

Feb. 25, 1969

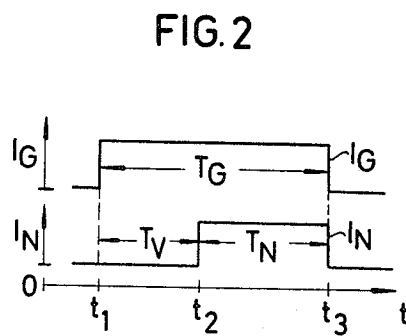
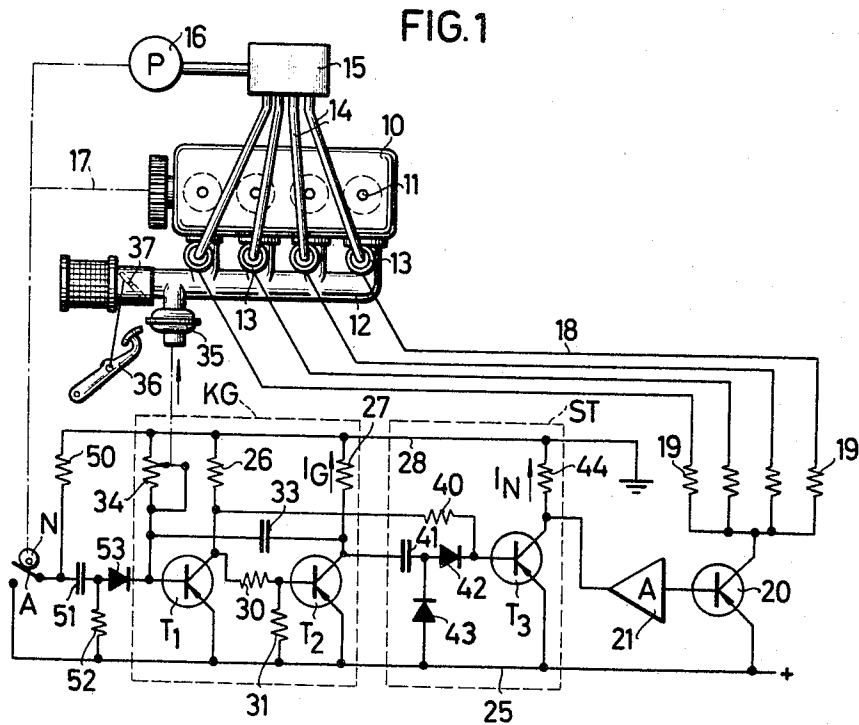
H. SCHOLL

3,429,302

ARRANGEMENT FOR CONTROLLING THE INJECTION OF FUEL IN ENGINES

Filed Aug. 21, 1967

Sheet 1 of 2



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3,429,302

ARRANGEMENT FOR CONTROLLING THE INJECTION OF FUEL IN ENGINES

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Sheet 2 of 2

FIG. 3

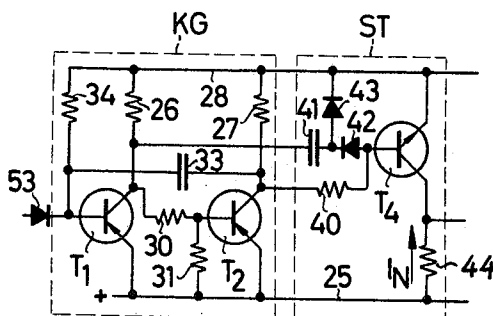


FIG. 4

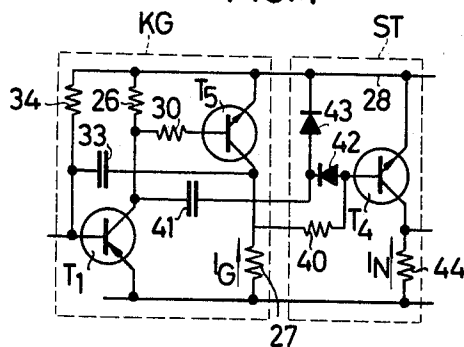
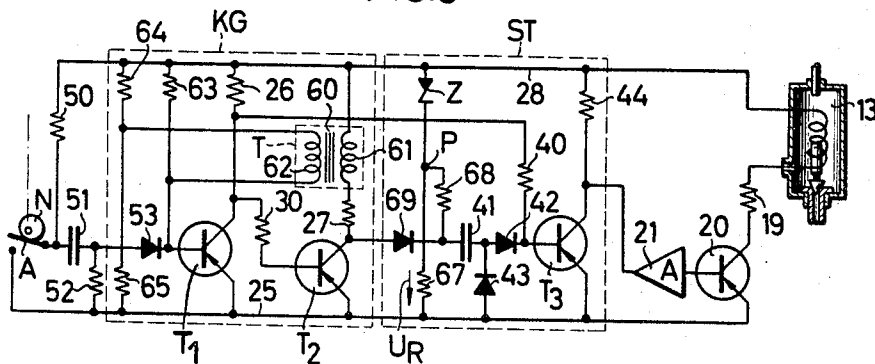


FIG. 5



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ARRANGEMENT FOR CONTROLLING THE INJECTION OF FUEL IN ENGINES

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11 Claims

ABSTRACT OF THE DISCLOSURE

An arrangement for controlling the injection of fuel in internal combustion engines. Electrical pulses of variable duration are generated and transmitted to the electromagnetic valves regulating the amount of fuel injected. The variable duration of the pulses is provided by a monostable multivibrator circuit which is operated by a switch periodically actuated by the engine crankshaft. The output of the monostable multivibrator circuit is applied to a delay circuit. When the monostable multivibrator circuit is actuated by the switch driven by the crankshaft of the engine, the delay circuit is also actuated. As a result, the output of the delay circuit provides a pulse which begins a fixed interval after the beginning of the pulse from the monostable multivibrator circuit. The end of the pulse from the delay circuit, however, coincides with the end of the pulse from the monostable multivibrator circuit. The output of the delay circuit thus provides control pulses to the fuel injection valves so that these are retained open for a predetermined amount of time, depending upon the functional parameters of the engine.

Background of the invention

In the commonly known arrangements to which the present invention pertains, the electromagnetically actuated injection valves receive current from a power transistor operated through the rotational action of the crankshaft in the internal combustion engine. Associated electronic circuit provides rectangular-shaped pulses, for controlling purposes, whereby the duration of the pulses determines the duration of the open period of the injection valves. As a result the amount of fuel injected during every injection cycle is determined. This condition is dependent upon that the fuel lines leading to the injection valves are always substantially under constant pressure. In order to adapt the amount of fuel injected to the various operating requirements of the internal combustion engine, it is essential to apply to the power transistor control pulses having a duration that may vary between, for example, 2 to 6 msecs. Since the pulse duration is determined by the time constant of the unstable state of a monostable multivibrator circuit, any variation or adjustment in the intercoupling branch which determines the time constant of the unstable state, results necessarily in a variation in the feedback conditions. Accordingly, the required region of adjustment or variation may be attained only with considerable difficulties. At the same time voltage variations resulting from the charged state of the batteries in the motor vehicle must also be taken into account. These batteries are used as the power supply for the control arrangement that acts upon the valves.

These difficulties are particularly encountered when the required variation in the pulse duration and in the amount of fuel to be injected are a function of the characteristics of the design and construction of the engine. Some of the parameters which tend to complicate the situation are, for example, the rotational speed, the pressure in the

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intake manifold, the barometric air pressure, the temperature of the cooling water, etc. A number of solutions have become known for this purpose of varying the injection duration. However, all of these known solutions, heretofore, exhibit difficulty when applied to the required short opening durations under approximately 4 msecs. This applies especially with regard to unburned gases in the exhaust when it is desired to regulate the fuel under partial load conditions in order to conserve the fuel without causing too severe drop in the fuel/air ratio.

These problems are solved by the electronic arrangement, of the present invention, by providing a delay stage coupled to the monostable multivibrator circuit. When the latter is actuated the delay stage is also actuated for beginning a delay period. A pulse at the output of the delay stage is not realized until the expiration of the delay inserted in the delay stage. The output pulse of the delay stage, however, ends coincident with the end of the pulse emitted by the monostable multivibrator circuit.

In accordance with the basic concepts of the invention, it is possible to realize rectangular-shaped pulses from the monostable multivibrator circuit, which may be varied through simpler means than that used by the conventional arrangements, hereinbefore. This is because constant duration pulses may be taken from the monostable multivibrator, as a result of the delay time applied by the delay stage. Thus, the pulses applied to the power transistors for controlling the opening of the injection valves, have a duration which is the difference between the pulse duration of the monostable multivibrator circuit and the delay time applied by the delay stage. As a result, the components within the intercoupling branch of the monostable multivibrator circuit become the subject of considerable decrease in variation.

The electronic pulse technology offers many arrangements for providing constant delay times. However when using such arrangements it is necessary to logically interconnect the output of the variable pulse with the output of the delay so as to result in a pulse applied to the power transistor, representing the difference between the two logically interconnected pulses. Such electric logical interconnection may be simply realized when in accordance with one embodiment of the present invention, the delay stage for providing a constant delay time is constructed of a single transistor whose base is coupled to the collector of one of the two transistors in a monostable multivibrator circuit, by way of a coupling resistor. A coupling capacitor connects the base of this transistor to the other collector of the two transistors in the monostable multivibrator circuit.

In this arrangement the transistor in the delay stage is cut off in the quiescent state. As a result its current amplification has no substantial influence on the delay time. In order to assure that the transistor in the delay stage provides a pulse that terminates at the same time as the pulse from the monostable multivibrator circuit, without any additional delay, a diode is provided in another embodiment of the present invention. This diode is connected in parallel with the emitter-base path of the transistor in the delay stage. The diode is connected so that it conducts in the same direction as the emitter-base path. One of the electrodes of the diode is directly connected to the base of the transistor in the delay stage. The coupling capacitor is, furthermore, connected to the junction point of the diode with another possible element that may be connected in series with the diode. The coupling resistor is, moreover, directly connected also to the base of the transistor in the delay stage. This other circuit element in series with the diode can be another diode whose conducting direction is the same as the first diode.

In the practical application of intake manifolds in motor vehicles, it has been found that the injection valves attain their opening positions with a delay whose magnitude increases with decrease in the voltage of the power supply generally in the form of the battery in the motor vehicle. Accordingly, in another embodiment of the present invention, compensation means is provided in the delay state so as to compensate against such drop in the voltage of the battery. This is simply achieved by inserting an additional diode in the connecting path from the collector of one of the transistors in the monostable multivibrator circuit to the coupling capacitor. The diode is directed so that when the transistor in the monostable multivibrator circuit is in the cut off state, it does not conduct. A voltage divider is, furthermore, provided which contains an element which is not voltage dependent. The voltage divider also contains, together with the emitter of the transistor in the monostable multivibrator circuit a voltage dependent circuit element, which in particular is a Zener diode. Furthermore, a resistor is provided between the junction of the voltage divider and the junction of the additional diode and the coupling capacitor.

Summary of the invention

An arrangement for controlling the injection of fuel in internal combustion engines: A monostable multivibrator circuit provides rectangular-shaped pulses of variable duration. The monostable multivibrator circuit is actuated or switched to its unstable state by means of a switch which is periodically operated by a cam driven by the crankshaft of the engine. The monostable multivibrator circuit includes a variable resistor for providing the variable duration of pulses used to control the fuel injection valves of the engine. The variable resistor is regulated by being coupled to a pressure-sensitive member in the intake manifold of the engine. The output of the monostable multivibrator circuit is applied to a delay circuit. The latter accepts the pulses from the monostable multivibrator circuit and, in turn, provides pulses which begin a fixed time interval from the beginning of the pulses transmitted by the monostable multivibrator circuit. The end of the pulses provided by the delay circuit coincides with the end of the pulses transmitted by the monostable multivibrator circuit. Thus, the delay circuit provides a pulse for each variable duration pulse emitted by the monostable multivibrator circuit, which has a duration that is a predetermined fraction of the duration of the pulses from the monostable multivibrator circuit. The output of the delay circuit is suitably amplified and applied directly to the electromagnetic valves controlling the amount of injected fuel.

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

Brief description of the drawing

FIG. 1 is an electrical schematic diagram of the control arrangement for providing pulses of predetermined duration to the electromagnetic valves regulating the amount of fuel injection in internal combustion engines shown in functional block form;

FIG. 2 is a graphical representation of the timing of the pulses generated by the control arrangement, in accordance with the present invention;

FIG. 3 shows another embodiment of the control arrangement of FIG. 1;

FIG. 4 is an electrical schematic diagram of a further embodiment of the control arrangement of FIG. 1;

FIG. 5 is an electrical schematic diagram of an embodiment, in accordance with the present invention, in-

cluding provision for compensating the controlling pulses applied to the fuel injection valves, against a drop in voltage of the battery supply associated with the engine.

Description of the preferred embodiments

The fuel injection arrangement in accordance with FIG. 1, is adapted to a four-cylinder engine 10. The spark plugs 11 of the engine are connected to a high voltage ignition supply (not shown). In the immediate vicinity of the intake valves (not shown), is an injection valve 13. The latter is mounted in the intake manifold 12 having branches to the individual cylinders. The injection valve 13 is electromagnetically actuated. Each of the injection valves communicates with a fuel line 14 leading to a fuel distributor 15. The fuel within the distributor 15 and the lines 14, is maintained at a substantially constant pressure of approximately 2 atm. This fuel pressure is maintained through the action of a pump 16 connected to and driven by the crankshaft 17 of the engine.

Each of the injection valves 13 is provided with an electromagnetic coil (not shown) which is connected, at one end, to ground. The other end of these coils is connected individually to a resistor 19 by way of the conducting path 18. The four resistors 19 are connected together, at one end, to the collector of a power transistor 20. The base of the transistor 20 is connected to a transistorized amplifier 21 which receives a rectangular-shaped control pulse with every revolution of the crankshaft 17. During this period of the pulse signal, one of the injection valves 13 receives current for opening the valve. The injected quantity into the cylinder from the manifold is thus proportional to the duration of the valve opening.

The regulating and control circuitry associated with the arrangements, in accordance with the present invention, comprises essentially two circuits: one of these is a monostable multivibrator circuit KG which provides a rectangular pulse I_G having a duration T_G which is variable and adapted to the requirements of the engine; the second circuit ST is connected to the monostable multivibrator circuit KG and provides a pulse I_N which begins at the instant t_2 delayed by the period T_V from the beginning of the pulse I_G , but ends at the same instant as the pulse I_G . The instant at which both pulses I_G and I_N ends, is denoted by t_3 . The pulse I_N provides for the opening of the magnetic valve during the interval from t_2 to t_3 . The duration of the pulse I_N is the difference between the duration T_G of the pulse I_G , and the delay period T_V .

The monostable multivibrator circuit KG includes, in particular, as shown in FIG. 1, a first transistor T_1 and a second transistor T_2 both of the p-n-p type. The emitters of these two transistors are connected, by way of the connecting path 25, to the positive terminal of a power source which may be in the form of a battery having a nominal voltage of 12 or 6 volts. The collectors of both of the transistors lead through the two resistors 26 and 27 to the opposite terminal of the battery which may be either of negative polarity or ground potential. This negative polarity terminal of the battery is designated by the conducting path 28.

In order to assure that the transistor T_2 is maintained nonconducting during the stable state of the monostable multivibrator KG, the base of the transistor T_2 is connected to the collector of transistor T_1 , via the resistor 30, and, at the same time to the positive terminal or conducting path 25, by way of resistor 31. A feedback capacitor 33 is connected between the base of transistor T_1 and the collector of transistor T_2 . The base of the transistor T_1 and junction with the capacitor 33 is also connected, by way of a variable resistor 34 to the minus terminal of conducting path 28. The capacitor 33 in conjunction with the variable resistor 34 forms the coupling network between the two transistors. The time constant of this coupling network corresponds to the unstable state

of the monostable multivibrator KG and therefore to the duration T_G of the pulse I_G .

In the conventional electronic control arrangement, for injection purposes, the pulse derived from the output of the second transistor collector is transmitted directly for controlling the power transistor 20. In such conventional arrangements, one or more such amplifiers 21 may be connected into the circuit for the purpose of amplifying properly the impulses. The duration of the control pulse, in such conventional or known electronic arrangements, must be of the order of 2 to 6 msec. Thus, the duration of the pulse must be made variable by a ratio of 3:1. For purposes of varying the duration of the pulse from the multivibrator circuit KG, a movable membrane 35 is provided in conjunction with the intake manifold 12 of the engine. The member 35 is located behind the throttle 37 positioned by the gas pedal 36. The movable membrane 35 adjusts the variable resistor 34 so that the ohmic resistance of the variable resistor 34 is made smaller with decrease in the absolute pressure within the manifold. With the decrease in the magnitude of the resistance of the variable resistor 34, the time constant of the coupling network including capacitor 33, is also made smaller. As a result, the pulse duration T_G is similarly made smaller.

In order to avoid the requirement that the pulse duration T_G be made variable in the ratio of 1:3 similar to the period that the magnetic valves are open, as for example 2-6 msec., the circuit ST is provided. This circuit ST applies a delay so that a pulse I_N is realized which has a pulse duration T_N corresponding to the opening period of the valves. With regard to the preceding numerical values, the delay period T_V is of the order of 2 msec. In accordance with the present invention, it is possible that the shortest duration of this pulse be of the order of 4 msec. instead of 2 msec. or I_G and during the greatest amount of fuel consumption requirement, this pulse may have a duration of 8 msec. As a result, it may be seen that under these conditions the pulse I_G must be made variable in the ratio of 1:2, through adjustment of the variable resistor 34.

In particular, the circuit ST has a single transistor T_3 which is also of the p-n-p type similar to the transistors in the monostable multivibrator KG. The emitter of the transistor T_3 is connected to the positive terminal of the power supply. This corresponds to the conducting path 25. The base of the transistor T_3 is coupled to the collector of the transistor T_1 by means of the resistor 40, in order that the transistor T_3 does not conduct when the monostable multivibrator circuit is in the stable state. In this stable or inoperative state of the monostable multivibrator circuit, the transistor T_1 is in the conducting state. The base of the transistor T_3 is also connected to the collector of transistor T_2 by way of the coupling capacitor 41. In the stable or inoperative state of the monostable multivibrator circuit, the transistor T_2 is nonconducting or cut off. A diode 42 is also connected between the base of the transistor T_3 and the coupling capacitor 41. The connection is thus that the cathode of the diode 42 is connected to the junction of the resistor 40 and the base of the transistor T_3 . The anode of the diode 42 is connected to the coupling capacitor 41, and furthermore to the cathode of another diode 43. The anode of this diode 43 is joined to the positive terminal 25 of the power supply. A resistor 44 is connected between the collector of transistor T_3 and the negative terminal 28 of the power supply. Current flows through this resistor 44 during the duration T_N of the pulse I_N .

In operation, the switch A at the input of the monostable multivibrator circuit is actuated by a cam N driven by the crankshaft 17 of the engine. If the switch A is closed at instant t_1 , then, upon reopening of the switch, a voltage rise will appear across the resistors 50 and 52 which, when transmitted via diode 53 to the base of transistor T_1 , forces the latter to be cut off. When the transistor T_1 becomes nonconducting in this manner, the tran-

sistor T_2 is made to conduct simultaneously. Since the feedback capacitor 33 had been charged positive through its connection with the base of transistor T_1 , the transistor T_1 remains turned off until the capacitor has discharged through the variable resistor 34. At that point, the base potential of the transistor T_1 will be less than the positive potential of the conducting path 25. Independent of any following opening of the switching contact A, the monostable multivibrator KG returns to its stable state at instant t_3 depending upon the capacity of the feedback capacitor 33 and the value of the variable resistor 34. As a result of the diode 53, the action of the switch A has no further effect on the monostable multivibrator KG. Once the monostable multivibrator circuit has returned to its original stable state, the second transistor T_2 is again turned off. The pulse I_G delivered by the circuit KG and made variable through the member 35, is thereby terminated at the instant t_3 .

In order to shorten the pulse I_G by the constant delay time T_V of the stage ST, the transistor T_3 must become conductive later than the transistor T_2 by the amount of the delay time. This is achieved with the coupling capacitor 41. If this capacitor 41 were to be removed from the circuit, and thereby have no connection from the base of transistor T_3 to the transistor T_2 , the transistor T_3 would have to become conductive simultaneously with the transistor T_2 which had been turned off also prior to this. During the time that the transistor T_2 is cut off, however, the coupling capacitor 41 can charge positively through the diode 43. When the transistor T_2 becomes, thereby, conductive at the instant t_1 , the positive charge of the coupling capacitor 41 raises the base potential of the transistor T_3 to the extent that the latter becomes cut off at the instant t_1 . The transistor T_3 remains cut off until the capacitor has discharged through the diode 42 and resistors 40 and 26. When the discharge has thus been accomplished, the base potential of the transistor T_3 is below that of the emitter or emitter potential and the transistor T_3 may again conduct. This occurs at the instant t_2 , and in this manner a delay is realized between the instant t_1 and the instant t_2 . This time delay is proportional to the discharge time constant of the coupling capacitor 41. Accordingly, the pulse I_N applied to the injection valves, begins later by the delay time T_V .

The diode 42 is provided for the purpose of meeting the requirement that the transistor T_3 is cut off simultaneously with the transistor T_2 at the instant t_3 corresponding to the end of the pulse I_G delivered by the circuit KG. Before the transition of the transistor T_2 to the cutoff state, the coupling capacitor 41 is discharged. As soon as this transistor T_2 is cut off, the capacitor is connected to ground potential or minus potential by means of its electrode through the resistor 27. The charging current to the other electrode of the capacitor 41 can, however, not flow over the emitter-base path of the transistor T_3 , and thus maintain the latter in the conductive state over the time instant t_3 . This is because the first diode 42 does not permit current flow from the base to the coupling capacitor 41. The charging current is directly led to the coupling capacitor 41 by way of the second diode 43, so that the transistor T_3 is influenced by the charging current, and is thereby returned to its cutoff state simultaneously with the transistor T_2 .

With the arrangement, in accordance with the present invention, therefore, a shortening of the pulse I_G by the amount of the constant delay time T_V is achieved. It is possible thereby to select a longer delay time T_V in accordance with the operating requirements of the engine and the adaptation thereto of the pulse I_G . As a result, the variable region of the resistor 34 may be made considerably smaller. Since this resistor must lie within predetermined minimum and maximum limits in view of the operating requirements of the first transistor T_1 , considerable simplification is realized for adapting the fuel requirements. This becomes of greater importance with

the greater the number of operating parameters that must be taken into account. In the embodiment of FIG. 1, the variation of the resistor 34 is selected by connecting a sliding contact 4 hereof to the intake manifold membrane 35. This arrangement has been selected because it may be simply realized and is representative of other, equally known, and essentially complicated arrangements for the purpose of adapting the pulse I_G to the operating parameters to be taken into account.

As described above, the two diodes 42 and 43 in the circuit stage ST serve the purpose to assure a reset time instant t_3 for the monostable multivibrator KG. It is possible to provide a resistor in place of the second diode 43. In view of the delay time T_V to be realized, it is essential that the magnitude of this resistor be larger than the coupling resistor 40. When the resistor 27 is made sufficiently small, it is also possible to eliminate the first diode 42. In this case, the latter is replaced by a simple conducting path. When resetting, thereby, a short resetting delay is encountered as a result of the charging current of the coupling capacitor 41. However, this resetting delay may be maintained quite small compared to the applied delay due to the discharge of the coupling capacitor 41.

In the embodiments of FIGS. 3 and 4 the circuit stage ST also is comprised of a single transistor T_4 . The latter however is of the n-p-n type and is thereby complementary to the transistor T_3 of the circuit stage in accordance with FIG. 1. The same relationship prevails with respect to the transistor T_1 which is of the p-n-p type in all of the embodiments, and which is maintained in the conducting state as a result of the resistor connecting its base to the negative conducting path 28.

The monostable multivibrator circuit KG in the embodiment of FIG. 3, has the same structure as the embodiment in accordance with FIG. 1. Since the second transistor T_2 is cut off in its quiescent state, and the transistor T_4 in the circuit stage ST is also cut off in the quiescent or nonoperative state of the circuit KG, the transistor T_4 has its base connected to the collector of transistor T_2 by way of the resistor 40. Because of the complementary configuration of the transistor T_4 , its emitter is directly connected to the negative path 28, and its collector is connected to the positive potential 25 by way of the resistor 44. As a result, the diodes 42 and 43 connected substantially in parallel with the base emitter path of the transistor T_4 must permit current to flow from the base to the negative conducting path, but must block any flow in the reverse direction. The coupling capacitor, in a manner differing from FIG. 1, is connected to the collector of the first transistor T_1 which is in the conducting state when the circuit is quiescent. In the unstable state of the circuit KG, the transistor T_1 , however, is cut off and the charging of the coupling capacitor is thereby made possible. In this case, however, negative charges appear on the electrode of the coupling capacitor connected to the base of the transistor T_4 . These negative charges cause the base potential of the transistor T_4 to be below the potential of the negative conducting path, at the instant t_1 corresponding to the transition of the first transistor T_1 to the cutoff state. The transistor T_4 is thereby maintained cut off until the instant t_2 , since the capacitor 41 has discharged after the expiration of the delay time T_V , to the extent that the base of the transistor T_4 has become positive with respect to the negative conducting path 28 and the transistor T_4 can again become conductive.

In accordance with the embodiment of FIG. 4, the circuit KG unlike in the embodiment described before, has two complementary transistors of which the first transistor T_1 is of the p-n-p type, and the second transistor T_5 is, however, of the n-p-n type. Both of the transistors are maintained conductive in the stable state of the monostable multivibrator circuit, in order that a precisely defined reset time t_3 for the pulse I_G is realized from the

unstable. Corresponding to the pulse duration T_G established by the circuit KG through the discharge time of the coupling branch containing capacitor 33. Conduction of both transistors in the stable or quiescent state of the circuit is assured by the variable resistor 34 which is connected between the base of the transistor T_1 and the negative path 28. In view of the complementary arrangement of the transistors T_1 and T_5 , the coupling capacitor 41 of the circuit stage ST is also, as in the embodiment of FIG. 3, connected to the collector of the first transistor T_1 which is conducting during the quiescent state. The coupling resistor 40 is connected to the collector of the second transistor T_5 .

The transistor T_4 is, as in the previously described embodiment, in the cutoff state during the quiescent or stable state of the monostable multivibrator circuit KG. The transistor first becomes conductive after the elapse of the delay time T_V at the instant t_2 . At that instant the injection valves 13 are in their open position. The delay time is established through the capacity of the charging capacitor 41 and the magnitude of the resistors 40, 27 and 26 in the charging path through the diode 42. At the end of the pulse I_G the second transistor T_5 becomes conducting at the instant t_3 , similarly as the first transistor T_1 , and cuts off thereby the transistor T_4 by way of the coupling resistor 40. This transition is achieved without any time delays because the influence of the coupling capacitor 41 upon the reset time instant t_3 is inhibited by the diode 42.

In the embodiment of FIG. 5 the pulse duration T_G of the pulse I_G is determined by an inductive timing network. Through this arrangement the embodiment of FIG. 5 differs from the preceding embodiments. The timing network includes a transformer T having an adjustable core 60 which is positioned in the direction of the arrow, by means of the membrane member 35. The position of the magnetic core 60 determines the magnetic coupling and inductants between the primary winding 61 and the secondary winding 62 of the transformer. The primary winding is in the collector circuit of the transistor T_2 and in series with the resistor 27. One end of the secondary winding 62 is connected to the base of the transistor T_1 as well as to the resistor 63 leading to the negative conducting path 28. This connection maintains the transistor T_1 conducting in the quiescent state of the monostable multivibrator circuit. The other terminal or end of the secondary winding 62 is connected to the junction of a voltage divider comprised of resistors 64 and 65. The second transistor T_2 which is cut off in the quiescent state, has its base connected to the resistor 30 leading to the collector of the transistor T_1 . As a result, the transistor can first become conductive when the switching arm A actuated by the cam N driven by the crankshaft is in contact with the switching contact that is opposite the one leading to the positive terminal 25, and not shown in the drawing. In this state, the first transistor T_1 is cut off, as it is in the embodiment of FIG. 3. In accordance with the inductants of the primary winding 61 determined by the magnetic core 60, the collector current increases in the second conducting transistor T_2 , and thereby produces a feedback voltage in the secondary winding 62 maintaining the first transistor T_1 in the cutoff state. The DC resistance of the primary winding is negligibly small compared to the resistor 27. The induced voltage in the secondary winding 62 first allows the transistor T_1 to become again conducting, in the commonly known manner, at the instant t_3 , at which time the second transistor T_2 is simultaneously cut off.

The circuit stage ST connected to the monostable multivibrator circuit KG is designed similarly to that used in FIG. 1. However in this case, the circuit ST provision for making the delay time T_V shorter with the decrease in the output voltage of the power supply or battery serving the electrical arrangement.

Thus, experience has shown that the injection valves 13 reach the opening position slower when the voltage of the power supply is lower. The batteries used in conventional motor vehicles have a nominal rating of 12.6 volts, but when fully charged, they deliver a voltage of 15 volts. Under severe load conditions and when the battery is insufficiently charged, the output voltage may drop to or below 12 volts. When the pulse duration T_N remains constant, the duration during which the valves remain open are shortened by approximately 0.3 msec., when the voltage of the power supply drops by one volt.

For the purpose of compensating the voltage effects, the circuit stage ST includes a Zener diode Z connected to the negative supply line 28. The Zener diode has a breakdown voltage of approximately 9 volts. A resistor 67 is connected in series with the Zener diode Z. When the battery supply is 12 volts, 3 volts will appear for the potential difference U_r across the resistor 67. When, on the other hand, the battery supply is 15 volts, the potential difference U_r attains a value of 6 volts. The coupling capacitor 41 is connected to a charging resistor 68 which leads to the junction P between the Zener diode Z and the resistor 67. In addition the connecting line to the capacitor 41 is also coupled to the collector of the second transistor T_2 by way of a third diode 69. The latter is directed so that it allows current flow only from the collector of the transistor T_2 to the coupling capacitor 41. The diode 69 inhibits current flow in the reverse direction.

When the transistor T_2 is cut off, the diode 69 serves to assure that the coupling capacitor 41 cannot be charged to the potential of the negative supply line 28, but instead only to the potential of the negative junction P. When the transistor T_2 transfers, at the instant t_1 , from the cut-off state to the conducting state, the charged capacitor 41 has a voltage corresponding to the potential difference U_r . At this value the potential of the base of the transistor T_3 is made positive, when the transistor T_2 becomes conducting and its collector thereby assumes the potential substantially that of the positive supply line 25. The switching on instant t_2 of the transistor T_3 which continues to be cutoff is first attained when the coupling capacitor 41 has discharged across the discharge resistor 40 from its previously charged voltage U_r . The delay time T_V determined by the discharge process becomes longer, the higher the initial charging voltage U_r of the coupling capacitor 41. Since the voltage U_r is also high when the battery supply is high, but has only low voltages of 9 volts when the battery supply is low, because of the practically constant voltage drop at the Zener diode Z, a shortened time delay T_V is realized when the battery supply drops. As a result an increase in the duration T_N for injection purposes is realized. The increase in this duration T_N is made larger the lower the voltage supply drops and the slower the magnetic valves 13 arrive at their opening positions.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of injection control arrangement for internal combustion engines differing from the types described above.

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

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

I claim:

1. An arrangement for controlling the injection of fuel in internal combustion engines comprising, in combination, fuel injection means; a monostable multivibrator circuit operated by said engine for providing rectangular-shaped pulses of variable duration; and delay circuit means actuated by said monostable multivibrator circuit and providing control pulses beginning a predetermined time interval after the beginning of said rectangular-shaped pulses of variable duration and terminating at the same instant that the variable duration pulses from said monostable multivibrator circuit terminate, whereby the duration of said control pulses is a predetermined fraction of the duration of said rectangular-shaped pulses of variable duration from said monostable multivibrator circuit, said control pulses actuating said fuel injection means to inject fuel for operating said engine in a predetermined controlled manner as a function of the operating characteristics of said engine.

2. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 1, including a first transistor and a second transistor in said monostable multivibrator circuit; a third transistor in said delay circuit means; resistor means connected between the base of said third transistor and the collector of one of said transistors in said monostable multivibrator circuit; and capacitor means connected between the base of said third transistor and the collector of the other one of said transistors in said monostable multivibrator circuit.

3. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 2, wherein said third transistor is cut off when said monostable multivibrator circuit is in its stable state.

4. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 3, wherein said first, second and third transistor are of the same conductive type, said first transistor being conductive and said second transistor being cut off when said monostable multivibrator circuit is in its stable state, said resistor means being connected between the base of said third transistor and the collector of said first transistor and said capacitor being connected between the base of said third transistor and the collector of said second transistor.

5. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 3, wherein said first transistor and said second transistor are of the same conductivity type and the conductivity of said third transistor is opposite to the conductivity of said first and second transistors, said resistor means being connected between the base of said third transistor and the collector of said second transistor, and said capacitor being connected between the base of said third transistor and the collector of said first transistor, said first transistor being conductive and said second transistor being cut off when said monostable multivibrator circuit is in its stable state.

6. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 3, wherein said first and second transistors are of opposite conductivity type and the conductivity type of said third transistor is the same as said second transistor, said resistor being connected between the base of said third transistor and the collector of said second transistor, said first and second transistors being conductive in the stable state of said monostable multivibrator circuit.

7. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 3, including a series circuit comprising a diode; and direct current transmitting means connected in series with said diode, said series circuit of said diode and said direct current transmitting means being connected in parallel with the emitter-base path of said third transistor, said diode being connected to the base of said transistor and said capacitor being connected to the junction of said diode

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and said direct current transmitting means, said resistor means being connected to the base of said diode transistor.

8. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 7, wherein said direct current transmitting means comprises a second diode transmitting current in the same direction as said first diode, the conduction direction of said series circuit of said first and second diodes being the same as the direction of conduction of said emitter-base path of said third transistor.

9. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 3, including power supply means having terminals of opposite polarity; a voltage divider connected across said terminals of opposite polarity of said power supply, said voltage divider comprising a Zener diode connected to a second resistor; a third resistor connected between the junction of said Zener diode and said second resistor and said capacitor means; and a third diode connected be-

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tween the collector of said second transistor and the junction of said third transistor and said capacitor means.

10. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 9, wherein said third diode is nonconducting when said second transistor is cut off.

11. The arrangement for controlling the injection of fuel in internal combustion engines, as defined in claim 9, wherein said power supply is a battery.

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