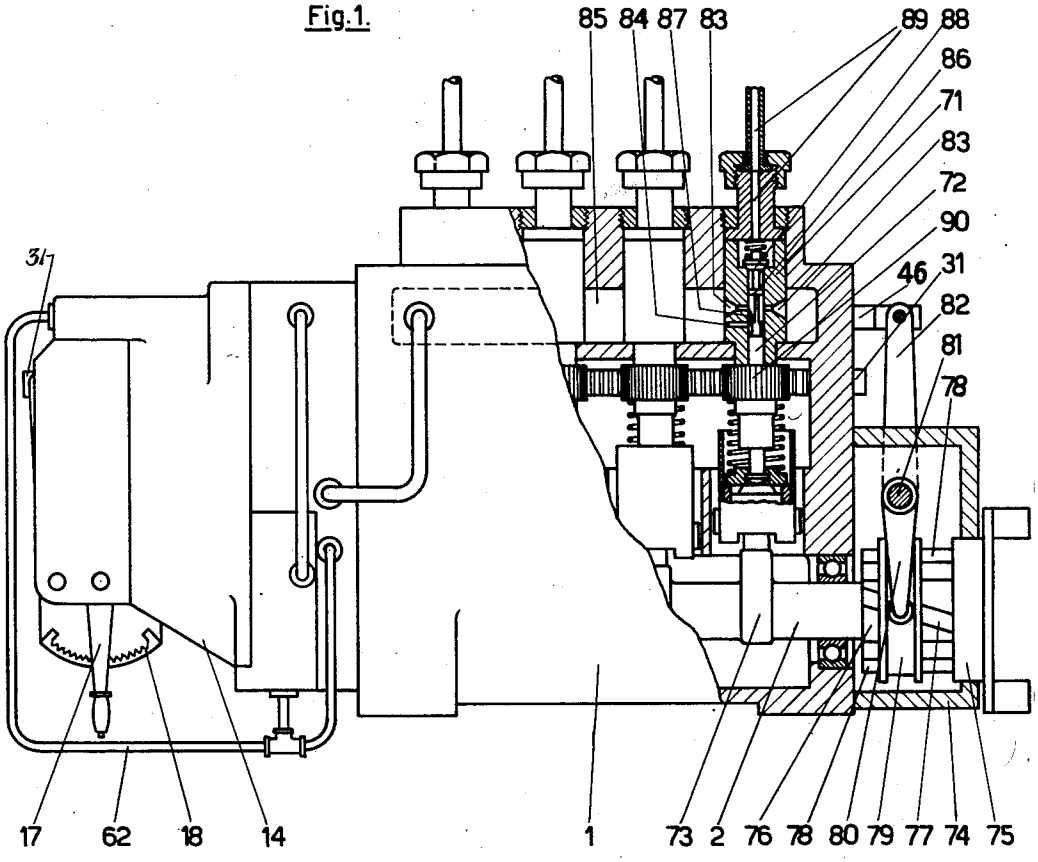
July 11, 1939. E. SCHAEREN 2,165,657

REGULATING APPARATUS FOR FUEL INJECTION PUMPS OF INTERNAL COMBUSTION ENGINES

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Fig.1.



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Fig. 2.

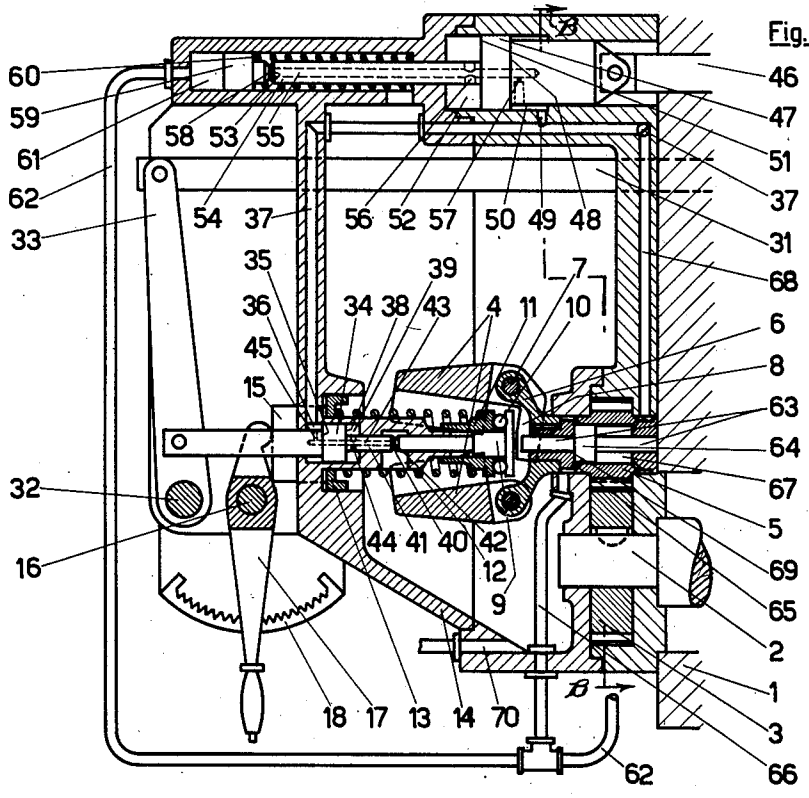
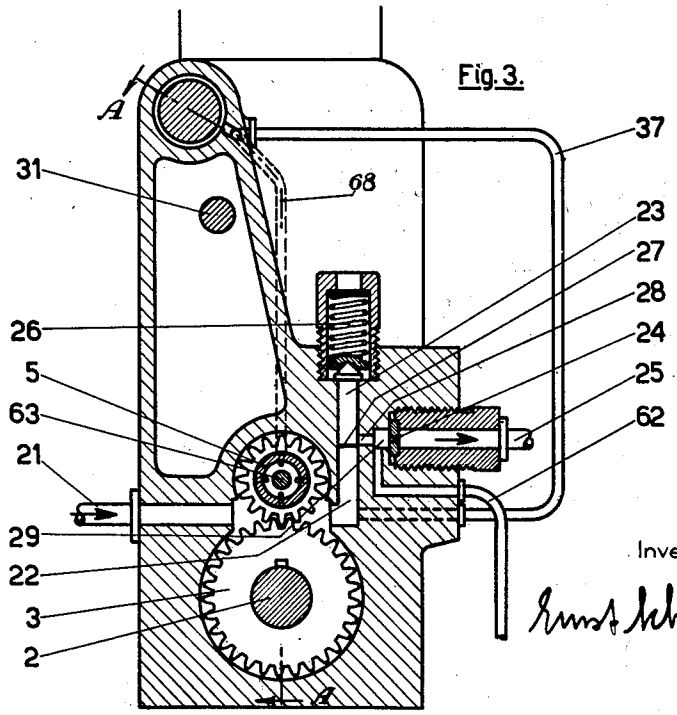


Fig. 3.



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REGULATING APPARATUS FOR FUEL INJECTION PUMPS OF INTERNAL COMBUSTION ENGINES

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11 Claims. (Cl. 123—140)

This invention relates to regulating apparatus for fuel injection pumps of internal combustion engines.

One object of the invention is to provide means for controlling the quantity of fuel supplied to the internal combustion engine according to engine speed.

Another object of the invention is to provide such regulating apparatus adapted to be manually adjusted to maintain the engine running at or about a given speed, or within a suitable speed range as long as its load permits.

A further object of the invention is to provide means automatically adjusting the time of the fuel injection in relation to the engine speed.

Still a further object is to provide such regulating apparatus of compact form and dimensions and of high regulating power so as to be suitable also for large injection pumps.

According to the invention, a device automatically regulating the pressure of the oncoming fluid and a restricted passage are provided one after the other in the path of a regulating fluid delivered by a regulating pump driven by the internal combustion engine.

With this general statement of the objects and purposes of my invention, I will now proceed to describe the embodiment thereof and the manner in which my invention may be carried out, and it will be understood that while I have described what may be considered as a preferable embodiment of my invention, I do not limit myself to the precise features, herein set forth, as they may be varied by those skilled in the art in accordance with the particular purposes for which they are intended and the conditions under which they are to be utilised.

In said preferred embodiment of the invention the fluid pressure ahead of a pressure regulating device acts upon the working member of a servomotor device for adjusting the fuel delivery of the injection pump, and the pressure ahead of a restricted passage acts upon a device for timing the fuel injection according to the engine speed. The said servomotor for adjusting the fuel delivery may itself be controlled by a centrifugal governor, and the said regulator pump may be a gearwheel pump also used as a gearing in the drive of said centrifugal governor. Further, a displaceable member of said centrifugal governor may be influenced, at least for a part of the governor stroke, by the fluid pressure ahead of said restricted passage. The timing of the injection may be effected indirectly by means of a servomotor, the control member of which is influenced by the fluid pressure ahead of said restricted passage, whilst the working member of said injection timing servomotor may be influenced by the pressure ahead of said pressure regulating device. Also, the regulating fluid may be fuel, and it may be supplied to the fuel injection pump after having passed the restricted passage. It has been found suitable to construct said pressure regulating device so that it keeps the pressure of the oncoming fluid substantially constant.

In the drawings,

Fig. 1 shows, partly in longitudinal section, a fuel injection pump having a regulating apparatus according to the invention.

Fig. 2 is a longitudinal section of the regulating apparatus on the lines A—A of Fig. 3.

Fig. 3 shows a cross-section of the same apparatus on the line B—B of Fig. 2.

1 indicates a fuel injection pump having a plurality of pump cylinders 71, in which pistons 72 are reciprocated by means of a pump shaft 2 provided with cams 73.

The pump cylinders 71 are pressed into the body of the injection pump 1 and provided with ports 83 and 84 communicating with a suction chamber 85. Each pump piston 72 has an edge 86 perpendicular to the piston axis controlling the ports 83 and an edge 87 oblique to said axis, controlling the port 84 and bounding a recess communicating with the pump chamber above the piston. On the up stroke of the piston the port 83 is closed by the edge 86, whereupon fuel is displaced from said pump chamber past the non-return valve 88 into the conduit 89 and thence through an injector (not shown) into the cylinder of the internal combustion engine.

When the edge 87 opens the port 84, the pressure in the pump chamber is relieved and the injection ended. Because the edge 87 is oblique, the opening of the port 84 occurs earlier or later in the pump stroke and the injected fuel quantity is therefore smaller or larger according to the angular position of the piston 72. The latter may be rotated about its axis by means of a pinion 90 in angular engagement with it, and of a rack 31 longitudinally displaceable in the pump body.

At the drive end of the shaft 2 an injection timing device is provided in the housing 74 which is fixed to the body of the injection pump 1. The casing 74 provides a bearing for the coupling plate 75 which is driven by the internal combustion engine in a way not shown in the drawings. The end of the pump shaft 2 carries

a bush 76 provided with a pair of helical ribs 77. Between the latter a pair of guides 78 carried by the coupling plate 75 extend along the bush 76 parallel to its axis. A coupling ring 79 displaceable along said guides 78 engages said helical ribs 77 so that the pump shaft 2 is coupled to the plate 75 in an angular relation which can be adjusted by axially displacing said coupling ring 79.

The latter has a circumferential groove engaged by a lever 80 carried by a shaft 81 supported in the housing 74. Outside the latter, a lever 82 connects the shaft 81 to a rod 46 longitudinally displaceable in the pump body. Thus, by displacing the rod 46, the pump shaft 2 may be angularly adjusted with reference to the internal combustion engine shaft, whereby the injection timing is altered. The left hand end of the shaft 2 carries a gearwheel 3 fixed thereto by a key. This wheel 3 forms part of a gearwheel pump 3, 5 serving also as a gearing in the drive of a centrifugal governor. The latter comprises two centrifugal weights 4 pivoted on journals 7 supported by arms 6 mounted on the second gearwheel 5 of the gearwheel pump 3, 5. Each centrifugal weight 4 has an arm 8 acting upon a plate integral with the governor pin 9 pressed onto said arms 8 by a helical spring 12. Between the latter and the aforesaid plate of the pin 9, a spring guide 11 and a ball bearing 10 are inserted to permit the rotation of the pin 9 relatively to said spring 12. The other end of the spring 12 bears against an abutment 13 which is axially displaceable within the casing 14 and which has extensions 15 on both sides of its axis. Said extensions abut the lever 17 pivoted on the journal 16 and adapted to be manually displaced and arrested on the toothed segment 18.

The gearwheel pump 3,5 is supplied with liquid fuel through a pipe 21 and displaces this fuel into the delivery chamber 22. In the further path of the fuel, there is a port 28, an auxiliary chamber 29 and a restricted passage 24. The communication of the chamber 22 with the port 28 is controlled by the control edge 27 of a plunger 23 fitting a cylindrical extension of said chamber 22 and pressed into the latter by a spring 26. Behind the restricted passage 24 the fuel flows off through the pipe 25 and thence to the suction chamber 85 of the fuel injection pump 1.

By means of the lever 33 pivoted at 32 the rack 31 is linked to a servomotor piston 34, slidably fitting a cylindrical recess formed in the casing 14. The servomotor piston 34 is constructed as a differential piston. Its smaller annular face 35 is exposed to the pressure in the servomotor chamber 36, which pressure tends to displace the servomotor piston 34 so as to increase the fuel quantity delivered by the fuel injection pump. Through the conduit 37 the chamber 36 is in open connection with the delivery chamber 22 located in the fuel path ahead of the pressure regulating device formed by the port 28 and the control plunger 23. The larger annular face 38 of the servomotor piston 34 faces the complementary chamber 39 in the servomotor cylinder. An extension 41 of the servomotor piston 34 passes through the complementary chamber 39 and through the adjoining bottom of the servomotor cylinder and has a face 40 outside the latter opposite the face 42 of the governor pin 9, so as to form a variable gap therewith. A longitudinal bore 43 issues in the face 40 and communicates by several large passages 44 with the complementary chamber 39 and through a restricted passage 45 of much narrower cross-section with the servomotor chamber 36.

The rod 46 provided in the injection pump 1 for timing the fuel injection is coupled to the timing servomotor piston 47, which is also a differential piston. Its face 48 is exposed to the fuel pressure in a timing servomotor chamber 50 connected to the delivery chamber 22 by the conduit 37 and the passage 49, whilst its opposite face 51 which is larger than the face 48 bounds the complementary chamber 52. The face 53 of the extension 54 surrounds the mouth of a longitudinal bore 55 provided in the piston 47. This bore 55 is connected through large openings 56 with the complementary chamber 52 and through a restricted passage 57 with the servomotor chamber 50. Opposite the face 53 and coacting with it to form a gap of variable breadth there is the face 58 of a coaxial timing control piston 59 subject to the pressure of a spring 60, which tends to remove the control piston 59 from the servomotor piston 47. The opposite face of the control piston 59 is exposed to the pressure in a control chamber 61 connected by a piping 62 to the auxiliary chamber 29 ahead of the restricted passage 24.

On a part of its stroke the governor pin 9 is in touch with the abutting pin 63 made integral with a piston 64 fitting a cylindrical recess in the hub of the gearwheel 5. One face of said piston 64 is exposed to the fuel pressure in an annular chamber 65 connected to the auxiliary chamber 29 through the pipes 62 and 66. The opposite face of the piston 64 is situated in another annular chamber 67 which communicates with the chamber 22 by means of a duct 68 and the aforementioned conduit 37. When the abutment pin 63 is in contact with the governor pin 9, the latter is therefore influenced both by the fuel pressure ahead of the pressure regulating device comprising the plunger 23 and the port 28, and by the pressure ahead of the restricted passage 24. An abutment 69 prevents the pin 63 from following the governor sleeve 9 on the whole of the latter's stroke.

The described regulating apparatus operates as follows:

The fuel arriving through the conduit 21 is fed to the delivery chamber 22 by the gear pump 3, 5 until the pressure in this chamber 22 is sufficient to lift the plunger 23 from its seat against the force of the spring 26, so that the control edge 27 in part uncovers the mouth of the port 28. The fuel further fed to the chamber 22 then escapes to the chamber 29. If a further rise of pressuure occurs in the chamber 22, the plunger 23 yields further back, and the cross-section whereby fuel can pass to the port 28 is increased. Then a larger quantity of fuel may escape through the latter and the rise of pressure in the chamber 22 is cancelled. In this way the pressure in the chamber 22 is regulated to a nearly constant value.

The quantity of fuel displaced by the pump 3,5 increases with the speed of the internal combustion engine. As the same fuel quantity also flows through the restricted passage 24, the fuel pressure in the auxiliary chamber 29 ahead of this passage also increases when the engine runs faster.

Both in the chamber 36 of the servomotor for adjusting the fuel delivery of the injection pump and in the chamber 50 of the servomotor for timing the fuel injection the pressure is nearly constant as in the delivery chamber 22. From said

servomotor chambers 36 and 50 fuel always flows through the corresponding restricted passages 45 and 57, through the longitudinal bores 43 and 55 and thence to the sump in the bottom of the casing from where it is evacuated by the pipe 70. In each of the longitudinal bores 43 and 55, and in the respective complementary chamber 39 or 52 connected thereto through one of the wide passages 44 or 56 a lower pressure prevails than in the corresponding servomotor chamber 36 or 50 on account of the throttling effect in the respective passage 45 or 57. The pressure difference between the chambers 36 and 39, or 50 and 52 varies in accordance with the fuel quantity spilled through the respective bore 43 or 55, and this quantity is influenced by the distance between the piston extension face 40 or 53 and the face 42 or 58 of the respective member 9 or 59. If the gap between such coacting faces is increased, more fuel is spilled through this gap also, and the pressure in the corresponding complementary chamber 39 or 52 drops. Thereby, the nearly constant fuel pressure in the servomotor chambers 36 and 50 is enabled to displace the corresponding servomotor piston until the gap between the coacting faces has become sufficiently small to reestablish the balance of forces on both sides of the servomotor piston. Thus, the servomotor piston 34 always follows the movements of the governor pin 9, thereby displacing the delivery adjustment rack 31 accordingly; similarly, the timing servomotor piston 47 follows the movements of the timing control piston 59 whereby the timing of the fuel injection is adjusted in a corresponding way.

To increase the speed of the internal combustion engine the spring 12 may be compressed by actuating the lever 18, so that the governor pin 9 is displaced towards the pin 63 against the centrifugal force acting upon the weights 4. The servomotor piston 34 follows the pin 9 and displaces the delivery adjusting rack 31 by means of the lever 33 so as to increase the fuel quantity delivered by the injection pump 1 to the internal combustion engine. As a consequence, the power of the latter is increased and causes the speed to rise. The centrifugal weights 4 are then swung out and the spring 12 compressed by the centrifugal force, whereby the governor pin 9 is moved towards the servomotor piston 34, and the latter displaces the delivery adjusting rack 31 into a position corresponding to a smaller fuel delivery, thus preventing a further rise of the engine speed. The spring 12 is calibrated in such a way as to allow the centrifugal weights 4 and the governor pin 9 to cover their whole stroke corresponding to the entire range of fuel delivery from zero to the maximum whilst the engine speed varies by a comparatively small amount. Thus it is possible to obtain a desired speed by convenient setting of the lever 17.

When the engine speed increases a high pressure establishes itself in the auxiliary chamber 29 and accordingly in the timing control chamber 61, so that the control piston 59 is displaced against the force of the spring 60. This displacement causes a corresponding movement of the timing servomotor piston 47, and the rod 46 is brought into a position where the fuel injection takes place earlier, as is desirable for the increased speed.

As the nearly constant pressure in the chamber 67 of the governor hub cylinder, which corresponds to the pressure in the delivery chamber 22 always exceeds the variable pressure in the chambers 29 and 65 on account of the throttling effect in the port 28, the piston 64 always abuts the stop 69 when the injection pump 1 delivers small fuel quantities at which the governor pin 9 is out of contact with the pin 63. However, if the governor pin 9 abuts the abutment pin 63, as occurs when the fuel quantity delivered by the injection pump 1 is large, the force exerted by the spring 12 upon the governor pin 9 is partly counteracted by the force resulting from the pressures upon the piston 64 in the chambers 65 and 67. This difference decreases when the engine speed augments, because the pressure in the chamber 67 is nearly constant and that in the chamber 65 increases with engine speed. If the lever 17 is set for maximum delivery, the force of the spring 12 is not sufficient at small engine speed to lift the piston 64 from its abutment 69 and to displace the pin 63. However, if the speed of the engine is high enough, the force resulting from the fuel pressure in the chambers 65 and 67 becomes so low that it cannot overcome the tension of the spring 12 and prevent the yielding of the abutment pin 63. The governor pin 9 may then move further and cause the rack 31 to be displaced so that an increase of the injected fuel quantity is obtained at high engine speeds without admitting the corresponding fuel quantities to be injected at low speeds.

What I claim is:

1. Control means for engines of the fuel injection type comprising in combination, a fuel injection device; means for varying the timing of said device; means for varying the quantity injected by said device; a governor responsive to engine speed; adjustable loading means for said governor for varying the speed at which the governor responds; an actuator for said quantity varying means controlled by said governor; a hydraulic pump operated at a speed proportional to engine speed and serving to develop a hydraulic pressure which varies with engine speed; means responsive to the varying hydraulic pressure and arranged to control said timing varying means; means also responsive, at least in part, to said varying hydraulic pressure and serving to modify the loading of said governor; and means for limiting the range of action of the last named means to a portion only of the range of action of the governor.

2. Control means for engines of the fuel injection type comprising in combination, a fuel injection device; means for varying the timing of said device; a hydraulic servo-motor for actuating said timing varying means; means for varying the quantity injected by said device; a hydraulic servo-motor for actuating said quantity varying means; a governor responsive to engine speed and arranged to control the second named servo-motor; adjustable loading means for said governor for varying the speed at which the governor responds; a hydraulic pump driven by said engine; a loaded vent valve for establishing a substantially uniform back pressure on said pump; connections for supplying motive fluid from said pump under said back pressure to said servo-motors; flow restricting means in the path of liquid leaving said vent valve for establishing a secondary pressure which varies with engine speed; and means responsive to said secondary pressure for controlling the first named servo-motor.

3. Control means for engines of the fuel injection type comprising in combination, a fuel injection device; means for varying the timing of

said device; a hydraulic servo-motor for actuating said timing varying means; means for varying the quantity injected by said device; a hydraulic servo-motor for actuating said quantity varying means; a governor responsive to engine speed and arranged to control the second named servo-motor; adjustable loading means for said governor for varying the speed at which the governor responds; a hydraulic pump driven by said engine; a loaded vent valve for establishing a substantially uniform back pressure on said pump; connections for supplying motive fluid from said pump under said back pressure to said servo-motors; flow restricting means in the path of liquid leaving said vent valve for establishing a secondary pressure which varies with engine speed; means responsive to said secondary pressure for controlling the first named servo-motor; means responsive at least in part to said secondary pressure to modify the loading of said governor; and means for limiting the range of action of the last named means to a portion only of the range of action of the governor.

4. Control means for engines of the fuel injection type comprising in combination a hydraulic servo-motor; a hydraulic pump operated at a speed proportional to engine speed; a loaded vent valve for establishing a substantially uniform back-pressure on said pump; connections for supplying motive fluid from said pump under said back-pressure to said servo-motor; flow restricting means in the path of liquid leaving said vent valve for establishing a secondary pressure which varies with engine speed; and control means for said servo-motor responsive to said secondary pressure.

5. Control means for engines of the fuel injection type comprising in combination a fuel injection device; means for varying the timing of said device; a hydraulic servo-motor for actuating said timing varying means; a hydraulic pump operated at a speed proportional to engine speed; a loaded vent valve for establishing a substantially uniform back-pressure on said pump; connections for supplying motive fluid from said pump under said back-pressure to said servo-motor; flow restricting means in the path of liquid leaving said vent valve for establishing a secondary pressure which varies with engine speed; and means responsive to said secondary pressure for controlling the said servo-motor.

6. Control means for engines of the fuel injection type comprising in combination a fuel injection device; means for varying the timing of said device; means for varying the quantity injected by said device; a hydraulic servo-motor for actuating said quantity varying means; means for controlling said servo-motor; a hydraulic pump operated at a speed proportional to engine speed; a loaded vent valve for establishing a substantially uniform back-pressure on said pump; connections for supplying motive fluid from said pump under said back-pressure to said servo-motor; flow restricting means in the path of liquid leaving said vent valve for establishing a secondary pressure which varies with engine speed; and means responsive to said secondary pressure and arranged to control said timing varying means.

7. Control means for engines of the fuel injection type comprising in combination a fuel injection device; means for varying the quantity injected by said device; a governor responsive to engine speed; adjustable loading means for said governor for varying the speed at which the governor responds; an actuator for said quantity varying means controlled by said governor; a hydraulic pump operated at a speed proportional to engine speed and serving to develop a hydraulic pressure which varies with engine speed; means responsive, at least in part, to said varying hydraulic pressure and serving to modify the loading of said governor; and means for limiting the range of action of the last named means to a portion only of the range of action of the governor.

8. Control means for engines of the fuel injection type comprising in combination a fuel injection device; means for varying the timing of said device; means for varying the quantity injected by said device; a governor responsive to engine speed; adjustable loading means for said governor for varying the speed at which the governor responds; an actuator for said quantity varying means controlled by said governor; a hydraulic servo-motor for actuating said timing varying means; a hydraulic pump operated at a speed proportional to engine speed; a loaded vent valve for establishing a substantially uniform back-pressure on said pump; connections for supplying motive fluid from said pump under said back-pressure to said servo-motor; flow restricting means in the path of liquid leaving said vent valve for establishing a secondary pressure which varies with engine speed; means responsive to said secondary pressure for controlling said servo-motor; means responsive at least in part to said secondary pressure to modify the loading of said governor; and means for limiting the range of action of the last named means to a portion only of the range of action of the governor.

9. Control means for engines of the fuel injection type comprising in combination a fuel injection device; means for varying the timing of said device; means for varying the quantity injected by said device; a hydraulic servo-motor for actuating said quantity varying means; a governor responsive to engine speed and arranged to control said servo-motor; adjustable loading means for said governor for varying the speed at which the governor responds; a hydraulic pump operated at a speed proportional to engine speed; a loaded vent valve for establishing a substantially uniform back-pressure on said pump; connections for supplying motive fluid from said pump under said back-pressure to said servo-motor; flow restricting means in the path of liquid leaving said vent valve for establishing a secondary pressure which varies with engine speed; means responsive to said secondary pressure and arranged to control said timing varying means; means responsive at least in part to said secondary pressure to modify the loading of the governor; and means for limiting the range of action of the last named means to a portion only of the range of action of the governor.

10. Control means for engines of the fuel injection type comprising in combination a fuel injection device; a hydraulic servo-motor arranged to control the operation of said device; a hydraulic pump operated at a speed proportional to engine speed; a loaded vent valve for establishing a substantially uniform back-pressure on said pump; means for supplying liquid fuel to said pump; connections for supplying liquid fuel from said pump under said back-pressure to said servo-motor; flow-restricting means in the path of the liquid fuel leaving said vent valve for establishing a secondary pressure which

varies with engine speed; control means for said servo-motor responsive to said secondary pressure; and connections for supplying to said fuel injection device liquid fuel leaving said flow-restricting means.

11. Control means for engines of the fuel injection type comprising in combination a fuel injection device; a hydraulic servo-motor arranged to control the operation of said device; a hydraulic pump operated at a speed proportional to engine speed; a loaded vent valve for establishing a substantially uniform back-pressure on said pump; means for supplying liquid fuel to said pump; connections for supplying liquid fuel from said pump under said constant back-pressure to said servo-motor; flow restricting means in the path of the liquid fuel leaving said vent valve for establishing a secondary pressure which varies with engine speed; control means for said servo-motor responsive to said secondary pressure; and means for delivering to said fuel injection device a portion of the fuel delivered by said pump.

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