A. H. HOADLEY.

FUEL PUMP FOR INTERNAL COMBUSTION ENGINES.

APPLICATION FILED DEC. 22, 1911.

1,080,216.

Patented Dec. 2, 1913.

2 SHEETS—SHEET 1.

Fig. 2.

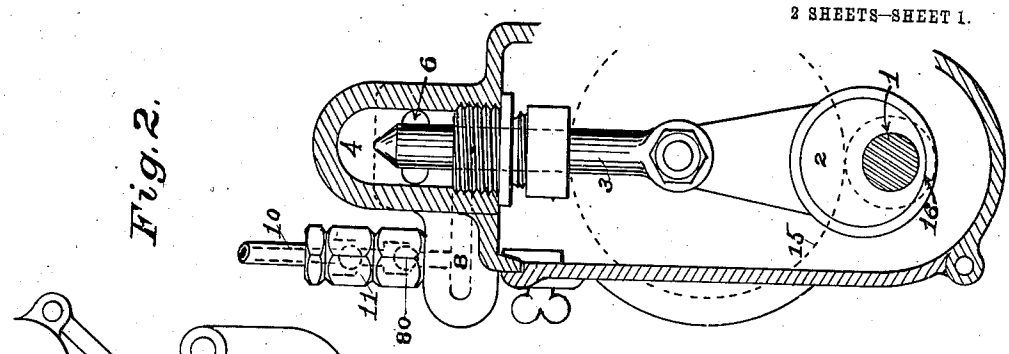
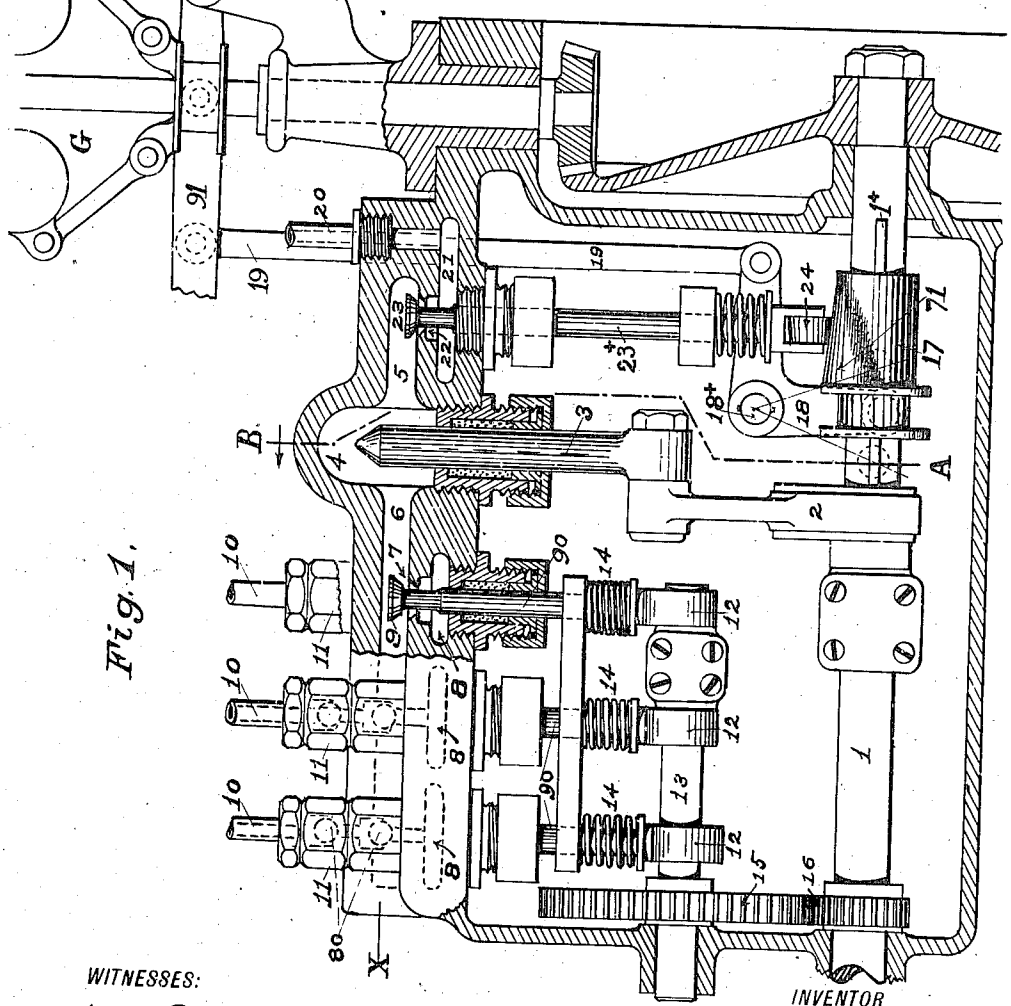


Fig. 1.



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2 SHEETS—SHEET 2.

Fig. 3.

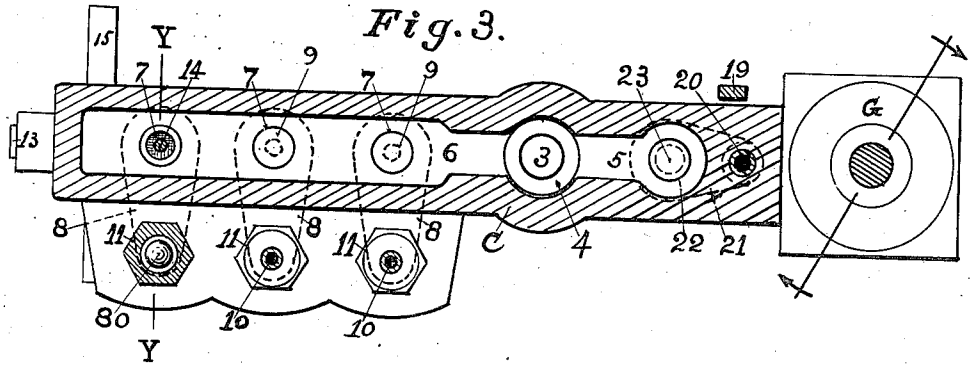


Fig. 5.

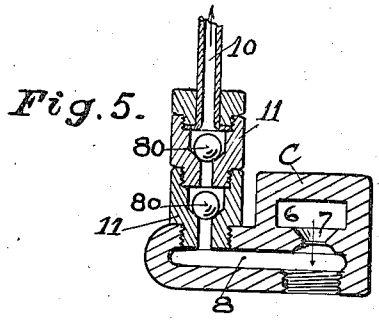


Fig. 6.

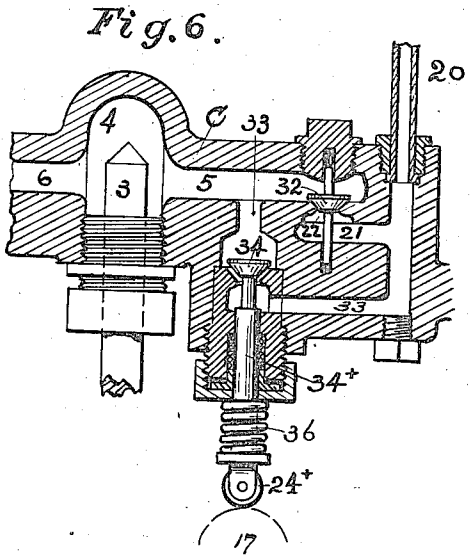
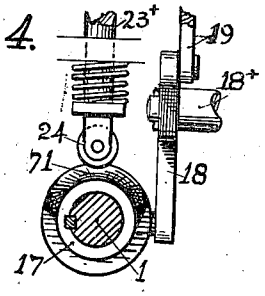


Fig. 4.



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FUEL-PUMP FOR INTERNAL-COMBUSTION ENGINES.

1,080,216. Specification of Letters Patent. Patented Dec. 2, 1913.

Application filed December 22, 1911. Serial No. 667,281.

To all whom it may concern:

Be it known that I, ALFRED H. HOADLEY, a citizen of the United States, residing at Providence, in the county of Providence and State of Rhode Island, have invented a new and useful Fuel-Pump for Internal-Combustion Engines, of which the following is a specification, reference being made therein to the accompanying drawings.

This invention relates to mechanism used to deliver liquid fuel into the cylinders of internal combustion engines of the type which compress a charge of air without admixture of the fuel element and therefore require a means of injecting the fuel at a pressure superior to the pressure of compression. This may be accomplished by the pump injecting the liquid fuel directly into the compressed charge of air in the combustion cylinder, or into an auxiliary charge of air of superior pressure, which in turn injects the mixture of fuel and air into the cylinder. It is this class of pump to which my invention more particularly applies, the object of my invention being primarily, to improve upon the apparatus heretofore in use for this purpose, and to provide a simple and efficient mechanism, comprising a combination of members, organized for operating with practical economy in expense and cost of maintenance. Also, to attain a better operation and results, and an improvement in the means of governing the speed of the engine through the operation of the improved pump.

My invention pertains more especially to multiple pumps, although some features of my improvements may be applied to pumps used to serve a single-cylinder engine.

Engines of the type named have heretofore, in some instances, been regulated in speed by varying the amount of the liquid fuel injected into the cylinder at each working stroke. The total amount of the fuel is always relatively small, while the variation in amount, due to small changes in load, is extremely small. It is therefore desirable that the pump should be capable of a positive and variable delivery of minute amounts, and against relatively heavy pressures. It would seem that a properly designed heavy-pressure pump having a variable-stroke plunger, variable from zero to maximum stroke by the action of a governor, would accomplish this end; but such a pump has been found, in practice, to fail to deliver reliably at the shorter ranges of its stroke. The most successful type of pump for this service is one having a constant, maximum-stroke plunger with a variable by-pass which shunts a portion of the pump delivery back into the suction pipe and closing the pass at that point in the stroke which represents the required delivery due to the remainder of the stroke. One application of the above named by-pass principle is to use the suction-valve as a by-pass, employing in connection with the valve, means controlled by the governor for holding the valve open during a part of the delivery stroke, whereby the fuel will flow back into the suction pipe instead of being delivered against a superior pressure, until the suction-valve closes; whereupon the delivery due to any uncompleted portion of the delivery stroke of the plunger, will take place. My invention applies equally well to pumps having either the delivery by-pass or the suction-valve variable closing system.

Heretofore, for multi-cylinder engines, it has been customary to employ a complete pump for each cylinder; that is, having a separate plunger, connections and operating details, for every cylinder, in order to insure positive and unvarying results. While such practice is effective as to results, it becomes expensive in engines of two or three cylinders, while in case of four, six or eight cylinders, (or even more as promise to obtain in marine units,) the cost becomes excessive, especially in high-pressure engines where the pumps must deliver against a pressure of five hundred pounds or more. My invention provides a simplified construction and novel mechanism, requiring but one pump to supply two or more cylinders, the single pump being timed as to speed to give a delivery stroke of the plunger for each firing stroke of each cylinder; and combined with the pump casing is a system of delivery passages and valves, one for each cylinder. These valves are controlled and timed in operating so as to deliver the pump discharge in required quantity to the proper one of the several cylinders at the proper time. An essential element in the combination is a by-pass valve, which can be arranged for operating in either of the ways above mentioned.

To serve, say, four cylinders, one pump and one by-pass will suffice; whereas heretofore a separate and complete pump and complete by-pass devices were required for each and every cylinder.

To illustrate the nature of my invention, I have shown, in the accompanying drawing, an embodiment thereof adapted to serve a three-cylinder engine, and a form wherein the by-pass function is performed by the suction-valve; but it will be understood that my invention is applicable for any other number of cylinders, and is equally well illustrated by the drawings as the proper elements for any additional number of cylinders would be combined and arranged to operate substantially like those here shown.

I do not limit myself to the exact details or to the precise arrangement of parts as shown; the illustration being typical in character, and various modifications can be made from the form shown and still embody my invention.

In the drawings, Figure 1 is a partly sectional elevation view showing the elements which are essential to my invention, together with such other parts as will pertain to a complete working pump of the character claimed. Fig. 2 is a fragmentary sectional view of the same taken on the line A B, and in a plane at right angles to Fig. 1. Fig. 3 is a horizontal section at line X on Fig. 1, and Fig. 4 is an end view of the slidable regulating cam whereby governor control is transmitted to valving means. Fig. 5 is a sectional detail view at line Y Y, of one of the check-valve-fittings for the cylinder ducts or delivering passages, and Fig. 6 is a fragmentary section showing a modification in the by-pass means.

In the construction shown the numeral 1 indicates a rotatable shaft, serving as the motor shaft for the parts shown, and which in practice is driven by connection with the engine-shaft at a speed ratio to the shaft which must bear a certain speed relation thereto determined by the number of cylinders in the engine. An eccentric 2 fixed upon shaft 1 is connected to operate the reciprocating pump-plunger 3. This works in the pump chamber 4 within the casing or body C of the pump, and into which a suction passage 5 debouches, and out of which a delivery passage 6 leads. Said passage 6 is provided with exits or delivery openings 7 that severally permit discharge into secondary passages or spaces 8; each opening 7 being controlled by a delivery valve 9. There must be a separate exit passage for each engine cylinder to be served, each passage being independent of the others beyond the delivery controlling valve. Leading out of the exits or secondary passages 8 are ducts or pipes 10, which deliver the fuel liquid to the cylinders. (Not herein shown.) These pipes connect with the pump apparatus and communicate with the secondary passages 8 by means of fittings 11, which are adapted to very high pressure, in this instance, and each contains a double check-valve device 80, of approved kind, to prevent return of any of the fuel liquid after entering the duct.

The delivery valves 9 have stems 90, and are individually opened by cams 12 carried on the shaft 13. In the present instance the valves are assisted in closing by springs 14. The cam-shaft 13 may be driven from the shaft 1 by spur gears 15 and 16, or otherwise. The manner of driving is unimportant so long as the rotation is positive and the speed-ratio correct. This ratio must be as the number of cylinders is to one revolution of shaft 1, in this case three to one. The series of cams 12, 12, 12, are designed and arranged to open one delivery at a time in succession, the open period of each corresponding with an entire delivery stroke of the plunger 3. It will therefore be understood that with the aforesaid speed ratio, three successive delivery strokes of the pump will discharge fuel successively into the three cylinders, as determined by the series of controlling cams 12, giving in the engine the same effect as to time and charges as would three individual pumps, operating at one-third the speed. It may be further noted that in any instance the speed of the single pump must be such as to give one revolution of the plunger-driving shaft 1 to each firing stroke of the engine.

My improved governing means consists of the combination of parts shown at the right-hand end of Fig. 1. Upon the shaft 1 is mounted a slidable cam 17 which is caused to rotate with the shaft by a spline 1^+ and is actuated by endwise movement from the engine governor G through any suitable means of connection. In this instance by a bell-crank lever 18 fulcrumed upon the stationary stud 18^+, and having one of its arms engaging a groove or flange on the cam body, while its other arm is connected by the link 19 with a lever, or member 91, that is moved by fluctuations of the governor element; which latter can be of any approved kind. The fuel, from a suitable source of supply, is delivered by a pipe 20 into a secondary chamber 21 and from there it passes into the suction passage 5 through the opening 22 controlled by the suction-valve 23, (Fig. 1) which valve is carried upon a stem 23^+ arranged through a suitable packing-gland and guide bearing, and is best provided with a roller 24 at its end, against which the cam 17 acts. The cam 17 is so formed that for one-half of its revolution it does not lift the suction-valve at all, which is free to act in a normal manner in response to the suction-stroke of the

pump-plunger. The other half of the cam is formed to effect a variable lift action on the suction-valve during the delivery stroke of the pump, by its protuberant portion 71 acting upon the roller 24 in the end of the suction valve-stem. When the cam is at one end of its sliding stroke with the small end under the roller 24, no lifting is given to the suction-valve by said cam during the delivery stroke of the pump plunger 3. Hence the entire volume of discharge for that stroke of the pump must go to one or the other of the cylinders. On the other hand, when the cam is at the other end of its slide-stroke with the large end of the cam beneath the roller 24, then the suction-valve will be lifted and held open during the entire discharge stroke of the pump, thus serving as a by-pass and consequently the fluid will all be pushed back into the suction pipe on account of the lesser pressure in that direction, and there will be no discharge whatever to either cylinder. In any intermediate position of the cam 17 there will be a corresponding part of the delivery-stroke, during which the suction-valve will be held open and a part of the discharge will go back into the suction-pipe; while, upon the closing of the suction-valve 23, that part of the discharge due to the remaining portion of the plunger stroke, will be forced into one or the other of the cylinders. Thus it will be seen that the suction-valve opens freely to admit the suction of fuel into the pumping chamber; but its closing action is mechanically regulated by the position of the cam 17, which is determined by the governor G. Hence the regulation of the quantity of fuel that is sent to a cylinder is very accurately adjusted to the requirements for a properly proportioned charge. This same mechanism will work equally well if applied to a separate by-pass, or by-pass-valve for the pump discharge, an example of which is illustrated in Fig. 6, wherein a separate or special by-pass conduit 33 is provided and the controlled valve 34 is arranged in said special conduit; the valve stem 34+ being actuated by the cam 17. A valve closing spring 36, having a tension power superior to the suction force exerted on the valve, is best combined with the valve stem, as indicated. If desired, this by-pass can be connected with the discharge side of the pump and lead back to the supply pipe 20, the operating effect being practically the same as above explained. In this modification there must be an independent suction-valve 32 in addition to the by-pass valve 34, and a separate passage from the suction pipe must be provided therefor.

I do not claim broadly, graduating the discharge of a pump, either by the suction-valve method or the by-pass method; my invention and claim having reference to a particular way or manner of operating a by-pass or a suction-valve whereby increased sensitiveness of governing is obtained, a more efficient action of the fuel supplying means secured; and the regulation of speed and action of the engine is improved. In my mechanism the cam 17, which has only one valve to operate, is subjected to practically no longitudinal thrust from the resistance of lifting the valve, what little thrust there may be, not being enough to overcome the sliding friction of the cam on the shaft, consequently the resistance to be overcome by the governor is only this sliding friction, which is very small and which is also a constant resistance. During from one half to about nine tenths of a revolution of the cam, practically no work is being done on the roller 24 by the cam. Hence the governor has this time to shift the cam practically without any resistance, and without any disturbance when the cam lifts the valve, whatever degree of pressure the valve may have to open against. The result is that the governing of the discharge will be as close as the governor is capable of producing, and untrammeled by undue and variable disturbances.

The effect of my herein described improvements and of their application to an internal combustion engine, is to equalize the intensity of the firing and enhance the efficiency in the regulation whereby smoothness of operation is attained and wear and tear is reduced, which advantages are additional to the reduction in the original cost of construction of the fuel pumping mechanism, as hereinbefore set forth.

I claim—

1. In an apparatus for supplying liquid fuel to the cylinders of an internal combustion engine, the combination of a unitary pump having a primal discharge chamber with a plurality of exits, operated delivery-valves including an independently acting valve for each of said exits, a freely operable mechanically controlled suction valve, means comprising a positively driven cam-shaft with a series of cams thereon disposed to severally operate said delivery valves, and means for varying the closing action of said suction valve working synchronously with the pump.

2. In an apparatus for supplying liquid fuel to the cylinders of an internal combustion engine, the combination of a single plunger pump having a plurality of delivery exit passages, individual conduits therefrom for the respective cylinders, a series of independently movable valves for the delivery-exit passages, mechanically actuated means for operating said delivery-valves, a by-pass valve controlling a by-pass located between the supply conduit and pump-cham-

ber for regulating the discharge of fuel, a suction valve, and means for operating said by-pass valve, for the purpose specified.

3. In a fuel pump for internal combustion engines, the combination, of a pump body including a pump-chamber, a suction passage, and a delivery passage, a pumping plunger working in said pump-chamber, a plurality of separate valve-controlled openings into underlying secondary passages that communicate by a separate feed-duct with the engine cylinders, a controlling puppet-valve for each of said openings into the secondary passages, said valves having endwise reciprocating stems at the exterior of the casing, and means comprising a rotating cam-shaft with a series of cams carried thereon, for individually operating said valves.

4. In mechanism for forcing liquid fuel into cylinders of multi-cylindrical internal combustion engines, the combination of a pump body including a pump-chamber having a suction-passage and discharge-passage connected therewith, a supply conduit with a port opening into said suction passage, a plurality of exit ports opening from said discharge passage, with secondary passages and fittings for attaching the several cylinder supply pipes, individual valves for the respective inlet and exit ports, each having a projecting stem, a single pumping element working in said pump chamber, a rotating shaft having means for reciprocating the pumping element, a supplemental shaft having means for individually opening said exit-valves, gearing operating said supplemental shaft at a speed ratio as the number of exit valves is to one stroke of the pump, an endwise movable cam acting against the stem of said inlet valve, and means for varying the relative position of said cam in accordance with the speed of rotation of the motor-shaft.

5. In a fuel-supply mechanism for multi-cylinder internal combustion engines, the combination of a pump casing including a chamber having a laterally extended area provided with a plurality of valve-seated egress openings and secondary separate chambers beneath said openings, a pumping element adapted for working therein with its strokes synchronous with the firing intervals of the series of cylinders, means for actuating said pumping element, an ingress passage to said chamber, a plurality of separately actuated egress valves, ducts for taking the discharge from the individual secondary chambers to the respective engine cylinders, said ducts provided with automatically acting check-valves, a rotating shaft actuated by positive gearing in conjunction with the actuating means for the pumping element, said shaft provided with individual cams for respectively opening the egress valves in sequence, one at each pumping stroke, and an ingress controlling means regulated by a governor, for permitting a variable quantity of the fuel element to pass back into the ingress passage.

6. In a fuel supply pump for multi-cylinder internal combustion engines, the combination of a single pumping element, a chamber therefor provided with an inlet passage and a valve therefor, a plurality of discharge passages, each provided with an independently acting closing valve having a projecting valve stem, individual conduits from said discharge passages for connecting the respective engine cylinders, said conduits having means for preventing backward flow therein, a revoluble cam shaft carrying a series of cams that individually actuate said discharge-valves in sequence, means for rotating said cam shaft at a speed ratio greater than pumping impulses.

Witness my hand this 20th day of December, 1911.

ALFRED H. HOADLEY.

Witnesses:

GEORGE P. MACREADY,

WILLIAM E. WHITE.