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Stumpp

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[54] **FUEL INJECTION APPARATUS FOR SPARK PLUG-IGNITED INTERNAL COMBUSTION ENGINES**

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[51] **Int. Cl.** **F02m 7/22**

[58] **Field of Search** ..... 123/119 R, 8.13, 123/140 CC, 140 MP

[56] **References Cited**

UNITED STATES PATENTS

2,856,910	10/1958	Goodridge	123/119 R
2,791,995	5/1957	Dietrich	123/119 R
2,943,614	7/1960	Bosch	123/139 R
3,621,825	11/1971	Ojala	123/119 R
2,899,951	8/1959	Olson	123/119 R

Primary Examiner—Clarence R. Gordon

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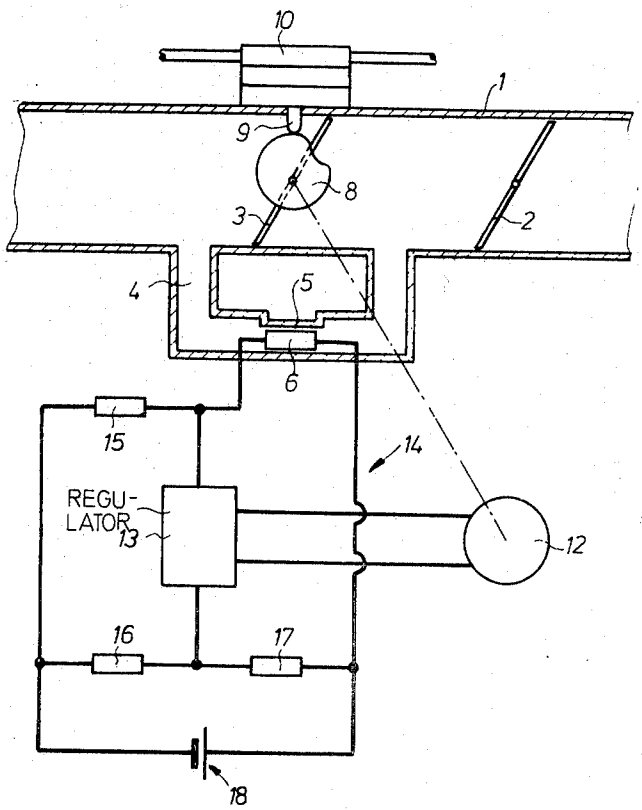
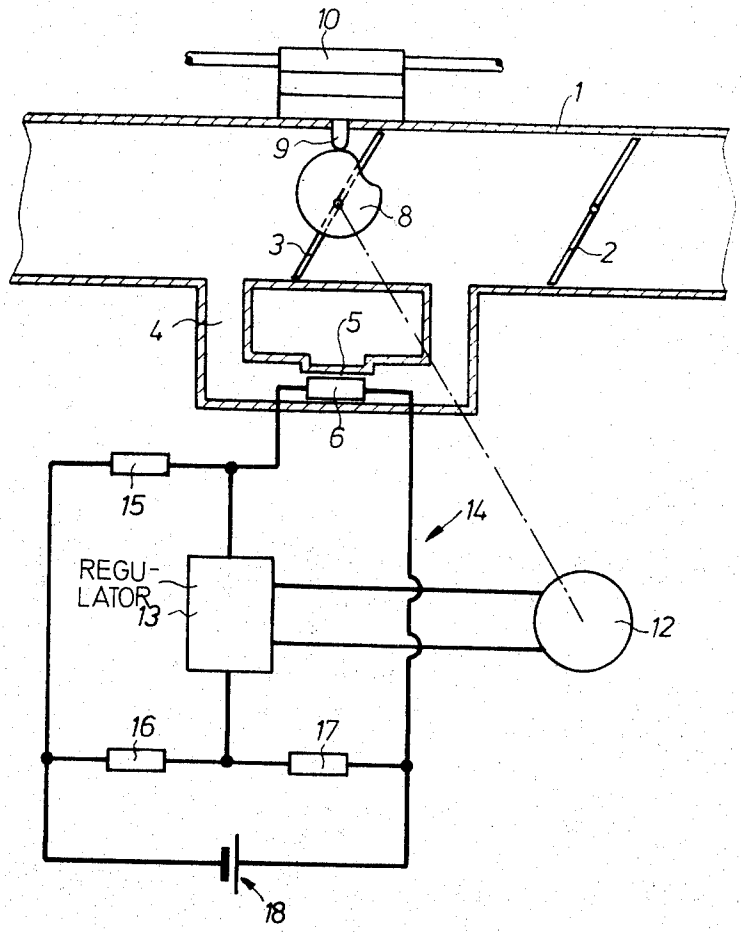
[57] **ABSTRACT**

In a fuel injection apparatus the fuel quantities injected in the associated internal combustion engine are determined as a function of the angular position of a throttle member disposed in the air intake tube of the engine. The angular position of the throttle member, in turn, is variable by an electric follower regulator circuit that includes, in a bridge circuit, a temperature-dependent resistance which is disposed in a channel bypassing the throttle member and which changes its resistance as a function of the velocity and density of the intake air passing through said channel.

10 Claims, 1 Drawing Figure

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FUEL INJECTION APPARATUS FOR SPARK PLUG-IGNITED INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates to a fuel injection apparatus for an externally ignited internal combustion engine having an air intake tube in which there are serially arranged an arbitrarily operable butterfly valve and an additional throttle member. The sensing of the air flow in the suction tube for the purpose of metering a fuel quantity which is proportionate to the air quantities is effected in a channel bypassing the aforenoted additional throttle member. A change in the sensed effects a change in the metered fuel quantities.

In a known fuel injection apparatus of the aforedescribed type such as disclosed, for example, in U.S. Pat. No. 2,943,614, in order to introduce an rpm-dependent control signal, the voltage at the terminals of a thermoresistance disposed in the suction tube is varied by changing the position of the butterfly valve. This voltage variation is used for controlling the fuel quantities.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved fuel injection apparatus of the aforenoted type for obtaining directly a mechanical measuring magnitude as a function of the flow rate of air passing through the suction tube(air quantity per time unit) to utilize said mechanical magnitude as a reference level for a corresponding fuel quantity.

Briefly stated, according to the invention, the throttle member, as the air flow varies in the bypass channel (in response to the change in the rpm and the position of the butterfly valve) is displaced with the aid of a follower regulator circuit in such a manner that in the bypass channel there is maintained a predetermined and constant measuring value. Further, the position of the throttle member is a measure for the fuel quantity metering.

The invention will be better understood as well as further objects and advantages become more apparent from the ensuing detailed specification of a preferred, although exemplary embodiment taken in conjunction with the sole FIGURE illustrating the invention schematically and in longitudinal section.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to the FIGURE, in an air intake tube **1** of an internal combustion engine (not shown), there are serially arranged an arbitrarily operable butterfly valve **2** and a throttle member **3.** The latter is bypassed by a bypass channel **4,** in the narrowest cross section **5** of which there is disposed a temperature-dependent resistance **6.** The conductance of the resistance **6** varies in a known manner as a function of the velocity and density of the air stream passing therethrough. According to the invention, a variation of the conductance is utilized to vary the position of the throttle **3** with the aid of a follower regulator circuit to be described hereinafter. Thus, as soon as the velocity and/or the density of the air (because of external effects) varies in the bypass channel **4** upon arbitrarily changing the setting of the butterfly valve **2,** the conductance of the resistance **6** also changes. As a result, the throttle member **3** is moved until the product of air velocity and air density

in the bypass **4** attains its earlier magnitude (i.e., prior to the change in conductance). Thus, when considering the entire control range, the aforenoted product of air velocity and air density in the bypass remains constant, so that the position of the throttle member **3** is a measure for the flow rate of air in the suction tube **1.** It is to be noted that in order to obtain a determined control value for the fuel metering even in the idling rpm range, a constant portion of the air always has to flow through the bypass channel **4.** Consequently, the butterfly valve **2** must never entirely close the intake tube **1** at idling rpm's; rather, it should maintain open a minimum flow passage section. The throttle member **3,** upon its displacement, changes the position of a cam track formed of a three-dimensional cam **8** which directly affects the fuel quantity control member (fuel rack) **9** of a fuel metering valve **10.** Further, the three-dimensional cam **8** may be axially displaced by means, not shown, as a function of the pressure in the air intake tube or as a function of the position of the butterfly valve **2** or as a function of other operational magnitudes of the internal combustion engine.

The rotation of the throttle member **3** is effected by a setting motor **12** which obtains command signals from a regulator **13** which, in turn, is formed as the diagonal component of a bridge circuit **14.** The regulator **13** is of known structure and may have, for example, a circuit diagram as shown in the Amplifier Handbook by R.F. Shea, pages 26–46 (FIG. 81) or pages 31–42 (FIG.61). The bridge circuit **14** is supplied with signals by the temperature-dependent resistance **6** constituting a component of the circuit **14.** Further signal transmitters **15** and **16** serve, in the first place, for the balancing of the bridge circuit **14** and, in the second place, for the application of other signals representing engine or environmental variables. Further, the bridge circuit **14** includes a compensating resistance **17** which senses the temperature of the intake air. The voltage supply necessary for the operation of the aforedescribed apparatus may be the stabilized DC voltage of a vehicle battery **18.**

The aforedescribed simple fuel injection apparatus may be used for effecting a continuous injection (injection of a fuel quantity per unit time) or for effecting a timed injection (injection of a fuel quantity per stroke).

The above-described fuel injection apparatus has several significant advantages. Its spatial requirements are small and so are the flow losses caused thereby. Further, effecting an input of correcting magnitude is simple, particularly because of the fact that the temperature-dependent resistance **6** also responds to the air density. Also, the throttle member **3** may be set without having to consider frictional losses inherent in mechanical regulator members. The apparatus according to the invention ensures the sensing of the flow rate independently from the air pressure and the air temperature. The use of the bridge circuit **14** eliminates the necessity to assign a constant amplification factor to the regulator **13.**

What is claimed is:

1. In a fuel injection apparatus associated with an internal combustion engine having an air intake tube and an arbitrarily movable butterfly valve disposed therein, said apparatus being of the type that includes (a) a channel in communication with said air intake tube and bypassing a portion thereof, (b) means disposed in said channel for sensing the flow of air therein and (c)

means for varying the injected fuel quantities in response to a change in the sensed value in said channel for metering fuel quantities in proportion to the air quantities flowing through said air intake tube, the improvement comprising

A. a throttle member disposed in a portion of said air intake tube and spaced from said butterfly valve, said channel bypassing said throttle member and

B. a follower regulator circuit operatively connected between said means disposed in said channel for sensing the flow of air therein and said throttle member for displacing said throttle member so as to maintain a substantially constant sensed value in said channel, said means disposed in said channel being responsive to velocity and density of air passing through said channel, the position of said throttle member being a measure for metering of fuel.

2. An improvement as defined in claim **1,** said means disposed in said channel being formed of a temperature-dependent resistance for maintaining the product of air velocity and air density constant in said channel.

3. An improvement as defined in claim **1,** including a fuel metering valve having a displaceable fuel rack and a cam track connected to said throttle member and to said fuel rack for displacing the latter in response to the motion of said throttle member.

4. An improvement as defined in claim **3,** said cam track being formed as a three-dimensional cam, said improvement including additional means for displacing said three-dimensional cam in response to an engine variable.

5. An improvement as defined in claim **1,** said follower regulator circuit being formed as an electric regulator circuit, said means disposed in said channel being formed of a temperature-dependent resistance, the conductance of which being varied in response to the product of air velocity and air density in said channel, said improvement further including means for applying electric signals from said resistance to said electric regulator circuit, said electric signals varying in response to changes in said conductance.

6. An improvment as defined in claim **5,** including means for applying to said electric regulator circuit signals characterizing additional engine variables.

7. An improvement as defined in claim **5,** including an electric motor controlled by said electric regulator circuit and connected to said throttle member for displacing the latter.

8. An improvement as defined in claim **5,** said electric regulator circuit being formed as a bridge circuit, said temperature-dependent resistance constituting a branch of said bridge circuit, the improvement further including a regulator forming the diagonal branch of said bridge circuit.

9. An improvement as defined in claim **8,** including further resistances forming part of said bridge circuit and being variable in response to engine parameters.

10. In a method of injecting fuel in an internal combustion engine of the type having an air intake tube and an arbitrarily movable butterfly valve disposed therein, said method including the known steps of (a) measuring the flow of intake air in said tube by sensing the air flow in a channel bypassing a portion of said air intake tube and (b) varying the metered fuel quantities in response to the variation of the value sensed in said channel, the improvement comprising the steps of

A. varying the flow passage section of said portion of said air intake tube in response to a change of the air flow in said channel so as to maintain in the latter a predetermined constant measured value and

B. varying the metered fuel quantities in response to the variation of the flow passage section of said portion,

C. and wherein said measuring step involves sensing velocity and density of air passing through said channel.

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