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[54] **FUEL INJECTION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES WITH ACCELERATING ENRICHMENT**
10 Claims, 3 Drawing Figs.

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[51] **Int. Cl.** **F02m 63/00**
[50] **Field of Search** ..... 123/119, 32 E, 32 E-1, 127, 139.17, 139.18, 140.2, 140.3

[56] **References Cited**

UNITED STATES PATENTS

2,896,600	7/1959	Scherenberg	123/140.3
2,962,015	11/1960	Serruys et al.	123/119
3,463,129	8/1969	Babitzka et al.	123/119X

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ABSTRACT: A fuel injection arrangement for enriching the air-fuel mixture during acceleration of the engine. The duration of a pulse applied to the electromagnetically actuated injection valve of the engine, is varied as a function of the pressure prevailing within the intake manifold of the engine. The pulse is supplied by a monostable multivibrator circuit which is actuated synchronously with the rotation of the engine crankshaft. The manifold includes two separate throttles with one throttle positioned by the gas pedal of the engine, and the second throttle positioned through a pressure difference sensing device which measures the difference between the pressure of the intake manifold between the two throttles, and in the intake direction of the manifold. A pressure sensor communicating with the intake manifold between the two throttles varies the inductance of a transformer which operates in conjunction with the monostable multivibrator.

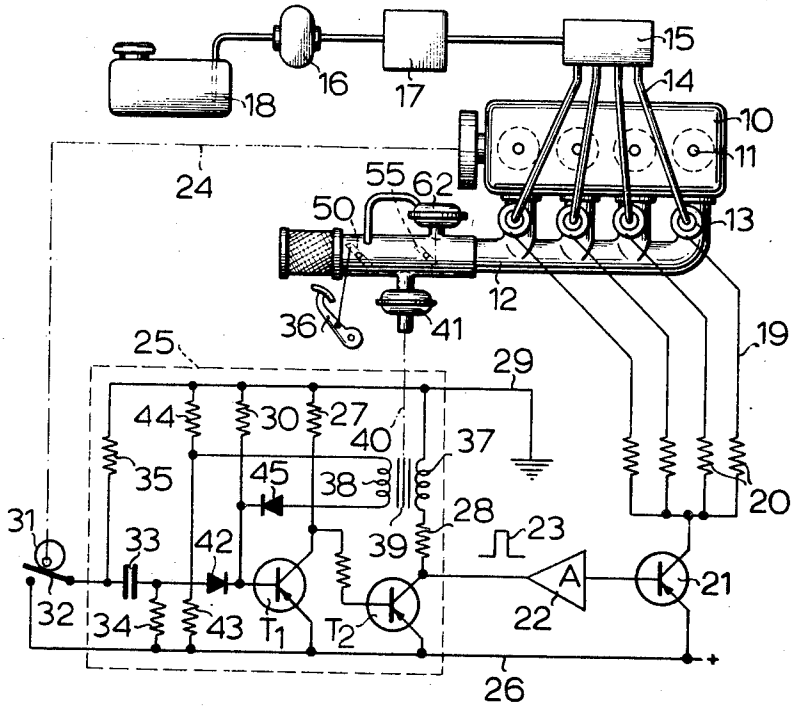


FIG.1

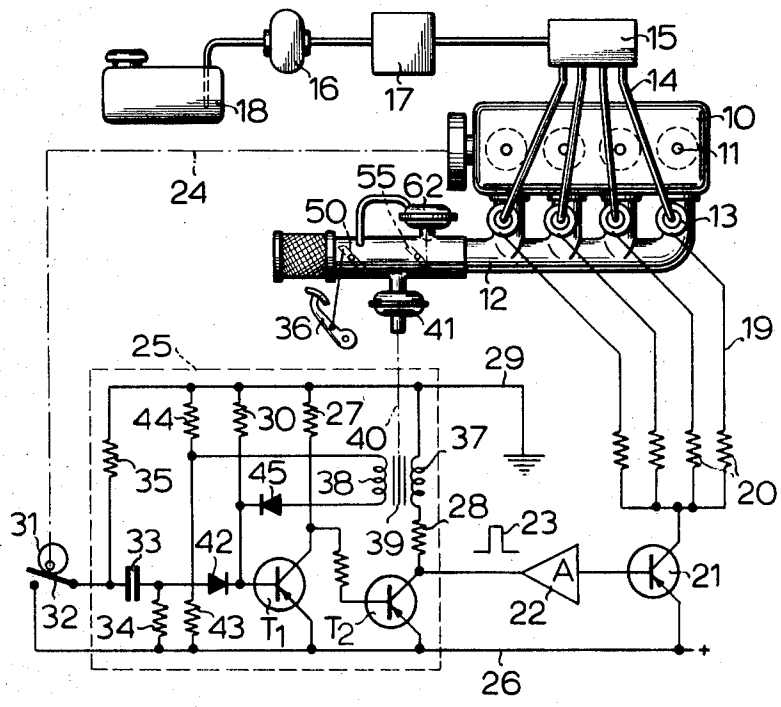


FIG. 3

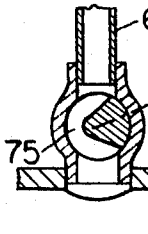
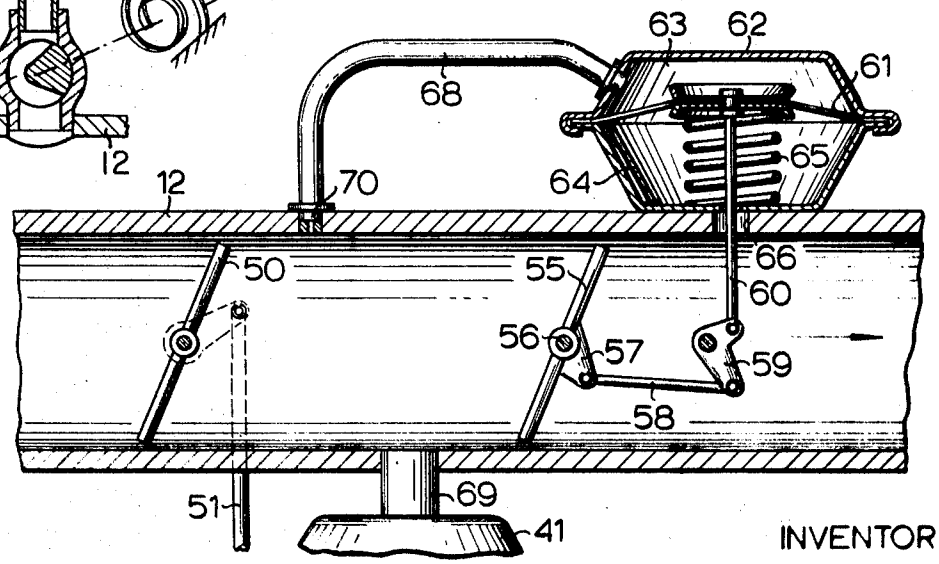


FIG.2



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FUEL INJECTION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES WITH ACCELERATING ENRICHMENT

BACKGROUND OF THE INVENTION

The present invention resides in an electrically controlled fuel injection arrangement adapted for internal combustion engines having at least one electromagnetically actuated injection valve. A control arrangement which is actuated synchronously with the speed of the engine cooperates with a pressure-sensing device located behind the throttle member within the intake manifold, when viewed from the intake direction. The control arrangement delivers opening pulses for the injection valve, such that the duration of the pulses is dependent upon the pressure prevailing within the intake manifold.

In internal combustion engines with fuel injection arrangements for intake manifold injection and remote ignition, a richer mixture is required when the throttle is opened corresponding to initiating and accelerating process. Thus, during the acceleration interval in going from a lower speed to a higher engine speed, the injected mixture requires a higher proportion of fuel, than it does in the steady state operation in which the throttle position remains constant and the opening angle of the throttle flap thereby also remains constant. An accelerating enrichment for electrically controlled fuel injection arrangements, can be achieved in a relatively simple manner when the quantity of injected fuel is made dependent upon the prevailing throttle position and the speed of the engine. Since the injected quantity of fuel is dependent upon the duration of the opening pulse applied to the injection valve, the duration of the individual injection processes during which the injection valves are opened must thereby be made dependent upon the prevailing throttle position and the rotational speed of the engine. When such a system is used, however, and the duration of the individual opening pulses are made dependent upon the suction pressure within the intake manifold, specific difficulties are encountered. Thus, in such a system the intake manifold pressure rises only with considerable delay after the opening motion of the throttle flap.

Accordingly, it is an object of the present invention to provide an injection arrangement of the aforementioned character with a fuel injection arrangement controlled by the intake manifold pressure, which assures that mixture enrichment is realized without fail during the transient interval when the throttle is opened. The arrangement is such that the enrichment takes place prior to the intake of the added air mass.

In accordance with the present invention, the principle of the accelerating enrichment arrangement rests upon the provision of a second throttle behind the gas pedal actuated throttle, when viewed from the intake direction. This second throttle is controlled through the pressure difference prevailing between the pressure behind the first throttle and behind itself, of the second throttle corresponding to the air suction pressure. The pressure sensor communicates with the section within the intake manifold which lies between the first and second throttles. A particular advantageous design of the present invention results when the opening time constants or the second throttle flap may be freely selected. Through such a design, it is possible to inject the optimum quantity of fuel with respect to the air mass during the transient interval, in which the engine is being accelerated.

SUMMARY OF THE INVENTION

A fuel injection arrangement for internal combustion engines. Electromagnetically actuated injection valves have opening pulses applied to them from a control circuit which consists of a monostable multivibrator operating in conjunction with a transformer. The inductance of the transformer is made variable as a function of the pressure prevailing within the intake manifold of the engine. Two throttles are provided within the intake manifold, such that one throttle is operated by the gas pedal of the engine, whereas the second throttle lies behind the first throttle when viewed from the intake direction of the manifold. The pressure-sensing device which adjusts the inductance of the transformer in the pulse-generating circuit is situated between the two throttles and communicates with the intake manifold therebetween. The monostable multivibrator is actuated by a cam operated switch, the latter is, in turn, operated synchronously with the rotation of the engine crankshaft. A pressure difference sensing device includes a membrane member which is positioned as a function of the difference between the pressure prevailing within the intake manifold between the two throttles, and the pressure behind the second throttle, with respect to the intake direction of the manifold. This membrane within the pressure difference sensing device positions the second throttle.

The novel features which are considered as characteristics for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a functional schematic diagram and shows the fuel injection arrangement with the electrical controlling circuit, in accordance with the present invention; and

FIG. 2 is a partial sectional view of the intake manifold of the engine of FIG. 1, and shows the throttle-positioning devices of the present invention; and

FIG. 3 is a partial sectional view of a modification of the intake manifold shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing, the fuel injection arrangement of FIG. 1 is adapted to a four-cylinder internal combustion engine **10** used to drive a motor vehicle. The spark plugs **11** are connected to a high voltage ignition arrangement, not shown. In direct proximity of the inlet valves of the engine, which are not shown, an electromagnetically actuated injection valve **13** is provided for each individual cylinder branched off from the intake manifold **12**. Fuel is applied to each injection valve from a distributor **15**, by way of the fuel lines **14**. The fuel is supplied from a storage tank **18** by means of a pump **16** driven through an electric motor. The intake of the pump **16** drips into the fuel storage tank **18**, whereas the outlet of the pump **16** is applied to a pressure regulator **17**. The latter is interposed between the pump **16** and the distributor **15**. It is the function of the pressure regulator **17** to maintain the fuel pressure within the distributor **15** and the fuel lines **14** at substantially constant value of approximately 2 atmospheres. Thus, as a result of the pressure regulator **17**, the pressure of the fuel in front of the injection valves is maintained substantially constant.

Each of the injection valves **13** contains a magnetizing coil, not shown, which has one terminal connected to ground potential. The other terminal of the magnetizing coils is connected to one of the resistors **20**, by way of one of the connections **19**. The resistors **20** are coupled together at one of their terminals, and also to the collector of a power transistor **21**. The base of the power transistor **21** is connected to a transistor amplifier **22** to which square wave or rectangular-shaped control pulses **23** are applied from an electronic regulating and control circuit to be described further subsequently. The control pulses **23** are generated for every revolution of the crankshaft **24**. The arrangement is such that each one of the injection valves **13** receives current through its magnetizing coil, for the duration of the pulse **23**. For every injection process or cycle, the quantity of fuel injected into the intake manifold and hence from there into the cylinder, is proportional to the opening duration of the injection valve, which in turn, is proportional to the duration of the pulse **23**. Such

quantity of injected fuel, therefore, must be matched or fitted to the operating requirement of the internal combustion engine.

The regulating and control circuit **25** which lies within the broken lines in FIG. **1**, includes essentially a monostable multivibrator which has a first switching transistor T_1 of the PNP type, and a second transistor T_2 of the same type. The emitters of both transistors are connected to the positive voltage supply line **26** of a voltage source in the form of the battery used for the motor vehicle. The nominal voltage of such a battery is 12.6 volts. The collectors of the two transistors T_1 and T_2 lead to the negative voltage supply line **29**, by way of the resistors **27** and **28**, respectively. The negative voltage supply line **29** is coupled to ground potential.

In the normal or quiescent state of the circuit **25**, the transistor T_1 is maintained in the conducting state through the resistor **30** which is connected between its base and the negative voltage supply line **29**. The transistor T_2 is thereby turned off. The base of the transistor T_1, furthermore, leads to a capacitor **33**. A resistor **34** is connected between one electrode of the capacitor and the positive voltage supply line of the battery. The other electrode of the capacitor **33** leads to the negative voltage supply line **29**, by way of a resistor **35**. The electrode of the capacitor **33** which is connected to the resistor **35**, is also joined to a switch **32** operated by a cam **31** which is rotated in accordance with the crankshaft **24** of the engine **10**. When the switch **32** is in the open circuit position, the capacitor **33** becomes charged so that negative potential appears at the electrode connected to the resistor **35** and switch **32**. When the switch **32** becomes actuated to closed circuit position by the cam **31**, on the other hand, this negatively charged electrode of the capacitor **33** becomes connected to the positive voltage supply line **26**. Thus, the unstable state of the monostable multivibrator circuit becomes initiated when the switch **32** is actuated to closed circuit position. During this unstable state of the monostable multivibrator, the opening duration of the magnetic valves **13** is established. Once the unstable state of the monostable multivibrator has been initiated, the transistor T_1 is turned off, and the transistor T_2 together with the power transistor **21** become conducting, and as a result the magnetic valves **13** become opened. The magnetic valves become again closed when the transistors T_1 and T_2 of the monostable multivibrator circuit return to their initial or quiescent state.

This instant of time depends upon the inductance of the primary winding **37** which is connected in series with the collector circuit of the transistor T_2. This primary winding **37** forms a transformer together with the secondary winding **38** and an adjustable ferromagnetic core **39**. The ferromagnetic core **39** is coupled to the membrane of a pressure-sensing device **41**, by way of a mechanical linkage **40**. The pressure-sensing device **41** is located directly behind the gas pedal **36**, when viewed from the intake direction. The gas pedal **36** is coupled to the throttle valve or flap **50** within the intake manifold **12**. When the absolute pressure within the the intake manifold **12** drops, the inductive coupling between the primary and secondary windings is reduced through the withdrawal of the ferromagnetic core.

One terminal or end of the coil of the secondary winding **38**, is connected to the base of the transistor T_1, through a diode **45**. The other end of this coil of the secondary winding **38** is connected to the junction of two resistors **43** and **44** connected in series and across the positive voltage supply line **26** and the negative voltage supply line **29**. When the switching arm **32** is brought against the stationary contact of that switch through the cam **31**, the transistor T_1 is turned off via a diode **42**. As a result, the transistor T_2 can deliver current through the primary winding **37**. This current through the primary winding rises at a rate which is inversely proportional to the inductance, and thereby gives rise to an induced voltage within the secondary winding **38**. This induced voltage maintains the transistor T_2 in the conducting state and independent of any further positioning of the switching arm **32**. This conducting state of the transistor T_2 is held until the current in the primary winding **37** has substantially attained the saturated value. The induced voltage which maintains the transistor T_1 cut off by way of the diode **45**, decreases as the saturation increases. This induced voltage then finally drops to the extent that the negative base potential of the transistor T_1 adjusted by the resistors **43** and **44**, is exceeded. At that point, the transistor T_1 is returned to its initial conducting state. As soon as this initial state of the transistor T_1 is attained, the power transistor **21** is cut off and the injection process or cycle is terminated.

With this electrical control system, the duration of the opening pulse **23** depends upon the suction pressure prevailing within the intake manifold **12**, behind the throttle valve or flap **50**, viewed from the intake direction. When, however, for purposes of acceleration, the gas pedal **36** is depressed and the throttle **50** is thereby turned to a greater opening angle as a result of the mechanical linkage of coupling rod **51**, the suction pressure will tend to rise only with delay in contrast with the opening motion of the throttle flap.

For the purpose of achieving an acceleration enrichment which takes place immediately, in any event, a second adjustable throttle valve or flap **55** is provided behind the throttle **50** which is actuated by the gas pedal **36**, viewed from the intake direction. This throttle **55** is set or adjusted as a result of the pressure difference between the intake manifold and the atmospheric pressure of the surrounding air.

The second throttle flap **55** is rotatable through an angle of substantially 85° about a horizontal axis **56**. The throttle flap is functionally connected with the membrane **61** of a pressure difference sensing device **62**, by way of the linkage members **57**, **58**, **59** and rod **60**. The pressure difference sensor **62** includes a first pressure chamber **63** and a second chamber **64**. A compression spring **65** which maintains the membrane **61** tensioned, is situated within the chamber **64**. Through a relatively large bore or opening **66**, the second pressure chamber **64** communicates with that portion of the intake manifold **12**, which is directly behind the second throttle member **55** within the intake manifold **12**. The pressure chamber **64** thereby also communicates directly with the individual branches of the intake manifold.

The first pressure chamber **63** of the pressure-sensing device **62** communicates with the section of the intake manifold **12**, between the first throttle **50** and the second throttle **55**. This communication between the pressure chamber **63** and this section of the intake manifold, is achieved through a short communicating pipeline or tube **68**. A connecting member **69** connects, furthermore, this particular section of the intake manifold between the two throttle valves, to the pressure-sensing device **41**, which operates upon the duration of the opening pulse in the manner described above. The communicating line or tubes **68** contains an orifice or throttle location **70** in the proximity of the intake manifold **12**. This throttle opening **70** has a relatively small cross-sectional opening which affects the opening time constant of the second throttle **55**, in a manner to be described.

In operation, the pressure difference applied to the membrane **61** is equivalent to the pressure drop at the second throttle **55**. This pressure drop balances the force of the spring **65** under steady state conditions of operation corresponding to constant speed of the engine and nonvarying position of the second throttle member. For each operating condition of the internal combustion engine, the throttle flap or member **55** assumes that position at which its pressure drop is a minimum. The pressure drop cannot be made precisely zero, since use is made of the principle of a proportional regulator with a regulating deviation proportional to the positioning force. This pressure drop can, however, be held sufficiently small through a large effective surface of the membrane **63** and sufficiently large lever relationship within the linkage or lever members **57**, **58** and **59**.

Assume that while the engine is running, the gas pedal **36** is depressed rapidly from its idling position to operation under load, so that the throttle **50** becomes rapidly opened. As a

result, the air pressure between the two throttle members **50** and **55** rises practically without delay, within the intake manifold. The pressure applied to the pressure-sensing device **41** thereby also rises without any substantial delay. Such pressure rise taking place almost immediately, is due to the condition that the second throttle member cannot immediately follow the opening motion of the first throttle. The pressure rise within the first chamber **63** of the pressure difference sensing device **62** does not take place rapidly or in a steep manner. Instead, this pressure rise occurs slower, the narrower the opening of the throttle position or orifice **70**. However, the higher the pressure rising within the first chamber **63**, the greater is the amount by which the rod **60** is depressed downward. Such downward depression of the rod **60** moves the second throttle **55** in the opening direction. Such opening motion of the throttle flap **55** takes place until there is a force balance between the pressure or force applied by the spring **65**, and the pneumatic pressure drop at the throttle **55** prevails.

In the disclosed embodiment of the present invention, the second throttle flap **55** is provided in the form of a rotatable member about the axis **56**. At the same time, it is also possible to provide, instead, a damper plate or air valve for this second throttle arrangement, and to set this air damper or air valve as a function of the pressure difference.

In another embodiment of the present invention, shown in part in FIG. **3**, possible to vary the cross-sectional area of the throttle location or orifice **70**, as a function of the operating temperature of the engine. Such variation in the throttle position **70** may be made with the aid of, for example, a bimetallic spring **72** connected to a turntable valve member **75** at the inlet orifice of the tube **68** so that the orifice opening is made smaller with decrease in operating temperature. Through such design, the transient enrichment process for cold engines may be enlarged or increased in an advantageous manner.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the types described above.

While the invention has been illustrated and described as embodied in few injection arrangements for internal combustion engines, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

What I claim as new and desire to be protected by Letters Patent is set forth in the appended claims.

1. A fuel injection arrangement for an internal combustion engine comprising, in combination, at least one electromagnetically actuated injection valve; first throttle means within the intake manifold of said engine and actuated by the gas pedal of said engine; second throttle means within said intake manifold and behind said first throttle with respect to the intake direction of said intake manifold; means for controlling the position of said second throttle means as a function of the difference in pressures behind said first and second throttle means; pressure-sensing means communicating with said intake manifold between said first and second throttle means; and control means actuated synchronously with the crankshaft rotation of the engine and operatively coupled to said pressure-sensing means, said control means applying pulses to said injection valve for opening said valve, the duration of said pulses being dependent upon the pressure prevailing within said intake manifold.

2. The fuel injection arrangement as defined in claim **1** wherein the opening time constant of said second throttle means is freely selectable.

3. The fuel injection arrangement as defined in claim **1** wherein said means for controlling said second throttle means comprises a pressure difference sensing device having a first pressure chamber communicating with the intake manifold in front of said second throttle means and having a second pressure chamber communicating with the intake manifold behind said second throttle means with respect to the intake direction of said manifold.

4. The fuel injection arrangement as defined in claim **3** including at least one connecting member between one of said chambers and said intake manifold; and means cooperating with said connecting means for applying substantial resistance to flow through said connecting means.

5. The fuel injection arrangement as defined in claim **4** wherein said means for applying resistance to flow through said connecting means comprises a member with an adjustable opening, said opening being decreased with increase in the operating temperature of said engine.

6. The fuel injection arrangement as defined in claim **5** including bimetallic spring means for adjusting the size of said opening as a function of the operating temperature of said engine.

7. The fuel injection arrangement as defined in claim **1** wherein said means for controlling said second throttle means comprises pressure-sensing means having a first chamber communicating with said intake manifold between said first and second throttle means; a second chamber separated from said first chamber and communicating with said intake manifold behind said second throttle means with respect to the intake direction of said manifold; a membrane member separating said first and second chambers; spring means within said second chamber and tensioning said membrane member; and linkage means connecting mechanically said second throttle means with said membrane member, whereby said second throttle means is positioned as a function of the position of said membrane member.

8. The fuel injection arrangement as defined in claim **7** including pipe means connecting said first chamber with said intake manifold between said first and second throttle means; and orifice means within said pipe means for restricting the flow through said pipe means.

9. The fuel injection arrangement as defined in claim **7** wherein said spring means comprises a compression spring.

10. The fuel injection arrangement as defined in claim **1** including monostable multivibrator means in said control means; switch means operated by the crankshaft of said engine and actuating said monostable multivibrator means; and transformer means operatively coupled to said monostable multivibrator means and to said pressure-sensing means, the inductance of said transformer means being varied as a function of the pressure sensed by said pressure-sensing means.