressure closed valve controlling the flow through said conduit, said valve comprising a reciprocating valve element and a cooperating valve seat, said reciprocating valve element being yieldingly biased toward open position and being balanced to close under relatively low pressures built up in the engine cylinder during the compression strokes of the engine piston materially in advance of combustion.

2. In a pumping mechanism operated by fluid pressure built up in the piston-equipped cylinder of a gas burning internal combustion engine having a cooled cylinder wall, said pumping mechanism having a conduit extending to the engine cylinder through said cooled wall thereof, and a normally open pressure closed valve controlling the flow through said conduit, said valve comprising a reciprocating valve element and a cooperating valve seat, said valve seat being located wholly within the confines of the cooled cylinder wall and being in direct heat exchange relationship therewith, said reciprocating valve element being yieldingly biased toward open position and being balanced to close under relatively low pressures built up in the engine cylinder during the compression strokes of the engine piston materially in advance of combustion.

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