

United States Patent

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[54] APPARATUS FOR REGULATING THE TIMING OF FUEL INJECTION IN INTERNAL COMBUSTION ENGINES
10 Claims, 1 Drawing Fig.

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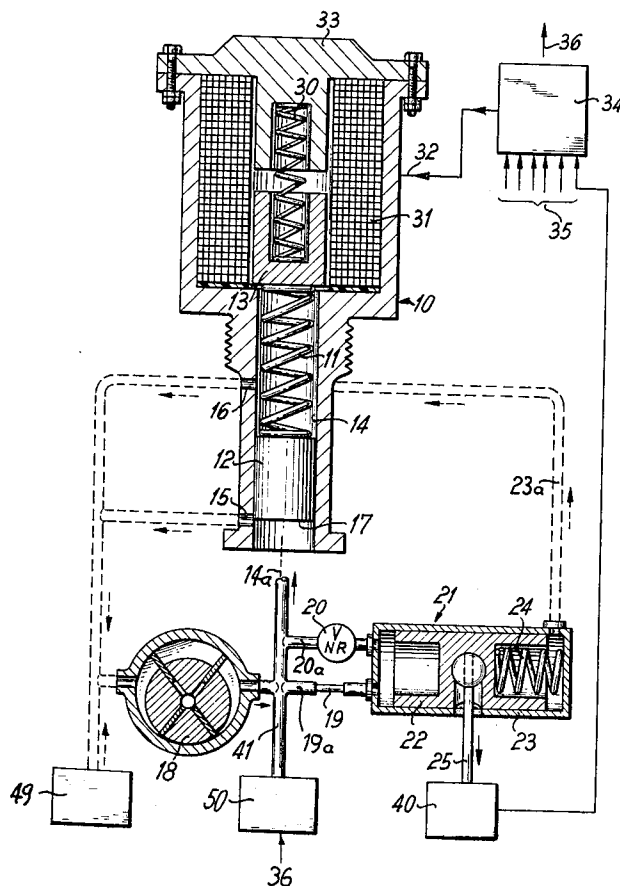
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139 E, 139.11, 139.13, 140, 140.1, 146.5, 117

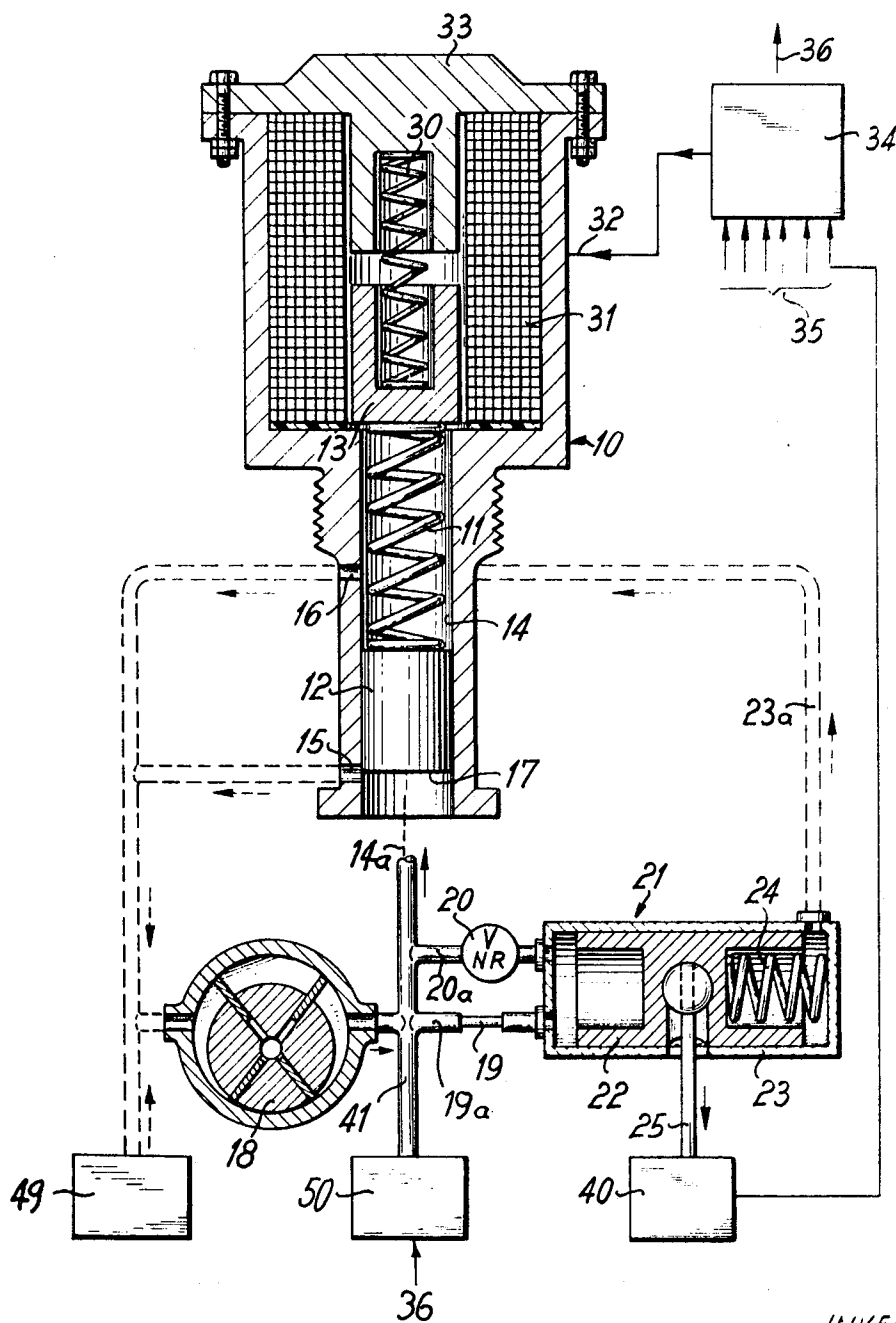
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ABSTRACT: A diesel engine wherein the fuel injection pump is adjustable to change the timing of fuel injection. The adjustment is effected by a lever which is movable by the piston of a hydraulic timer wherein the axial position of the piston depends on fuel pressure at the outlet of a fuel pump which delivers fuel to the injection pump. The fuel pressure can be varied by the fuel pump in dependency on the rotational speed of the engine and also in dependency on the load upon the engine. The second adjustment is effected by a control circuit which energizes an electromagnet whose armature influences a pressure regulating valve for the fuel pump.





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APPARATUS FOR REGULATING THE TIMING OF FUEL INJECTION IN INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The present invention relates to apparatus for regulating the timing of fuel injection in internal combustion engines. More particularly, the invention relates to improvements in apparatus for timing the injection of fuel in electronically controlled internal combustion engines. Still more particularly, the invention relates to apparatus which are especially suited for timing the injection of fuel into the cylinders of diesel engines.

In diesel engines, wherein the fuel is injected directly into the combustion chambers of the cylinders, it is necessary to delay the injection of fuel in response to increasing load on the engine. Presently known apparatus for controlling the timing of fuel injection in diesel engines employ a hydraulic timer mechanism including a piston which is adjustable as a function of changes in the pressure of a liquid. The liquid pressure is determined by a pressure regulator which cooperates with the fuel pump. The latter is coupled to the drive for the fuel injection pump. The amount of fuel which is delivered by the fuel pump is proportional to the rotational speed of such pump, normally a conventional vane pump. The fuel acts on the piston of the timer mechanism against the opposition of a spring whereby the piston changes the cross-sectional area of a bypass channel wherein the fuel can flow from the pressure side to the suction side of the fuel pump. The changes in timing of fuel injection which can be achieved with such apparatus are insufficient for internal combustion engines operating at high rotational speeds because the adjustments are not dependent on changes in the load upon the engine.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved apparatus for regulating the timing of fuel injection into the cylinders of internal combustion engines, particularly diesel engines.

Another object of the invention is to provide an apparatus wherein the timing of fuel injection can be changed while the rotational speed of the engine remains unchanged.

A further object of the invention is to provide an apparatus which can alter the timing of fuel injection in a novel way in dependency on changes in the load upon the engine.

An additional object of the invention is to provide an apparatus which can regulate the timing of fuel injection in high-speed diesel engines.

The invention is embodied in an apparatus for regulating the timing of fuel injection into the cylinders of internal combustion engines, particularly into the cylinders of electronically controlled high-speed diesel engines, wherein the injection of fuel is effected by a fuel injection pump which is adjustable to vary the timing of fuel injection and receives fuel from the outlet (pressure side) of a fuel pump at a pressure which is a function of rotational speed of the engine. The apparatus comprises hydraulic timer means connected with the outlet of the fuel pump and having adjusting means connected with the fuel injection pump to regulate the timing of fuel injection as a function of changes in fuel pressure at the outlet of the fuel pump, adjustable regulating means for changing the fuel pressure at the outlet of the fuel pump, and control means for adjusting the regulating means as a function of changes in the load upon the engine.

Thus, the timing of fuel injection can be changed by the fuel pump (by way of the timer means) in dependency on changes in rotational speed of the engine as well as in dependency on changes in the load upon the engine. The second adjustment is effected by the timer means in response to such changes in fuel pressure which are brought about by the regulating means in response to signals from the control means.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved apparatus itself, however, both as to its

construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a diagrammatic partly sectional view of an apparatus for regulating the timing of fuel injection by means of a fuel injection pump in a high-speed diesel engine.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The drawing illustrates a housing 10 which contains an adjustable fuel pressure regulating valve and an electromagnet forming part of a control unit which adjusts the regulating valve as a function of the load upon the engine. The lower portion 14 of the housing 10 is a cylinder which accommodates a helical spring 11 and a valve member or plunger 12. The spring 11 biases the plunger 12 downwardly and reacts against the armature 13 of the electromagnet. The chamber in the cylinder 14 communicates with a radial relief port 15 and with a second port 16. The lower end face 17 of the plunger 12 is subjected to the pressure of fuel which is delivered by a conduit 14a connected to the outlet of a fuel pump 18. The latter is a vane pump and its inlet is connected with a fuel tank 49. The inlet of the fuel pump 18 is further connected with the ports 15 and 16. The outlet of the fuel pump 18 is connected with a hydraulic timer mechanism 21 by way of a conduit 19a containing a flow restrictor 19 of constant cross-sectional area. A second conduit 20a, which also connects the outlet of the fuel pump 18 with the timer mechanism 21, contains a one-way valve 20. One of the conduits 19a, 20a and the corresponding fuel flow regulating element (19, 20) is optional.

The timer mechanism 21 comprises a piston 22 which is reciprocable in a cylinder 23 and is biased by a helical spring 24 which opposes the fuel pressure against the left-hand end face of the piston 22. The latter is coupled to an adjusting lever 25 which directly or indirectly adjusts a fuel injection pump 50 as a function of the axial position of the piston 22. A conduit 23a connects the right-hand chamber of the cylinder 23 with the inlet of the fuel pump 18 to compensate for losses due to leakage. The connection between the inlet of the fuel pump 18 and the port 16 serves the same purpose.

The armature 13 is biased toward the plunger 12 by a helical spring 30 and can be shifted upwardly, as viewed in the drawing, by the electromagnetic field on energization of the winding 31. The extent of upward displacement of the armature 13 against the opposition of the spring 30 is a function of the strength of the current supplied to the winding 31 by conductor means 32. A feedback element can be employed to stabilize the armature 13.

The spring 30 reacts against a cover portion 33 which is screwed, bolted or similarly secured to the housing 10. The magnetic flux which is produced by the winding 31 passes through the cover portion 33. The conductor means 32 is connected with one output of an electronic control circuit 34 having several inputs 35 to receive signals which indicate various factors influencing the operation of the internal combustion engine. A second output 36 of the control circuit 34 is connected with the adjustable elements of the fuel injection pump 50.

The adjusting lever 35 is connected with a signal generator 40 which transmits to one of the inputs 35 signals indicating the axial position of the piston 22 and hence the position of the armature 13. The reference character 41 denotes a fuel supply line which connects the outlet of the fuel pump 18 with the fuel injection pump 50. At least one of the inputs 35 furnishes signals which are indicative of the load upon the engine.

The operation:

The pressure of fuel delivered by the pump 18 acts on the end face 17 of the plunger 12 whereby the plunger moves up-

wardly to stress the spring 11 and to expose a portion of the relief port 15. The extent to which the relief port 15 is exposed determines the quantity of fuel which can be recirculated from the pressure side to the suction side of the fuel pump 18. Thus, the plunger 12 controls an overflow or bypass path for fuel. It is assumed that the apparatus contains the conduit 19a with flow restrictor 19 as well as the conduit 20a and the one-way valve 20. Rapid rise of fuel pressure in the cylinder 23 of the timer mechanism 21 in response to rapid increase in rotational speed of the engine is insured by the one-way valve 20. Furthermore, closing of the valve 20 results in a rise of pressure at the left-hand side of the piston 22 which pressure counteracts the moment of reaction of the drive for the high-pressure pump. On the other hand, the timer mechanism 21 is less sensitive to rapidly decreasing fuel pressure because the return flow of fuel from the cylinder 23 can take place only by way of the conduit 19a and flow restrictor 19.

Axial adjustments of the armature 13 serve the purpose of adjusting the timer mechanism 21 in dependency on other factors which depend on the load upon the internal combustion engine. Such axial adjustments of the armature 13 change the bias of the spring 11 and hence the axial position of the plunger 12. Such changes in axial position of the plunger 12 change the effective cross-sectional area of the relief port 15. The arrangement is such that, when the load upon the engine increases, the conductor means 32 supplies to the winding 31 current at a rate to move the armature 13 upwardly and to relieve the stress on the spring 11. Therefore, the fuel acting on the end face 17 can move the plunger 12 upwardly to enlarge the effective cross-sectional area of the relief port 15. Thus, the timing of sparks is then a function of rotational speed of the fuel pump 18 (which is proportional to the speed of the engine) as well as a function of the strength of current supplied to winding 31 by the control circuit 34. Such current strength is a function of the load upon the internal combustion engine.

An important advantage of the just-described apparatus is that the timing of sparks can be changed at a time when the rotational speed of the engine is constant. Thus, by changing the intensity of the output signal at 32, the control circuit 34 can influence the axial position of the piston 22 at a time when the rotational speed of the fuel pump 18 remains unchanged. The adjustment which is effected by the control circuit 34 is a function of changes in the load.

The improved apparatus is susceptible of many modifications without departing from the spirit of my invention. For example, the spring 11 can be replaced with a spring which is stressed in response to shifting of the armature 13 when the load on the engine increases. This would merely amount to changing the signs of current changes which bring about auxiliary adjustments in the position of the piston 22 as a function of changes in the load upon the engine.

The purpose of the signal generator 40 is to insure that the adjustment of the timing of fuel combustion in response to changes in load is effected in accordance with a predetermined schedule. The signal generator 40 produces electrical signals which are supplied to one of the inputs 35 and whose intensity is a function of the axial position of the piston 22.

The fuel pump 18 delivers fuel to the high-pressure inlet of the fuel injection pump 50 by way of the conduit 41.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

1. Apparatus for regulating the timing of fuel injection into the cylinders of an internal combustion engine wherein the injection is effected by a fuel injection pump which is adjustable to regulate the timing of fuel injection and receives fuel from

the outlet of a fuel pump at a pressure which is a function of the rotational speed of the engine, comprising hydraulic timer means connected with the outlet of the fuel pump and having adjusting means connected with the fuel injection pump to regulate the timing of fuel injection as a function of changes in fuel pressure at the outlet of the fuel pump; adjustable regulating means for changing the fuel pressure at the outlet of the fuel pump; and control means for adjusting said regulating means as a function of changes in the load upon the engine, said control means comprising an electromagnet having an armature movable between a plurality of positions each indicative of a different load upon the engine and said regulating means comprising a pressure regulating valve having a valve member movable between a plurality of positions each corresponding to a different fuel pressure at the outlet of the fuel pump and each depending on a different position of said armature, said pressure regulating valve further comprising a cylinder for said valve member, resilient means arranged to bias said valve member in a given direction with a force which is a function of the position of said armature and conduit means connecting said outlet with said cylinder so that the fuel in said conduit means exerts on the valve member a force tending to move the valve member counter to said given direction, said cylinder having at least one relief port which is controlled by said valve member and communicates with said conduit means to an extent which is a function of the position of said valve member.

2. Apparatus as defined in claim 1, wherein said timer means comprises a second cylinder, a conduit connecting the outlet of the fuel pump with said second cylinder, a piston reciprocable in said second cylinder under and against the pressure of fuel supplied by the fuel pump, and resilient means acting on said piston to oppose the pressure of fuel in said second cylinder, said adjusting means being operatively connected with said piston.

3. Apparatus as defined in claim 1, wherein said resilient means comprises a spring which bears against said valve member and reacts against said armature.

4. Apparatus as defined in claim 1, further comprising means for furnishing to said control means signals indicating the position of said armature.

5. Apparatus for regulating the timing of fuel injection into the cylinders of an internal combustion engine wherein the injection is effected by a fuel injection pump which is adjustable to regulate the timing of fuel injection and receives fuel from the outlet of a fuel pump at a pressure which is a function of the rotational speed of the engine, comprising hydraulic timer means connected with the outlet of the fuel pump and having adjusting means connected with the fuel injection pump to regulate the timing of fuel injection as a function of changes in fuel pressure at the outlet of the fuel pump; adjustable regulating means for changing the fuel pressure at the outlet of the fuel pump; control means for adjusting said regulating means as a function of changes in the load upon the engine, said control means comprising an electromagnet having an armature movable between a plurality of positions each indicative of a different load upon the engine; and means for furnishing to said control means signals indicating the position of said armature.

6. Apparatus as defined in claim 5, wherein said electromagnet is energized to an extent which is a function of the load upon the engine and said armature is arranged to adjust said regulating means as a function of such energization, said control means further comprising a control circuit for energizing said electromagnet, said circuit having a plurality of inputs arranged to receive signals indicative of factors which influence the load upon the engine.

7. Apparatus as defined in claim 5, wherein said regulating means comprises a pressure regulating valve having a valve member movable between a plurality of positions each corresponding to a different fuel pressure at the outlet of the fuel pump and each depending on a different position of said armature.

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8. Apparatus as defined in claim 5, wherein said timer means comprises a cylinder, a conduit connecting the outlet of the fuel pump with said cylinder, a piston reciprocable in said cylinder under and against the pressure of fuel supplied by the fuel pump, and resilient means acting on said piston to oppose the pressure of fuel in said cylinder, said adjusting means being operatively connected with said piston.

9. Apparatus as defined in claim 2, further comprising flow

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restrictor means provided in said conduit.

10. Apparatus as defined in claim 2, further comprising a second conduit connecting the outlet of the fuel pump with said second cylinder and one-way valve means provided in said second conduit to permit the flow of fuel into said second cylinder.

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