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FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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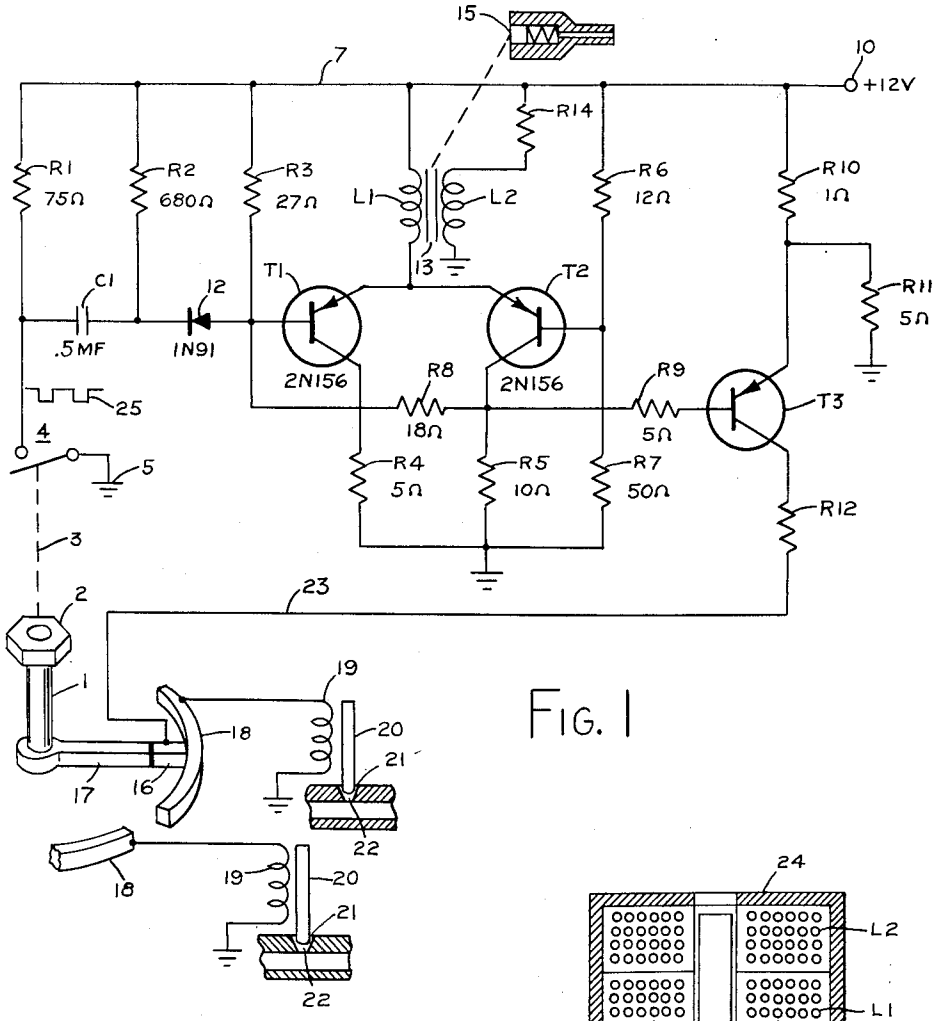


FIG. 1

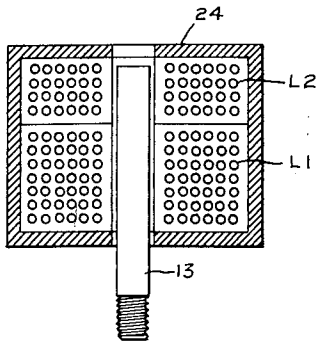


FIG. 2

INVENTOR.
NOBLE F. PRIBBLE
BY
ATTORNEY

United States Patent Office

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FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

Noble F. Pribble, Lutherville-Timonium, Md., assignor to The Bendix Corporation, a corporation of Delaware

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5 Claims. (Cl. 123—119)

This invention relates to a fuel injection system for internal combustion engines and more particularly to a fuel injection system incorporating transistorized multivibrator circuits of the monostable type wherein inductive control means are utilized.

This application is a division of my copending application Serial Number 611,654, filed September 24, 1956, now Patent 2,967,953, issued Jan. 10, 1961.

In certain uses of monostable multivibrators it is desirable to be able to accurately control the duration of the unstable state of the circuit and thus the duration of the output pulse thereof. In the past this has usually been done by the use of a combination of resistance and capacitance in which a capacitor is charged by the operation of the circuit in response to a triggering impulse and discharges through a resistor.

When power transistors are substituted for electron tubes, however, the low impedance of the transistors makes it difficult to utilize a resistance capacitance combination capable of providing an output pulse duration of any considerable value. For this reason only transistors of high impedance and low power handling capabilities can be used and an amplifier chain is required to amplify the multivibrator output to the level needed. Furthermore, the potentiometer necessary for varying pulse duration in the resistance capacitance control circuit has several drawbacks. It is expensive and subject to wear which impairs its life and reliability.

It is an object of the present invention to provide a control for a monostable multivibrator which is adapted for use with the low impedances of power transistors.

It is a further object to provide such a control which is inexpensive, reliable and has a long life.

It is another object to provide a means for compensating for variations in amplitude of the multivibrator output due to variations in supply voltage level.

These and other objects and advantages of the invention are realized by a circuit in which an iron cored inductor is incorporated as a control element, and a separate inductor on the same core varies its saturation as a function of supply voltage level.

In the drawing:

FIG. 1 is a schematic diagram of a fuel injection system employing a circuit embodying the invention; and

FIG. 2 is a cross-sectional view of one form of control inductor.

By way of illustrating one use for a multivibrator of the type referred to and to disclose a complete system employing the invention, there is shown, in FIG. 1, a schematic representation of a fuel injection system for an internal combustion engine in which fuel is provided by means of a separate solenoid operated fuel injection valve for each cylinder of the engine. The energization of the solenoids is effected by the application thereto of the output pulses of the multivibrator which is triggered in synchronism with the rotation of the engine. The speed of the engine is controlled by the throttle setting which varies the duration of the pulses and which, in turn, varies the open time of the valves.

There is shown in FIG. 1 a shaft **1**, which may be the distributor shaft of the engine, and is driven in accordance with engine rotation. The shaft **1** has mounted on

it, for rotation therewith, a lobed cam **2** having a lobe for each engine cylinder. The cam is connected by a mechanical linkage **3** to one contact element of a single pole, single throw switch **4**. This contact element is connected to a voltage reference plane shown as ground at **5**.

The other contact element of the switch **4** is connected by way of a resistor R_1 and a conductor **7** to a positive terminal **10** of a source of supply voltage. The said other terminal of switch **4** is also connected by way of a condenser C_1 and a diode **12** to the base electrode of a transistor T_1. The junction of capacitor C_1 and diode **12** is connected to conductor **7** by a resistor R_2, and the junction of diode **12** and the base electrode of transistor T_1 is connected to conductor **7** by a resistor R_3.

The emitter electrode of transistor T_1 is connected to the emitter electrode of a second transistor T_2 and their junction is connected by a coil L_1 to conductor **7**. The coil has a movable iron core for varying its inductance. The core is indicated by the lines **13** and is connected by a mechanical linkage to a piston **15** driven by manifold vacuum. A second coil L_2 is also wound about the core **13** and has one terminal connected by way of a resistor R_{14} to the conductor **7** and the other terminal connected to the voltage reference plane.

The collector electrode of transistor T_1 is connected by way of a resistor R_4 and that of transistor T_2 by a resistor R_5 to the voltage reference plane. The base electrode of T_2 is connected through a resistor R_6 to conductor **7** and through a resistor R_7 to the voltage reference plane.

The base electrode of T_1 is connected through a resistor R_8 to the collector electrode of T_2 and through an additional resistor R_9 to the base electrode of a third transistor T_3. The emitter electrode of T_3 transistor is connected by way of a resistor R_{10} to conductor **7** and by way of a resistor R_{11} to the voltage reference plane.

The collector electrode of T_3 is connected by way of a resistor R_{12}, and a conductor **23** to a wiping contact element **16** carried by and insulated from an arm **17** mounted on the shaft **1** for rotation therewith. The element **16** makes sequential wiping contact with a plurality of contact segments **18**, of which one is provided for each cylinder, only two being shown. Each segment **18** is connected to one terminal of a respective solenoid **19** having an armature **20**. The armature is a valve stem having a valve element **21** formed on its lower end. The element **21** seats in a seat **22** formed in the intake manifold of the engine close to the fuel intake valve of a respective cylinder. The remaining terminal of each solenoid **19** is connected to the voltage reference plane.

FIG. 2 illustrates a manner in which the coils L_1 and L_2 may be wound about the core **13**. The coils are housed in a container **24**.

In the operation of the circuit described above, the cam **2** closes the switch **4** and opens it once while the contact element **16** is wiping each segment **18**. Closing of the switch causes the undriven contact of the switch to be placed at the potential of the ground reference plane, while opening the switch causes this contact to assume the voltage of the terminal **10**. The result is a square waveform as indicated at **25**. This waveform is differentiated by the combination of R_1 and C_1 and the negative-going spikes of the resulting waveform are passed by the low impedance of the diode **12** and applied to the base electrode of the transistor T_1.

In the multivibrator composed of T_1 and T_2, the transistor T_2 is normally conducting. In this state there will be a drop of about 1.5 volts across the D.C. resistance of the inductor L_1. There will be a drop of .7 volt from the emitter of T_2 to its collector. The drop across the resistor R_8 is such that the base of T_1 is

biased to a positive potential with respect to its emitter and T_1 will thus be cut off.

When the switch 4 is closed the negative spike applied to the base electrode of T_1 will cause T_1 to conduct, which will increase the drop across the coil L_1. This will reduce the conduction of T_2, applying as a result a negative voltage to the base of T_1, thus increasing the conduction of T_1. This regenerative action will terminate in the cut off of T_2. T_2 will remain cut off until the current build up through the coil L_1 is complete. When the emitter of T_2 is again more positive than the base the reverse action will take place and T_2 will conduct again. The time constant of this action is determined by the inductance of L_1 and the resistance of R_4. The inductance of L_1 is varied by varying the position of the iron core 13.

The output of the multivibrator is applied through the resistor R_9 to the base electrode of transistor T_3. It is amplified in a conventional manner and applied by way of resistors R_{12}, conductor 23, contact element 16, and contact segment 18 to the coil 19.

The function of the coil L_2 is to compensate for changes in the amplitude of the pulses in the output of the multivibrator due to changes in the voltage of the supply source. When this source is the battery of an automobile, for example, the voltage is subject to variation and tends to be low when starting and thus to provide a pulse of reduced amplitude. The reduced amplitude results in the injection valves being opened more slowly and an increase in pulse duration is needed to compensate for this effect. The coil L_2 increases the saturation of the core when the supply voltage increases and this results in a reduction in the duration of the pulse. Conversely a reduction in supply voltage decreases the saturation of the core and increases the duration of the pulse. This action is desirable, for example, when starting.

The use of the inductive control means described above makes it possible to use low impedance power type transistors for the multivibrator and to thus effect a reduction in the number of transistors needed for the whole circuit. The circuit illustrated utilizes three power transistors, whereas with a resistance capacitance type of control circuit power transistors with their low impedances could not be used in the multivibrator and a total of five transistors would be required to provide the desired pulse output.

The component values shown on the drawing are provided solely for the purpose of illustrating typical satisfactory values, and should not be considered as restricting the invention.

I claim:

1. In a fuel injection system for internal combustion engines: means for generating pulses of electrical current including a power source; a monostable multivibrator circuit having an input circuit communicating with the power source; means for timing the initiation of said pulses in synchronism with the rotations of the engines; means for timing the duration of said pulses including an inductive element in said input circuit; means for continuously varying the inductance of said inductive element in accordance with a running function of the engine; means for varying the time duration of said pulses as a function of voltage changes in the power source; and, means actuated by said pulses for supplying fuel to the engine.

2. A fuel injection system as set forth in claim 1 in which the inductive element comprises a coil serially connected between the multivibrator input circuit and said power source, and in which the means for varying the inductance of said coil comprises: a movable core of magnetizable material; and means responsive to variations in the engine parameters for moving said core with respect to said coil.

3. A fuel injection system as set forth in claim 2 in which the means responsive to variations in engine parameters for moving said core comprises means responsive to variations in the intake vacuum of the engine.

4. A fuel injection system as set forth in claim 2 in which the means for varying the time duration of said pulses as a function of voltage changes in the power source includes a second coil connected directly across the power source wound about said core.

5. A fuel injection system as set forth in claim 1 in which the means for varying the time duration of said pulses as a function of voltage changes in the power source comprises: a movable core of magnetizable material extending into said inductive element; and, a coil connected directly across the power source wound about said core.

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