

[54] FUEL INJECTING SYSTEMS FOR
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[58] Field of Search 123/119 R, 32 AE, 32 EA

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[57]

ABSTRACT

A fuel injecting system includes pulse transformers, each of them comprising a saturable magnetic core of a rectangular hysteresis loop, an input-winding, a bias-winding, an output-winding and a speed-winding. Voltage pulses are generated across the output-winding as the result of such flux reversal in the magnetic core that takes place when the ampere-turns in the various windings cancel one another. The timing of the generation of the pulse can be changed by introducing such an impedance in the circuit of the output-winding than can be variable in accordance with the various parameters of the operation of the engine such as the negative pressure and the temperature in the intake pipe of the engine, the speed and the acceleration of the engine and the atmospheric pressure. The voltage pulse is utilized in order to initiate or finish the injection intervals of fuel injection nozzles or valves.

14 Claims, 9 Drawing Figures

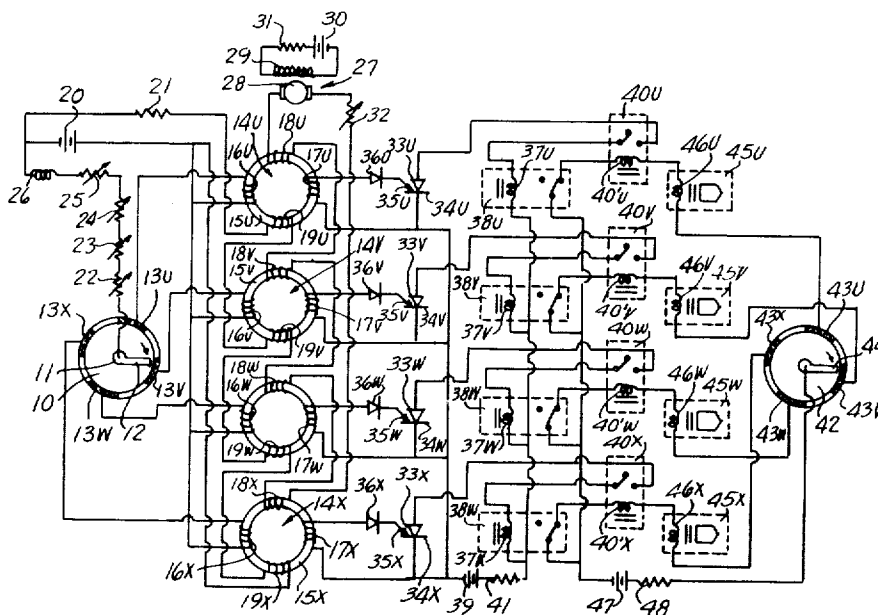


FIG. 1.

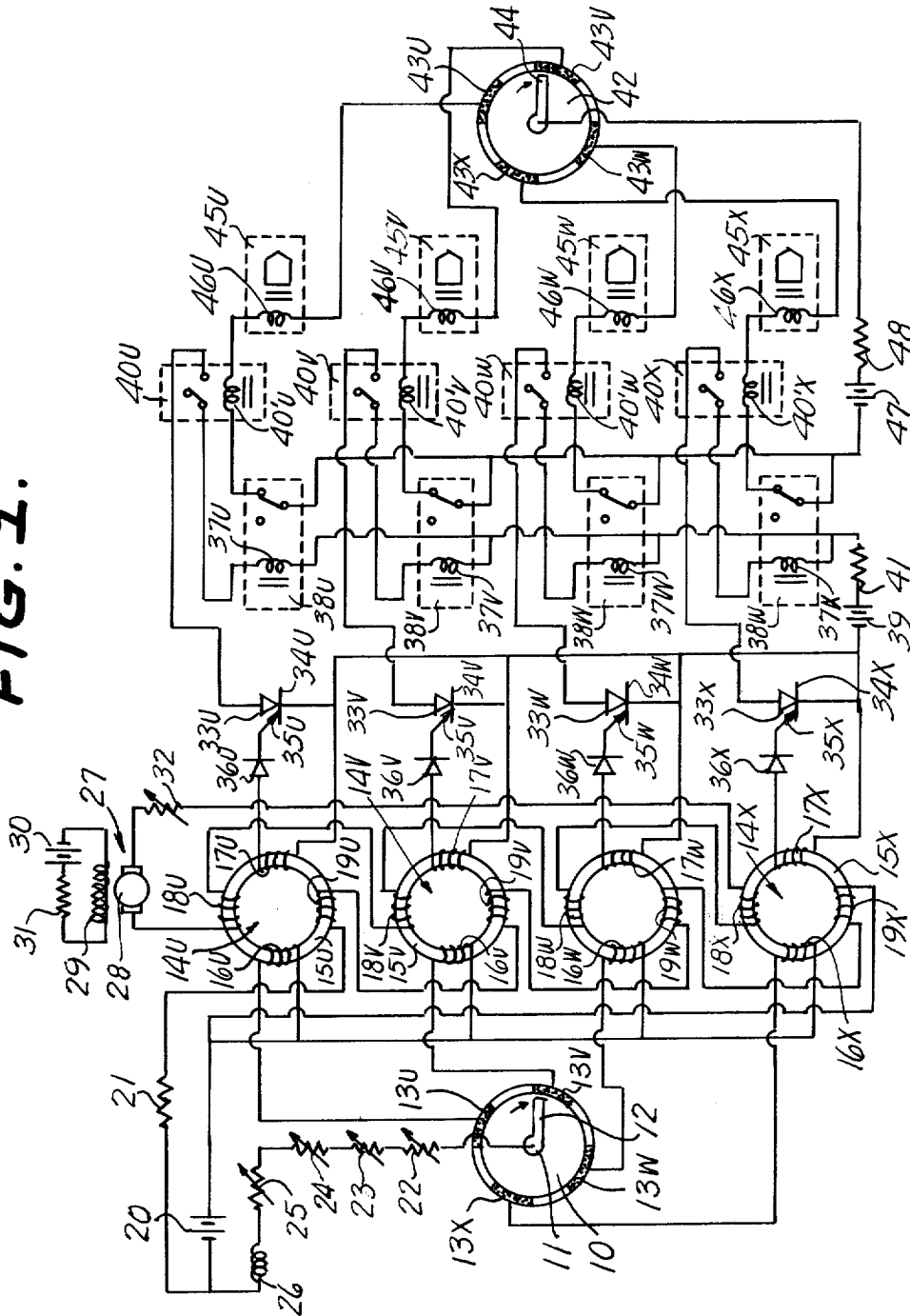


FIG. 2.

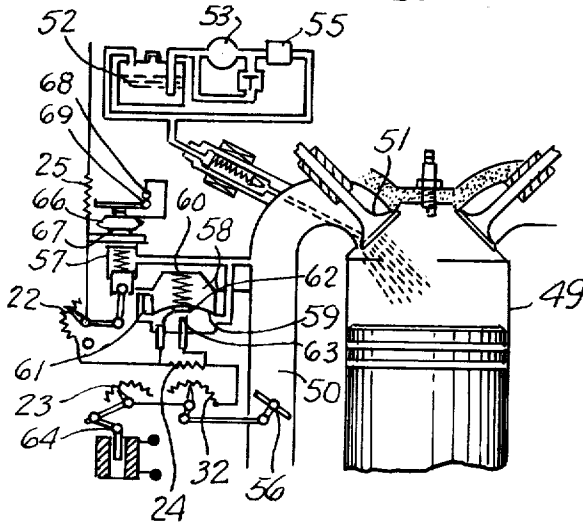


FIG. 3.

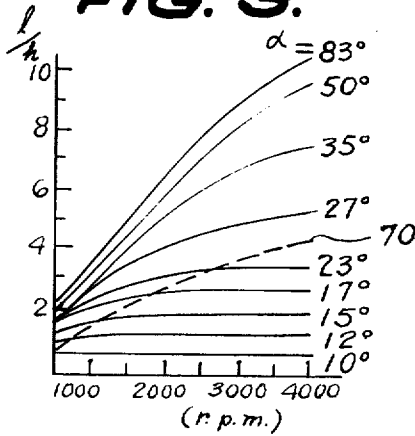


FIG. 4.

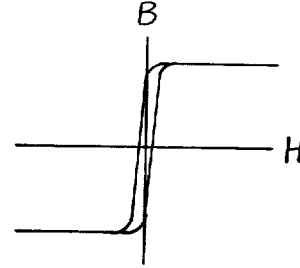


FIG. 5.

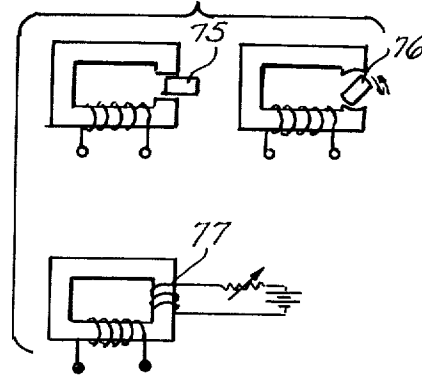


FIG. 8.

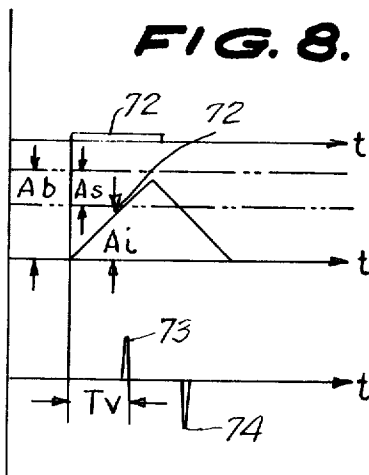


FIG. 9.

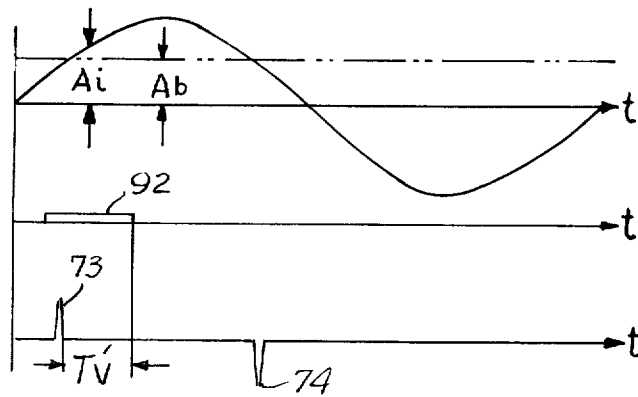
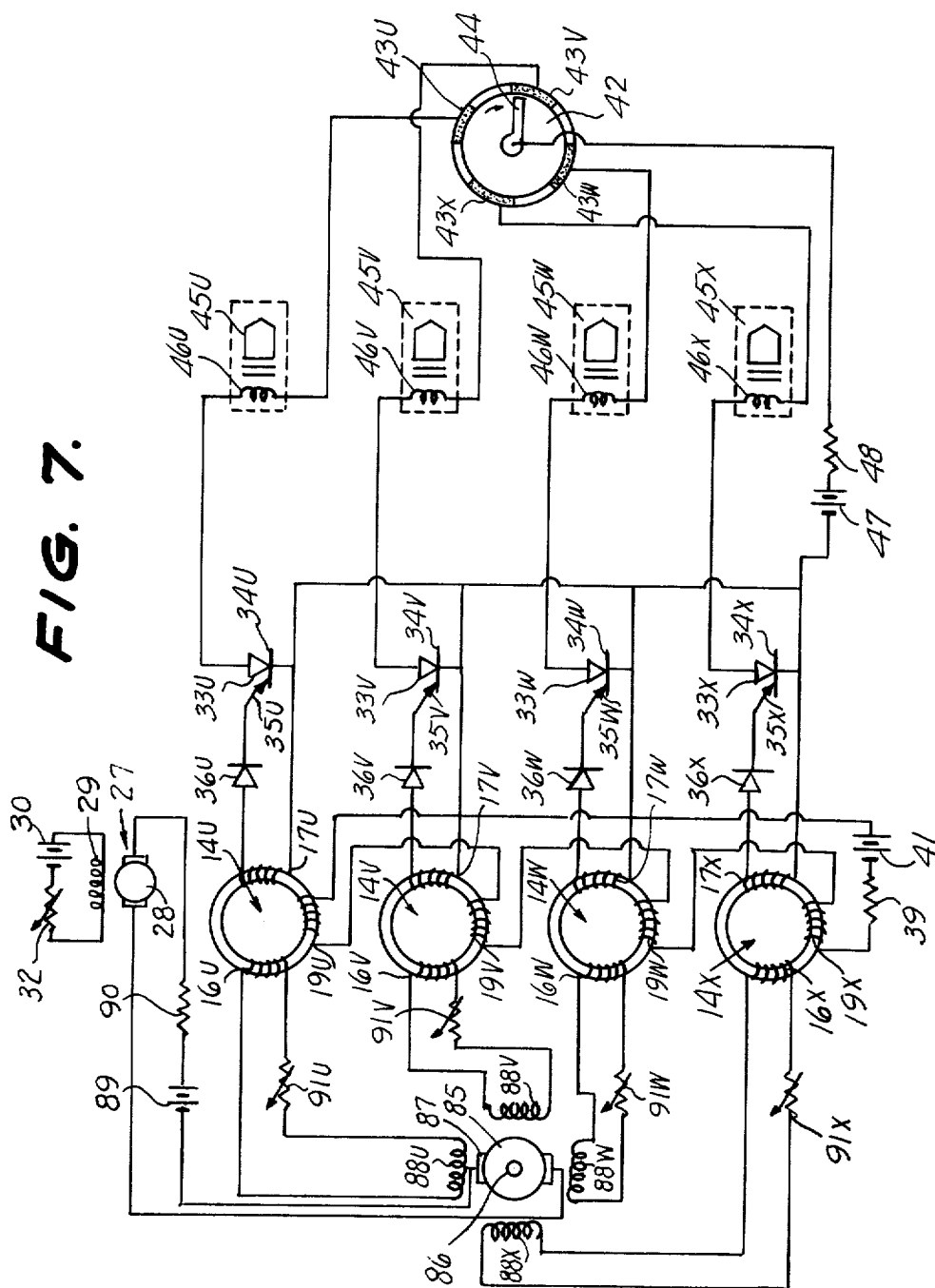


FIG. 7.



FUEL INJECTING SYSTEMS FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates to a fuel injecting system for internal combustion engines such as gasoline engines. The object of this system is to give engine-cylinders fuel-air mixture suitable for various situations of engine operation. As the legal control over the atmospheric pollution due to the exhaust gas from automobiles becomes severe, the term "suitable" not only means the optimum conditions for the operation of the automobile alone and the fuel economy but also implies whether the harmful components in the exhaust gas can be controlled within a certain limit or not. The main harmful components in the exhaust gas have been found to be carbon monoxide CO, nitrogen oxide NOx, and hydrocarbon HC. However, these harmful components are generated inconveniently in the different situations of the operation of the engine and the means for suppressing each of these components must be considered separately. Further it must be taken into account that the reduction of such harmful components would result, more or less, in the degradation of the functions proper to the engine. For example, if the negative pressure in the intake pipe is reduced in order to suppress the emission of the harmful components in the overrunning situation, the function of the engine break would become insufficient. On the other hand, so long as a combustion system in which fuel-air mixture is burned or exploded and the burned gas is exhausted directly into the atmosphere is adopted, it would be impossible to eliminate the emission of CO completely however ideal the combustion process may be rendered. Accordingly, the various counter-means for the harmful emissions must be taken into account separately because of various harmful components originating in different situation of the engine operation and besides there is brought about a problem how one can make compatible those counter-means for the harmful components which often contradict one another, without sacrificing the function proper to the engine. Except for eliminating and making harmless the harmful components generated in the combustion chambers, the substantial point for solving the present problem lies in controlling the combustion process in the engine-cylinders in accordance with the working conditions of the engine and the atmospheric situations. The utilization of conventional carburetters is not sufficient for this purpose and a fuel injecting system is required in which the injection of fuel has many-sided controllability with the r.p.m. of the engine, the negative pressure in the intake pipe, the temperature in the intake pipe and so on. Conventionally there have been devised purely mechanical fuel injecting systems and electronic ones provided with a small-sized electronic computer as a computing center. The former has the advantages of reliability or safety and cheapness but is lacking in the many-sided controllability because it is constructed under an assumption that the gas volume taken in per one cycle of the engine operation depends on the negative pressure but not on the r.p.m. of the engine. Such an assumption is correct indeed when the engine is giving output but would not be so in general at the time of overrunning. The latter electronic fuel injecting system has sufficient many-sided controllability but is unreliable or insecure as a system to be mounted on auto-

mobiles running at high speed if one remembers that the electronic computer and the electronic circuits associated with it are assemblies of pulse circuits. Moreover, it is by no means cheap. Considering the sensing speed and the accuracy of various sensors as primary means of automatic control, the inertia of the motion of fuel and the time lag resulting from the mixing process of the fuel with air, it would be a question whether a small-sized electronic computer must be carried by an automobile at the sacrifice of economy in order to raise the speed and the accuracy of control. Raising the speed and the accuracy of the control is one problem but making the control many-sided is another.

SUMMARY OF THE INVENTION

The present invention is for solving many problems pointed out above. For the purpose of changing the injection interval of fuel injection valves or nozzles, a pulse transformer is utilized which comprises a saturable magnetic core of a rectangular hysteresis loop, an input-winding, control windings such as a bias-winding and a speed-winding and an output-winding. The input-winding is connected with the series connection of an assembly of variable resistors, an inductor, a rotary switch and a d.c. source. In the bias-winding, a d.c. bias current flows and if the bias current is cancelled by the ampere-turns in the other windings, a voltage pulse is generated across the output-winding. The timing of the generation of the pulse can be changed in accordance with the negative pressure in the intake pipe of the engine, the temperature in the intake pipe, the speed and the acceleration of the engine and atmospheric pressure, by making the resistances of said variable resistors be changed with these parameters of the engine operation, because the transient growth rate of the current in the input-winding, which is initiated by the closure of the rotary switch, is determined by the variable resistors and the inductor. These voltage pulses can be utilized to turn-on switching elements which interrupt the injection valve energizing currents established by the closure of another rotary switch. In stead of the combination of the inductor and the variable resistors in the circuit of the input-winding, an a.c. generator is used which is adapted to generate sinusoidal voltages of the number equal to that of the engine-cylinders and with phase differences corresponding to the difference of the injection timings for all the engine-cylinders. In this case, the influences of the various parameters of the engine operation are introduced to the field current of the a.c. generator or to the ampere-turns in the various windings of the pulse transformer. The voltage pulses in this case are utilized in order to initiate the injection interval, which is finished by the break of a rotary switch. In order to establish the reliability of the operation, one or two groups of relays are used for interrupting the currents in the switching elements and the coils of the fuel injection valves.

Important relationships have been described and it will be understood that the fuel injection system according to the present invention is provided with highly many-sided controllability. According to the present invention, such drooping characteristic of the fuel consumption per one cycle of the engine operation against the r.p.m. of the engine that becomes more noticeable as the opening angle of the throttle valve decreases is realized satisfactorily. Moreover, this many-sided controllability is obtained with pulse transformers and grid-

controlled rectifying elements at most as electronic elements. Less pulse generating elements are used compared with usual electronic devices and other members such as relays, switches and generators are suitable for being mounted on automobiles running at high speed. The present system can be manufactured cheaply and does not suffer electrical disturbances because the pulses controlling the essential operations of the system are generated as the magnetic flux reversal in the saturated magnetic cores.

IN THE DRAWING

FIG. 1 is an electric connection diagram of a first embodiment;

FIG. 2 is a schematic view showing the relationship between an engine and a fuel injecting system;

FIG. 3 is a graph showing the relationship between the r.p.m. of the engine and the fuel consumption;

FIG. 4 is a graph showing the hysteresis loop of magnetic cores;

FIG. 5 is a plan view of variable inductors;

FIG. 6 is an electric connection diagram of the embodiment as shown in FIG. 1 in which a single grid-controlled rectifying element is used commonly for all the engine-cylinders;

FIG. 7 is an electric connection diagram of an embodiment in which an a.c. generator adapted to synchronize with the rotation of the engine is used;

FIG. 8 is a view showing the wave forms of various electric signals in the embodiment shown in FIG. 1; and

FIG. 9 is a view analogous to FIG. 8 but concerning the embodiment shown in FIG. 7.

Referring to FIG. 1, an embodiment is described with respect to a four-cylinder engine and members of the same construction but belonging to different cylinders are given same reference numerals. However, if it is necessary to show the engine-cylinder to which any of the same members belongs, the member is distinguished by a suffix *u*, *v*, *w* or *x*. A kind of rotary switch 10 of the same construction as a conventional distributor or the like comprises a rotating shaft 11 adapted for rotation with the same r.p.m. of the rotating shaft of the distributor or the like, a rotary contact 12 mounted on the rotating shaft 11 and a series of fixed contacts 13u, 13v, 13w and 13x which are aligned for contact with the rotary contact 12 along a circle concentric with the rotating shaft 11 and at regular circumferential intervals. The circumferential length of the fixed contacts 13 must be adjusted so that the contacting interval of this fixed contact with the rotary contact 12 may be longer than the maximum value of the injection intervals under various operational conditions of the engine. This rotary switch may be replaced by another type of switch which can operate successively as does rotary switch 10. A pulse transformer 14 comprises a toroidal magnetic core 15 having a rectangular hysteresis loop as shown in FIG. 4 (In this figure *H* is magnetomotive force and *B* magnetic induction.), an input-winding 16, an output-winding 17, a speed-winding 18 and a bias-winding 19. The bias-windings 19u—19x are connected in series with one another so that they can give each of the magnetic cores a bias ampere-turn in the same direction and are connected to a d.c. source 20 through a protective resistor 21. The one terminal of each of the input-windings 16u—16x is connected to the corresponding one of the fixed contacts 13 and the other terminals are connected together to the plus terminal of

the d.c. source 20. The rotary contact 12 is connected to the minus terminal of the d.c. source 20 through the series connection of a negative pressure-resistor 22, a temperature-resistor 23, an accelerator-resistor 24, an atmospheric pressure-resistor 25 and an inductor 26. In this case, the ampere-turn of the input-winding 16 is adjusted to be opposite to that of the bias-winding 19. A d.c. generator 27 adapted to be actuated by the engine has an armature 28 and a field winding 29 which is connected to a d.c. source 30 through a field rheostat 31. The speed-windings 18u—18x are connected in series with one another and are connected to the armature 28 through a throttle-resistor 32 so that the ampere-turns of these speed-windings are opposite to those of the bias-winding 19. The d.c. generator 27 can be replaced by a combination of an a.c. generator and suitable rectifiers. 33 represents a grid-controlled rectifying element and the output-winding 17 is connected between its cathode 34 and grid 35 through a diode 36. The coil 37 of a d.c. energized relay 38 is connected to a d.c. source 39 through the class-A contact (closing when energized) of another relay 40 of the same construction as the relay 38, the grid-controlled rectifying element 33 and a protective resistor 41. Another rotary switch 42 is constructed quite same as the rotary switch 10 and the intervals and the timing of the contact between fixed contacts 43u—43u and a rotary contact 44 are also same. A usual fuel injection valve or nozzle 45 is designed in such a manner that the energized interval of its coil 46 is proportional to the fuel quantity injected. The coil 46 is connected to a d.c. source 47 through the corresponding fixed contact 43, the rotary contact 44, the coil 40' of the relay 40, a protective resistor 48 and the class-B contact (closing when deenergized) of the relay 38.

Now referring to FIG. 2, the mechanical relationship of the present embodiment is described. Numerals 49, 50 and 51 represent an engine-cylinder, an intake pipe and an intake valve respectively. A fuel tank 52, a fuel pump 53, a relief valve 54 by-passing the fuel pump 53 and a fuel strainer 55 are provided in order to supply fuel of constant pressure to the fuel injection valve 45 mounted near the intake valve 51. In the intake pipe 50 is provided a throttle valve 56 which engages the throttle-resistor 32 and varies the resistance of it in accordance with the opening angle of the throttle valve. A negative pressure sensor 57 is communicated with the intake pipe 50 and engages the negative pressure-resistor 22 to vary its resistance in accordance with the variation of the negative pressure. An acceleration sensor 58 communicated with the intake 50 comprises a diaphragm 59, a return spring 60, a bleed jet 61 communicating two chambers separated by the diaphragm 59 and the movable contact 63 adapted to be actuated by the diaphragm 59. The movable contact 63 is detached from the fixed contact 62 at the time of acceleration i.e. at the time of abrupt change in the pressure in the intake pipe 50. The contacts 62 and 63 are connected to both terminals of the acceleration-resistor 24 respectively so as to short-circuit this resistor when the contacts 62 and 63 are closing. A temperature sensor 64 is for detecting the temperature in the intake pipe 50 and includes a bimetal adapted to work to vary the resistance of the temperature-resistor 23 in accordance with the variation of the temperature. An atmospheric pressure sensor 66 for correcting the fuel quantity to the atmospheric pressure comprises a bellows 67 en-

closing a certain volume of gas of constant pressure, a movable contact 68 actuated by the bellows 67 and a fixed contact 69. The contact 68 is detached from the contact 69 thus varying discretely the resistance of the resistor 25 when the atmospheric pressure falls below a certain value.

The operation of the fuel injecting system described above is as follows. Because the detail operational characteristics of an internal combustion engine are different from those of another, the fuel combustion per unit cycle of the engine operation depends on the negative pressure in the intake pipe and the r.p.m. of the engine. Accordingly, now suppose a general fuel consumption curve as shown in FIG. 3. Because the ordinate of this graph, which represents the fuel consumption per unit time, can also be considered to show (fuel consumption per unit cycle) X (the r.p.m. of the engine), the fuel consumption is constant so long as the fuel consumption curve is represented by a straight line passing the origin. This tendency of constant fuel consumption is substantially the case for the output region over a dotted zero-torque curve 70 but for the over-running region under the zero-torque, the fuel consumption curve becomes gradually parallel with the axis of abscissa with increasing r.p.m., the fuel consumption per unit time tending to be saturated. This shows nothing but the decrease of the fuel consumption per one cycle. This tendency for the fuel consumption to be changed by the r.p.m. of the engine begins at lower speed of the engine the smaller the opening angle α of the throttle valve. Of course, there is a negative correlation as usually known between this opening angle of the throttle valve and the negative pressure in the intake pipe. On the base of these fundamental considerations, the operation of the present system is described. With respect to an engine-cylinder represented by the suffix v , the closing interval of the rotary switch 10 is shown by 71 of FIG. 8. (In this figure t represents time.) This closing interval is adjusted to be shorter than the interval of the intake stroke but the position of the closing interval in the intake stroke can be adjusted by changing the angular position of the rotating shaft 11 with respect to its driving shaft such as the rotating shaft of the distributor or the cam shaft of the engine. When the contacts 12 and 13 v close, a transient current

$$i=E/R(1-\exp(-t/CL/R))$$

(1)

results, where L is the inductance of the inductor 26, R the combined resistance of the variable resistors included in the circuit under consideration and E the electromotive force of the d.c. source 20. The time when the contacts 12 and 13 v close is taken as the origin of the time. Under a condition $t/(L/R) \ll 1$, equation (1) becomes

$$i=E/Lt-1/2ER/L^2+2$$

(2) ps

With constant E, L and R the ampere-turn A_i of the input-winding 16 v increases parabolically with time but the parabolic increase is not essential and indeed, the increase is approximately linear with respect to time when t is very small. At the same time, also the contacts 43 v and 44 of the rotary switch 42 are closing during the interval shown by 71 of FIG. 8, the coil 46 v of the

fuel injection valve 45 is energized through the rotary switch 42, the class-B contact of the relay 38 v and the coil 40 v' of the relay 40 v . Thus, the fuel injection valve 45 v begins to work. On the other hand, a current is flowing through the speed-winding 18 v from the d.c. generator 28 as the result of the rotation of the engine and the difference A_b-A_s of the ampere-turn A_b of the bias-winding 19 v and the ampere-turn A_s of the speed-winding 18 v is given to the magnetic core 15 v in the opposite direction as the ampere-turn of the input-winding 16 v . Of course, it is necessary that $A_b > A_s$ holds. As is shown in FIG. 8 by a reference numeral 72, flux reversal occurs in the magnetic core 15 v at the time when $A=A_b-A_s$ is established and a positive pulse 73 is generated in the output-winding. If a switching core made of ferrite or permalloy is used as the magnetic core 15 and the ampere-turns are suitably large, the width of this pulse can be regarded as to be negligibly small as compared with such period of one cycle of the engine operation that corresponds to no more than 8000 r.p.m. at most. The pulse 73 is led to the grid 35 v of the grid-controlled rectifying element 33 v through the diode 36 v and turns-on it. As the coil 40 v' of the relay 40 v is energized through the class-A contact of the relay 40 v and the grid-controlled rectifying element 24 v , the class-B contact of the relay 28 opens and the fuel injection to the engine cylinder represented by the suffix v finishes at the time T_v . When the relay 28 v is deenergized, its class-A contact opens, thereby eliminating the current in the grid-controlled rectifying element 24 v . This rectifying element keeps the turn-off situation till the positive pulse of the next cycle is applied to its grid. Because the current in the input-winding 16 v disappears when the contacts 12 and 13 v of the rotary switch 10 open, flux reversal in the magnetic core 15 v results in the reverse direction and generates a negative pulse 74, which, however, is blocked by the diode 36 v . With reference to equation (2) the change in the resistance of any one or several ones of the resistors 22-25 results in the change of the injection interval and it is understood that the combined resistance and the inductance must be made large in order to prolong the injection interval. Only the variation of the resistance of the negative pressure-resistor 22 is described, because the variations of resistances associated with other resistors are similar. In order to make the variable resistor 22 have the desired resistance-negative pressure characteristic, two methods can be considered. One is to make the linear displacement or the angular displacement of the movable portion of the resistor proportional to the negative pressure in the intake pipe and to distribute uniformly resistive material along the direction of the movement of the movable portion and the other is to combine a non-uniform distribution of resistance and a non-linear relation between the displacement and the negative pressure. The connection of the various resistors is not only series one but may be parallel one or series-parallel one. For example, if the fuel injection is controlled principally by the negative pressure in the intake pipe and the change of the fuel injection due to the temperature in the intake pipe is considered as a correction, the parallel combined resistance R of the negative pressure-resistance R_p and the temperature-resistance R_t is approximately

$$R \approx R_p - R_p^2 / R_t$$

where $R_t \gg R_p$. Thus, not only the individual effects of the negative pressure and the temperature but also the collective one of them can be introduced into the control of fuel injection by suitably selecting the variable properties of the resistances R_p and R_t . As is seen from the equation (2), it is possible to change the injecting interval by adapting the inductor to be variable in accordance with the changes of the negative pressure, the temperature and so on. In order to make the inductor variable without using a usual method to change the number of turns of windings, a lineally movable magnetic piece 75 or a rotatable magnetic piece 76 is provided, which constitutes part of the magnetic path, as shown in FIG. 5. These movable pieces are adapted to be actuated by the negative pressure sensor. It is another method to provide a d.c. exciting circuit 77 whose exciting current is varied in accordance with the negative pressure and the temperature. In this case, the change of the differential permeability of the core material is utilized.

Next, as the engine rotates at higher speed, the ampere-turn A_s increases and even if the values of R and L are constant, the timing of the generation of the positive pulse 73 becomes earlier, thus the fuel injection per one cycle decreasing. If the throttle-resistor 32 so adapted as to have larger resistance as the opening angle α of the throttle valve 56 increases, it is possible that the reduction of the fuel injection per one cycle with increasing r.p.m. of the engine is made effective at a considerably lower value of r.p.m. for the overrunning region and at a higher value of it for the output region. It would be understood easily that similar operations take place with a certain time interval also for the engine-cylinders represented by suffixes u , w and x . It is also possible for the purpose of increasing reliability to connect the circuits giving four bias ampere-turns in parallel with one another to the d.c. source 20. In the above embodiment, the rotary switch is used to make or break the current in the input-winding. However, it is also possible to let an electrical switching element make or break this current and to make the rotary switch generate trigger voltages for the electrical switching element.

Next, referring to FIG. 6, another embodiment is described. In this and following embodiments, those members which are of the same construction as those of previous embodiments are given same reference numerals when there is not any need to distinguish and the description about the construction of them are omitted. A grid-controlled rectifying element 78 has its grid 79 and cathode 80 connected to both the terminals of the series connection of the output-windings 17u-17x, 81 and 82 represent relays and between the anode 80' and the cathode 80, the source 39, the protective resistor 41, the coil 83 of the relay 81 and the class-B contact of the relay 82 are connected in series. The one end terminals of the coils 46u-46x are connected to the minus terminal of the source 47 through the coil 84 of the relay 82 and the class-B contact of the relay 81. The operation of this embodiment is a little inferior in reliability but it would be seen that the equivalent operation as that of the embodiment of FIG. 1 can be carried out with a single grid-controlled rectifying element.

Next, still another embodiment is described with reference to FIG. 7. An a.c. generator 85, which is adapted to rotate synchronously with the distributor of the engine, comprises a rotating-field winding 87 and armature windings 88u-88x, which are set in the stator of the a.c. generator so as to generate essentially four sinusoidal voltages with different phases. The phase differences among these voltages correspond to the differences among the injection timings of the four engine-cylinders. The rotating-field winding 87 is connected to the d.c. generator 27 through a d.c. source 89 and a protective resistor 90 so that the electromotive forces of the d.c. generator and the d.c. source 89 may be in the same direction. The armature winding 88v is connected to the corresponding input-winding through a variable resistor 91v, which is shown as the combined resistor of the various variable resistors of the previous embodiment and is changeable in accordance with all or some of the negative pressure, the acceleration and atmospheric pressure.

Next, the operation of the above embodiment is as follows. When the r.p.m. of the engine is constant, a current proportional to the ampere-turn A_i of FIG. 9 is established in the input-winding 17v for example, of the engine-cylinder represented by the suffix v . (In this figure t represents time.) The phase of this current is adjustable by changing the angular position of the rotating shaft 86 with respect to the cam shaft of the engine or the shaft of the distributor. When the ampere-turn A_i of the input-winding 17v becomes equal to the ampere-turn A_b of the bias-winding 19v a voltage pulse 73 occurs and turns-on the grid-controlled rectifying element 33v. Because the contacts 43v and 44 are closing during the interval shown by 72 in FIG. 9, the coil 46v is energized and the fuel injection valve 45v begins to operate. After the break of the contacts 43v and 44, fuel injection is stopped and the grid-controlled rectifying element is turned-off to be ready for the pulse of the next cycle. Thus, the injection interval is T_v' . The reduction of the resistance of the variable resistor 91 results in steepening the slope of the current in the input-winding and prolonging the injection interval. Across the input-winding 16v also the negative pulse 74 appears but it is blocked by the diode 36v. When the speed of the engine increases rapidly, the injection interval will be shorter because the frequency of the output voltage of the armature winding 88v increases and the generation of the positive pulse and the break of the contacts 43v and 44 occur earlier with the other conditions unchanged. However, as the speed of the engine increases, the field current of the a.c. generator 85 increases due to the rising output voltage of the d.c. generator 27 and the positive pulse 73 is generated earlier. Thus, by changing the resistance of the throttle-resistor 32, the injection interval can be made independent of the r.p.m. of the engine for a certain opening edge of the throttle valve 56 or to have a drooping characteristic against the speed of the engine for other value of the opening angle. The function to prolong the injection interval by the d.c. generator 27 can be effectuated through the speed-winding 18 of the pulse transformer 14 as is done in the embodiment of FIG. 1. Also, a single grid-controlled rectifying element can be used commonly for all the engine-cylinders, as is done in the embodiment of FIG. 6. Although the turned-on state of the grid-controlled rectifying element has been used in order to initiate the energization of the coil 46 in this

embodiment, it is also possible to make use of this turned-on state for the deenergization of the coil 46 and to initiate the energization by means of mechanical switches.

What we claim is:

1. A fuel injecting system for an internal combustion engine, a throttle-resistor adapted to have a variable resistance in accordance with the opening angle of a throttle valve; used together with an engine having cylinders, an intake pipe and a throttle valve, comprising: pulse transformers each of them having a saturable magnetic core of a rectangular hysteresis loop, an input-winding; a bias-winding; a speed-winding; and an output-winding; switching elements connected so as to be turned on by the output of said pulse transformers, the number of said switching elements being equal to that of the engine-cylinders; an inductor; a negative pressure-resistor adapted to have a resistance variable in accordance with the negative pressure in the intake pipe; a successively operating switching having pairs of electrodes of a number equal to that of the engine-cylinders and adapted to close or open according to the rotation of the engine, said inductor, said negative pressure-resistor and said successively operating switch all being connected in series to said input-winding; said bias winding being connected so as to be energized with direct current; a d.c. source adapted to generate a D.C. voltage variable with the r.p.m. of the engine; a throttle-resistor adapted to have a resistance variable in accordance with the opening angle of the throttle valve of the engine, said speed-winding being connected to said d.c. source through said throttle-resistor; and fuel injection valves or nozzles of a number equal to that of the engine-cylinder, the energizing circuit for the injection valves being closed by said successively operating switch in accordance with the rotation of the engine and being opened by the current flowing in said switching elements and the circuit including said switching elements being opened as the result of the deenergization of said fuel injection valves.

2. A fuel injecting system for an internal combustion engine as claimed in claim 1 in which said switching elements include an SCR.

3. A fuel injecting system as claimed in claim 1 which includes a first group of relays of a number equal to that of the engine-cylinders and second group of relays of the same number and a second successively operating switch having pairs of electrodes of a number equal to that of the engine-cylinders and adapted to close or break according to the rotation of the engine, the energizing circuit of said fuel injection valves including a corresponding pair of electrodes for said second successively operating switch; the class-B contact (closed when deenergized) corresponding to one of the first group of relays and the coil corresponding to one of the second group of the relays, and the circuit of said switching elements including a coil corresponding to one of said first group of relays; and the class-A contact (closed when energized) corresponding to one of said second group of relays.

4. A fuel injecting system for an internal combustion engine, a throttle-resistor adapted to have a variable resistance in accordance with the opening angle of a throttle valve; used together with an engine having cylinders, an intake pipe and a throttle valve, comprising: pulse transformers, each having a saturable magnetic core of a rectangular hysteresis loop; an input-winding;

a bias-winding; a speed-winding; and an output-winding, the number of said pulse transformers being equal to that of the engine-cylinders; a switching element connected so as to be turned-on by the output across the series connection of said output-windings; an inductor; a negative pressure-resistor adapted to have a resistance variable in accordance with the negative pressure in the intake pipe of the engine; a successively operating switch having pairs of electrodes of a number equal to that of the engine-cylinders and adapted to close or open according to the rotation of the engine, said inductor, said negative pressure-resistor and successively operating switch all being connected in series to said input-winding; said bias winding being connected so as to be energized with direct current; a d.c. source adapted to generate a d.c. voltage variable with the r.p.m. of the engine; a throttle-resistor adapted to have a resistance variable in accordance with the opening angle of the throttle valve of the engine, said speed-winding being connected to said d.c. source through said throttle-resistor; and fuel injection valves or nozzles of a number equal to that of the engine-cylinders, the energizing circuit for the injection valves being closed by said successively operating switch in accordance with the rotation of the engine and being opened by the current flowing in said switching element, and the circuits including said switching elements being opened as the result of the deenergization of said fuel injection valves.

5. A fuel injecting system as claims in claim 4 which includes a first common relay, a second common relay, a second successively operating switch having pairs of electrodes of a number equal to that of the engine-cylinders and adapted to close or break according to the rotation of the engine, the energizing circuit of said fuel injection valve including the class-B contact (closed when deenergized) of said first common relay and the coil of said second common relay; and the circuit of said switching element including the coil of said first common relay and the class-A contact (closed when energized) of said second relay.

6. A fuel injecting system as claimed in claim 1 which includes: a temperature-resistor adapted to have a resistance variable in accordance with the acceleration of the engine; and an atmospheric pressure-resistor adapted to have a resistance variable in accordance with the atmospheric pressure, said temperature-resistor, said acceleration-resistor and said atmospheric pressure-resistor being connected to the circuit of said input-winding.

7. A fuel injecting system as claimed in claim 1 in which said resistor has a constant resistance and said inductor is adapted to have a value variable in accordance with the negative pressure in the intake pipe, the temperature in the intake pipe, the acceleration of the engine and the atmospheric pressure.

8. A fuel injecting system for an internal combustion engine, a throttle-resistor adapted to have a variable resistance in accordance with the opening angle of a throttle valve; used together with an engine having cylinders, an intake pipe and a throttle valve, comprising: pulse transformers, each having a saturable magnetic core of a rectangular hysteresis loop, an input-winding, a bias-winding, a speed-winding and an output-winding; switching elements connected so as to be turned-on by the output of said output-winding, the number of said pulse transformers and switching elements being equal

to the number of engine-cylinders; an a.c. generator having armature windings of a number equal to that of the engine-cylinders and adapted to generate output voltages with phase differences corresponding to the timing of the fuel injections, said a.c. generator being actuated from the engine; a variable resistor adapted to have a resistance variable in accordance with at least one of: the negative pressure, the temperature in the intake pipe, the acceleration of the engine and the atmospheric pressure; the armature windings of said a.c. generator being connected to the corresponding input-windings through said variable resistor; said bias winding being connected so as to be energized with direct current; a d.c. source adapted to generate a d.c. voltage variable with the r.p.m. of the engine, a throttle-resistor adapted to have a resistance variable in accordance with the opening angle of the throttle valve of the engine; said speed-winding being connected to said d.c. source through said throttle-resistor; fuel injection valves or nozzles of a number equal to that of the engine-cylinders; the energizing circuit for the injection valve being closed by said successively operating switch in accordance with the rotation of the engine and being opened by the current flowing in said switching elements; and the circuits including said switching elements being opened as the result of the deenergization of said fuel injection valves.

9. A fuel injecting system as claimed in claim 8 which includes a first group of relays of a number equal to that of the engine-cylinders, a second group of relays of the same number; a second successively operating switch having pairs of electrodes of a number equal to that of the engine-cylinders and adapted to close or break according to the rotation of the engine, the energizing circuit of said fuel injection valve including a corresponding electrode of said second switch, a class-B contact corresponding with the first group of relays and a coil corresponding to the second group of relays; and the circuit of said switching element including a coil corresponding to said first group of relays and a class-A contact (closed when energized) corresponding to said second group of relays.

10. A fuel injection system for an internal combustion engine, a throttle-resistor adapted to have a variable resistance in accordance with the opening angle of a throttle valve; used together with an engine having cylinders, an intake pipe and a throttle valve, comprising: pulse transformers each having a saturable magnetic core of a rectangular hysteresis loop; an input-winding; a bias-winding; a speed-winding; and an output-winding; the number of said pulse transformers being equal to that of the engine-cylinders; a switching element connected so as to be turned-on by the output of the series connection of said output-winding; an a.c. generator having armature windings of a number equal to that of the engine-cylinders and adapted to generate output voltage with phase differences corresponding to the differences among the timings of the fuel injections, said a.c. generator being actuated from the engine; a variable resistor adapted to have a resistance variable in accordance with at least one of: the negative pressure, the temperature in the intake pipe, the acceleration of the engine and the atmospheric pressure; the armature winding of said a.c. generator being connected to the corresponding input-windings through said variable resistor; said bias winding being connected so as to be energized with direct current; a d.c. source

adapted to generate a d.c. voltage variable with the r.p.m. of the engine; a throttle-resistor adapted to have a resistance variable in accordance with the opening angle of the throttle valve of the engine, said speed-winding being connected to said d.c. source through said throttle-resistor; and fuel injection valves of nozzles of a number equal to that of the engine-cylinders, the energizing circuit for the injection valves being closed by said successively operating switch in accordance with the rotation of the engine and being opened by the current flowing in said switching element; and the circuits including said switching element being opened as the result of the deenergization of said fuel injection valves.

11. A fuel injecting system as claimed in claim 10, which includes a first common relay, a second common relay, a second successively operating switch having pairs of electrodes of a number equal to that of the engine-cylinders and adapted to close or break according to the rotation of the engine, the energizing circuit or said fuel injection valve including a corresponding electrode of said second successively operating switch, the energizing circuits of said fuel injection valves including the class-B (closed when deenergized) contact of said first common relay and the coil of said second common relay; and the circuit of said switching element including the coil of said first common relay and the class-A contact (closed when energized) of said second common relay.

12. A fuel injecting system for an internal combustion engine, a throttle-resistor adapted to have a variable resistance in accordance with the opening angle of a throttle valve; used together with an engine having cylinders, an intake pipe and a throttle valve, comprising: pulse transformers each of them having a saturable magnetic core of a rectangular hysteresis loop; an input-winding; a bias-winding; and an output-winding; switching elements connected so as to be turned-on by the output of said output-winding, the numbers of said pulse transformers and said switching elements being equal to the number of the engine-cylinders, an a.c. generator having armature windings of a number equal to that of the engine-cylinders and adapted to generate output voltages with phase differences corresponding to the differences among the timings of the fuel injections; said a.c. generator being actuated from the engine; a variable resistor adapted to have a resistance variable in accordance with at least one of: the negative pressure, the temperature in the intake pipe, the acceleration of the engine and the atmospheric pressure; a throttle resistor adapted to provide a variable resistance in accordance with the opening angle of the throttle valve; the armature winding of said a.c. generator being connected to the corresponding one of said input-windings through said variable resistor; said bias winding being connected so as to be energized with direct current; a d.c. source adapted to generate a d.c. voltage variable with the r.p.m. of the engine, said throttle-resistor being connected to the regulating circuit of said d.c. source, the field winding of said a.c. generator being connected to said d.c. source; and fuel injection valves or nozzles of a number equal to that of the engine-cylinders, the energizing circuits of said fuel injection valves being closed as the result of the turn-on of said switching element and opened correspondingly.

13. A fuel injecting system as claimed in claim 12, which includes a successively operating switch having

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pairs of electrodes of a number equal to that of the engine-cylinders and adapted to close or break according to the rotation of the engine, the energizing circuit of said fuel injection valve including the corresponding electrode of said successively operating switch.

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14. A fuel injecting system as described in claim 12 in which a single switching element is used commonly for all the engine-cylinders.

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