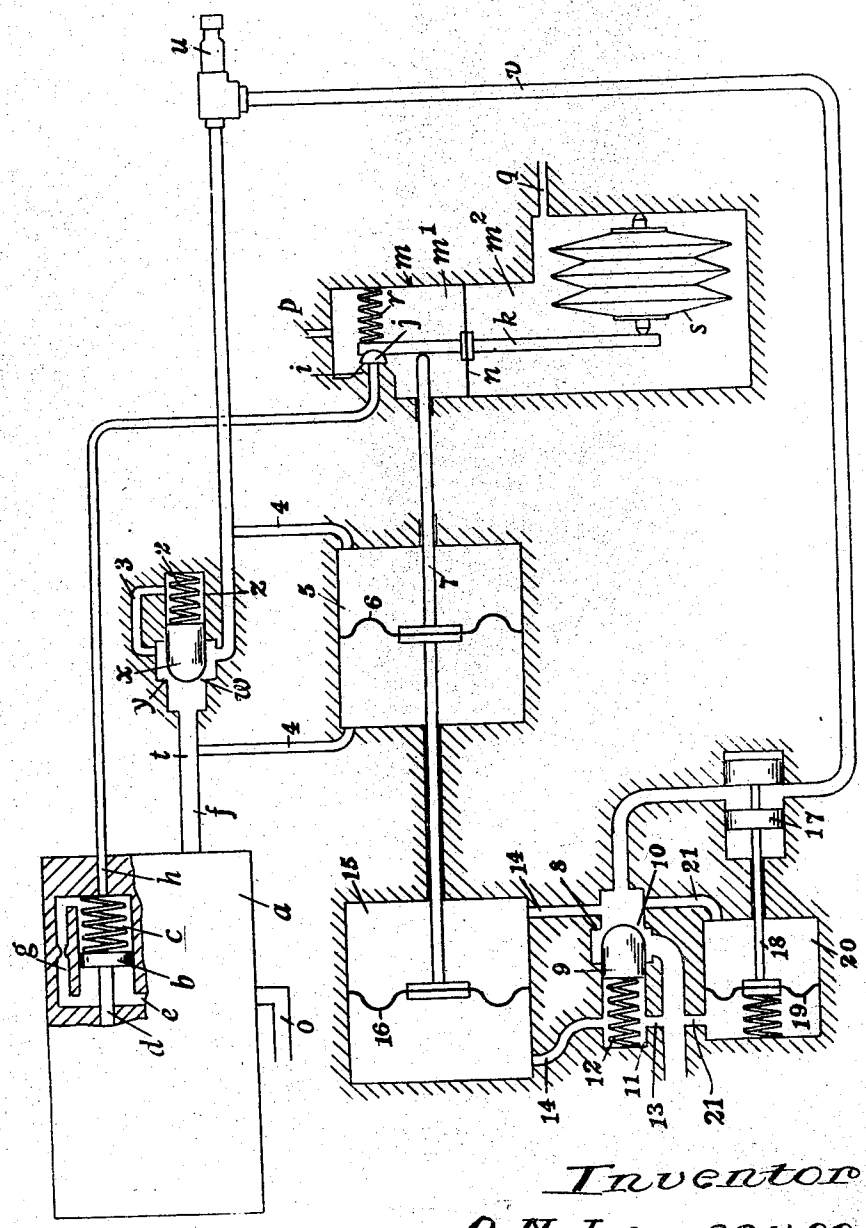
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LIQUID FUEL SUPPLY SYSTEM FOR INTERNAL-COMBUSTION PRIME MOVERS

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LIQUID FUEL SUPPLY SYSTEM FOR INTERNAL-COMBUSTION PRIME MOVERS

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This invention relates to liquid fuel supply systems for internal combustion prime movers, of the kind comprising a variable-delivery pump, one or more swirl-type nozzles for supplying the liquid fuel to a combustion chamber in the form of a spray, and controlling means responsive to liquid fuel pressure, and other conditions associated with the system (such as atmospheric pressure), for automatically regulating the quantity of liquid supplied to the nozzle or nozzles.

The required swirl of the liquid on emerging from the nozzle or nozzles depends in part on the velocity at which the liquid fuel is supplied, and to enable this velocity to be adequate under all conditions of flow it is already known to supply the liquid to the nozzle or nozzles at a rate which is in excess of that required to meet load requirements, the excess liquid being returned to the system before emergence from the nozzle or nozzles.

The object of the invention is to provide a system of the kind above specified, having improved means for controlling the supply of fluid to, and the return of excess fluid from, the nozzle or nozzles.

The invention comprises a system of the kind aforesaid having in combination, a variable orifice situated in the supply passage between the pump and the nozzle or nozzles, a device responsive to the pressure difference at the opposite sides of the orifice for actuating a pump controlling means, a second variable orifice in the return passage from the nozzle or nozzles, a second device responsive to the pressure difference at the opposite sides of the second orifice and adapted to co-operate with the first mentioned device for actuating the pump controlling means, and a valve situated in the return passage and responsive to the pressure difference associated with the second orifice.

The accompanying diagram illustrates one mode of carrying the invention into effect.

In the diagram *a* indicates a variable delivery pump which may have any convenient form, but which is preferably of the swash plate type, the pump being adapted in any convenient manner to be driven by the prime mover (not shown) to be supplied with fuel. The pump *a* has combined with it fluid-operable means for automatically varying the pump output. Such means may consist as shown of a spring loaded piston *b* which is slidable in a cylindrical chamber *c*, and which is connected by a rod *d* to the angularly adjustable swash plate (not shown) of the pump *a*. The end of the chamber *c* to the left of piston

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b communicates through a passage *e* with the outlet *f* of the pump *a*, and also communicates through a restricted passage *g* with the end of the chamber to the right of the piston. The latter end of the chamber *c* is provided with a venting passage *h* which at its outer end forms a seating *i* for a valve *j* formed on or attached to one end of a lever *k* in a chamber *m*. When the valve *j* is closed the liquid pressures at the two sides of the piston *b* are equal, and the piston is moved by its spring loading to a position in which the pump gives its maximum output. Opening of the valve *j* causes the pressure in the right hand end of the cylinder to fall, whereupon the piston will be moved by the preponderance of fluid pressure in the left hand end of the cylinder in the direction for reducing the pump output until a new condition of equilibrium is reached. The lever *k* is supported at a position intermediate its ends by a flexible diaphragm *n* which divides the chamber *m* into two compartments m^1, m^2, the compartment m^1 being in communication with the pump inlet *o* or a sump (not shown) through a passage *p*, and the compartment m^2 being in communication with the outer atmosphere through a passage *q*. Also the lever *k* is loaded by a spring *r* which tends to hold the valve *j* on its seating *i*, and by a capsule or other device as *s* which is responsive to atmospheric pressure and is situated in the compartment m^2. Movement of the valve *j* by the lever *k* causes the output of the pump *a* to be varied.

The outlet *f* of the pump *a* is connected by a pipe or other passage *t* to one or more swirl type nozzles as *u* for supplying liquid fuel in the form of a spray to a combustion chamber of the prime mover (not shown), and the nozzle or nozzles is or are connected to one end of a return pipe or other passage *v* through which excess liquid fuel can flow to the pump inlet *o* or the sump above mentioned.

In the passage *t* leading from the pump *a* to the nozzle or nozzles as *u*, there is provided a variable orifice *w* adapted to set up between its two sides a pressure difference which is proportional to the rate of flow of liquid fuel through this passage. The orifice *w* may be formed by a spring-loaded closure member *x* co-operating with a seating *y*, the closure member being slidable in a cylindrical housing *z* which contains the loading spring 2 of the closure member and communicates through a passageway 3 with the part of the passage *t* containing the seating. At opposite sides of the orifice *w* the passage *t* is connected by branch pipes or passages 4 to a pres-

sure responsive device which, in the example shown, comprises a chamber 5 divided into two compartments by a flexible diaphragm 6, the arrangement being such that the diaphragm is subject to the said pressure difference. A rod 7 secured to the diaphragm 6 and extending through the ends of the chamber 5, acts at one end on the spring-loaded lever *k* carrying the valve *j* above mentioned. As the lever *k* is also acted on by the capsule or other device *s* which is responsive to atmospheric pressure, the pump output (which is variable under the control of the valve *j* on the lever) depends on both atmospheric pressure and the difference of pressure at the orifice *w*.

In the return passage *v* by which excess liquid fuel is returned from the nozzle or nozzles *u* to the pump inlet *o* or the sump above mentioned, there is provided a second variable orifice 8 which is essentially similar to the one above described. Thus, the orifice 8 may be formed by a spring loaded closure member 9 co-operating with a seating 10, the closure member being slidable in a cylindrical housing 11 which contains the loading spring 12 of the closure member and communicates through a passageway 13 with the return passage. At opposite sides of the orifice 8 the return passage *v* is connected by branch pipes or passages 14 to a second pressure responsive device which is also similar to the one above described. Thus, the second pressure responsive device comprises a chamber 15 divided into two compartments by a flexible diaphragm 16, the arrangement being such that this diaphragm is subject to the pressure difference at the orifice 8. The diaphragms 6, 16 of the two pressure responsive devices are interconnected by the rod 7 above mentioned, and the arrangement is such that the action of the second diaphragm 16 opposes that of the first diaphragm 6, that is to say the adjacent ends of the chambers 5, 15 are respectively in communication with the higher pressure sides of the two orifices *w*, 8.

Also there is arranged in the return passage *v* between the nozzle or nozzles as *u* and the second orifice 8, a normally open controlling valve 17. Preferably this valve 17 is of the piston type, and is connected by a rod 18 to a spring-loaded diaphragm 19 dividing another chamber 20 into two compartments, the latter being connected by branch pipes or passages 21 to the return passage *v* at opposite sides of the associated orifice 8. The arrangement is such that when the pressure drop across orifice 8 in the return passage *v* exceeds some predetermined amount, the valve 17 is moved in the direction for retricting the flow in this passage. It will be assumed that the pump *a* is supplying the required amount of fuel to the nozzle or nozzles *u* with the prime mover at a given altitude. In this condition the forces exerted on the valve lever *k* by the spring *r*, the rod 7, and the capsule *s* will balance each other, and the valve lever will be in a position of equilibrium in which fluid leakage past the valve *j* relieves the fluid pressure in the right hand end of the cylinder *c* sufficiently to prevent movement of the piston *b* by its spring loading. With change of altitude, the variation in the air pressure acting on the capsule *s* disturbs the equilibrium of the valve lever *k* which is thereupon moved under the control of the diaphragm 6 in the direction for varying the pump output until a new condition of equilibrium is reached. Thus, with lowering of altitude the pressure exerted by the capsule *s* on the valve lever *k* is reduced with the result that the output of the pump is increased. This causes corresponding increase of the pressure drop across the orifice *w*, and consequential movement of the diaphragm 6 which serves by acting on the valve lever *k* through the medium of the rod 7 to move the valve lever into a new position of equilibrium. With raising of altitude the opposite effect is obtained in that the output of the pump *a* and the pressure drop across the orifice *w* are appropriately reduced.

It will be seen, therefore, that the diaphragm 6 which is responsive to the pressure drop across the orifice *w* controls the movement of the valve lever *k*. Movement of the diaphragm 6, however, is opposed by the diaphragm 16 which is responsive to the pressure drop across the orifice 8 in the return passage *v*. Consequently the pump *a* must at all times create across the orifice *w* a pressure drop sufficient to enable the diaphragm 6 to overcome the opposing action of the diaphragm 16. As, moreover, the valve 17 in the return passage *v* serves to maintain the return flow through this passage substantially constant, it follows that the opposing action of the diaphragm 16 is also substantially constant, and as a result the amount of excess liquid fuel delivered by the pump corresponds to the quantity of liquid fuel flowing through the return passage.

The purpose of the controlling means above described is to satisfy the requirement that the rate of supply of liquid fuel by the pump should be such as to provide always, in addition to the quantity of fuel required to meet the load requirements of the prime mover to be supplied with liquid fuel by the nozzle or nozzles, an excess quantity equal to (that is, neither more nor less than) that which is returned from the nozzle or nozzles, and by my invention I am able to meet this requirement automatically in a very simple and satisfactory manner. The invention is not, however, limited to the example above described as subordinate details may be varied to suit different requirements.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. A liquid fuel supply system for an internal combustion prime mover, comprising in combination at least one swirl-type nozzle for supplying liquid fuel to the prime mover in the form of a spray, a liquid fuel supply passage connected to said nozzle and containing a variable orifice, a variable-delivery pump for supplying liquid fuel through said supply passage to said nozzle at a rate in excess of that necessary to meet the load requirements of the prime mover, a return passage into which the excess liquid fuel can flow before emergence at said nozzle, and which contains a scond variable orifice, means including a member forming a part of the pump for varying the pump output, pump controlling means operatively associated with the output-varying member of said pump, a device responsive to the pressure difference at the opposite sides of the first mentioned variable orifice for actuating said pump controlling means, a second device responsive to the pressure difference at the opposite sides of said second variable orifice and connected to the first mentioned device so as to co-operate therewith for actuating said pump controlling means, a valve situated in said return passage, and means responsive to the pressure difference at the opposite sides of said second variable orifice for actuating said valve.

2. A liquid fuel supply system as claimed in claim 1, in which each of the variable orifices is

formed by a spring loaded slidable closure member, and a seating for co-operating with the closure member.

3. A liquid fuel supply system as claimed in claim 1, in which the two pressures responsive devices are arranged to oppose each other, and are interconnected by a rod adapted to act on the pump controlling means.

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