United States Patent

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[33] **France**
[31] **179,459**

[54] **ELECTRONIC DISTRIBUTOR OF ELECTRIC SIGNALS CONTROLLING THE OPERATION OF INTERNAL COMBUSTION ENGINE**
16 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** ..... **123/32 EA**
[51] **Int. Cl.** **F02m 51/00, F02b 3/06**
[50] **Field of Search** ..... 123/32 AE, 32 EA, 149, 148 E

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ABSTRACT: An electronic distributor of electric signals adapted to start operation of the spark plugs or injectors of an internal combustion engine in the desired sequence and if required, for a predetermined lapse of time. This is obtained by means of a static ring counter including as many semiconductor elements as there are tracks leading to the different cylinders. The operation of the engine produces signals in accordance with the speed of rotation so as to enable a main transistor to energize the cathodes of said semiconductor elements in sequence and to operate the corresponding sparking plugs or injectors at the desired sequence. Means are provided to constrain the cycle of energization of the counter components to always start with a predetermined component.

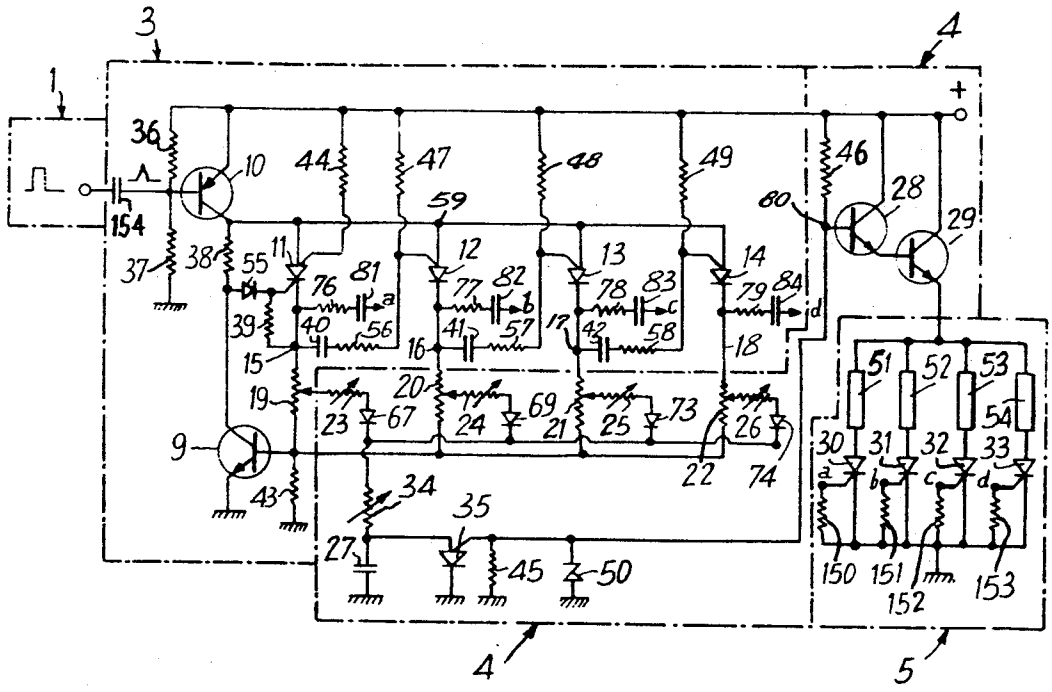

Fig. 1

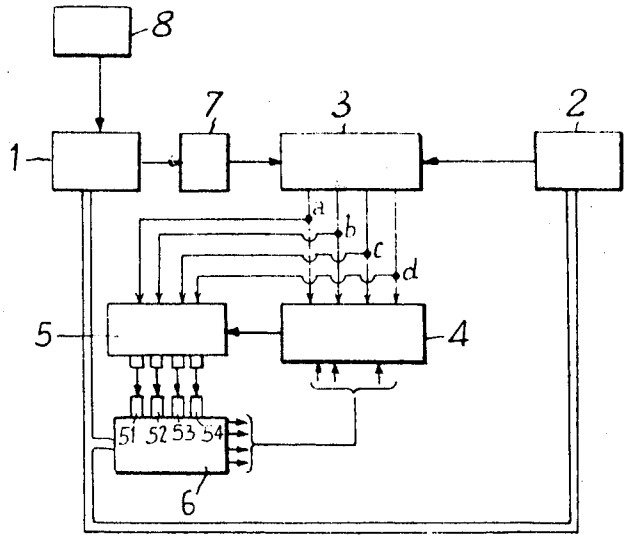

Fig. 2

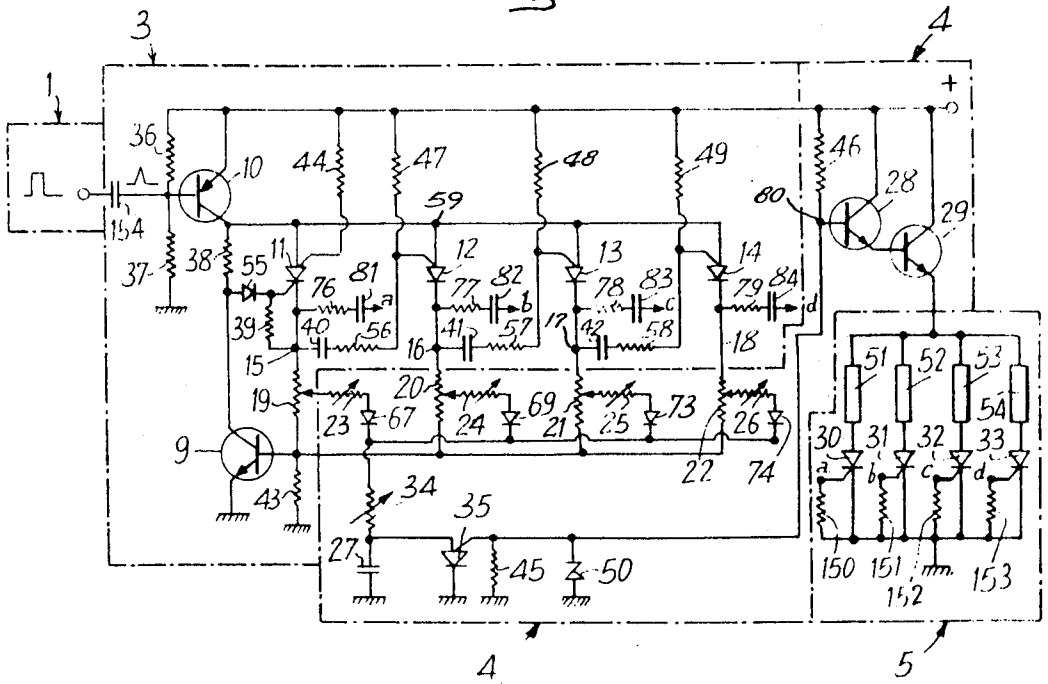

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Fig. 3

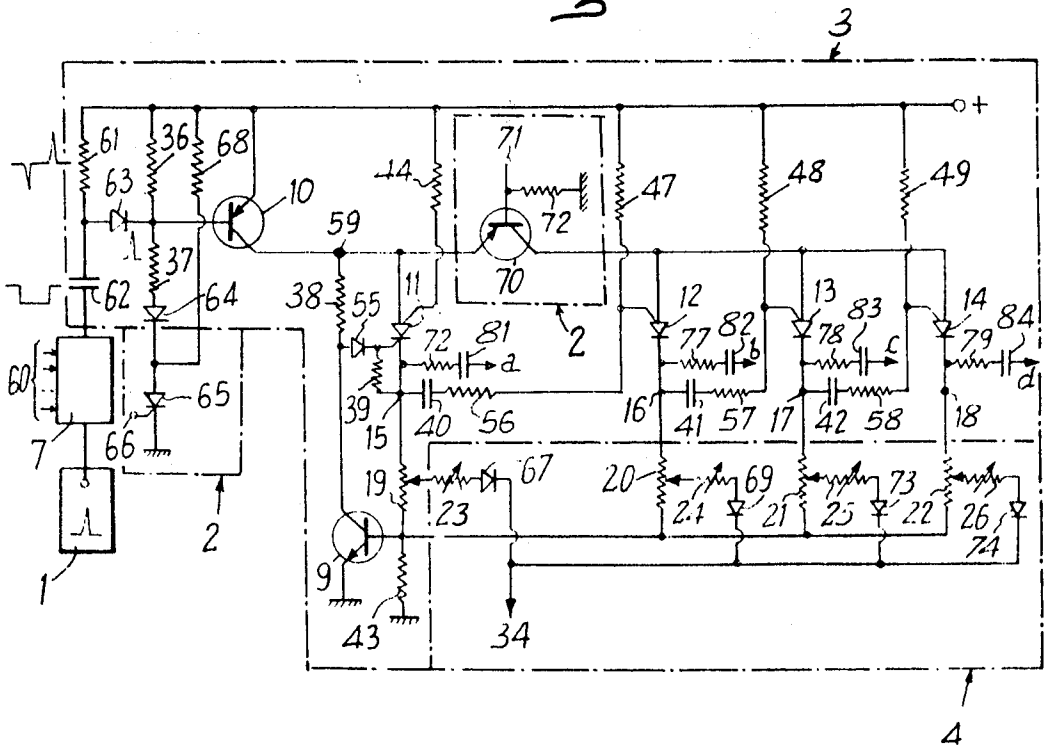
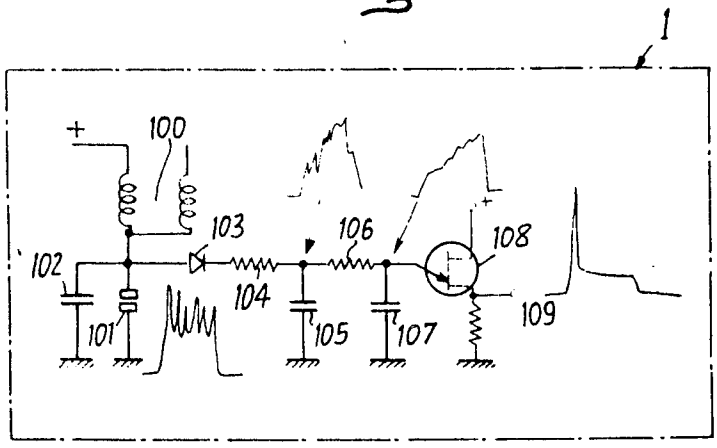


Fig. 4



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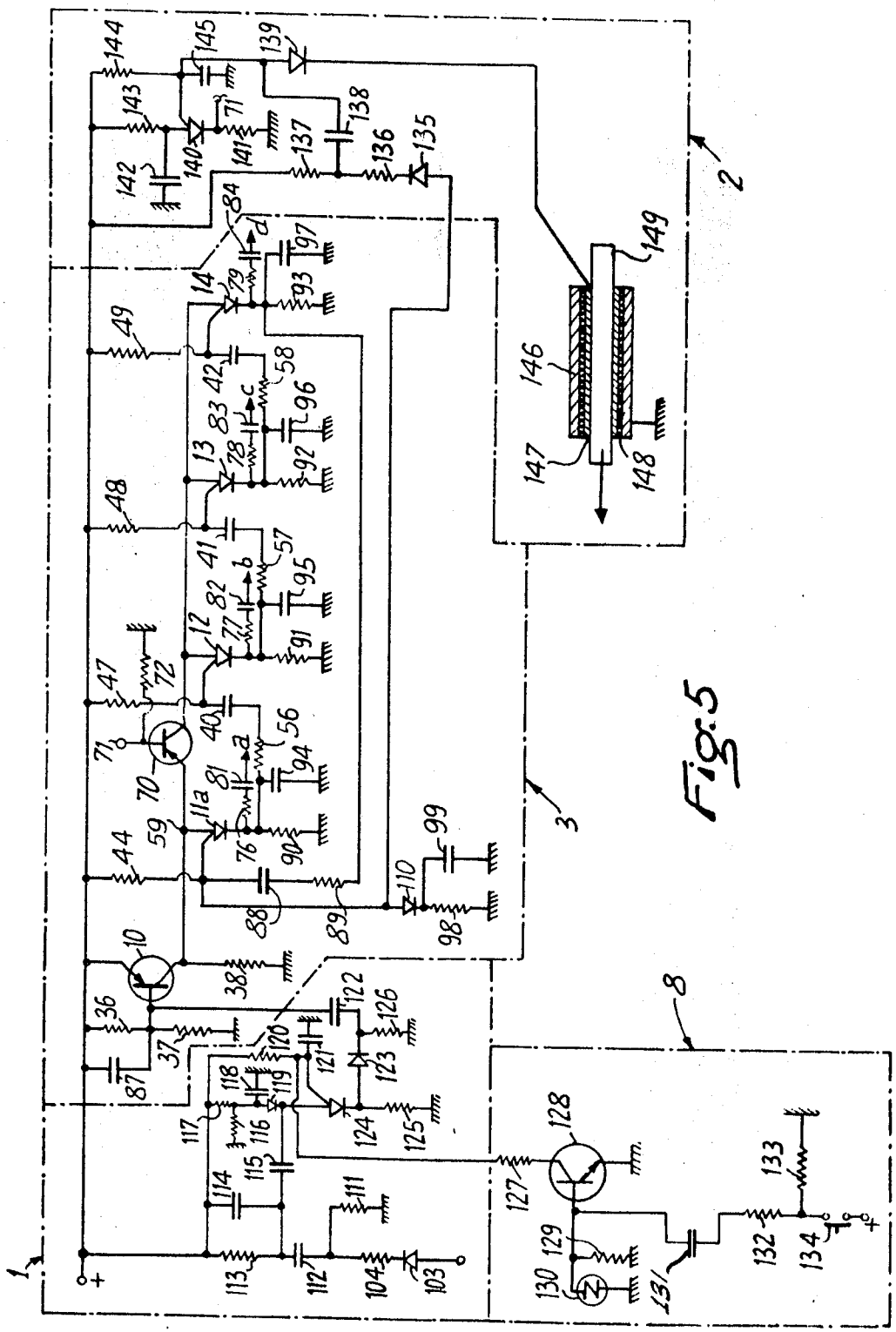

Fig. 5

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ELECTRONIC DISTRIBUTOR OF ELECTRIC SIGNALS CONTROLLING THE OPERATION OF INTERNAL COMBUSTION ENGINE

The present invention has for its object an electronic distributor of electric signals for internal combustion engines. As a matter of fact, the distribution of signals for ignition or injection under electric control requires a channeling of said signals along a plurality of tracks in a predetermined sequence whenever the engine includes more than one cylinder. In practice, it it necessary to separate the two parts to be played by the distributor, to wit on the one hand the triggering of the signal-producing means each time and at the accurate moment at which a signal is required and on the other hand the actual distribution of the signals between the different tracks in a predetermined sequence. It is therefore possible to state that a signal-distributing system should ensure both the cyclic repetition of the distribution of the signals and the channelling of the said signals towards the corresponding tracks at the accurate moment at which the signal is required on said track.

The conventional ignition means include for instance a circuit breaker actuated by the engine each time an ignition is to be obtained and the distribution towards the corresponding spark plug is ensured by a projection revolving over stationary contact-pieces connected with the corresponding spark plugs. Thus, the moment of ignition and the sequence of the distribution is defined through mechanical means.

In the case of electrically controlled injection systems, a problem arises that is a signal is sent into an arrangement defining the moments of injection each time an injection is to be executed and the signals controlling the injection are distributed towards the injectors in accordance with the predetermined sequence of operations of the latter.

In order to prevent the rotary power-feeding contact-pieces which are a cause of trouble by reason of the unavoidable wear and of the more or less uncertain contacting between floating parts, it has already been proposed to resort to distributors with rotary contact-pieces or the like pulse-generating distributors operating in the desired sequence, no longer for distributing the power current acting on the injectors or on the ignition coils but merely for distributing low intensity signals to the control electrodes of thyristors inserted between the arrangement producing the ignition or injection signals and the primary of the injection coil or the injector as the case may be.

Obviously however, such prior arrangements do not provide the advantages which may be obtained by an entirely static electronic distribution. As a matter of fact any electromechanical contacting means even when they are not subjected to any considerable load produce somewhat uncertain signals and it is necessary in all cases to standardize said signals and to give them the desired shape. Furthermore, it is a difficult matter to introduce into such arrangements a lead or a lag depending on the operative parameters of the engine such as its speed of rotation or the loads to which it is subjected. This may be summarized by stating that an entirely static arrangement provides a much greater versatility of operation while much larger possibilities are afforded for subjecting the triggering signal to any desired transformation.

The present invention has primarily for its object to provide an electronic distributor of electric signals for internal combustion engines wherein a signal-producing system associated with the rotation of the engine produces an electric signal each time an operation is to be triggered, said signal-producing system being connected with a ring counter ensuring a cyclic repetition of the operations and including as many elements as there are tracks for the distribution, each signal causing a progression by one element of the energization of the ring counter.

Further objects of the invention are as follows:

To provide a resetting system associated with the rotation of the engine which produces a resetting signal each time the distribution begins a further cycle, said signal being transmitted to a ring counter such that the ring counter is constrained to start its further distributing cycle with an energization of the first element after receiving the resetting signal, whatever the actual position of said annular counter may be with reference to each cycle.

According to a modification of the resetting system the annular counter remains locked against operation as long as the resetting signal has not been produced.

To provide a distributor adapted to control electromagnetic injectors in the desired sequence through the agency of thyristors while a further arrangement controlling a ring counter triggers said counter independently of the signal-producing system and without the engine revolving so as to produce several measured injections before the engine actually starts.

To provide means for transmitting the ignition-controlling signals including a circuit breaker controlling the injection and means for transmitting resetting signals constituted by a collector inserted in a high voltage wire feeding the spark plug.

To provide means for transmitting the injection-controlling signals and means for transmitting the resetting signals which feed pulses to the annular counter through an electronic delay arrangement which causes said delay to vary in accordance with the parameter defining the operation of the engine.

Other features of the invention will appear in the reading of the following description given by way of example only and it should be remarked that all the details although important are not essential, the scope of the invention not being limited otherwise than by the accompanying claims.

In order to further the understanding of the description, the accompanying drawings illustrate various embodiments of the invention.

FIG. 1 is a block diagram of the signal-distributing system according to the present invention.

FIG. 2 is a schematic wiring diagram of a part of an arrangement according to the invention including the means defining the duration of the control signal.

FIG. 3 is a schematic wiring diagram of a similar arrangement to FIG. 2 including lag-producing means and means for resetting and locking in position the distributing system according to the invention.

FIG. 4 is a schematic wiring diagram of means transmitting control signals and connected with the distributor.

FIG. 5 is a schematic wiring diagram of a distributing system according to a further embodiment including a counter-resetting means and means for controlling the distributor independently of the signal-producing means associated with the rotation of the engine.

Turning to the drawings, FIG. 1 shows that the internal combustion engine 6 drives a first signal generator 1 which produces a signal each time an operation is to be started such as the ignition in a cylinder or an injection of fuel. The second signal generator 2 which is also associated with the rotation of the engine 6 produces a signal each time a complete cycle of operation is at an end and it is necessary to start operation again with the first cylinder. Such signals are transmitted to the distributor 3 forming a ring counter possibly through the agency of lag-producing means 7.

The signals produced by the ring counter 3 are fed on the one hand into the system 4 defining the duration of the signals if the injection of fuel is to be controlled, said duration depending on the operative parameters of the engine which are fed into said system 4. Said signals produced by the counter are on the other hand fed into the system 5 adapted to distribute the power controlling the injectors 51, 52, 53 54, the signals transmitted by 4 being distributed the injectors in accordance with the desired sequence of injection. The system 8 controls the starting of the ring counter 3 which operates independently of the engine.

FIG. 2 illustrates a complete circuit. The transmitter counter 3 and systems 4 and 5 are shown in said figure within dot-and-dash lined enclosures. The ring counter 3 is constituted by a four-layer semiconductor 11 and three single-

junction transistors 12, 13, 14 subjected to a program, this arrangement being applied in the illustrated embodiment to a four-cylinder engine. The anodes of said semiconductor elements 11, 12, 13 and 14 are connected with the collector of a transistor 10 the emitter of which is connected with the voltage supply while its base receives the positive triggering pulse from pulse generator 1 through a connection constituted by the capacitor 154 and resistances 36, 37 which are connected so as to form a voltage divider. The connecting point 59 between the anodes of the semiconductor elements 11, 12, 13 and 14 on the one hand and the transistor 10 on the other hand is connected with the collector of a second transistor 9 through a resistance 38, the emitter of said second transistor 9 being grounded whereas its base is connected with the cathodes of the semiconductor elements 11, 12, 13 and 14 through the potentiometric voltage-dividing means 19, 20, 21, 22, said base being connected to ground resistance 43. The electrode of the four-layer semiconductor 11 is biased negatively by its connection with the supply of voltage through the resistance 44 but it plays no active part in the arrangement. In contradistinction the control electrode of said semiconductor 11 to be biased positively is connected with the collector of the transistor 9 through a diode 55 and with the cathode of said semiconductor 11 through a resistance 39 at the point designated by the reference number 15. Said point 15 is connected with the voltage supply through a capacity 40 and the resistances 56 and 47 while the electrode biasing negatively the single junction transistor 12 adapted to be controlled by a program is connected with the connecting point between the resistances 56 and 47. Similarly, the points 16 and 17 in the circuits of the single-junction transistors 12 and 13 are connected with the voltage supply through the capacitances 41 and 42 and the resistances 57–48 and 58–49, respectively, and with the negatively biasing electrodes of the corresponding single-junction transistors 13 and 14 controlled by the program through the connecting points between the resistances 57–48 and 58–49, respectively.

The system 4 adapted to define the duration of the injections is constituted by transistors 28 and 29. The emitter of transistor 28 is connected with the base of transistor 29. The system 4 further the resistance 46, the programme-controlled single-junction transistor 35, capacitance 27, variable resistances 23, 24, 25, 26 and 34. The variable resistances 23, 24, 25 and 26 are connected with the sliders of the potentiometric voltage dividing system 19, 20, 21, 22 respectively and they are also connected in parallel with the variable resistance 34 through the corresponding diodes 67, 69, 73, 74. The single-junction programme-controlled transistor 35 is connected through its anode with the connecting point between variable resistance 34 and the grounded capacity 27 while its cathode is grounded. Its negative control electrode is connected with the base of the transistor 28 through the point 80 which is also connected with the supply of voltage through the resistance 46. The negative control is connected to ground by resistance 45 and optionally included by Zener diode 50.

The power-distributing system 5 includes thyristors 30, 31, 32 and 33 which are associated respectively with injectors 51, 52, 53 and 54. The control electrodes for said thyristors 30, 31, 32, 33 are connected at *a*, *b*, *c*, and *d*, with the cathodes of the corresponding semiconductor elements 11, 12, 13 and 14 of the ring counter through capacitances 81, 82, 83 and 84 respectively and resistances 76, 77, 78 and 79 and respectively. In order to discharge said capacitances 81, 82, 83 and 84 after the passage of a pulse, resistances 150, 151, 152, 153 connected with the thyristors, are grounded.

The operation of the system is as follows:

At the moment of energization, transistor 10 becomes conductive and energizes the anodes of semiconductor elements 11, 12, 13 and 14. At the same time a positive pulse is applied to the control electrode of the four-layer semiconductor 11 through the diode 55 so that said semiconductor becomes conductive which makes transistor 9 conductive. Consequently, capacitance 27 begins to charge through potentiometric voltage divider 19, the variable resistance 23, the diode 67 and the variable resistance 34. Since at the moment of the energization of the system, the single-junction programme-controlled transistor 35 is still nonconducting, a voltage is applied to the base of the transistor 28 which becomes conductive so that transistor 29 also becomes conductive. Since the control electrode of thyristor 30 was subjected to a triggering pulse at the moment at which semiconductor 11 became conductive, the solenoid controlling the injector 51 is energized and produces an injection of fuel. Said injection lasts until the voltage across the terminals of capacitance 27 produces an energization of the single-junction programme-controlled transistor 35. When transistor 35 conducts the base of transistor 28 becomes grounded and transistor 28 is cut off. This cuts of the current feeding the injector solenoid 51. The single-junction transistor 35 remains conductive as long as the semiconductor 11 also remains conductive.

When a positive pulse is now applied to the base of transistor 10, the voltage at point 59 becomes zero, but at the same time the capacitance 40 is charged by the voltage supply and keeps transistor 9 conductive during a time which is longer than the duration of the pulse acting on transistor 10. The charging of capacitor 40 causes current to flow through resistances 47–56 and the voltage applied to the control electrode of the semiconductor 12 decays transiently, which allows it to become conductive when voltage returns to the point 59. Resistances 23 and 34 are chosen so that the current is not sufficient to maintain the conductivity of transistor 35 which therefore cuts off. This causes conductivity of transistor 28 and consequently, upon application of a pulse, semiconductor 11 has been cut off and semiconductor element 12 has been rendered conductive. The complete cycle may therefore begin over again with a charging of capacitance 27, and an injection through the injector 51 as long as said capacity 27 is not charged. At each pulse, the next semiconductor element is energized and the preceding semiconductor is cut off. It should be remarked that only the semiconductor following that which should be cut off may become conductive since only the capacitance inserted between the cathode of the semiconductor to be cut off and the control electrode of the semiconductr which is to be triggered is discharged at the moment of the cutoff. Thus, only said capacitance produces the negative pulse adapted to trigger the next semiconductor. In contradistinction, the other capacitances are charged and can therefore produce no transient signal.

In order to make the cycle begin over again when the last semiconductor 14 is cut off, there is no connection between the cathode of said semiconductor 14 and the electrode controlling semiconductor 11 and consequently transistor 9 is cut off when semiconductor 11 is cut off. Thus, when transistor 10 becomes conductive again at the end of the pulse applied to its base, a positive pulse is applied to the electrode controlling semiconductor 11 which again becomes conductive so that the cycle begins over again.

It is apparent that the ring counter forms a static distributor controlled by a signal which causes said counter to progress by one step each time a signal is thus applied to it.

However, in the wiring diagram according to FIG. 2 there is no absolute relationship between the beginning of the operative cycle of the engine and the starting of the ring counter. As a matter of fact, each time said ring counter is energized it has already been triggered once without a signal being applied to the base of the transistor 10. Furthermore, in the case of internal combustion engines the injections or the ignitions are controlled in accordance with a predetermined sequence, each injection or ignition being associated with a predetermined angular position of the engine crankshaft. Now when the engine is at rest, the position of the crankshaft is completely undefined and it is necessary to reset the distributing system at the moment of the starting of the engine.

To this end a resetting system 2 is provided which produces a signal each time the engine has finished a complete operative cycle, that is, each time all the injectors have received an

order for injection and the series of injections is to begin over again starting with the first injector.

Said resetting system **2** produces a positive signal longer in duration than the time required for charging capacitors **40, 41** and **42** and said signal is applied to the base of transistor **70** (FIG. 3) of which the emitter-collector circuit is inserted in the circuit feeding the semiconductors **12, 13,** and **14**. Consequently each time such a signal is applied to the base of transistor **70** through the point **71** which is grounded through the resistance **72**, semiconductors **12, 13** and **14** are cut of as is transistor **9**. None of these elements can be reenergized since transistor **70** remains cut off during a period of time longer than the time required for charging capacities **40, 41** and **42**. Consequently, semiconductor **11** is triggered by a positive pulse applied to its control electrode through diode **55** and the ring counter then again starts operating, starting with the first semiconductor **11**. It should be remarked that said resetting system does not prevent a number of pulses from being produced with an erroneous setting with reference to the crankshaft of the engine. This is not objectionable in the case of indirect control of an injection into the engine but in the case of the control of the ignition or of the direct control of the injection, more particularly in Diesel engines, it is essential to prevent a triggering of the ring counter before the resetting signal has actually reached it. To this end there is provided (FIG. 3) a grounded thyristor **65** connected with the resistance **37** through the diode **64**, the connecting point between the thyristor **65** and diode **64** being connected with the voltage supply through resistance **68**. Thus as long as said thyristor **65** is not conductive a positive voltage is applied through **36** to the base of transistor **10**, which maintains it in a nonconductive state. Said thyristor **65** is triggered a positive pulse applied to its control electrode at the point **66**, which pulse is produced by a signal from the resetting system, which signal is applied simultaneously through the point **71** to the transistor **70**. Thus, the ring counter remains in a nonoperative state as long as the resetting signal has not been produced.

In certain cases, it may be of advantage to provide a lead or a lag at the moment when the distributor is triggered. This can be obtained in a very simple manner with the static distributor according to the invention. It is sufficient as a matter of fact to insert between the signal transmitting system **1** and the ring counter **3** an electronic delay system **7** (FIG. 3). Said system **7** may be constituted by a monostable flip-flop for instance, which assumes its astable condition upon application of the signal produced by the signal transmitter **1** and which returns into its stable condition at the end of a predetermined lapse of time defined by the other parameters introduced into the circuit of the monostable flip-flop **7** at **60** under control of the operative conditions of the engine such as its speed of rotation, the load applied to it and the like. The rectangular signal produced by the monostable flip-flop **7** is transformed by capacitance **62** and diode **63** associated with resistance **61** into a positive peak applied to the base of transistor **10**. Consequently, there is a variable lapse of time between the moment of production of the signal by the system **1** and its application to the ring counter. This results in the possibility of obtaining a lead or a lag through an electronic control, either for ignition if the ring counter controls the primary of the ignition coils or else for injection.

With the arrangement disclosed it is also possible to utilize an ignition circuit breaker to trigger the annular counter.

As illustrated in FIG. 4, the ignition circuit breaker **101** controls directly the switching off of current in the primary of ignition coil **100**. The said primary of ignition coil **100** forms an oscillating circuit with capacitance **102** so that the signal assumes a very uncertain shape. In order to obtain a positive pulse of a well-defined shape and duration there is provided an auxiliary circuit connected with the induction coils and including in series a diode **103**, a resistance **104**, another resistance **106** and a grounded capacity **107**, a grounded capacity **105** being connected with the connecting point between the resistances **104** and **106**. The signals assume the shape shown underneath the illustration of said auxiliary circuit. The capacitance **107** is charged for a predetermined length of time in accordance with the curve also illustrated in FIG. 4. The positive terminal of said capacitor **107** is connected with the emitter of the single-junction transistor **108** and consequently the latter is triggered when the voltage across the terminals of capacitor **107** reaches a predetermined value depending on the characteristic properties of the single-junction transistor **108**. The capacitor **107** discharges then through an avalanche effect into resistance **109** and there is obtained on the base of said single-junction transistor **108** a powerful positive pulse also illustrated in FIG. 4, which pulse triggers the ring counter **3**.

The ring counter of FIG. 5 is somewhat simpler than in the preceding case since all the semiconductors in the counting circuit are constituted by programme-controlled single-junction transistors **11*a***, **12, 13** and **14** while the cathode of the transistor **14** is connected with the negative control electrode of the transistor **11*a*** in a manner similar to that of the connection between the cathodes of the transistors **11*a*12, 13** and the corresponding control electrodes of the transistors **12, 13, 14** respectively, as provided through a resistance **89** and a capacitance **88**. Similarly, all the control electrodes are connected with the supply of voltage through the resistances **44, 47, 48** and **49**. In order to be certain that the single-junction transistor **11*a*** is always the first to be triggered upon application of the first signal to the base of the transistor **10** it is sufficient to break the symmetry of the counting circuit by grounding the control electrode of the transistor **11*a*** through the diode **110** and a resistance **98**, which is in parallel with the grounded capacitance **99**. Experience has shown that with such a circuit, the cycle begins always with a triggering transistor **11*a***. It is even possible to obtain a resetting of the ring counter by applying simply a resetting signal to the control electrode of said first transistor **11*a*** of the ring counter. It is however possible for the sake of greater reliability to insert, as in the case of FIG. 3, a transistor **70** in the line feeding the anodes of the semiconductor elements **11*a*, 12, 13** and **14** beyond **11*a*** and ahead of the transistors **12, 13** and **14**. The control is then performed as described above; that is, a positive resetting signal is applied at **71** in order to cut off transistor **70**. Similarly for positively cutting off one of the programme-controlled single-junction transistors **12, 13** and **14** through the agency of transistor **11*a***, it is sufficient to provide a connection between the cathode of said transistor **11*a*** and the capacitances **40, 41,** and **42** through diodes which are not illustrated and which short circuit the resistances **56, 57** and **58** respectively.

In contradistinction with the circuits illustrated in FIGS. **2** and **3**, the cathodes of the transistors **11*a*, 12, 13** and **14** are, in FIG. **5**, grounded directly through resistances **90, 91, 92, 93** respectively in parallel with the corresponding capacitances **94, 95, 96** and **97**. But, obviously, the system **4** defining the duration of injection may be connected in the manner disclosed above.

FIG. **5** shows furthermore a modification of the resetting system **2** which is illustrated in detail and incorporates the system producing the resetting signals, while a special control is provided for the ring counter **3** independently of the rotation of the engine.

The resetting system **2** is provided with a generator of resetting signals constituted by a tubular capacitory collector fitted over the cable **149** feeding a spark plug. Said collector is constituted by an inner metal tube **147**, and insulating layer **148** and an outer metal tube **146**. The latter is grounded whereas the inner tube **147** is connected with the control electrode of the programme-controlled single-junction transistor **140** through a diode **139**. Said control electrode is connected with the voltage supply through a resistance **144** and is grounded through a capacitance **145**. The anode of the single junction transistor **140** is grounded through a capacitance **142** and is connected with the supply of voltage through a resistance **143** whereas its cathode is grounded through a re-

sistance 141. A connection is additionally provided between the electrode controlling the single-junction transistor 11*a* and the electrode controlling the transistor 140 through a diode 135, a resistance 136 and a capacitance 138, the point of connection between said resistance 136 and the capacitance 138 being additionally connected with the supply of voltage through a resistance 137. When a spark jumps across the electrodes of the ignition plug, a weak negative pulse is produced in the capacitory collector 146, 147, 148 and is transmitted to the electrode controlling the transistor 140 which is then triggered. Consequently, an intense current is caused to flow through said electrode which results in a strong negative pulse on the control electrode of the transistor 11*a* which is thus triggered in its turn. Upon triggering of said transistor 140, the capacitance 142 is discharged and this results again in a cutoff of said transistor. The positive pulse which may appear on the base of the transistor 70 at the point 71 may be tapped off the cathode of said transistor 140 and fed to said point 71.

The auxiliary system 8 controlling the ring counter is associated with the transmitter 1 producing the triggering signals. Said signal generator is connected with the ignition circuit breaker through a diode 103, a resistance 104, a capacitance 112 and resistance 113, said resistance 113 in parallel with the capacitance 114 being connected with the voltage supply. A resistance 111 grounds the connecting point between the resistance 104 and the capacitance capacity 112.

A programme-controlled single-junction transistor 124 is also provided, the anode of which is connected with the supply of voltage through a diode 119 and a resistance 117, the connecting point between said diode 119 and resistance 117 being grounded through a resistance 116 and a capacitance 118. The anode of said transistor 124 is further connected with the connecting point between the capacitance 112 and the resistance 113 through a further capacitance 115. The cathode of said transistor 124 is grounded through a resistance 125 and it is connected with the base of the transistor 10 through the diode 123 and capacitance 122 which can discharge through the grounded resistance 126. Lastly the control electrode of the transistor 124 is grounded through the capacitance 121 and is connected with the voltage supply through the resistance 120 and with the collector of the transistor 128 through the resistance 127. Said transistor 128 forms part of the auxiliary system 8 controlling the ring counter. The emitter of said transistor 128 is grounded and its base is also grounded in parallel through a resistance 129 and a thermistance 130, but said base is also connected with the voltage supply through a capacitor 131, a resistance 132 and a pushbutton 134. A resistance 133 grounds the point connecting the resistance 132 with the pushbutton 134.

In the pulse transmitter 1, the capacitor 112 is normally charged by the supply of voltage in the direction indicated. When a positive pulse passes from the circuit breaker to the diode 103, said capacitor 112 is charged to a voltage which is higher than the supply voltage and the capacitor 112 transmits its voltage to the anode of the single-junction transistor 124 through capacitance 115, which triggers said transistor 124 since its control electrode remains at a voltage equal to that of the voltage supply. The triggering of transistor 124 transmits a positive signal to the base of transistor 10 through diode 123 and capacitance 122. However, as soon as the capacitance 118 discharges into the transistor 124, the latter is cut off again until a further signal is fed to it generated by the ignition circuit breaker.

It is also possible however to trigger said transistor 124 starting from the auxiliary control system 8 by closing the circuit through the pushbutton 134. The capacitor 131 is then charged suddenly and discharges into the resistance 129 and the thermistance 130 whereby the transistor 128 is conductive during said period of time. The duration of the discharge depends on the value of the thermistance 130, which depends in its turn on the temperature of the engine, for instance. During the period of conductivity of the transistor 128 the voltage of the control electrode of the transistor 124 decays and the latter becomes conductive feeding a positive pulse to ring counter 3 which then causes an injection of fuel. Said transistor 124 remains conductive until the capacitor 118 is discharged, after which it is cut off again. This being done, capacitor 118 is charged again and transistor 124 is triggered again and so on. In other words, as long as the transistor 128 is conductive there is a sort of oscillation between triggering and cut off of programme-controlled single-junction transistor 124. At each oscillation a pulse is sent into the ring counter, which progresses each time by one step.

Consequently, the arrangement disclosed allows injections to be produced without the engine revolving. This produces a preliminary injection before the actual starting which is thus furthered.

It should be remarked that the various parts described may be associated otherwise than in the manner disclosed with reference to the accompanying drawings without widening thereby the scope of the invention as defined in the accompanying claims.

I claim:

1. In an internal combustion engine having a plurality of cylinders and electrically controlled means associated with each of said cylinders for effecting combustion therein, and wherein a pulse generator produces a plurality of pulses having a predetermined relationship to the position of the engine crankshaft, one of said pulses being produced for each combustion to be executed in one of said cylinders, improved distributing means for distributing said pulses to said means for effecting combustion in said cylinders, comprising in combination:

a. a static ring counter comprising a plurality of counter elements equal in number to the number of said cylinders, each element corresponding to one of said cylinders and adapted to be energized by one of the pulses produced by said pulse generator;

b. means for successively energizing said counter elements in said ring counter in response to successive pulses produced by said pulse generator;

c. a plurality of switching elements equal in number to the number of said cylinders, each switching element being operatively connected to a corresponding counter element of said ring counter; and

d. means for successively energizing each of said switching elements when the corresponding counter element is energized so as to actuate said means for effecting combustion associated with the cylinder corresponding to said counter element.

2. The combination set forth in claim 1 further including means for producing a resetting signal each time the cycle of energization of the ring counter components is to begin and means for causing said resetting signal to start said cycle with a predetermined counter element independently of the last element to have been previously energized.

3. The combination set forth in claim 2 wherein the combustion-effecting means comprise electromagnetically controlled fuel injectors, and wherein said switching elements comprise a plurality of thyristors equal in number to said injectors and adapted to energize the latter, and further including auxiliary means adapted to be energized independently of said pulse generator for energizing the elements of said ring counter in sequence to thereby obtain measured injections prior to starting the engine.

4. The combination set forth in claim 2 wherein said engine is of the spark ignition type and said pulse generator comprises the circuit breaker of the ignition system, said resetting signal producing means including a collector connected to the high voltage lead feeding a spark plug and adapted to produce said resetting signal.

5. The combination set forth in claim 1 further including means for producing an adjustable delay in the operation of the combustion-effecting means.

6. The combination set forth in claim 5 wherein said means for producing an adjustable delay comprises a flip-flop circuit

connected between said combustion-effecting means and said pulse generator.

7. The combination set forth in claim 1 further comprising a resetting system controlled by the angular position of the engine crankshaft and adapted to generate a resetting signal each time the cycle of energization of the ring counter elements is to begin, means for enabling said resetting signal to start said cycle beginning with a predetermined counter element independently of the last element to have been previously energized and means for preventing further operation of the counter whenever the resetting signal is not generated after energization of the last element in the cycle to be energized.

8. The combination set forth in claim 1 comprising a main transistor the base of which is adapted to receive a pulse from the pulse generator and wherein the elements of the counter are each constituted by a unijunction electrode-controlled transistor, the anodes of the unijunction transistors being connected in parallel with the emitter-collector circuit of said main transistor so as to be held at a zero voltage throughout the duration of said pulse, the cathode of each counter element being connected with the combustion-effecting means of the corresponding cylinder, a resistance grounding each of said cathodes, a further resistance and a capacitance connecting each of said cathodes with the electrode controlling the next successive counter element, a connection being provided between the cathode of the last counter element and the electrode controlling the first counter element, resistances connecting the electrode controlling the counter elements with a supply of energy and a diode and a resistance capacitance circuit in parallel grounding the electrode controlling the first said unijunction transistor.

9. The combination set forth in claim 1 wherein the first element of the counter is constituted by a four-layer semiconductor provided with two control electrodes, the other elements being constituted by unijunction transistors each having a control electrode further comprising a main transistor feeding the anodes of said elements in parallel and the base of which receives the pulses thereby to hold said anodes at zero voltage, a second main transistor, a resistance connecting the cathode of each element with the base of said second main transistor, a resistance grounding said base of said second main transistor, a resistance connecting in series the emitter-collector circuits of both said main transistors, resistances connecting a supply of energy in parallel with the electrodes controlling said unijunction transistors and the negative control electrode of said four-layer semiconductor, a resistance and a capacitance between the electrode controlling each unijunction transistor and the cathode of the preceding element, a diode and resistance connected between the positive control electrode of the four-layer semiconductor and the supply of energy, a further resistance connecting the cathode and negative control electrode of the four-layer semiconductor and resistance and capacitance connections between the cathode of each element and the combustion effecting means of the corresponding cylinder.

10. The combination set forth in claim 1 wherein said engine is provided with spark plug fed by high voltage wires, said distributing means comprising a main transistor the base of which is adapted to receive a pulse from the pulse generator and wherein the elements of the ring counter each comprise a unijunction electrode-controlled transistor the anodes of the unijunction transistors being connected in parallel with the emitter-collector circuit of said main transistor thereby to be held at zero voltage throughout the duration of said pulse, the cathodes of the unijunction transistors being connected with the combustion effecting means of the corresponding cylinders, a resistance grounding each of said cathodes, a further resistance and a capacitance connecting each of said cathodes with the electrode controlling the next counter element, a connection being provided between the cathode of the last counter element and the electrode controlling the first counter element, resistances connecting the electrodes controlling the counter elements with a supply of energy, a diode and a resistance capacitance circuit in parallel grounding the electrode controlling the first unijunction transistor counter element, a collector fitted round the wire feeding one of said spark plugs and comprising two coaxial metal tubes separated by an insulation, means grounding the outer tube and means connecting said inner tube and the electrode controlling the first counter element for energizing said first element to start each cycle of energization of said counter.

11. The combination set forth in claim 1 comprising a main transistor the base of which is adapted to receive a pulse from the pulse generator and wherein the elements of the counter are semiconductors, the anodes of said semiconductors being connected in parallel with the emitter-collector circuit of said main transistor so as to be held thereby at a zero voltage throughout the duration of said pulse, the cathode of each said element being connected with the combustion-effecting means associated with the corresponding cylinder, a resistance grounding each of said cathodes, a further resistance and a capacitance connecting each of said cathodes with the electrode controlling the next successive counter element, a connection being provided between the cathode of the last counter element and the electrode controlling the first counter element, resistances connecting the electrodes controlling the counter elements with a supply of energy, a resetting system controlled by the operation of the engine and adapted to start the cycle of energization of the counter elements and including a further transistor connected between the anode of the first counter element and the anodes of the other counter elements.

12. The combination set forth in claim 1 comprising a main transistor the base of which is adapted to receive a pulse from the pulse generator and wherein the elements of the counter each comprise a semiconductor the anodes of the semiconductors being connected in parallel with the emitter-collector circuit of the main transistor so as to be held thereby at a zero voltage throughout the duration of said pulse, the cathode of each element being connected with the combustion-effecting means of the corresponding cylinder, a resistance grounding each of said cathodes, a further resistance and a capacitance connecting each of said cathodes with the electrode controlling the next counter element, a connection being provided between the cathode of the last counter element and the electrode controlling the first counter element, resistances connecting the electrodes controlling said counter elements with a supply of energy, a resetting system controlled by the operation of the engine and adapted to produce a resetting signal each time the cycle of energization of the counter elements is to begin and means for enabling said resetting signal to start said cycle including a semiconductive element connected with the base of said main transistor so as to keep said main transistor nonconducting until the setting signal is received.

13. The combination set forth in claim 1 comprising a main transistor the base of which is adapted to receive a pulse from said pulse generator and wherein the elements of the ring counter each comprise a semiconductor, the anodes of the semiconductor elements being connected in parallel with the emitter-collector circuit of the main transistor so as to be held thereby at zero voltage throughout the duration of said pulse the cathodes of said elements being connected with the combustion-effecting means of the corresponding cylinder, a resistance grounding each of said cathodes, a further resistance and a capacitance connecting each of said cathodes with the electrode controlling the next counter element, a connection being provided between the cathode of the last counter element and the electrode controlling the first counter element, resistances connecting the electrodes controlling the counter elements with a voltage supply and an auxiliary oscillatory circuit adapted to control the counter independently of the pulse generator, including a unijunction transistor and a capacitance, a resistance connected between the supply of energy and said capacitance for charging said capacitance,

means for applying to the electrode controlling said unijunction transistor a voltage lower than the voltage charging said last-mentioned capacitance to discharge said capacitance and means feeding the pulses produced by said discharge to the base of the main transistor to start operation of the counter.

14. The combination set forth in claim 1 comprising a main transistor the base of which is adapted to receive a pulse from the pulse generator and wherein the elements of the counter are each constituted by a semiconductor the anodes of the semiconductor elements being connected in parallel with the emitter-collector circuit of the main transistor so as to be held thereby at zero voltage throughout the duration of said pulse, the cathode of each counter element being connected with the combustion-effecting means of the corresponding cylinder, a resistance grounding each of said cathodes, a further resistance and a capacitance connecting each of said cathodes with the electrode controlling the next successive element, a connection being provided between the cathode of the last counter element and the electrode controlling the first counter element, resistances connecting the electrodes controlling the counter elements with a voltage supply, an auxiliary oscillatory circuit adapted to control the counter independently of the pulse generator including a unijunction transistor and a capacitance, a resistance connected between the voltage supply and the capacitance for charging said capacitance, a resistance connecting the voltage supply to the electrode controlling said unijunction transistor, a further auxiliary transistor the collector of which is connected with said unijunction transistor, means grounding the emitter of said auxiliary transistor and a switch through which the base of said auxiliary transistor is connected with the voltage supply, a resistance and a thermistance grounding in parallel the base of said auxiliary transistor to keep the oscillatory circuit energized as long as said auxiliary transistor remains conductive whereby the electrode controlling said unijunction transistor is fed a voltage lower than the voltage charging said last-mentioned capacitance so that said capacitance discharge periodically into the base of the main transistor to start operation of the counter.

15. The combination set forth in claim 1 wherein said engine is of the spark ignition type with spark plugs fed through a circuit breaker, comprising a main transistor the base of which is adapted to receive a pulse from the pulse generator and wherein the elements of the counter each comprise a semiconductor the anodes of said semiconductor elements being connected with the emitter-collector circuit of the main transistor to be thereby held at zero voltage throughout the duration of said pulse and the cathode of each element being connected with the combustion-effecting means of the corresponding cylinder, a resistance grounding each of said cathodes, a further resistance and a capacitance connecting each of said cathodes with the electrode controlling the next successive counter element, a connection being provided between the cathode of the last counter element and the electrode controlling the first counter element, resistances connecting the electrodes controlling the counter elements with a voltage supply, an auxiliary oscillatory circuit adapted to control the counter independently of the pulse generator including a unijunction transistor and a capacitance, a resistance connected between the voltage supply and the capacitance for charging said capacitance a connection between the circuit breaker and the unijunction transistor to feed the electrode controlling said unijunction transistor with a voltage lower than the voltage charging said last-mentioned capacitance to discharge the latter and means feeding the pulses produced by said discharge to the base of the main transistor to start operation of the counter.

16. The combination set forth in claim 1 wherein said engine is of the fuel injection type further comprising a timing circuit including two transistors the emitter of one of which is connected with the base of the other transistor, a resistance connecting the base of the said one transistor with a voltage supply, a further resistance grounding said base of the said one transistor, a connection through which the emitter of the said other transistor controls the fuel injectors, an auxiliary unijunction transistor the control electrode of which is connected with said base of the said one transistor and the cathode of which is grounded, a capacitance one terminal of which is grounded and the other is connected with the anode of said auxiliary unijunction transistor, an adjustable potentiometric voltage divider connected between said anode of said auxiliary unijunction transistor and the semiconductor elements of the counter, said last-mentioned unijunction transistor periodically triggering the timing circuit and consequently the operation of the injectors during the time required for the charging of said last-mentioned capacitance in accordance with the setting of said potentiometric voltage divider.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,612,011 Dated October 12, 1971

Inventor(s) Louis A. Monpetit

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the Abstract page, line 4, "lapse" should be -- period --.

Column 1, line 20, after "of" and before "said" delete -- the --.

Column 2, line 25, "parameter" should be -- parameters --.

line 69, after "the" and before "injectors" insert -- to --.

line 73, after "transmitter" insert -- 1, --.

Column 3, line 18, after "ground" and before "resistance" insert -- through --.

line 43, after "further" and before "the" insert -- includes --.

line 56, after "control" and before "is" insert -- electrode --.

line 64, after "79" and before "respectively" delete -- and --.

Column 4, line 15, "of" should be -- off --.

line 42, "conductr" should be -- conductor --.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,612,011 Dated October 12, 1971

Inventor(s) Louis A. Monpetit

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 5,

line 10, "of" should be -- off --.

line 13, "capacities" should be -- capacitances --.

line 32, after "triggered" and before "a" insert -- by --.

Column 6, line 32, after "triggering" and on line 33 before "transistor" insert -- of --.

Column 7, line 26, after "capacitance" delete -- capacity --.

Column 10, line 54, "setting" should be -- resetting --.

Column 11, line 37, "discharge" should be -- discharges --.

Signed and sealed this 16th day of May 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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