

[54] FUEL INJECTION SYSTEM

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UNITED STATES PATENTS

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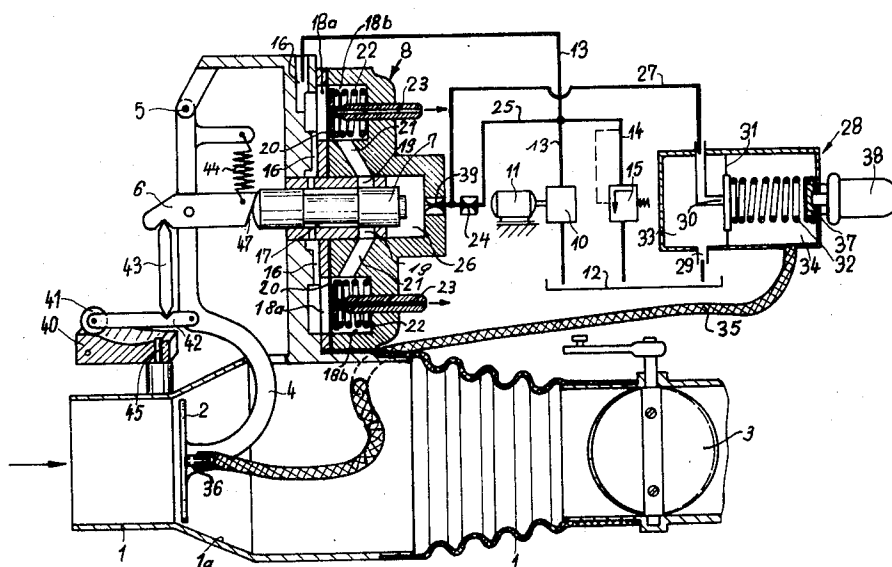
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[57] ABSTRACT

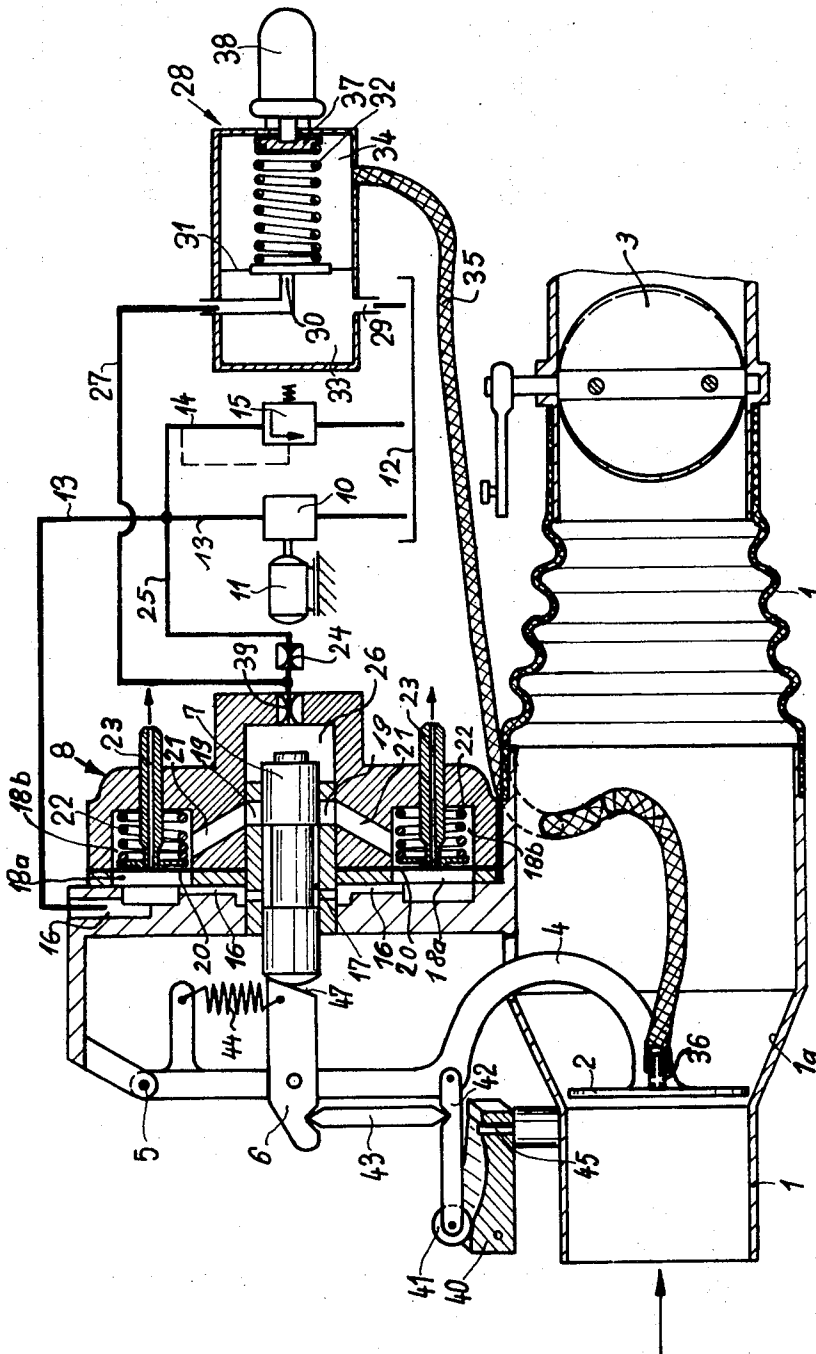
The supply of fuel to an internal combustion engine is controlled by a sensor plate mounted in the suction duct and which deflects in response to air intake rate into a conically flared duct portion. The plate is mounted on a pivoted arm, on which is pivotably mounted a rocker engaging the slider of a fuel measuring distributor valve. Pivotal movement of the arm causes a roller to sense a cam surface and adjust the rocker. The cam surface is movable in response to an engine operating condition to provide different relationships.

14 Claims, 1 Drawing Figure



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FUEL INJECTION SYSTEM

FIELD OF THE INVENTION

The invention relates to a fuel injection system for an external-ignition combustion engine operating with compression of a fuel mixture and with continuous injection into the suction duct.

BACKGROUND OF THE INVENTION

In a prior engine of the type referred to, there is provided in the suction duct a sensor member as well as an arbitrarily adjustable throttle member, the sensor member being movable proportionally to the rate of air flow against a constant return force and the valve member of a fuel distributor valve provided in the fuel supply line for measuring off an amount of fuel in linear dependence on the air intake rate.

The object of the known fuel injection system is to provide automatically in an auto engine during all operating conditions a favorable proportion of the fuel-air mixture, so as to obtain an optimally complete combustion of the fuel and prevent the generation of poisonous exhausts while retaining high engine efficiency and low fuel consumption. To achieve this, the amount of fuel supplied must be measured off very accurately in accordance with the operating conditions of the engine. The above-mentioned linear relationship between air and fuel supply must therefore be modified in dependence on factors characterizing the engine operation, such as, rpm, loading or temperature.

There is previously known from the published German Pat. No. 1,401,224 a fuel injection system in which the modification in response to an engine operating characteristic is achieved by means of a control of the return force acting on the sensor member. In the normal case where a spring is used to provide the return force, this type of control has several disadvantages. In order to obtain a reasonably constant return force, the spring has to be relatively weak and of great length so as to have a flat characteristic. This, however, makes it necessary to effect a large displacement to modify the proportionality factor. On the other hand, if a hard spring having a steep characteristic is used, the constancy of the return force required in normal operation is practically impossible to achieve.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide a fuel injection system of the type referred to above, in which the modification of the proportionality factor can be achieved without changing the return force of the sensor member.

The invention is characterized by means for modifying the factor of proportionality between the air and fuel supply rates in dependence on engine operating characteristics such as rpm, loading or temperature by varying the relative positions of the sensor member and the valve member of the distributor valve.

In an embodiment of the invention, the sensor member comprises a plate attached to one end of an arm, the other end of which is pivoted at a fixed point and which pivotably supports a rocker for actuating the valve member of the distributor valve, the rocker being angularly adjustable in dependence on an engine characteristic. This makes it possible to obtain a point-

by-point modification of any desired type in dependence on the engine operating characteristic without having to tamper with the return force. The required change in the proportionality factor is not more than 10 percent at the utmost, so that the kinetic conditions for the rocker cam configuration and the movement can be made very favorable.

To obtain a particularly robust modifying control, the rocker is adjustable angularly with the aid of a roller or sensor engaging a three-dimensional cam surface, the roller being movable together with the arm in the plane thereof, and/or the cam surface being adjustable perpendicularly to said plane. The perpendicular adjustment of the cam surface can be obtained, for instance, in dependence on the suction duct pressure downstream of the throttle.

The return force may be provided by pressure liquid acting continuously on the distributor valve with a normally constant pressure, a pressure line with a damping restriction therein being provided for supplying the liquid under pressure.

A sensor member of this type tends to overshoot and to rattle when the engine is opened up. Owing to the damping restriction, the time characteristic of the control circuit is influenced and there is provided an adjustable amount of damping in a simple and uncomplicated manner.

In a further embodiment of the invention, to correct for possible errors in the deflection of the sensor member owing to friction in the arm or in the valve member, a regulator is provided in the supply line downstream of the distributor valve for causing a transitory variation of the liquid pressure. The regulator is actuated in the closing direction by a spring and in the opening direction by the difference between atmospheric pressure and the normally constant pressure obtaining in the suction duct between the sensor member and the throttle.

To obtain an exact measurement of the pressure in the suction duct between the sensor member and the throttle, the pressure is preferably taken off immediately downstream of the sensor member and as close as possible to the center thereof, whereby the measuring point is not subject to pressure reduction in dependence on flow conditions in the duct.

According to a further embodiment, the force of the return spring may be variable in response to temperature so as to provide in a simple manner a richer mixture when the engine is cold.

THE DRAWING

An embodiment of the invention is shown in the drawing and will be described in detail below.

DESCRIPTION OF THE EMBODIMENT

The drawing shows the suction duct 1 of an internal combustion engine, through which air is drawn in the direction of the arrow. The air passes by a pivotably suspended sensor 2 and an arbitrarily adjustable pivotable throttle 3 to one or more cylinders (not shown) of the engine. Sensor 2 is shown as comprising a plate positioned perpendicular to the direction of flow and attached at its center to a pivot arm 4 which is pivotable in a plane about a point 5. However, as an alternative sensor 2 may also comprise a piston which is dis-

placeable perpendicularly to the direction of flow. In any case, sensor 2 moves in accordance with a certain law within duct 1, this law being an approximately linear function of the amount of air flowing through the duct. If sensor 2 is subjected to a constant return force and a constant air pressure is present head thereof, the pressure between sensor 2 and throttle 3 will also be approximately constant.

Sensor 2 acts on the slider 7 of a distributor valve 8 via arm 4 and a rocker 6 pivoted thereto. The inner end face of slide valve 7 is subject to a constant liquid pressure serving as a return force for sensor 2.

Fuel is supplied by a fuel pump 10 which is driven by an electric motor 11 and draws fuel from a container 12 and feeds it through a line 13 to measuring and distributing valve 8. A feedback line 14 branches off from line 13 and has provided therein a pressure-limiting relief valve 15. From line 13 fuel flows into a channel 16 provided in the housing of valve 8. Channel 16 connects with an annular notch 17 on slider 7 and with various branches leading to chambers 18a, where the fuel pressure acts on one side of a diaphragm 20. Depending on the position of the slider, notch 17 overlaps to a greater or lesser extent a number of control notches 19, which connect via channels 21 to corresponding chambers 18b, which are separated by diaphragms 20 from the corresponding chambers 18a. From chambers 18b the fuel flows via channels 23 to corresponding injection valves not shown on the drawing, which are provided in the suction duct line in proximity of the engine cylinders. Diaphragm 20 serves as the movable valve member of a flat seat valve, which is held open in normal operation by a spring 22. Chambers 18a and 18b provide for a substantially constant pressure drop at distributor valve 17, 19 independently of the degree of overlapping between notch 17 and notches 19, i.e. independently of the amount of fuel flowing to the injection valves. This guarantees that the displacement of slider 7 is linearly dependent on the measured-out fuel quantity.

Movement of arm 4 causes sensor 2 to move within a conical section 1a of suction duct 1, the annular space between the sensor plate and the conical wall being also intended to be a linear function of the deflection of sensor 2. If this requirement is fulfilled, there is also a linear relationship between the displacements of sensor 2 and of slider 7, so that there is always measured out an amount of fuel which is proportional to the amount of air flowing through the suction duct.

The liquid exerting a constant return pressure on slider valve 7 is also fuel. To this end, a line 25 branches off from line 13 to the space 26, into which slider 7 extends with its inner end. Provided in line 25 is a restriction 24 for damping the movements of slider 7. From line 25 a further line 27 branches off to a flow regulator 28, from which a return line 29 returns the fuel without pressure to container 12. Regulator 28 corrects possible errors in the position of pivot arm 4 which may be due to friction of slider 7 or of arm 4 itself by creating a transitory pressure variation in space 26 to increase or decrease the normally constant return force acting on slider 7 and sensor 2.

Regulator 28 comprises a valve having a nozzle 30, the flow through which is controlled by a diaphragm 31, this diaphragm being loaded in the closing direction

by a spring 32. The fuel therefore flows through line 27 and nozzle 30 into a space 33, from which it is drained off via return line 29 to container 12. Container 12 is subject to atmospheric pressure and substantially the same pressure is therefore present in space 33. The space 34 on the other side of diaphragm 31 in which spring 32 is mounted, is connected via an air tube 35 to a point 36 of the section of duct 1 between sensor 2 and throttle 3, where normally a constant pressure prevails. To reduce as much as possible measuring errors due to air currents, the measuring point 36 is arranged in duct 1 immediately behind sensor 2. As soon as any friction effects cause sensor 2 to be deflected out of proportion to the rate of air flow, a variation occurs in the pressure drop between sensor 2 and throttle 3. This pressure change within duct 1 is transmitted via tube 35 to space 34, whereby for instance in response to a decrease in pressure, diaphragm 31 is deflected against the force of spring 32, so that more fuel can flow through nozzle 30 to container 12. Owing to this opening of nozzle 30, the pressure in space 26 decreases and the friction forces can be overcome, after which nozzle 30 is again reduced and the previous constant pressure in space 26 is restored. The force of spring 32 is variable by means of an adjustable spring washer 37. The adjustment can be obtained with the aid of a temperature-responsive member 38, which operates when engine temperature goes down to reduce the compression of spring 32. This causes nozzle 30 to be more open when the engine is cold and the pressure in space 26 to be correspondingly lower, and the injected fuel-to-air ratio is increased.

The pressure is transmitted to space 26 via a damping restriction 39, which causes a substantially temperature-independent damping of the movements of sensor 2, since fuel is used as a damping liquid and the viscosity thereof is only very little variable with temperature in comparison with that of hydraulic oils. As was mentioned above, the damping is necessary to limit the overshoot reaction when the engine is opened up and therefore to adjust the operating characteristics of the engine and also to limit the influence of suction shocks therefrom.

Rocker 6 is pivoted on arm 4 and is adjusted in dependence upon the operating characteristics of the engine. To this end, there is provided a three-dimensional cam surface 40 which is sensed by a sensor or follower roller 41. The output control effect thus obtained is translated via a lever 42 and a push rod 43 into angular movement of rocker 6. The use of push rod 43 results in practically frictionless transmission of the control effect. Push rod 43 and roller 41 are held in engagement by means of a spring 44. Cam 40 is mounted on a pivot 45 and may respond in a manner not shown in the drawing to the pressure prevailing in suction duct 1 downstream of throttle 3. However, cam 40 may also be angularly adjusted by some other control effect characterizing the operating condition of the engine. Cam 40 is sensed by roller 41 in the plane in which arm 4 is pivotable in dependence on the air intake of the engine, since lever 42 is attached to arm 4 at the opposite end relative to roller 41. If surface cam 40 is furthermore rotated in dependence on the pressure in suction duct 1 downstream of throttle 3, the adjustment of rocker 6 will take place in dependence on the air intake as well as on the loading of the engine. The end face 47

of rocker 6 which engages slider 7 can be given a cam shape in such a way as to compensate for errors due to construction.

That which is claimed is:

1. In a fuel injection system for an external-ignition combustion engine operating on fuel continuously injected into the suction duct and including an arbitrarily controllable throttle member in said suction duct, said system being of the type that includes (a) a fuel distributor valve having a movable valve member for metering the fuel quantities supplied to said engine, (b) an air sensor means being at least partially positioned in said suction duct spaced from said throttle member, said air sensor means being movable in said suction duct by and as a function of the air flowing in said suction duct, (c) coupling means for transmitting the motion of said air sensor to said movable valve member, said last-named means determining the positional relationship between said movable valve member and said air sensor means and (d) means for applying to said sensor member a substantially constant return force to ensure a linear proportionality between the rate of air flow in said suction duct and the amount of fuel metered by said fuel distributor valve, the improvement comprising

A. shiftable means connected to said coupling means for changing said positional relationship between said movable valve member and said air sensor means to change the factor of said linear proportionality, said shiftable means and said means for applying to said sensor member a substantially constant return force being separate and independent from one another whereby a change in said positional relationship leaves said return force unaffected and

B. means moving in response to at least one operating characteristic of said engine, said last-named means being connected to said shiftable means to vary said factor as a function of said operating characteristic.

2. A system according to claim 1, in which said operating characteristic is the rpm of the engine.

3. A system according to claim 1, in which said operating characteristic is temperature.

4. A system according to claim 1, in which said operating characteristic is the degree of loading of said engine.

5. A system according to claim 1, in which said air sensor means comprises a plate mounted at an end of a

movable arm, the other end of said arm being pivoted at a fixed point, a rocker being pivotably mounted on said arm for engaging said movable valve member, said rocker forming part of said coupling means and said shiftable means.

6. A system according to claim 5, in which said means moving in response to an operating characteristic comprises a surface cam and said shiftable means comprises a follower engaging said surface cam, said follower being angularly adjustable relative to said movable arm in the plane of movement thereof and coupled for controlling the angular position of said rocker.

7. A system according to claim 6, in which said surface cam is adjustable perpendicularly to said plane.

8. A system according to claim 1, comprising means for supplying pressure liquid to exert a continuous return force of normally constant pressure on said movable valve member of said distributor valve.

9. A system according to claim 8, comprising a pressure line for supplying said pressure liquid, a damping restriction being provided in said line.

10. A system according to claim 9, in which said pressure liquid is fuel and said movable valve member comprises a slider.

11. A system according to claim 8, comprising a flow regulator provided in said fuel supply line downstream of said distributor valve for causing a transitory adjustment of said return pressure, spring means exerting pressure in the closing direction on said regulator and means for subjecting said regulator in the opening direction thereof to the difference between atmospheric pressure and the pressure in said suction duct between said sensor and said throttle members.

12. A system according to claim 11, in which said flow regulator comprises a valve having a valve plate and a diaphragm supporting said valve plate and separating a first and a second space, said first space having said spring mounted therein and being connected to said suction duct and said second space being connected through said supply line to a fuel container at atmospheric pressure.

13. A system according to claim 11, comprising means for taking off the pressure of said suction duct immediately downstream of said sensor member and close to the center thereof.

14. A system according to claim 11, in which said spring means comprises a temperature responsive spring.

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