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[54] **DEVICE FOR THE FUEL QUANTITY CONTROL IN RESPONSE TO OPERATIONAL VARIABLES OF AN INTERNAL COMBUSTION ENGINE**

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.** **F02m 69/00,** F02m 63/02

[58] **Field of Search** ....123/139 AW, 139 BG, 119 R; 261/50 A, 44 R

[56] **References Cited**

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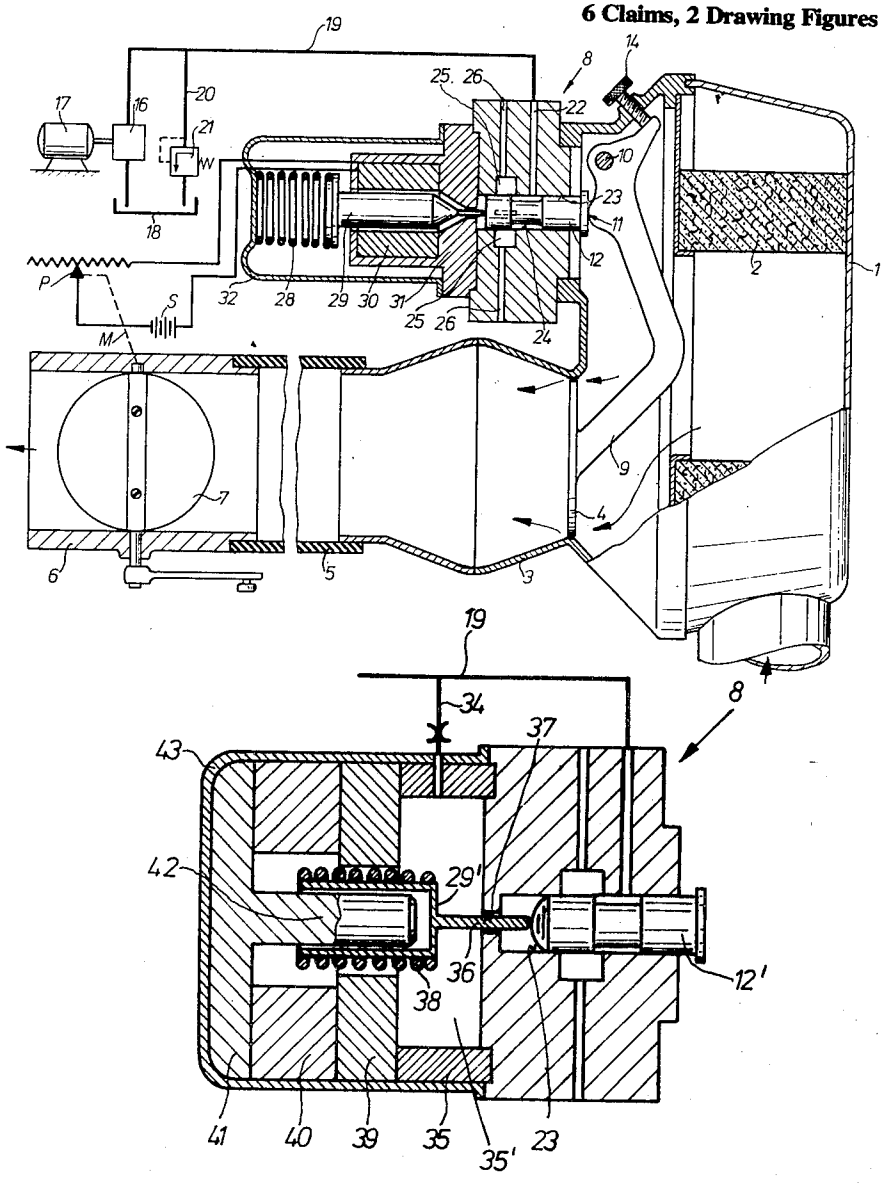
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[57] **ABSTRACT**

In an internal combustion engine, a sensor, disposed in the suction tube and deflected as a function of the flow rate of air, operates a fuel quantity control member against a force which is derived from the magnetic flux of an electromagnet, the energizing current intensity of which changes as a function of operational variables (such as load, rpm or temperature) of the engine.

6 Claims, 2 Drawing Figures



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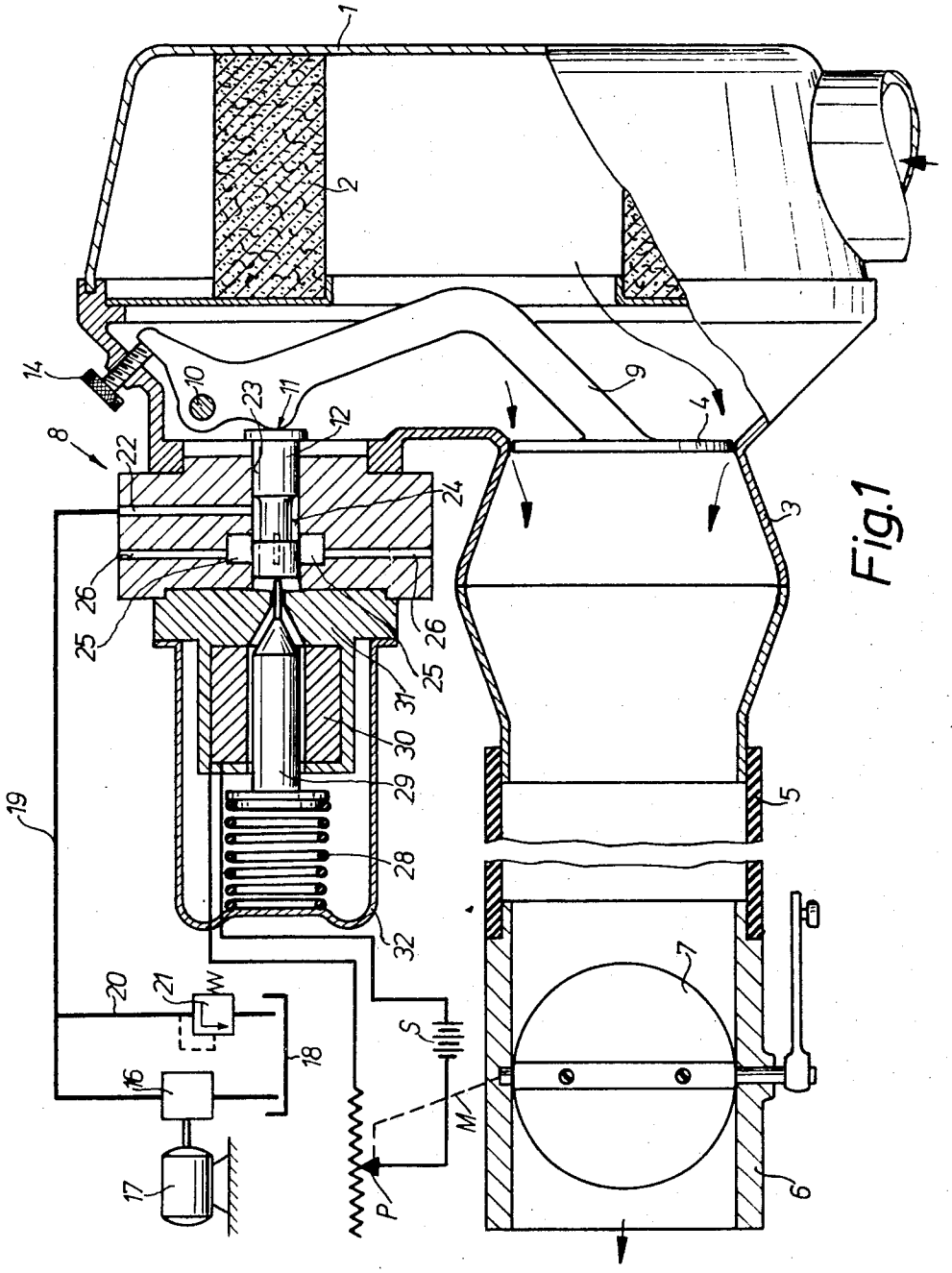


Fig.1

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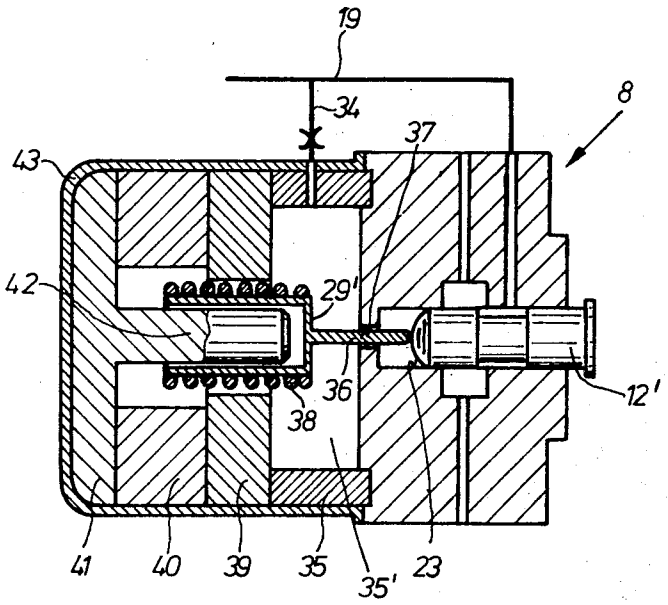


Fig.2

DEVICE FOR THE FUEL QUANTITY CONTROL IN RESPONSE TO OPERATIONAL VARIABLES OF AN INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

This invention relates to a fuel injection system and is of the type that effects a continuous injection of fuel into the suction tube of an externally ignited internal combustion engine. In the suction tube there are serially arranged a sensor and an arbitrarily operable butterfly valve. The sensor is deflectable against a constant resetting force to an extent proportional to the flow rate of air passing through the suction tube. The resetting force is variable as a function of engine characteristics. The sensor, by virtue of its displacement, actuates the movable member of a quantity divider valve disposed in the fuel line for metering a fuel quantity that is proportional to the flow rate of air.

The purpose of fuel injection systems of the aforenoted type is to automatically ensure in an Otto-engine under all operating conditions a favorable air-fuel mixture ratio for an as complete a fuel combustion as possible. In the manner, a best possible efficiency of the internal combustion engine is obtained and it is further ensured that the fuel consumption is at a minimum and the poisonous pollutants in the exhaust gases are either eliminated or very substantially reduced. For this purpose, the fuel quantities have to be very accurately metered according to the requirements of each operational condition of the internal combustion engine. This, in turn, necessitates that the ratio of the air quantities to the fuel quantities be variable as a function of engine characteristics such as load, rpm and temperature.

In a known fuel injection system of the aforenoted type (such as disclosed in U.S. Pat. No. 2,583,406), the resetting force applied to the sensor is constituted by a spring, the bias of which is variable as a function of the temperature. The use of a spring which is to exert a possibly constant resetting force at normal operation and which is also to be variable in its resetting force changing the air-fuel ratio, has, from a purely structural point of view, substantial disadvantages. In order to obtain a reliably constant resetting force, the spring should be as soft and as long as possible, i.e., its characteristic curve should have a flat course. On the other hand, the spring, in order to be able to effect a variation in the air-fuel ratio without necessitating a substantial spring travel, should have a characteristic curve that is as steep as possible. That is, a variation of spring force should occur upon relatively short displacements of the spring. The transmission of variable magnitudes of engine characteristics to a spring operating as a resetting spring also necessitates a bulky and expensive structure.

OBJECT, SUMMARY AND ADVANTAGES OF THE INVENTION

It is an object of the invention to provide an improved fuel injection system of the aforenoted type wherein the above-mentioned disadvantages are eliminated.

Briefly stated, according to the invention, the alteration of the resetting force is effected by an electromagnet, the magnetic flux of which is variable dependent upon engine characteristics and is oriented in the direction of the resetting force.

The engine characteristics may be either sensed electronically or after converting them into electric signals, applied to an electric control apparatus, and, as current intensities, affect the resetting force through the electromagnet. It is an advantage of such an arrangement that the sensors responsive to the engine variables as well as the control apparatus may be disposed at a location remote from the sensor responsive to the flow rate of air. In addition, in electronic devices it is relatively simple to amplify a sensed force and to obtain very accurate measured values with small losses of efficiency.

The invention will be better understood, as well as further objects and advantages of the invention will become more apparent, from the ensuing detailed specification of two exemplary embodiments taken in conjunction with the drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a sectional and partially schematic view of a fuel injection system incorporating a first embodiment of the invention; and

FIG. 2 is a sectional, partially schematic view of a second embodiment of the invention.

DESCRIPTION OF THE EMBODIMENTS

Turning now to FIG. 1, the internal combustion engine (not shown) draws air in the direction of the arrows through an air filter 2 held in a housing 1, through an intake tube portion 3 in which there is disposed a sensor 4, through a coupling hose 5 and through an intake tube portion 6 which contains an arbitrarily variable butterfly valve 7.

The sensor 4 may be, as shown in the drawing, a plate oriented normal to the direction of air flow, or a piston displaceable normal to the air flow, or a gate pivotable about an eccentrically held shaft. Regardless of the structure used, the sensor 4 moves in the intake tube portion 3 according to an approximately linear function of the flow rate of air passing through the intake tube. Given a constant resetting force exerted on the sensor 4 and a constant air pressure upstream of the sensor, the pressure prevailing between the sensor 4 and the butterfly valve 7 is also at least approximately constant.

The sensor 4 controls directly a quantity divider valve 8 through which the fuel is metered to the individual fuel injection nozzles (not shown) disposed in the suction tubes in the vicinity of the engine valves. For transmitting the setting motion of the sensor 4, there is provided a lever 9 which is integral with the sensor 4 and which is supported with very low friction on a shaft 10. During its pivotal motion, the lever, with an integral nose 11, displaces the movable valve plunger 12 against a constant return force. The position of rest of the lever 9 is determined by a setting screw 14.

The fuel is supplied to the fuel injection system by a fuel pump 16 which is driven by an electromotor 17. The pump 16 draws fuel from a tank 18 and, through a conduit 19, delivers it to the quantity divider valve 8. From the conduit 19 there extends a return conduit 20 which terminates in the tank 18 and contains a pressure limiting valve 21. From the conduit 19 the fuel is admitted into a channel 22 extending in the housing block of the fuel quantity divider valve 8. Channel 22 merges into a cylindrical bore 23 which is also formed in said

housing block and in which there is disposed a reciprocable plunger 12 in a fluid-tight fit. The plunger 12 is provided with a circumferential annular groove 24 which is in continuous registry with the mouth of channel 22 in the cylinder 23. Dependent upon the axial position of the control plunger 12 in the bore 23, the groove 24 is to a greater or lesser extent in an overlapping position with the control slots 25 from which then the fuel is admitted through the channels 26 to the individual fuel injection nozzles (not shown).

In the embodiment according to FIG. 1, the plunger 12 is exposed to the force of a spring 28 which, in order to ensure a constant spring force, is relatively soft and thus has a flat spring characteristic. Between the plunger 12 and the spring 28 there is disposed an armature 29 surrounded by a solenoid 30 and a soft iron core 31. The last-named three components form an electromagnet. In order to ensure that the electromagnetic force exerted on the armature 29 does not substantially change by virtue of a change in the position of the latter, that is, to ensure that the force generated by the electromagnet and superposed on the force of spring 28 remains constant under constant current intensities, the armature 29 as well as the aligned bore in the soft iron core 31 at its side facing the plunger 12, have a conical configuration. The spring 28 engages with its end remote from the armature 29 an iron hood 32 which covers the magnetic system. The flux generated in the electromagnet is altered dependent upon operational variables such as load, rpm and temperature, by changing, in a manner known by itself, the intensity of the electric current flowing through the solenoid 30, in response to the changing value of said variables. As a simplified example, such changes in the current intensity may be effected, for example, by the butterfly valve 7. As illustrated schematically, there is provided an electric circuit which contains the solenoid 30, a potentiometer P and a current source S. The potentiometer P is adjusted as a function of the position of the butterfly valve 7 by virtue of, for example, a linkage means M. Thus, the energizing current of the solenoid 30 will be a function of the angular position of the butterfly valve 7. It will be understood that instead of the latter, the potentiometer may be coupled to an rpm-responsive centrifugal regulator or an engine temperature-responsive heat expandable element.

FIG. 2 illustrates a second embodiment of the invention and depicts only those components which differ from the first embodiment. In the second embodiment, for generating the electromagnetic force which is superposed to the returning force, a plunger coil-type electromagnet is used. The constant returning force itself is supplied by a pressurized fluid which may be fuel and which is admitted into a chamber 35' of the magnet system 35 through a conduit 34 extending from the conduit 19. The armature 29' of the electromagnet has a pin 36 which transmits the magnetic force exerted on the armature 29' to the plunger 12'. The cylindrical bore 23, in which the plunger 12' reciprocates, is connected with the chamber 35' by means of a port 37 through which the pin 36 of armature 29' extends. The diameters of pin 36 and bore 37 are so selected that the annular gap formed thereby serves as a hydraulic damping throttle for the setting motion of the plunger 12'.

The armature 29' which is formed as a sleeve having an open end, carries a coil 38 firmly wound thereon. The coil 38 is surrounded by an annular soft iron core 39 which is joined in an axial direction by a permanent magnet 40, also of annular shape. To the permanent magnet 40 there is attached a soft iron plate 41 which has a pin 42 extending into the armature sleeve 29' through its open end. The entire magnetic system is covered by an iron hood 43 which also serves to secure the magnetic system to the fuel quantity divider valve 8. As soon as the electric current intensity flowing through the coil 38 is varied dependent upon the engine characteristics, the force exerted by pin 36 on the plunger 12' and derived from the magnetic flux also changes. In this manner, the force superposed on the hydraulic return force also varies. By virtue of the structure of the second embodiment it is ensured that for a given current intensity the electromagnetic force exerted on the armature 29' and thus on the plunger 12', remains constant for the entire stroke thereof.

What is claimed is:

1. In a fuel injection system associated with an internal combustion engine and being of the type that includes (A) an arbitrarily operable butterfly valve disposed in the suction tube of said engine for varying the flow rate of intake air, (B) a sensor disposed in said suction tube spaced from said butterfly valve and displaceable to an extent proportional to the flow rate of intake air, (C) means exerting a resetting force opposing the displacement of said sensor in response to the flow rate of air, said resetting force is changeable as a function of operational variables of said engine and (D) a quantity divider valve having a movable element actuated by said sensor for metering fuel in proportion to the flow rate of intake air, the improvement comprising
   A. means for applying hydraulic pressure to said movable element of said quantity divider valve, said hydraulic pressure forming at least one part of said resetting force,
   B. an electromagnet generating an electromagnetic force of a magnitude dependent upon at least one operational variable of said engine,
   C. means varying said resetting force and
   D. means for applying said magnetic force to said means varying said resetting force to change the latter in response to said operational variable.

2. An improvement as defined in claim 1, wherein said electromagnet includes a movable armature which forms part of said means varying said resetting force, said armature is operatively connected to said movable element of said quantity divider valve.

3. An improvement as defined in claim 2, wherein said electromagnet includes a stationary coil surrounding said movable armature and forming part of the means defined in (D); the path of travel of said armature is in alignment with that of said movable element.

4. An improvement as defined in claim 2, wherein said electromagnet includes
   A. an electric coil firmly wound on said movable armature and forming part of the means defined in (D) and
   B. a stationary permanent magnet surrounding said armature.

5. An improvement as defined in claim 1, including
   A. a housing block forming part of said quantity divider valve and containing

1. a bore in which said movable element is reciprocably held with a snug fit,

2. a port extending from said bore through said housing block for admitting hydraulic fluid under pressure to said movable element and for dampening the motion thereof and

B. a movable armature constituting part of said electromagnet and forming part of said means varying said resetting force, said movable armature includes an integral part extending through said port and contacting said movable element of said quantity divider valve.

6. An improvement as defined in claim 1, wherein said sensor includes

A. a plate disposed in said suction tube normal to the direction of air flow, said plate is displaceable in the direction of air flow into a flaring portion of said suction tube to an extent proportional to the flow rate of air and

B. a pivotally secured lever affixed to said plate and connected to said movable element to transmit thereto the forces generated by the displacement of said plate.

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