April 29, 1952 J. G. SHARP ET AL 2,594,689

FLUID OPERATED SPEED GOVERNOR

Filed Dec. 30, 1946 3 Sheets-Sheet 1

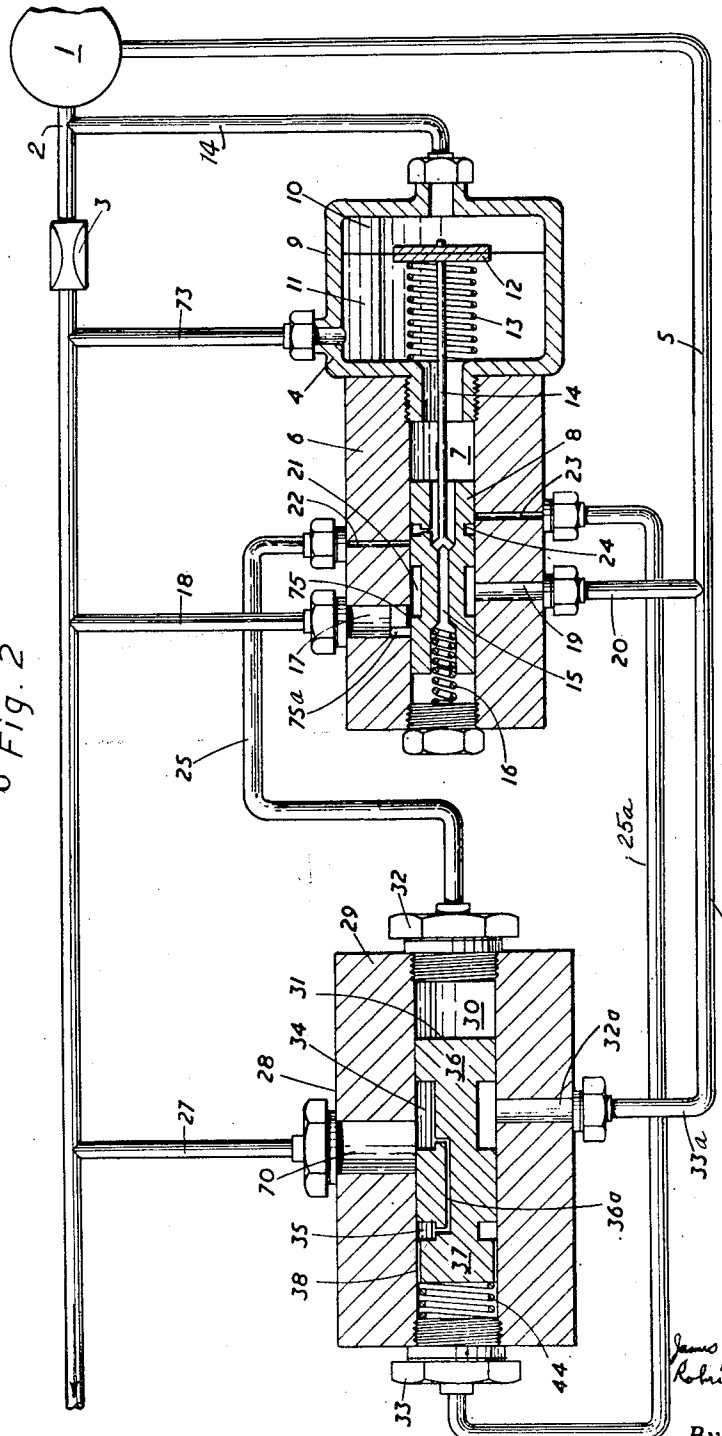


Fig. 1

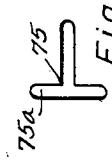


Fig. 2

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FLUID OPERATED SPEED GOVERNOR

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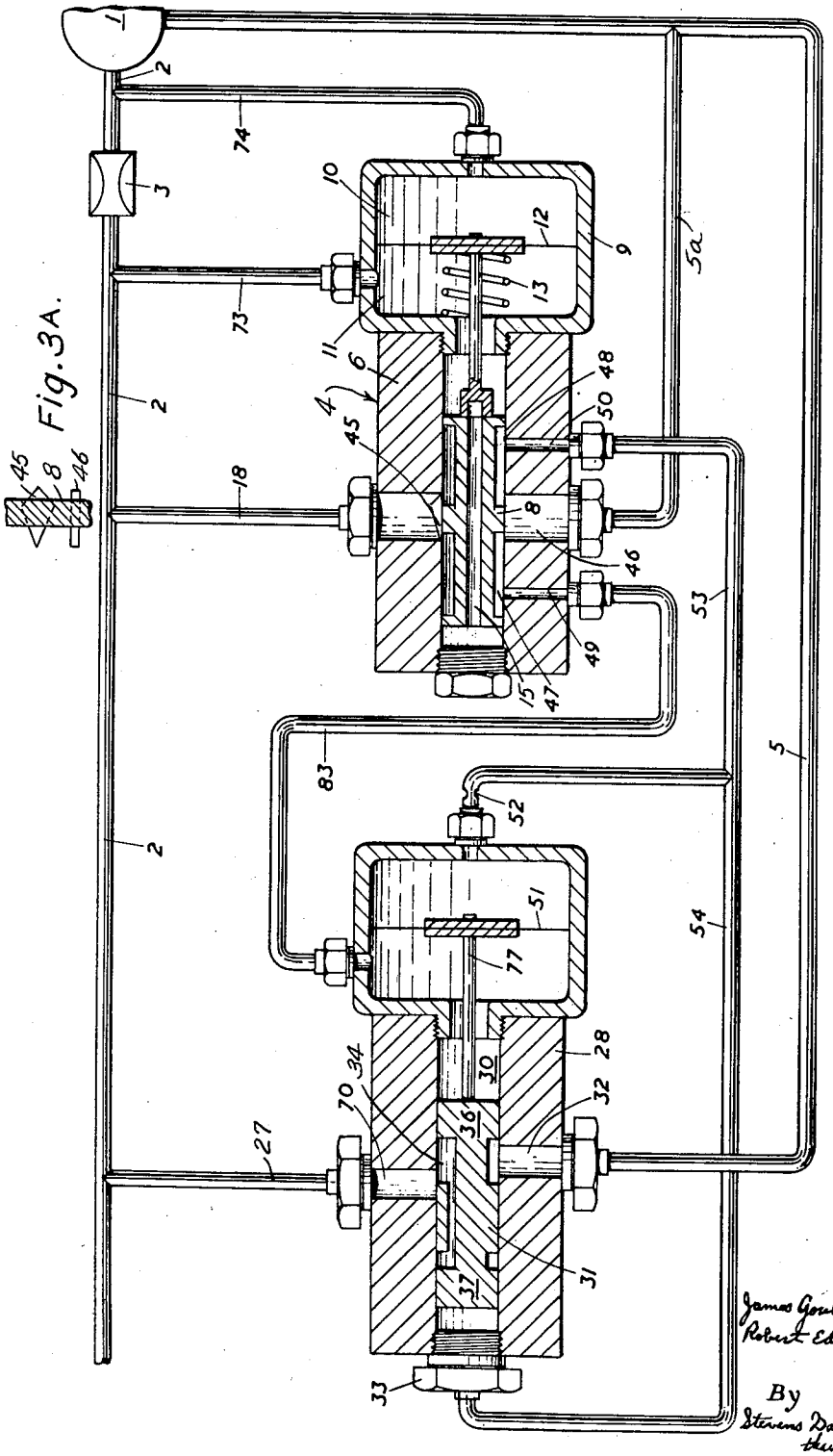


Fig. 3A.

Fig. 3

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FLUID OPERATED SPEED GOVERNOR

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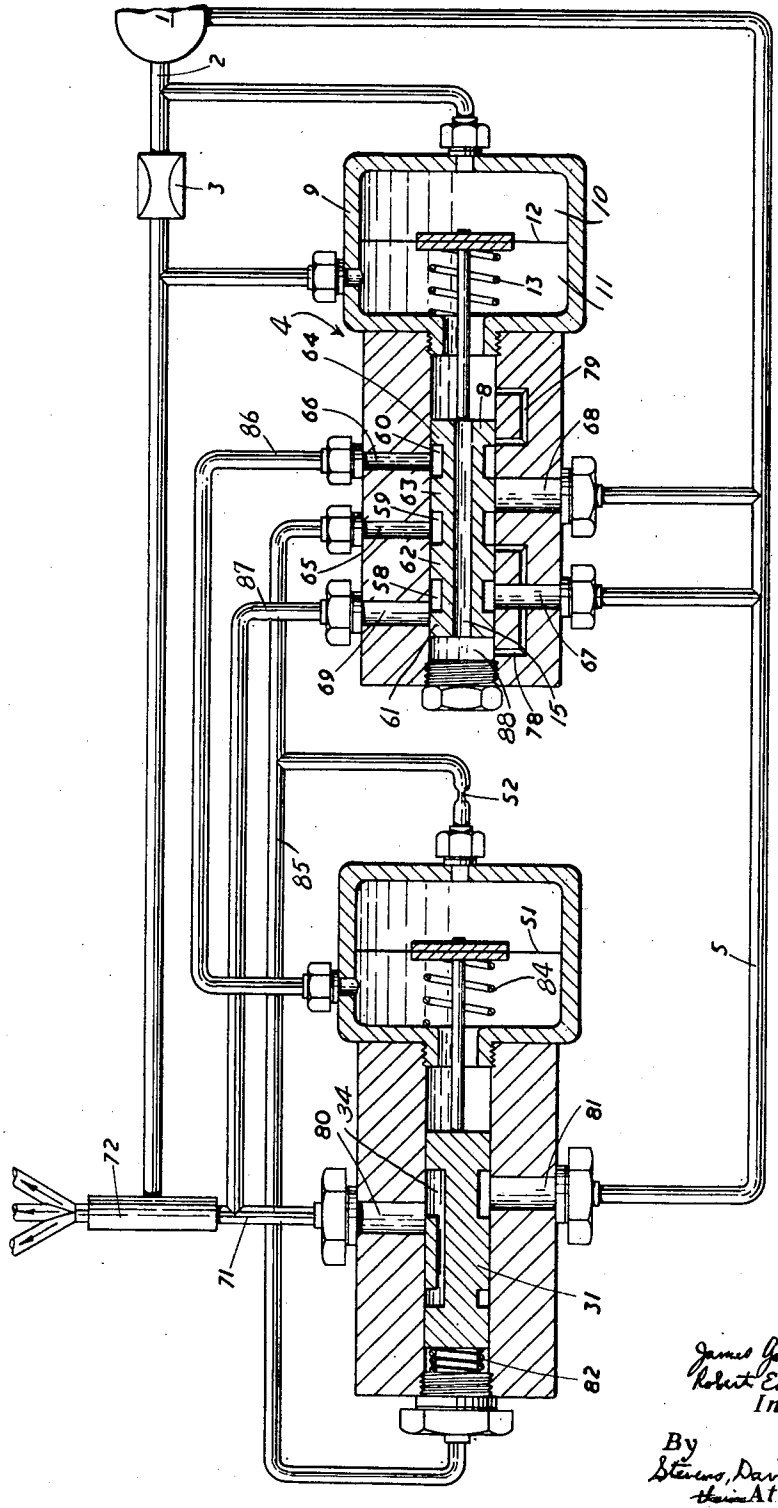


Fig. 4

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FLUID OPERATED SPEED GOVERNOR

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6 Claims. (Cl. 158—36)

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This invention relates to improvements in governors and is intended to be particularly although not exclusively applicable to governors for use in gas turbine engines, especially for aircraft. The kind of governor here envisaged is that known as an all-speed governor, i. e. one which automatically maintains the engine speed constant at any pre-selected value.

The essential requirements of an all-speed governor are that at a given throttle setting it shall maintain the selected engine speed irrespective of variations in any of the factors normally influencing engine speed, e. g. altitude and load. The governor is also required if possible to prevent positively any tendencies of the engine to exceed the predetermined maximum values of speed or, in the case of gas turbine aero-engines for jet propulsion, the speed corresponding to maximum permissible temperature of the gases in the jet pipe, and to allow rapid accelerations and decelerations.

For fulfilling the above mentioned requirements an all-speed engine governor according to the invention comprises at least two fluid pressure sensitive valves, of which one is operable by the other, each being adapted to spill fuel from a fuel pressure delivery line in response to the extent of variations of pressure of the operating fluid consequent on changes in engine speed. The fluid may be the fuel itself.

The operating force for one or both valves may be the pressure drop across an orifice in the fuel delivery line, the area of said orifice being preferably adjustable.

In one form of embodiment of the invention the delivery of a fuel pump is passed through a variable area orifice the pressure drop across which operates a spring-loaded diaphragm of a spill type "pilot" valve adapted to spill fuel from the delivery line back to the pump inlet. For any given orifice area setting the pressure drop is dependent on the fuel flow which in turn is determined by engine speed, variations of which cause movement of the diaphragm. The latter can actuate a spill valve plunger co-operating with spill ports arranged so that an increase or decrease in engine speed (which correspondingly increases or decreases the pressure drop) causes more or less fuel respectively to be spilled from the supply line to counteract the engine speed variations. Movement of this plunger also correspondingly opens or closes associated servo ports in the pilot valve body and so delivers servo liquid (which in this case is conveniently the fuel) to one side or the other of a plunger of a "compensating" valve moving to cause spill ports

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in the compensating valve to open or close respectively following the opening or closing of the pilot valve spill ports.

With this arrangement a small increase in engine speed to a value above the pre-selected speed determined by the orifice setting causes the pilot valve immediately to open and spill fuel (or more fuel) from the delivery line. If the increase is large, then due to the opening of the servo ports the compensating valve is also actuated (but relatively more slowly) and also spills fuel (or more fuel) from the delivery line. The compensating valve plunger continues to move until the engine speed returns to the pre-selected value whereupon its movement ceases. A decrease in engine speed below this value causes the valves to close and spill less fuel.

In the accompanying drawings which illustrate, by way of example, three forms of embodiment of the invention:

Figure 1 is a diagrammatic representation of one form of embodiment showing the valves in longitudinal section;

Figure 2 is a view of a detail constituting a cross-section of the slot 75;

Figure 3 is a similar representation of a second form of embodiment; and Figure 3A is a detail showing of elements in said Figure 3.

Figure 4 is a similar representation of a third form of embodiment.

In Figure 1 a fuel pump delivers fuel to engine burners (not shown) through a delivery line 2 in which is a manually adjustable variable area orifice 3. Across orifice 3 is connected a pilot valve 4 which spills fuel from the line 2 back through a spill return line 5 to the inlet of pump 1.

The pilot valve comprises a substantially cylindrical body 6 having an axial bore 7 in which slides a valve plunger 8, and a cap 9 is divided internally by a diaphragm 12 into two chambers 10, 11 of which chamber 11 communicates with bore 7 and, through pipe 73, with one end of orifice 3 while chamber 10 communicates through pipe 74 with the opposite end of said orifice so that chamber 10 is at higher pressure than chamber 11.

Diaphragm 12 is spring-loaded by spring 13 against movement in the direction from high pressure to low pressure and is linked to plunger 8 by rod 14 secured at opposite ends to the diaphragm and the plunger. The latter itself has an axial bore 15 for pressure balancing purposes and is spring-loaded by spring 16 in the same sense as diaphragm 12.

A lateral slot 17 in the body 6 is connected to

the downstream side of orifice 3 by a spill pipe 18, and a lateral bore 19 in the opposite side of the body 6 and axially offset from slot 17 is connected through a spill lead 20 to spill line 5. Plunger 8 has a recessed portion 21 which permits bore 19 to communicate with slot 17 to a greater or lesser extent depending on the position of the plunger.

The lateral bores 22, 23 are also provided on opposite sides of the body 6 and axially offset from each other. These are intended to function as servo ports and the plunger 8 is provided with a recess 24 communicating with bore 15 and adapted to communicate with either bore 22 or 23 when the plunger is in the appropriate position.

The pilot valve 4 is connected through pipes 25 and 25a to a compensating valve 28 comprising a substantially cylindrical body 29 having an axial bore 30 in which slides a cylindrical plunger 31, and unions 32, 33 at each end through which the bores 22, 23 respectively communicate with opposite ends of bore 30.

From the delivery line 2 and on the downstream side of orifice 3 a spill lead 27 is taken to a lateral slot 70 in the wall of body 29, and from a lateral bore 32a opposite to and axially offset from slot 70 is taken a spill lead 33a to spill line 5.

Plunger 31 has a recessed portion 34 which puts slot 70 into communication with bore 32a to a greater or lesser extent according to its position and also has a recess 35 which communicates through a bleed line 36a with recess 34. The effect of the recesses 34, 35 is to form two lands 36, 37 on the plunger 31 which are of substantially equal dimensions.

The slot 17, at least at its lower end 75 where it enters the bore 7 is T-shaped in horizontal section as shown in Fig. 2. Thus, when, in response to a great increase in engine speed, the plunger 8 moves far enough to uncover the transverse limb 75a of the T there is a sudden increase in the available area of slot 75 and thus a sudden increase in the spill from pipe 18, which effect tends to correct the engine speed promptly.

The compensating valve 28 also has a light spring 44, tending to close it so as to ensure that plunger 31 shall always be returned to the correct position for starting.

The operation of this arrangement is as follows:

At the normal pre-selected speed the pressure in chamber 10 tending to move diaphragm 12 to the left exactly balances the combined pressures of spring 13 and fluid in chamber 11 tending to move diaphragm 12 to the right. If there is an increase in engine speed, the pressure drop across orifice 3 increases and the balance is disturbed, diaphragm 12 therefore moving to the left and moving with it rod 14 and plunger 8.

If this speed increase is small, the movement of plunger 8 will also be small and only just sufficient to increase communication between slots 17 and 19 through recess 21 and thence increase the spill from pipe 18 through pipe 5 to the extent necessary in order to diminish the fuel supply and correct the speed increase.

If, however, this increase is large, movement of plunger 8 is then large enough to bring recess 24 into communication with slot 22 and thence through pipe 25 into communication with valve 28 which then comes into operation.

Plunger 31 is moved to the left and thus increases the extent of communication between

spill lead 27 and recess 34, and between recess 24 and spill pipes 33a and 5, thereby increasing the amount of fuel spilt by valve 28 and thus causing an additional check in the engine speed. The diameter of the land 37 is slightly less than that of bore 30, thus providing clearance 38 between the surface of land 37 and the wall of bore 30 to permit the liquid in the bore to the left of land 37 to leak through the clearance to recess 35 and thence through recess 34 to spill pipe 5. This permits leftward movement of plunger 31 and also provides a hydraulic damping effect for said plunger which consequently moves much more slowly than plunger 8 of pilot valve. After plunger 31 has traveled leftwards to increase the spill of valve 28 sufficiently for the necessary speed correction, the value of this speed returns to the pre-selected value thus enabling plunger 8 of valve 4 to return to its original position and plunger 31 ceases to move.

A decrease in engine speed causes plunger 8 and if necessary also plunger 31 to move to the right thus decreasing the spill and increasing the fuel supply which increases the speed to the preselected value.

It will thus be seen that the arrangement is such that small variations in the fuel supply are quickly corrected solely or mainly by the pilot valve 4 while larger variations are corrected mainly by the compensating valve 28.

In Figure 3 the compensating valve 28 is diaphragm operated, and openings 45, 46 in the wall 6 of pilot valve 4 serve as spill outlets. These openings are arranged diametrically opposite and are so shaped and disposed relative to recesses in plunger 8 that movement of the latter produces a differential pressure between fluid in recesses 47 and 48 which actuates diaphragm 51 and thence plunger 31. In the form shown in Fig. 3A opening 45 is of quadrilateral section so as to have an effective area which varies with axial movement of plunger 8. The other opening 46 is in the form of a slot. Plunger 8 has two recessed portions 47, 48 of which recess 47 is adapted to communicate with openings 45, 46 and is always in communication with a lateral bore 49, while recess 48 is adapted to communicate with openings 45, 46 and is always in communication with a lateral bore 50. Opening 46 is connected through spill pipe 5a to source.

Compensating valve 28 is provided with a diaphragm 51 connected by rod 77 to plunger 31; bore 49 is connected by pipe 83 to one side of the diaphragm while bore 50 of valve 4 communicates through pipe 53 and a restrictor 52 with the other side of diaphragm 51 and also through pipe 54 with the left-hand end of bore 30. The general construction of valve 28 and plunger 31 is the same as in Figure 1 except that in this case no clearance is provided between land 37 and the wall of bore 30, the liquid in this bore located to the left of land 37 communicating through pipe 54 when plunger 31 moves to the left. The restrictor 52 provides the required hydraulic damping means.

In the normal position as shown in Figure 3A the central land of plunger 8 lies across the central portions of the openings 45 and 46. In operation if the engine speed increases and plunger 8 of valve 4 is consequently moved to the left, owing to the quadrilateral shape of opening 45, the portion of the opening 45 located to the right of the central land of plunger 8 is increasing in effective area at a rapid rate while on the other hand the portion of the opening 45 on the left-

hand side of this land is closed less rapidly. Thus the spill from opening 45 to recess 48 is being increased rapidly while the spill from opening 45 to recess 47 is decreasing less rapidly, and therefore the net spill through pipe 5a is increased. At the same time the pressure in recess 48 will increase relatively to the pressure in recess 47. The pressure in recess 48 is transmitted through pipe 53 and restrictor 52 to the right hand side of diaphragm 51 of valve 28, while the pressure in recess 47 is transmitted through pipe 83 to the left hand side of the diaphragm 51. Thus the diaphragm 51 together with rod 77 and plunger 31 all move to the left, and thus increases the spill from 27 through recess 24 to spill pipe 35.

If engine speed decreases then the operation of the apparatus is the reverse of that described above and both plungers 8 and 31 move to the right to decrease the amount of fuel spilt.

The invention may also be used with so called spill controlled burners i. e. wherein part of the fuel delivered to each burner is ejected through the burner nozzle for combustion while the remainder is returned through a spill pipe to source 1, the nozzle delivery being controlled by a throttling device in the spill pipe. In this case the throttling device comprises the pilot valve and compensating valve system of the invention.

In Figure 4 which illustrates such a system, the pilot valve plunger 8 is provided with three recesses 58, 59, 60 so as to form four lands 61, 62, 63, 64. The valve body 6 is provided with two servo ports 65, 66 on one side and with two spill ports 67, 68 on the diametrically opposite side, and also with a slot 69, preferably T shaped as slot 75 of Figure 1. The spill port 67 when in communication through the recess 58 with the slot 69 is adapted to ensure that spill therefrom shall pass to the main spill return pipe to source 1, while the spill port 68 is adapted for communication either with the recess 59 or the recess 60 according to the direction of displacement of the plunger 8 from its normal position, thereby ensuring the return of any required spill from either of said recesses back through the main spill return pipe to source 1.

The general arrangement is such that in the mean position of plunger 8, land 61 partly covers slot 69, and recess 58 communicates with bore 67. The recess 59 then communicates with bore 65 and recess 60 with bore 66.

One or more bleed lines are provided either in the valve body 6 or in plunger 8 and arranged so that movement of plunger 8 to the right causes recess 60 to be at higher pressure and recess 59 to be at lower pressure. In the present case a bleed line 78 is provided in the body 6 and is closed in the mean position by land 62. A second bleed line 79 is closed in the mean position by land 64.

Valve 28 has a diaphragm 51 linked to a plunger 31 moving in bore 30. The port 65 in pilot valve 4 communicates through restrictor 52 with the left hand side of diaphragm 51 and through pipe 85 with the left hand end of bore 30. Port 66 communicates through pipe 86 with the left hand side of diaphragm 51.

The compensating valve body 29 has a spill bore 81 and a lateral spill slot 80 axially offset therefrom. The slot 69 in valve 4 and slot 80 of valve 28 are both connected to the spill pipe 71 of a spill-controlled burner 72. The spill bore 81 and ports 67, 68 are all connected to the main spill return piping 5.

The plunger 31 or compensating valve 28 is similar to that of Figure 1.

In operation if the engine speed increases, the pressure drop across the orifice 3 increases and at the same time the actual pressure on both sides of the orifice is also increased. Plunger 8 of valve 4 is moved to the left and thus increases the amount of fuel spilt from pipe 71 through pipe 87 to recess 62 and thence through spill pipe 5 back to source.

At the same time the space 88 in the bore 30 located to the left of plunger 8 communicates through bleed line 78 with port 59 and thence through restricted bore 52 with diaphragm 51 to valve 58 so that any increase in pressure in chamber 11 of valve 4 is transmitted through the axial bore 15 to the right hand side of diaphragm 51. The pressure on the left hand side of diaphragm 51 remains unchanged so that plunger 31 moves to the left thus increasing the spill from pipe 71 through recess 34 to slot 81 and spill return pipe 5.

For a decrease in engine speed the bleed line 79 comes into operation to effect the movement of plunger 31 to the right so as to decrease the amount of fuel spilt back to source. The restrictor 52 acts in the same way as in Figure 3 as a hydraulic damping means to effect slow movement of plunger 31.

It may be necessary to provide means whereby slot 80 connected to the burner spill outlet is never completely closed off so as to provide for starting purposes. These means may conveniently comprise light springs 82 and 84 of suitable strength to bring plunger 31 to the correct position for starting.

We claim:

1. In a fluid operated governor for a variable speed engine comprising a source of fluid and a pump connected to said source and to a fluid delivery line having a restricted orifice, the provision of at least two fluid pressure sensitive valves each having spill means affording permanently open connection to said fluid delivery line downstream of said orifice and said source, one of said valves, the pilot valve, comprising an element connected directly across the orifice whereby one side of said element is freely open to the pressure existing immediately upstream of said orifice while the opposite side of said element is freely open to the pressure existing immediately downstream of said orifice, and the other valve, the compensating valve, is hydraulically connected to and is thereby operated by the pilot valve.

2. In an engine, a governor according to claim 1, wherein the fuel delivery line includes a variable area orifice, and the pilot valve comprises a body having an internal longitudinal bore, transverse passages communicating with said bore, a diaphragm connected across said orifice and adapted to move a plunger slidable in said longitudinal bore and adapted to control the effective area of said passages, at least one of said passages being connected to a spill return line, and at least two other of said passages communicating with said compensating valve.

3. A governor according to claim 1, wherein the pilot valve and compensating valve each comprise a substantially cylindrical body having an axial bore and a plurality of lateral passages leading into said axial bore, an end cap rigid with said body and divided internally by a diaphragm into two chambers each provided with an inlet, a recessed plunger slidable in said axial

bore and linked to said diaphragm, one of said lateral passages in the pilot valve communicating through a restrictor with an inlet of one of said chambers of the compensating valve, a second lateral passage in the pilot valve communicating with the inlet of the other of said chambers in the compensating valve, and a third lateral passage in the pilot valve communicating with that end of the axial bore in the compensating valve remote from the diaphragm.

4. A governor according to claim 1, wherein the pilot valve comprises a substantially cylindrical body having an axial bore and a plurality of lateral passages leading into said axial bore, an end cap rigid with said body and divided internally by a diaphragm into two chambers each provided with an inlet, a recessed axially bored plunger slidable in said axial bore and linked to said diaphragm, at least two of said lateral passages communicating with the compensating valve, and at least one of said passages being adapted to serve as a spill outlet.

5. A governor according to claim 1, wherein the pilot valve comprises a substantially cylindrical body having an axial bore and a plurality of lateral passages leading into said axial bore, an end cap rigid with said body and divided internally by a diaphragm into two chambers each provided with an inlet, a recessed axially bored plunger slidable in said axial bore and linked to said diaphragm, at least two of said lateral passages communicating with the compensating valve, and at least one of said passages being adapted to serve as a spill outlet, at least one of said lateral passages being of T section, one limb of the T being axially disposed and the other limb radially disposed.

6. A governor according to claim 1, wherein the pilot valve comprises a substantially cylindrical body having an axial bore and a plurality of lateral passages leading into said axial bore, an end cap rigid with said body and divided internally by a diaphragm into two chambers each provided with an inlet, a recessed axially bored plunger slidable in said axial bore and linked to said diaphragm, at least two of said lateral passages communicating with the compensating valve, and at least one of said passages being adapted to serve as a spill outlet, at least one of said lateral passages having a section such that the effective area of said passage varies with axial movement of the pilot valve plunger.

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