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MEANS FOR CONTROLLING THE FLOW OF
LIQUID FUEL TO PRIME MOVERS

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2 Sheets-Sheet 1

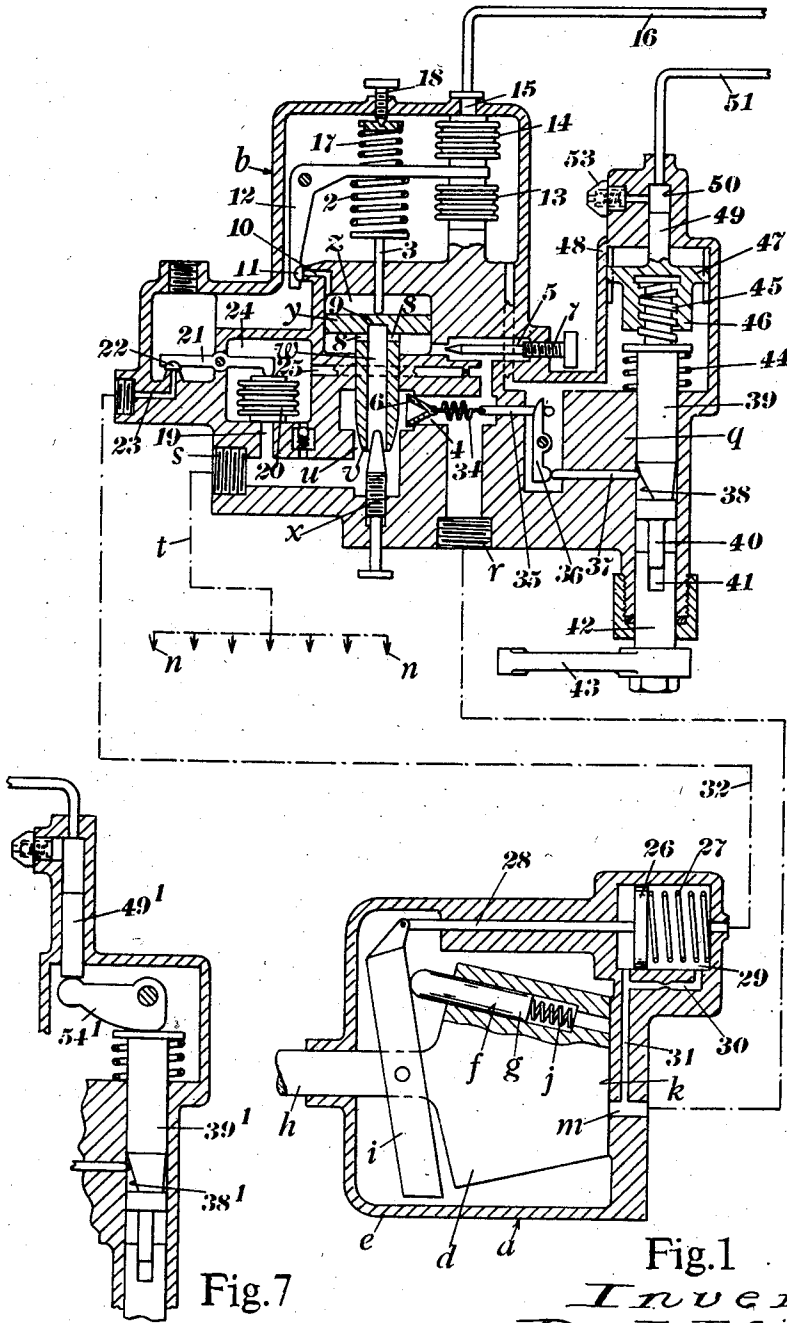


Fig.1

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MEANS FOR CONTROLLING THE FLOW OF
LIQUID FUEL TO PRIME MOVERSRichard Joseph Ifield, Birmingham, England, as-
signor to Joseph Lucas Limited, Birmingham,
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4 Claims. (Cl. 158—36.4)

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This invention has for its object to provide improved means for automatically controlling the supply of liquid fuel to the combustion chamber or chambers of a prime mover, and more especially a controlling means adapted to enable the following condition to be met, namely

$$m = k \cdot p \cdot (t_2 - t_1) / \sqrt{t_2}$$

where

m = rate of fuel mass flow,

p = pressure at which air is supplied to the combustion chamber,

t_1 = temperature of the blower air,

t_2 = temperature of the hot gases in the combustion chamber,

k = a constant.

In the accompanying sheets of explanatory drawings:

Figure 1 is a diagrammatic sectional side view of a pump and means constructed in accordance with the invention for automatically controlling the supply of liquid fuel from the pump to the combustion chamber or chambers of an internal combustion prime mover, and Figure 2 is a sectional side view of a part of the prime mover.

Figure 3 is a side view, illustrating to a larger scale than Figures 1 and 2 a cam forming part of the controlling means, and Figures 4, 5 and 6 are cross sections taken respectively on the lines 4—4, 5—5 and 6—6 of Figure 3.

Figure 7 is a sectional side view illustrating a modified feature.

In Figure 1 of the drawings a indicates a liquid fuel pump, and b indicates means for automatically controlling the supply of liquid fuel from the pump to the combustion chamber or chambers as c of an internal combustion prime mover, such as that illustrated in part by Figure 2.

The pump a comprises a rotary cylinder block d arranged in a casing e and having formed around its axis a plurality of bores as f in each of which is arranged a reciprocating plunger as g . The cylinder block d is adapted to be driven in any convenient manner through the medium of a shaft h . During rotation of the cylinder block a the plungers g are moved in one direction by an angularly movable swash plate i and in the opposite direction by springs as j , the latter being situated in the bores f , and serving to hold an end face of the cylinder block in contact with a flat seating k in the casing e . The seating k is formed with a fuel delivery outlet m , and with a fuel inlet (not shown).

The combustion chamber of each combustion chamber c is provided at one end with a fuel

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injection nozzle n , and is surrounded by an air jacket o , air being supplied under pressure to this end of the combustion chamber and to the air jacket by a blower p .

In constructing the controlling means b in accordance with the invention, I employ a hollow body part q having an inlet r and outlet s whereby the body part can be connected in a liquid fuel pipe system t between the pump a and the nozzle or nozzles n . Between the inlet r and outlet s there is provided in the body part q an orifice u through which liquid fuel can flow from the inlet to the outlet, and the effective area of this orifice is variable by an axially slidable plug v having one end shaped to a tapered or other appropriate configuration, this end being located in the orifice. Preferably and as shown a second orifice w through which liquid fuel can flow from the inlet r to the outlet s is arranged in parallel with the orifice u . The second orifice is formed by an axial bore in the plug v , and its effective area is variable by an adjustable (but otherwise stationary) plug x of tapered or other appropriate form carried by the body part and having one end extending into the adjacent end of the bore in the plug v . At one end the plug v is formed with a piston y which is contained in a cylindrical chamber z in the body part q , the piston being loaded by a spring 2 which (through the medium of a stem 3) tends to move the plug in the direction for reducing the effective areas of both orifices u, w .

In the body part q , and in communication with the inlet r , are provided two passages 4, 5. The passage 4 serves to connect the inlet r to the orifice u under the control of a valve 6 to be described more fully later. The other passage 5 serves to connect the inlet r to one end of the cylindrical chamber z , and is controlled by an adjustable choke 7. From this end of the chamber z liquid fuel can pass through holes 8 in the plug v to the orifice w within the plug. Also liquid fuel can pass through a restricted orifice 9 in the piston y , or a restricted passage in the wall of the chamber z , to the other end of the chamber. The latter end of the chamber z is formed with a vent 10 which is controlled by a closure member 11 on one arm of a bellcrank lever 12. The other arm of the lever 12 supports one end of the spring 2 acting on the piston y , and is loaded by a pair of opposed capsules 13, 14, the capsule 13 being evacuated, and the capsule 14 being open to a pipe connection 15 to which air under pressure can be supplied by the blower p through a pipe 16 connected to the

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inlet end of the air jacket, or one of the air jackets *o*. Also a second spring 17 may be arranged to act on the side of the last mentioned lever arm opposite to that supporting the first spring 2, the pressure exerted by the second spring being adjustable by a screw 18. The pressure of the air delivered by the blower *p* tends, by its action on the capsule 14, to move the lever 12 in the direction for opening the vent 10, and thereby allowing liquid to escape from the adjacent end of the chamber *z*. This causes the piston *y* to be moved by the liquid pressure in the other end of the chamber *z* in the direction for increasing the effective areas of the orifices *u*, *w*.

At the outlet side of the orifices *u*, *w* above mentioned there is formed in the body part *q* a branch passage 19 leading from the outlet *s* to the interior of a capsule 20. Against the closed end of the capsule 20 bears one end of a lever 21 which at its other end carries a closure member 22 for controlling a vent 23 associated with fluid-operated means (hereinafter referred to) whereby the rate of output of the pump *a* is varied. Also the capsule 20 is contained in a chamber 24 formed in the body part *q* and communicating through a passage 25 with the inlet *r*. Consequently the capsule 20 is subject to the difference of fluid pressure (or pressure drop) between the inlet *r* and outlet *s*, and this drop is utilised to actuate the lever 21 for controlling the vent 23 and, hence, the rate of delivery of the pump *a*.

The above mentioned fluid-operated means for varying the rate of output of the pump *a* may be of any convenient form. In the example shown it comprises a piston 26 which is loaded at one side by a spring 27, and is adapted through the medium of a rod 28 to vary the angle of the swash plate *i* of the pump *a*. The piston 26 is contained in a cylinder 29 having both of its ends in communication through a restricted passage 30. At the end remote from the spring 27, the cylinder 29 is connected by a passage 31 to the pump outlet *m*, or other source of liquid under pressure. The other end of the cylinder 29 is adapted to be connected by a pipe 32 to the above mentioned vent 23. On opening the vent 23 liquid is allowed to escape from one end of the cylinder 29, and the piston 26 is then movable against the action of its loading spring 27 by the fluid pressure acting on the opposite side of the piston, the movement being continued until the vent is again closed. The arrangement of the capsule 20 above mentioned is such that when the pressure drop across the orifices *u*, *w* exceeds some predetermined amount the vent 23 is opened to enable the output of the pump *a* to be reduced until the normal pressure drop is restored.

So far I have described how the variable orifices *u*, *w* are variable in response to blower pressure, and have thereby shown how one of the desired conditions is satisfied. I will now describe the manner in which the above mentioned valve 6 between the inlet *r* and the orifice *u* is controlled. The valve 6 is adapted to be held on its seating by a spring 34 and to be moved off its seating by the pressure of the liquid in the inlet *r*. To enable the force exerted by the spring 34 to be varied, the spring serves to connect the valve 6 to a drag link 35 which is acted on by one end of a lever 36, the other end of this lever being acted on by a thrust piece 37 which is supported by a tapered cam-like surface 38 on a slidable and rotatable rod 39. At one end the rod 39 is slidably connected by a tongue 40 and slot 41

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to one end of a rotatable but axially immovable spindle 42 which at its other end is attached to a control lever 43, the latter being movable manually in accordance with the required temperature (t_2) of the hot gases at the outlet end *c* of the combustion chamber or chambers *c*. Near its other end the rod 39 is loaded by a spring 44, and this end of the rod is provided with a multi-start screw thread 45 which engages a complementary screw threaded nut 46, the latter being formed on a piston-like member 47 which is slidable but non-rotatable in a chamber 48 on the body part *q*, and which is subject to fluid-operated means responsive to the temperature (t_1) of the air delivered by the blower *p*. Such fluid-operated means comprise a plunger 49 which is formed on or secured to the side of the piston-like member 47 remote from the nut 46, and is slidable in one end of a bore 50 formed in the adjacent end of the chamber 48, the other end of the bore being adapted for connection by a pipe 51 to a thermometer bulb 52 in the inlet end of the air jacket *o* associated with the combustion chamber or one of the combustion chambers *c*. The bore 50, pipe 51 and thermometer bulb 52 are filled with any suitable thermometer liquid through a nipple 53 on the chamber 48. The configuration of the cam-like surface 38 is such that the endwise movement of the rod 39 which is dependent on t_1 and the angular position of the t_2 control lever 43 causes the loading of the spring 34 to vary as the square of this movement and the spring loading is divided by an amount depending on the angular position of the t_2 control lever. The spring loading is varied through the control lever 43 by the attendant to the appropriate t_2 setting, and the t_1 correction is made automatically.

Instead of employing the cam surface above described I may employ the modification shown in Figure 7, in which parts similar or analogous to those above described are indicated by the same reference characters suffixed by 1. In this modification the plunger 49¹ is adapted to act on the rod 39¹ through the medium of a pivotal cam 54¹ having an operative surface such that the endwise movement imparted to the rod by the plunger in response to t_1 is proportional to the square of the plunger movement. This enables the shape of the cam-like surface 38¹ on the rod 39¹ to be simplified.

By this invention, the desired control of the rate of fuel supply to the combustion chamber, and particularly a control which satisfies the equation above mentioned can be obtained in a convenient and reliable manner. The invention is not, however, restricted to the examples described, as subordinate details may be modified to suit different requirements.

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

1. Liquid fuel controlling means having in combination coaxially arranged and relatively movable members forming a variable orifice, a liquid fuel inlet passage leading to one side of said variable orifice, a liquid fuel outlet passage communicating with the other side of said variable orifice, means for controlling the supply of liquid fuel to said inlet passage in response to the pressure drop in liquid fuel flowing from said inlet passage to said outlet passage through said orifice, means responsive to air pressure for varying the effective area of said orifice by causing relative movement of the members forming

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said orifice, a valve arranged in said inlet passage for controlling the flow of liquid fuel there-through, and manually adjustable and temperature responsive means for controlling the said valve.

2. Liquid fuel controlling means having in combination coaxially arranged and relatively movable members forming a variable orifice, a liquid fuel inlet passage leading to one side of said orifice, a liquid fuel outlet passage communicating with the other side of said orifice, means for controlling the supply of liquid fuel to said inlet passage in response to the pressure drop in liquid fuel flowing from said inlet passage to said outlet passage through said orifice, means responsive to air pressure for varying the effective area of said orifice by imparting relative movement to the members forming said orifice, a valve arranged in said inlet passage for controlling the flow of liquid fuel therethrough, a slidable and rotatable control member provided with a cam-like surface, a spring acting on said valve, a thrust piece through which the loading of said spring is variable by said cam-like surface, a manually operable lever for imparting to said control member rotational adjusting movement dependent on a required temperature condition, and fluid-operated means for imparting to said

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member sliding movement dependent on another temperature condition.

3. Means as claimed in claim 2, in which the fluid-operated means comprises a plunger responsive to fluid pressure, and having a screw thread connection with the slidable and rotatable member, so that the latter is slidable with but capable of movement relatively to the plunger.

4. Means as claimed in claim 2, in which the fluid-operated means comprise in combination a plunger responsive to fluid pressure, and a pivotal cam for transmitting movement from the plunger to the slidable and rotatable member.

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