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[54] **FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINE**

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[52] **U.S. Cl.** .... **123/32 EA,** 123/119 R

[51] **Int. Cl.** **F02b 1/02**

[58] **Field of Search** .... 123/32 EA

[56] **References Cited**

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[57] **ABSTRACT**

The proposed system comprises electromagnetic injectors feeding the fuel cyclically into the inlet manifold of the engine. The operation of the injectors is controlled by an electronic device having at least three driven multivibrators.

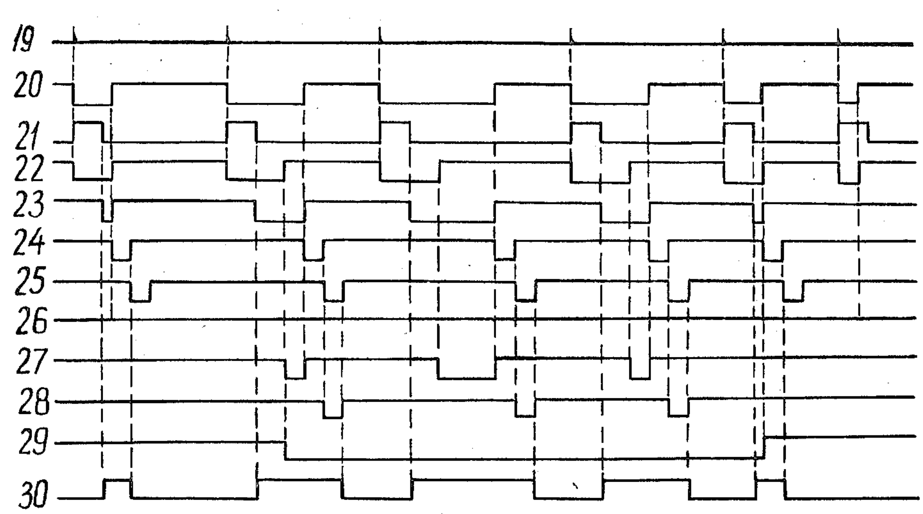
One multivibrator receives the signals from the engine speed transducer and from the pressure transducer responding to the air pressure in the inlet manifold of the engine and shaping pulses whose repetition frequency depends on the speed of the engine and whose duration depends on the pressure in the inlet manifold.

The second multivibrator receiving the signals from the engine speed transducer shapes pedestal pulses of a specified duration in synchronism with the engine speed.

The durations of the pulses of the first and second multivibrators are compared, and a signal is produced which triggers the third multivibrator when the duration of the pulse of the first multivibrator exceeds the duration of the pulse of the second multivibrator.

This provides for a jumpy change in the characteristic of the pulses controlling the injectors without using electromechanical transducers operating when shifting the engine to full-power operation and when cutting off the fuel supply.

3 Claims, 4 Drawing Figures



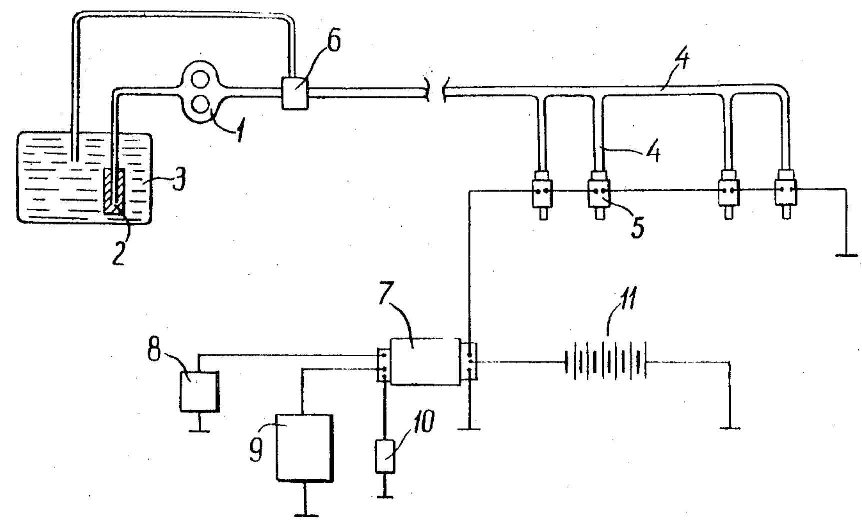


FIG.1

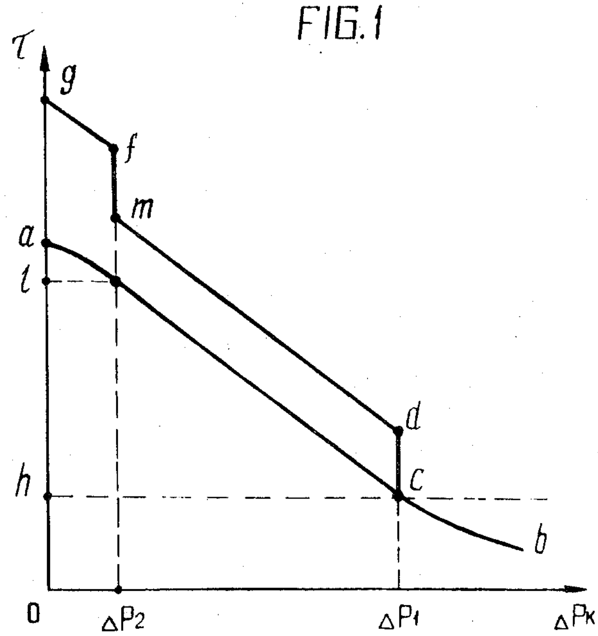


FIG. 4

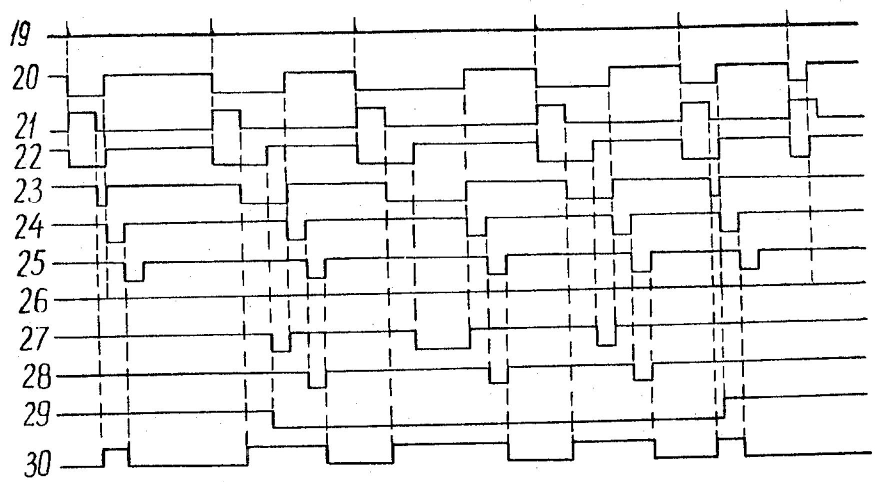


FIG. 3

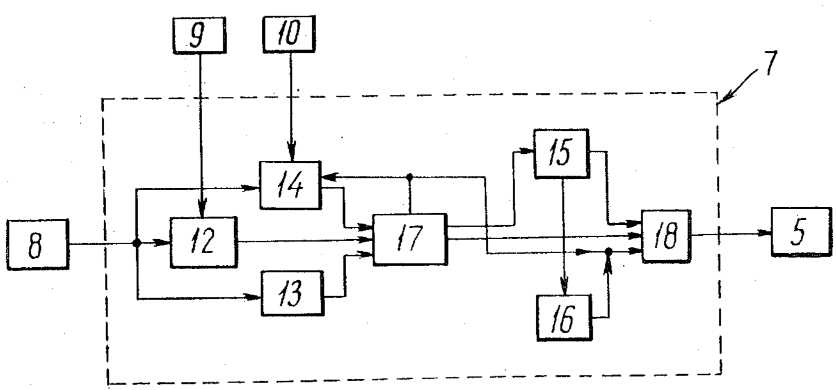


FIG. 2

FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINE

The present invention relates to internal combustion engines and, more particularly, the invention relates to fuel injection systems of internal combustion engines.

The invention can be most successively used in automobile petrol engines with forced ignition.

Such engines usually operate under widely variable operating conditions characterized by countless combinations of speeds and loads. All the same, in order to provide for the highest efficiency of the engine, its cylinders must always be fed with a combustible mixture having an optimum composition at all times both at economical running and full-power operation.

These requirements cannot be met by the known carburettor fuel systems.

In this respect the most promising fuel systems are those providing for cyclical injection of fuel into the inlet manifold of an engine through electromagnetic injectors, in which the fuel supply is automatically controlled by means of a semiconductor electronic device.

Known in the art are internal combustion engines equipped with systems for cyclical injection of fuel into the inlet manifold of the engine in which the electromagnetic injectors supplying the fuel are controlled by electric pulses from an electronic device having three of more driven multivibrators one of which receives the signals from the engine speed transducer and from the pressure transducer responding to the air pressure in the inlet manifold of the engine.

In these systems the output of the first multivibrator storing the master program of control is connected to the output of the second multivibrator. The timing capacitor of the second multivibrator is charged to a potential whose magnitude is proportional to the duration of the pulse of the first multivibrator.

As a result, the second multivibrator produces pulses whose duration is equal to that of the pulses of the first multivibrator multiplied by a predetermined constant. Then the pulses of the first and second multivibrators are added and the pulses of the total duration are fed through amplifiers to the windings of the electromagnetic injectors thereby obtaining the pulses of a required width for controlling the injectors of the engine.

The remaining multivibrators perform auxiliary functions such as deenergizing the electric fuel pump after a time delay following the cut-off of the control pulses fed to the injectors, etc.

The known fuel injection systems have the following disadvantages.

In addition to the absolute air pressure transducer provided in the inlet manifold of the engine, such systems employ a pressure transducer responding to the air pressure in the inlet manifold relative to the ambient medium (full-power pressure transducer) for correction of the duration of the pulses controlling the operation of the injectors when shifting the engine from economical running to full-power operation. This additional transducer is usually a contact-type electromechanical device.

When the magnitude of the vacuum in the inlet manifold of the engine is close to zero (ΔP_k<50–70 mm Hg), the contacts of the transducer controlling the engine during the full-power operation close and send a signal for increasing the cyclical supply of fuel.

What is more, the cut-off of the fuel supply needed under the throttle-down operating conditions is effected by means of a transducer for cutting off the fuel supply coupled with the axle of the throttle valve, the last-named transducer also being a contact-type electromechanical device. Its contact operate when the throttle valve is closed, in which case an electric signal is sent to the pulse producing device which cuts off the control pulses being transmitted to the injectors.

Thus in the known systems, besides the main transducers, i.e., the air pressure transducer in the inlet manifold of the engine and the engine speed transducer, there are provided additional transducers a full-power operation transducer and a fuel cut-off transducer. The use of these additional electromechanical transducers complicates the system, reduces its reliability and increases its cost.

An object of the present invention is to provide a fuel injection system for an internal combustion engine which makes it possible to supply the engine with a combustible mixture having an optimum composition under all operating conditions to obtain high thermal efficiency and high power and economical characteristics of the engine without using the additional transducers and this, in the final analysis, simplifies the system, increases its reliability and reduces the cost of production.

According to the invention, this object is attained due to the fact that in the pulse producing electronic device the second multivibrator receives through its input the signals from the engine speed transducer and produces pulses of a fixed duration in synchronism with the pulses of the first multivibrator; the output of the second multivibrator and the output of the first multivibrator through a logical circuit comparing the duration of the pulses of these multivibrators are connected to the input of a third multivibrator producing a pulse when the duration of the pulses of the first multivibrator exceeds the duration of the fixed pulse.

Such a solution of the problem makes it possible to obtain a jumpy characteristic of the dependence of the duration of the pulses controlling the injectors upon the vacuum in the inlet manifold when shifting the engine from economical running to full-power operation or under the conditions of cutting off the fuel supply which are predetermined in the electronic device by a specified duration of the pedestal pulse.

The uneven (jumpy) characteristic of the process of fuel supply allows one to exclude one of the electromechanical transducers from the fuel injection system, for example the full-power transducer or the fuel cut-off transducer and this, in turn, simplifies the system, increases its reliability and reduces the cost of production.

In one of the modifications of the fuel injection system the pulse shaping electronic device is equipped with more than three driven multivibrators. In this case, at least two of these multivibrators shape pedestal pulses, each pulse having a predetermined duration. The inputs of the multivibrators are connected to the output of the engine speed transducer while the output of each multivibrator in pair with the output of the first multivibrator through a logical unit is connected to a multivibrator shaping a pulse when the duration of the pulses of the first multivibrator exceeds the duration of the corresponding pedestal pulse.

Such a solution of the problem makes it possible to obtain a jumpy characteristic of the dependence of the duration of the pulses controlling the injectors upon the vacuum in the inlet manifold when shifting the engine from economical running to full-power operation and under the conditions of cutting off the fuel supply. The operating conditions of the engine are predetermined in the electronic device by specifying the duration of the fixed pulses.

The jumpy operating characteristic of the fuel injection system allows one to exclude two electromechanical transducers, i.e., the full-power transducer and the fuel cut-off transducer from the system thereby simplifying this system, increasing its reliability and reducing the production cost.

It is expedient that in the pulse producing electronic device the inputs of the multivibrators producing the fixed pulses are connected to the outputs of the transducers responding to the operating conditions of the engine.

Such a solution of the problem makes it possible to make a fuel supply system which would provide for feeding the engine with a combustible mixture having an optimum composition under all operating conditions at high thermal efficiency and high full-power and economical characteristics of the engine without using the full-power and fuel cut-off transducers.

The present invention will be better understood from a consideration of the following detailed description of one particular embodiment of the invention, reference being made to the accompanying drawings, in which:

FIG. 1 is a schematic diagram of the fuel injection system for an internal combustion engine;

FIG. 2 is a block diagram of the device for producing electric pulses;

FIG. 3 is a time diagram of the operation of the pulse producing device;

FIG. 4 is a diagram of the dependence of the duration τ of the produced pulses upon the vacuum Δ P in the inlet manifold of the engine.

The fuel injection system of an internal combustion engine comprises a fuel pump **1** (FIG. **1**) taking up the fuel from a fuel tank **3** through a filter **2** and forcing it under a constant pressure into electromagnetic injectors **5** through a pipeline **4**. The constant fuel pressure is maintained by a reducing valve **6**.

The electromagnetic injectors **5** inject the fuel into the inlet manifold of the engine (not shown) when feeding the windings of these injectors with electric pulses produced by a pulse producing electronic device **7**.

To provide for simultaneous operation of the electronic device **7** and of the engine and to control the duration of the pulses fed to the injectors in accordance with a given program, the device **7** is connected to electromechanical transducers: an engine speed transducer **8**, a transducer **9** responding to the vacuum in the inlet manifold of the engine and a pressure transducer **10** responding to the pressure of the ambient medium. The device **7** may also be connected to other auxiliary transducers such as devices responding to the temperature of the suction air, cooling water, engine block, etc. The electronic device **7** is powered from a storage battery **11** of the automobile.

The pulse producing device **7** consists of five driven multivibrators **12, 13, 14, 15** and **16**, an auxiliary logical unit **17** and an amplifier unit **18**. The structural block diagram of these components is shown in FIG. **2**.

Connected to the first multivibrators **12** are the outputs of the transducer **9** responding to the vacuum in the inlet manifold of the engine and of the engine speed transducer **8**.

The multivibrator **13** produces fixed duration pulses for shifting the engine to high-power operation by means of the device **7**; the engine speed transducer **8** is connected to the input of the multivibrator **13**.

The multivibrator **14** produces fixed duration pulses for cutting off the fuel supply. Connected to the input of the multivibrator **14** are the outputs of the pressure transducer **10** responding to the pressure of the ambient medium and of the engine speed transducer **8**.

The multivibrator **15** produces pulses for cutting off the fuel supply; its input is connected to the output of the unit **17**. The multivibrator **16** produces full-power operation pulses and its input is connected to the output of the multivibrator **15**.

The unit **17** includes a logical circuit for comparing the duration of pulses, a circuit for logical addition of pulses by their duration and a trigger whose output is connected to the input of the multivibrator **14** and to the output of the multivibrator **16**; the outputs of the multivibrators **12, 13** and **14** are connected to the input of the unit **17**.

The unit **18** comprises an amplifier whose input is connected with the outputs of the multivibrators **15** and **16** and with the outputs of the unit **17**; the output of the amplifier is connected to the windings of the electromagnetic injectors **5**.

The pulse producing device **7** operates as follows.

The engine speed transducer **8** in synchronism with the rotation of the camshaft of the engine produces differentiated timing pulses **19** (FIG. **3**) (one pulse per revolution of the camshaft), which are simultaneously fed to the inputs of the multivibrators **12, 13** and **14**.

When the multivibrator **12** receives the timing pulses and the signals from the vacuum transducer **9**, it produces pulses **20** the duration of which depends on the vacuum Δ P. This dependence at a constant pulse repetition frequency (at a constant speed of the engine) is illustrated by the curve *ab* in FIG. **4**.

The multivibrator **14** receives the timing pulses from the transducer **8** responding to the engine speed and from the transducer **10** responding to the pressure of the ambient medium and produces a fixed duration pulse **21** (FIG. **3**) for cutting off the fuel supply, which pulse serves simultaneously as a barometric correction pulse. The duration of this pulse **21** varies depending on the atmospheric pressure and is shown by the line *oh* in FIG. **4**.

The multivibrator **13**, which also receives the timing pulses from the transducer **8**, produces a fixed duration pulse **22** (FIG. **3**) of full-power operating conditions having a duration *ol* (FIG. **3**).

The pulses shaped by the multivibrators **12, 13** and **14** are fed to the unit **17** for logical comparison of the durations of the pulses of the multivibrator **12** with the fixed pulses of the multivibrators **13** and **14**, so that the corresponding signals are produced at the output of the unit **17**. At the same time, in the unit **17** the duration *oh* of the pulse of the multivibrator **14** is substracted from the duration of the pulse of the multivibrator **12**.

When the vacuum Δ P in the inlet manifold of the engine is lower than the vacuum ΔP_1 at which the fuel supply is to be cut off, i.e., when the duration of the pulse of the multivibrator 12 exceeds the duration *oh* of the fixed pulse of the multivibrator 14, a differential pulse 23 (FIG. 3) appears at the output of the unit 17. The multivibrator 15 producing a fuel cut-off pulse 24 (FIG. 3) from the trailing edge of the differential pulse 23. The duration of the pulse 24 is shown by the line *cd* in FIG. 4. The differential pulse 23 and the fuel cut-off pulse 24 are fed to the input of the amplifier unit 18 whose output pulses are applied to the windings of the duel injectors 5.

When the vacuum ΔP in the inlet manifold of the engine is higher than the vacuum ΔP_1 at which the fuel supply must be cut-off, the duration of the pulse 20 of the multivibrator 12 becomes less than the duration *oh* of the fixed pulse 21 of the multivibrator 14, the differential pulse 23 is no longer applied to the output of the unit 17, and the multivibrator 15 produces no pulses for cutting off the fuel supply. No pulses are applied to the input of the amplifier unit 18, therefore, to the windings of the injectors 5 thus obtaining a required jump-like cut-off of the fuel supply when the engine operates with a closed throttle valve.

The necessary enrichment of the combustible mixture when shifting the engine from economical running to full-power operation is effected due to a sudden increase in the duration of the pulse applied to the windings of the injectors 5 due to the pulse 25 produced by the multivibrator 16 from the trailing edge of the pulse 24 of the multivibrator 15. The duration of the pulse 25 of the multivibrator 16 is shown by the line *mf* in FIG. 4. The multivibrator 16 is connected to the input of the amplifier unit 18 and is disconnected therefrom by a trigger provided in the unit 17. The trigger is operated by the signals applied to both its inputs.

If the vacuum ΔP in the inlet manifold of the engine is higher than the vacuum ΔP_2 of the change-over of the engine from economical running to full-power operation, the multivibrator 12 produces pulses whose duration is less than the duration *ol* of the fixed pulse 22 of the multivibrator 13, and a signal 26 (FIG. 3) produced after the comparison of the pulses 22 and 23 is applied to one of the inputs of the trigger and holds it in that state, in which case the full-power duty multibibrator 16 is disconnected from the amplifier unit 18.

If the vacuum ΔP is lower than the vacuum ΔP_2, the duration of the pulse of the multivibrator 12 exceeds the duration *ol* of the fixed pulse 22 of the multivibrator 13. In this case a signal 27 (FIG. 3) is applied to the other input of the trigger and renders it to the state where the output of the multivibrator 16 is connected to the input 18 so that only pulses 28 (FIG. 3) of the pulses 25 are applied to the input of the amplifier unit 18. The change in the potential at the output of the trigger which is shifted from one state to another by the signals 26 and 27 is shown in FIG. 3 by the position 29.

The durations of the pulses 23, 24 and 28 are added at the input of the amplifier unit 18, and the total pulse 30 is applied to the windings of the injectors 5.

Consequently, the electromagnetic injectors 5 are controlled by the pulses whose duration is changed depending on the vacuum ΔP in the inlet manifold in accordance with the characteristic shown by the broken line *cdmfgh* in FIG. 4.

The zero reading of the pulse duration in this characteristic is effected from the level defined by the line *hc*.

The length *hg* defines the pulse duration corresponding to the maximum value of the cyclical fuel supply in the engine under the vacuum $\Delta P = 0$.

The inflection of the curve at the points *m* and *f* defines the jumpy change in the pulse duration under a vacuum ΔP_2 when shifting the engine from economical running to full-power duty.

The inflection of the curve at the points *d* and *c* defines the sudden disappearance of the pulses under a vacuum ΔP_1 for cutting off the fuel supply at a closed throttle valve.

In the case of full-power operation of the engine the dependence of the change in the duration of the pulses applied to the injectors upon the change in the ambient medium pressure must be much more pronounced than in the case of economical running. Such a regularity is achieved due to the action of the trigger of the unit 17 which under a vacuum of $\Delta P < 50–70$ mm Hg changes the parameters of the timing circuit of the multivibrator 14 producing the fixed duration pulse for cutting off the fuel supply.

The required correction of the pulses applied to the injectors to suit the engine speed is effected by correspondingly changing the duration of the pulse of the multivibrator 15 to cut off the fuel supply. The correction can also be effected by changing the duration of the pulse of the multivibrator 12.

We claim:

1. A fuel injection system for an internal combustion engine comprising in combination: a fuel tank; a fuel pump taking up the fuel from said tank through a fuel filter; electromagnetic injectors connected with said fuel pump through pipelines, said pump forcing the fuel into said pipelines; a reducing valve installed on the high-pressure side of said fuel pump, said valve maintaining a constant fuel pressure in said electromagnetic injectors which force the fuel into the inlet manifold of said engine; an electronic device sending control pulses to said electromagnetic injectors for feeding fuel into a motor or engine in accordance with its operational mode and conditions, and having at least three driven multivibrators; a power source supplying an electric current to said electronic device; an engine speed transducer sending signals to said electronic device; a pressure transducer responding to the air pressure in the inlet manifold of said engine; the first of said multivibrators receiving the signals from said transducers and producing pulses in synchronism with the engine r.p.m., the duration of these pulses being dependent on the pressure in the engine inlet manifold; the second of said multivibrators receiving the signal from said engine speed transducer and producing pulses of a fixed duration in synchronism with the engine r.p.m.; a logical unit comparing the durations of the pulses of said first and second multivibrators and sending to said electromagnetic injectors pulses whose duration equals a difference between the durations of the pulses of said first and second multivibrators in the case where the duration of the pulses of said first multivibrator exceeds that of said second multivibrator; the third of said multivibrators receiving the signals from said first and second multivibrators via said logical unit and producing pulses in the case where the duration of the pulses of said first multivibrator exceeds that of the pulses of said second multivibrator; the third of said multivibrators sending pulses to said electromagnetic injectors, which are additive to said difference pulses.

2. A system as claimed in claim **1**, wherein, upon more than three driven multivibrators being available, at least two of said multivibrators produce pulses each of its own fixed duration, their inputs being connected to the output of said engine speed transducer, whilst each output thereof in pair with the output of said first multivibrator through said logical unit is connected to a respective additional multivibrator producing a pulse in the case where the duration of the pulses of said first multivibrator exceeds the fixed duration of the pulses of a corresponding one of said two additional multivibrators, and sending thus produced pulses to said electromagnetic injectors which are additive to said difference pulses.

3. A system as claimed in claim **2**, wherein there are connected to the inputs of each of said multivibrators producing pulses of fixed duration, the outputs of the transducers responding to the engine operation mode and conditions and so as to accordingly correct said fixed durations of the pulses.

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