Feb. 13, 1962 SHIGENOBU SEKINE ET AL 3,020,897

IGNITION SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

Filed Nov. 15, 1960 3 Sheets-Sheet 1

Fig. 1

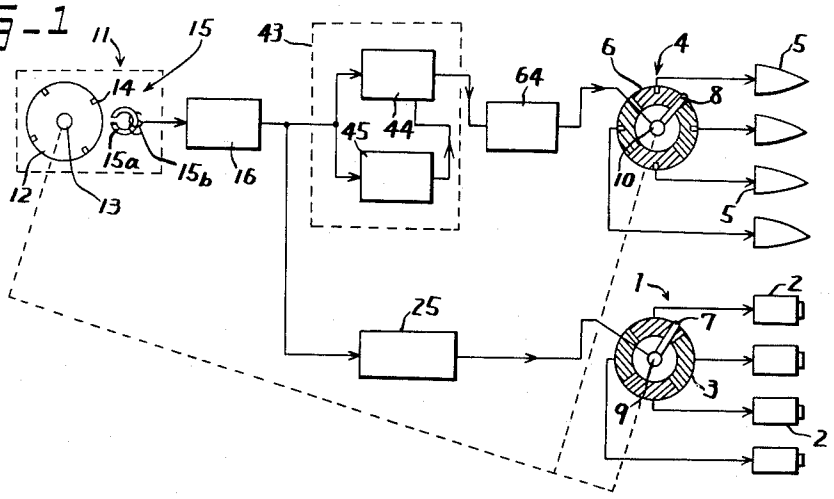


Fig. 2

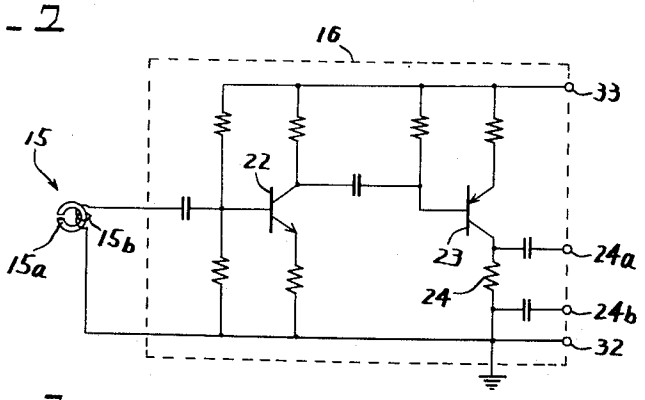
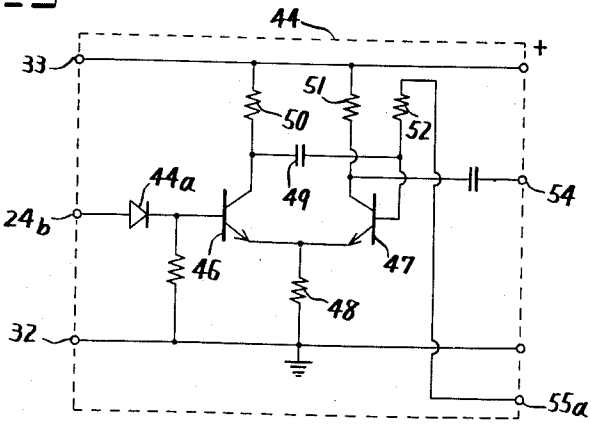


Fig. 3



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Fig - 4

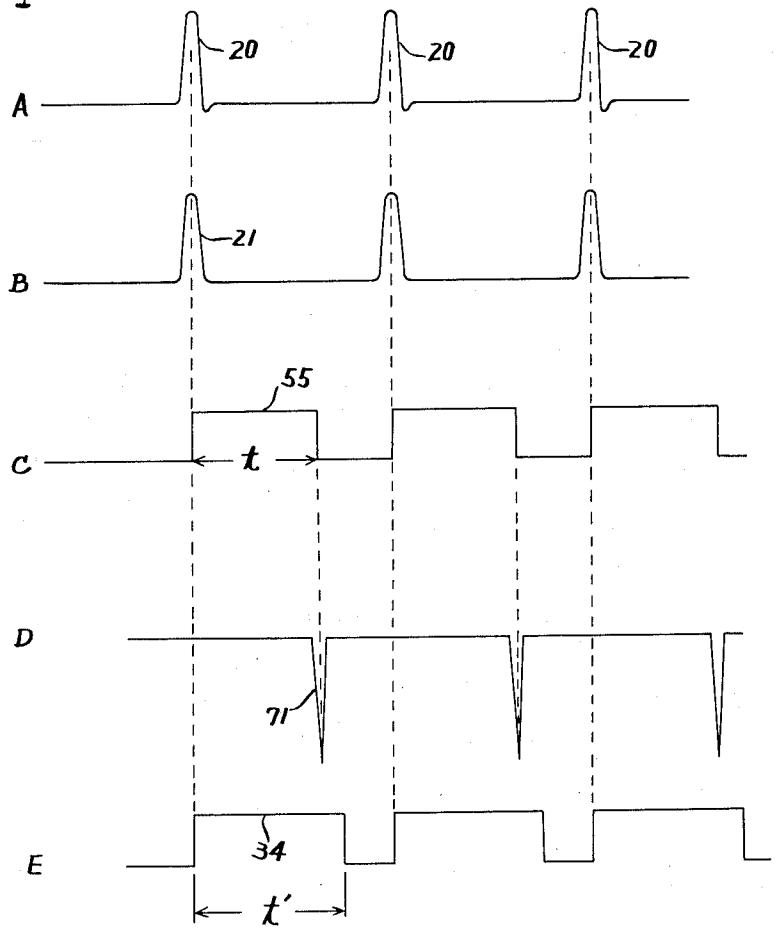
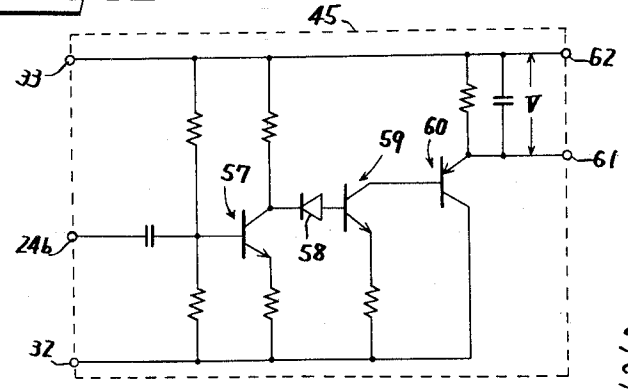


Fig - 5



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IGNITION SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

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Fig - 6

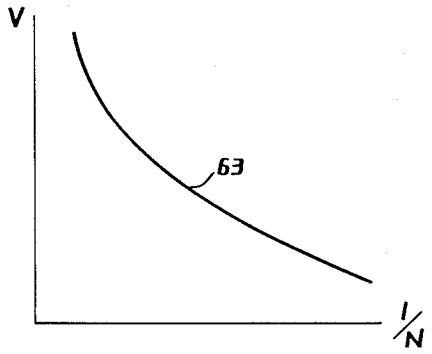


Fig - 7

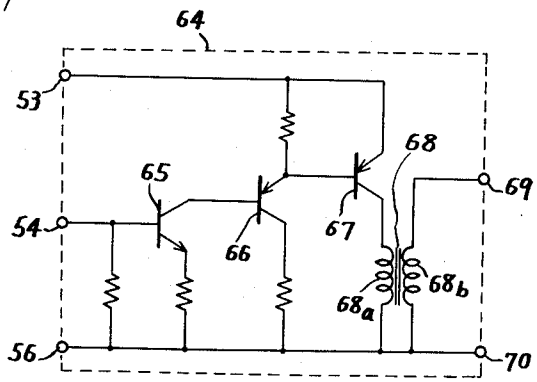
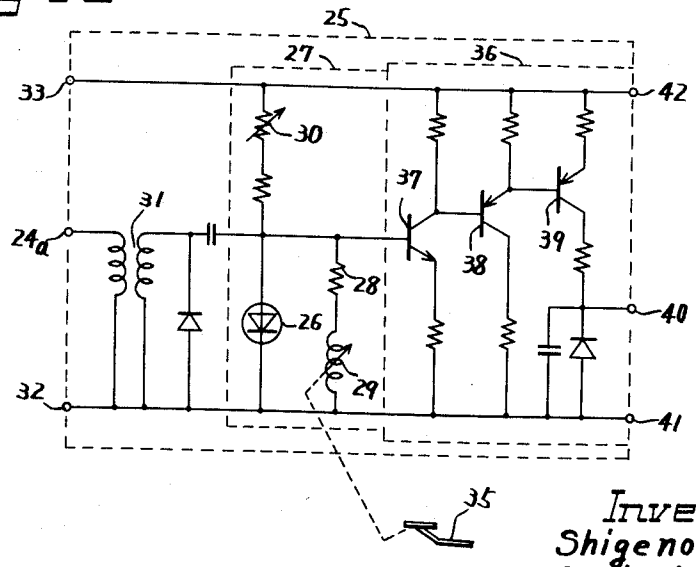


Fig - 8



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IGNITION SYTEM FOR AN INTERNAL COMBUSTION ENGINE

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Claims priority, application Japan Nov. 18, 1959
7 Claims. (Cl. 123—32)

This invention relates to ignition and fuel supply systems for internal combustion engines and, more particularly, to means for electronically controlling the ignition and fuel supply systems of such an engine.

It is an object of this invention to provide an ignition and fuel supply system for an internal combustion engine wherein pulses for controlling the system are electrically generated in synchronism with the revolution of the engine without using any mechanical contact points.

It is another object of this invention to provide an ignition and fuel supply system for an internal combustion engine wherein the detonation time and the fuel injection time are electronically controlled in response to the running condition of the engine.

It is still a further object of this invention to provide an ignition and fuel supply system for an internal combustion engine in which the detonation time and the fuel injection time are accurately controlled and can be varied in accordance with the running condition of the engine or to ambient conditions of the engine such as the surrounding temperature or the engine temperature.

It is still another object of this invention to provide a system which electronically controls the setting of the ignition spark in accordance with the load on the engine and electronically controls the amount of fuel injected in accordance with acceleration of the engine.

Further objects, features and advantages of the invention will be more apparent from the following detailed description taken in connection with the accompanying figures of the drawings in which:

FIGURE 1 is a schematic diagram of an ignition and fuel supply system for an internal combustion engine constructed in accordance with this invention;

FIGURE 2 is a schematic diagram of a pulse shaping and amplifier circuit for the system illustrated in FIGURE 1;

FIGURE 3 is a schematic diagram of a monostable multivibrator circuit for the system illustrated in FIGURE 1;

FIGURE 4 is a schedule of waveforms which illustrates the operation of this system;

FIGURE 5 is a schematic diagram of a direct-current amplifier for the system illustrated in FIGURE 1;

FIGURE 6 is a curve of the output voltage of the direct-current amplifier with respect to engine speed;

FIGURE 7 is a schematic diagram of a circuit for generating a relatively high potential; and

FIGURE 8 is a schematic diagram of a circuit for controlling the fuel supply.

With reference to the system illustrated in FIGURE 1, the numeral **1** indicates a fuel injection distributor that includes a plurality of electromagnetically controlled fuel injection bulbs **2** which are electrically connected to four stationary contact points **3**. The numeral **4** indicates generally an ignition system distributor that includes a plurality of spark plugs **5** which are electrically connected to four stationary contact points **6**. The distributors **1** and **4** have rotating contact points **7** and **8**, respectively, which are mounted on revolving shafts **9** and **10**. These two shafts are so connected, such as by mechanical means, to each other that they revolve in synchronism.

In accordance with this invention, a non-mechanical pulse generator **11** is provided which is coupled to the

shafts **9** and **10** of the distributors **1** and **4** in such a manner that pulse signals are generated in synchronism with the revolving shafts **9** and **10**. The rate at which the pulse signals are obtained from the generator **11** is determined by the speed of the engine and the pulse signals generate high potential pulses which are supplied to the spark plugs **5**.

The non-mechanical pulse generator **11** preferably includes a revolving member or disc **12** which has a plurality of equally spaced permanent magnets **14** mounted on its periphery. The same number of permanent magnets **14** as there are electromagnetic bulbs **2** or spark plugs **5** are provided. The shaft **13** on which the disc **12** is mounted is coupled to the revolving shafts **9** and **10** of the distributors **1** and **4** so that the disc **12** rotates in synchronism with the rotating contact points **8** and **7**.

A magnetic head **15** which includes a magnetic core **15***a* and a coil **15***b* is disposed adjacent the periphery of the revolving disc **12** so that the permanent magnets **14** induce voltages in the coil **15***b* as they pass the core **15***a*. Therefore, during every revolution of the disc **12** the number of pulse signals generated, which are represented by signal **20**, FIGURE 4A, is equal to the number of stationary contact points **3** and **6** on the distributors **1** and **4**.

The position of the magnetic head **15** relative to the permanent magnets **14** is arranged to correspond to the positions of the rotating points **7** and **8** relative to the stationary contact points **3** and **6**, so that one pulse signal **20** is generated by the head **15** when the rotating contact points **7** and **8** are on each one of the stationary contact points **3** and **6**, respectively. It is apparent that the synchronizing pulse signals are obtained without any mechanical contacts.

The pulse signals obtained at the output of the magnetic head **15** are preferably delivered to a pulse shaping and amplifier circuit **16** which is illustrated schematically in FIGURE 2. This circuit **16** eliminates the negative portion of the signal and amplifies it. The output signals **20** from the magnetic head **15** are connected to the input of a suitable amplifier circuit that includes two transistors **22** and **23**. Multiple output terminals **24***a* and **24***b* of the circuit **16** are connected across a collector resistor **24**. The numeral **32** indicates a common ground terminal and the numeral **33** indicates an electrical power supply line. The pulse signals **21** that appear at the output terminals **24***a* and **24***b* of the circuit **16** will hereinafter be referred to as trigger pulse signals.

The circuit following the amplifier circuit **16** is a retardation and amplifier circuit **43** which advances or retards the ignition time in accordance with variations in the engine speed. This retardation and amplifier circuit **43** includes a monostable multivibrator **44** and a direct-current amplifier **45** which are connected to receive the trigger pulse signals **21** from the amplifier **16**.

FIGURE 3 is an illustration of a well known typical monostable multivibrator circuit that can be used. It includes two transistors **46** and **47** which are connected to the output of a diode **44***a*; the emitter electrodes of the transistors **46** and **47** are grounded through a common emitter resistor **48**; the collector electrode of the transistor **46** is connected to the base electrode of the transistor **47** through a capacitor **49**; the collector electrodes of the two transistors are connected to the electrical power supply line **33** through resistors **50** and **51**; the base electrode of the transistor **46** is connected to the input terminal; the base electrode of the transistor **47** is connected to a direct-current source terminal **55***a* through a base resistor **52**; and the collector electrode of the transistor **47** is connected to an output terminal **54**.

If the values of the base resistor **52** and the capacitor **49** are properly selected and if the trigger pulse signals **21** are connected to its input, the monostable multivi-

brator 44 will be triggered "on" by each signal 21 and it will return to its "off" condition before the next pulse signal arrives. The pulse signals 55 shown in FIGURE 4C are obtained at the output terminal 54 of the monostable multivibrator. The width t of each pulse singal 55 can be varied by adjusting the value of either the base resistor 52 or the capactor 49, or both of these. Further, the width t of the signals 55 can also be varied by adjusting the direct-current voltage applied to the terminal 55*a* instead of varying the resistor 52.

In order to vary the width t of the pulse signals 55 in accordance with engine speed, the output voltage of the direct current amplifier 45 is connected to the terminal 55*a*. Any conventional direct current amplifier can be employed for purposes of this invention, but it is preferable to use a transistorized circuit of the type illustrated in FIGURE 5. This circuit includes a first stage transistor amplifier 57 which is connected across the output terminals 24*b* and 32 of the pulse shaping and amplifier 16, a diode 58 which is connected to the output of the amplifier 57 for rectifying the incoming signal, and two transistor amplifier stages 59 and 60 which are connected to the output of the diode 58 for amplifying the direct-current output of the diode 58.

In operation, the pulse signal 21 shown in FIGURE 4B, is fed to the amplifier 57, rectified into direct-current by the diode 58, and the resulting amplified direct-current voltage V, FIGURE 5, appears across the output terminal 61 and the electrical power supply line 33. It will be apparent that the direct-current voltage V appearing at the output terminal 61 increases with an increase of the frequency of the pulse signals 21. Since the frequency of the pulse signals 21 is proportioned to the number of revolutions N of the engine, the voltage V will increase as the engine speed increases as represented by the curve 63 in FIGURE 6, which is a plot of the voltage V against the reciprocal of the engine speed N.

When the terminal 61 is connected to the terminal 55*a* of the monostable multivibrator 44, the width of the pulse signal 55 appearing at the output terminal 54 will correspond to the number of revolutions N of the engine.

At the output of the monostable multivibrator 44 is connected a high potential generator 64 which is illustrated in detail in FIGURE 7. This high potential generator includes three transistors 65, 66 and 67 and a transformer 68. The pulse signal 55 from the monostable multivibrator 44 is fed to the base electrode of the transistor 65 and amplified by the three stages. The primary winding 68*a* of the high potential generating transformer 68 is connected to the collector electrode of the transistor 67 and a high potential pulse signal 71 appears across the terminals 69 and 70 of the secondary winding 68*b* of the transformer 68. It should be noted in this case that the circuit constants of the high potential generator 64 are selected so that the high voltage peak 71 is obtained at the trailing edge of the pulse signal 55. This is because the leading edge of the pulse signal 55 becomes dull to some extent during amplification. Therefore, the high potential pulse signal 71, as shown in FIGURE 4D, is easily obtained only at the trailing edge of the pulse signal 55.

The high potential signals 71 from the high potential generator 64 are fed to the rotating contact point 8, FIGURE 1, of the ignition system distributor 4 through the terminal 69.

By the described arrangement, the pulse signals 21 are generated in synchronism with the revolution of the engine without using any mechanical contact points, and the ignition or detonation time for each cylinder is determined by the signals 21. The high potential signals 71 are delayed behind the signals 21 for the time interval corresponding to the width t of the pulses 55 by the retardation and amplifier circuit 43 and are supplied to the spark plugs 5 through the distributor 4. Since the width t of the pulses 55 is proportional to the engine speed, the detonation or ignition time is varied in accordance with the number of revolutions or the load on the engine.

In general, it is desirable that the ignition time of an internal combustion engine be advanced with an increase in engine speed which requires that the delay time become longer with a decrease in the number of revolutions. In accordance with this invention the high voltage pulses 71 are supplied to the spark pulses 5 in such a manner as to attain the above requirement.

The trigger pulse signals 21 are also fed to a fuel injection quantity controlling amplifier which determines the conducting time of the electromagnetic bulbs 2. Pulse signals having a width that varies in accordance with surrounding conditions are delivered to the electromagnetic bulbs in such a manner as to control their operating time.

A fuel injection quantity controlling amplifier 25, illustrated in detail in FIGURE 8, is switched "on" or "off" by the trigger pulse signals 21 received from the pulse shaping and amplifier circuit 16. This circuit 25 generates pulse signals having pulse widths that vary in accordance with a selected variable parameter. The fuel injection quantity controlling amplifier 25 includes a monostable multivibrator circuit 27 that has a tunnel diode 26. A load resistor 28 and a variable inductor 29 are connected across the tunnel diode 26. A variable electrical potential supply resistor 30, which mainly determines the width of the output pulse signal is also connected to the diode 26.

The trigger pulse signal 21 from the pulse shaping and amplifier circuit 16 is preferably coupled to the monostable multivibrator 27 through a transformer 31. If the value of the inductor 29 or the resistor 30 is properly selected, a pulse signal 34, shown in FIGURE 4F, will be initiated by each pulse signal 21 and the multivibrator will return to its normal condition before the arrival of the next pulse signal 21. The width t' of the pulse signal 34 can be varied by adjusting either the inductor 29 or the resistor 30. The resistor 30 is preferably set in advance at a value that will provide proper circuit operation and the coil 29 is coupled to a variable parameter such as an accelerator pedal 35. It will be noted that the inductor 29 may be so constructed that its inductance can also be varied as a function of the ordinary operating conditions of the engine such as the ambient or engine temperature, etc.

It should be noted that the inductor 29 need not necessarily be mechanically coupled to the accelerator pedal 35 since any operative connection will suffice.

The output from the monostable multivibrator 27 is connected to an amplifier 36 which may include several stages, if necessary. The amplifier 36 may be of any desired type but it preferably includes three transistors 37, 38 and 39. The numerals 40 and 41 indicate output terminals, and 42 is an electrical power source terminal. The output terminal 40 of the amplifier 36 is connected to the rotating contact point 7 of the fuel injection distributor 1.

In the above described system, the trigger pulse signals 21 which are synchronized with the rotation of the contact point 7 of the distributor 1, are produced by the magnetic head 15 without using any mechanical contact points. The pulse signals 34, which are initiated by the trigger pulse signals 21, are controlled by a condition surrounding the engine and are applied to the distributor 1, thereby energizing the electromagnetic bulbs 2 in succession. The electromagnetic bulbs 2 are opened during the time corresponding to the width t' of the pulse signals 34, during which time fuel is injected into a cylinder.

As previously described, the pulse signals which determine both the ignition time and fuel injection time are synchronized with the revolution of the engine and are generated without using any mechanical contact points. The ignition time can be changed in accordance with

engine speed and the fuel injection time of the electromagnetic bulbs can be changed in accordance with ordinary operating conditions or the surrounding conditions of the engine. Thus this invention has an important advantage in that the ignition system and the fuel supply system can be effectively operated using an all electrical system that does not have any mechanical contact points.

Conventional mechanisms may be used to couple the shafts **9**, **10** and **13** to the engine in such a manner that they rotate in synchronism with the engine and with each other. For example, one shaft can be coupled to the engine similar to the usual coupling between an engine and a distributor shaft, and the other shafts connected to it by a gear train.

The stationary contact points **3** and **6**, FIGURE 1, are of course insulated from each other. The stationary contact points should be wide enough so that the fuel injection and ignition times can be advanced or retarded through a suitable range.

It will be apparent that modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

What is claimed is:

1. An ignition and fuel injection system for internal combustion engine comprising a non-contact pulse generator for generating pulse signals which are synchronized with the revolution of the engine, an electrical circuit which is connected to said non-contact pulse generator for producing pulse signals which control the ignition time in accordance with engine speed, an ignition distributor having a first movable contact and a plurality of first stationary contacts, said first movable contact being connected to the output of said electrical circuit, said first stationary contacts being adapted to be connected to a plurality of spark plugs, a fuel injection controlling circuit which is responsive to a source of pulse signals and produces pulses that vary in accordance with a condition of the engine, a fuel injection distributor having a second movable contact and a plurality of second stationary contacts, said second movable contact being connected to the output of said fuel injection controlling circuit, and said second stationary contacts being adapted to be connected to a plurality of fuel injection electromagnetic bulbs.

2. An ignition and fuel injection system for an internal combustion engine comprising a non-contact pulse generator for generating pulse signals in synchronism with the revolution of the engine, an electrical circuit which is connected to said non-contact pulse generator for producing pulse signals which control the ignition time in accordance with engine speed, an ignition system distributor that has a first movable contact and a plurality of first stationary contacts, said first movable contact being connected to the output of said electrical circuit and said first stationary contacts being adapted to be connected to a plurality of spark plugs, a fuel injection controlling circuit which is connected to the output side of said non-contact pulse generator for producing a pulse signal which varies in accordance with a condition of the engine, a fuel injection distributor that has a second movable contact and a plurality of second stationary contacts, said second movable contact being connected to the output of said fuel injection controlling circuit and said second stationary contacts being adapted to be connected to a plurality of fuel injection electromagnetic bulbs.

3. An ignition and fuel supply system for an internal combustion engine comprising a non-contact pulse generator for generating pulse signals in synchronism with the revolution of the engine, an electrical circuit which is connected to said non-contact pulse generator for producing pulse signals which control the ignition time in accordance with engine speed, an ignition plug distributor having a first movable contact and a plurality of first stationary contacts, said first movable contacts being connected to the output of said electrical circuit and said first stationary contacts being adapted to be connected to a plurality of spark plugs, a fuel injection quantity controlling circuit which is connected to the output of said non-contact pulse generator for producing a pulse signal which varies in accordance with a running condition of the engine, a fuel injection distributor having a second movable contact and a plurality of second stationary contacts, said second movable contact being connected to the output of said fuel injection quantity controlling circuit and said second stationary contacts being adapted to be connected to a plurality of spark plugs.

4. An ignition and fuel supply system for an internal combustion engine comprising a non-contact pulse generator for generating pulse signals in synchronism with the revolution of the engine, a retardation and amplifying circuit which is responsive to said pulse generator for determining the width of the pulse signals which control the ignition time, said pulse width being controlled in accordance with the number of revolutions of the engine, a high potential generator which is connected to the output terminal of said retardation and amplifying circuit which produces higher and accurate controlling pulse signals in accordance with the width of said pulse signals, an ignition plug distributor having a first movable contact and a plurality of first stationary contacts, said first movable contact being connected to the output of said high potential generator, said plurality of first stationary contacts being adapted to be connected to a plurality of spark plugs, a fuel injection quantity controlling amplifier which is connected to the output side of said non-contact pulse generator for producing pulse signal which varies in accordance with a running condition of the engine, a fuel injection distributor that has a second movable contact and a plurality of second stationary contacts, said second movable contact being connected to the output of said fuel injection quantity controlling amplifier, and said second stationary contacts being adapted to be connected to a plurality of fuel injection electromagnetic bulbs.

5. An ignition and fuel supply system for an internal combustion engine comprising a non-contact pulse generator for generating pulse signals in synchronism with the revolution of the engine, a pulse shaping and amplifying circuit which is connected to the output of said non-contact pulse generator for shaping the pulse output of said non-contact pulse generator, a retardation and amplifying circuit having a monostable multivibrator and a direct-current amplifier for adjusting the width of the pulse signals in order to control the ignition time in accordance with engine speed, a high potential pulse generator connected to the output terminal of said retardation and amplifying circuit which produces higher and accurate controlling pulse signals which vary according to the width of said pulse signal, an ignition plug distributor that has a first movable contact and a plurality of first stationary contacts, said first movable contact being connected to the output of said high potential generator and said plurality of first stationary contacts being adapted to be connected to a plurality of spark plugs, a fuel injection quantity controlling amplifier which is connected to the output of said pulse shaping and amplifier circuit for producing pulse signals the width of which is varied in accordance with a running condition of the engine, a fuel injection distributor having a second movable contact and a plurality of second stationary contacts, said second movable contacts being connected to the output circuit of said fuel injection quantity controlling amplifier, and said second stationary contacts being adapted to a plurality of fuel injection electromagnetic bulbs.

6. An ignition and fuel supply system for an internal combustion engine comprising a non-contact pulse generator having a revolving disc which is provided with a plurality of magnets which are disposed on the periphery thereof, and a magnetic head which is provided with a

magnetic core and a coil wound on said magnetic core which are disposed opposite to said magnets for generating a pulse signal in the synchronism with the revolution of the engine, a pulse shaping connected to said coil of said magnetic head of said non-contact pulse generator for shaping the pulse of said non-contact pulse generator with a proper amplitude, a retardation and amplifying circuit connected to the output of said pulse shaping circuit which has a monostable multivibrator and a direct-current amplifier and which is adapted to determine the width of the pulse signal which controls the ignition time in accordance with engine speed, a high potential generator which is connected to the output terminal of said retardation and amplifying circuit for producing higher and accurate controlling pulse signals which vary in accordance with the width of said pulse signals, an ignition plug distributor having a first movable contact and a plurality of first stationary contacts, said first movable contact being connected to the output of said high potential generator, a plurality of spark plugs which are connected to said first stationary contacts, a fuel injection quantity controlling amplifier which is connected to the output of said pulse shaping and amplifier circuit for producing a pulse signal the width of which is varied in accordance with a running condition of the engine, a fuel injection distributor having a second movable contact and a plurality of second stationary contacts, said second movable contact being connected to the output of said fuel injection quantity controlling amplifier, and a plurality of fuel injection electromagnetic bulbs connected to said second stationary contacts.

7. An ignition and fuel supply system for an internal combustion engine comprising a non-contact pulse generator having a revolving disc which is provided with a plurality of magnets disposed on its periphery and a magnetic head which is provided with a magnetic core and a coil which are disposed adjacent to said magnets for

generating pulse signals in synchronism with the revolution of the engine, a pulse shaping and amplifying circuit which has a differentiating circuit and which is connected to said coil of said magnetic head of said non-contact pulse generator for shaping the pulse of said non-contact pulse generator with a proper amplitude, a retardation and amplifying circuit connected to said pulse shaping and amplifying circuit and having a monostable multivibrator and a direct-current amplifier for determining the width of the pulse signals which control the ignition time in accordance with the number of revolutions of the engine, a high potential generator which is connected to the output of said retardation and amplifying circuit for producing higher and accurate controlling pulse signals which vary in accordance with the width of said pulse signals, an ignition plug distributor having a first movable contact and a plurality of first stationary contacts, said first movable contact being connected to the output of said high potential generator and said first stationary contacts being adapted to be connected to a plurality of spark plugs, a fuel injection quantity controlling amplifier which has a monostable multivibrator and which is connected to the output of said pulse shaping and amplifier circuit for producing a pulse signal the width of which varies in accordance with the acceleration of the engine, a fuel injection distributor having a second movable contact and a plurality of second stationary contacts, said second movable contact being connected to the output circuit of said fuel injection quantity controlling amplifier, and said second stationary contacts being adapted to be connected to a plurality of fuel injection electromagnetic bulbs.

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