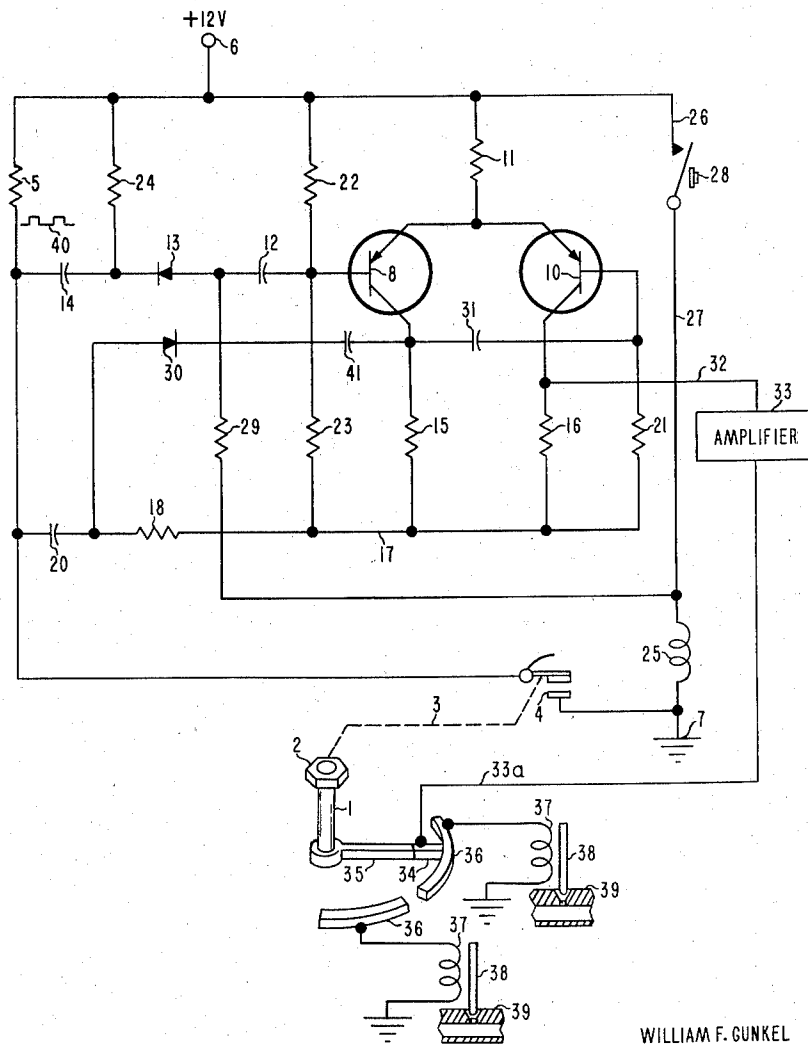


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MULTIVIBRATOR TRIGGERING CIRCUIT
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FUEL INJECTION SYSTEM WITH STARTER ACTUATED MULTIVIBRATOR TRIGGERING CIRCUIT

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5 Claims. (Cl. 123-179)

This invention relates to fuel injection systems for internal combustion engines and more particularly to such a system incorporating a circuit responsive to a signal of square waveform to trigger a monostable multivibrator coincident with either one or both terminal edges of each excursion of the square waveform at the will of an operator.

While such a circuit may have many applications it has particular application to a fuel injection system of the type disclosed in U. S. Patent 2,807,244 to Andrew S. Barclay, issued September 24, 1957, in which fuel under pressure is supplied to a plurality of solenoid operated injection valves of which there is one for each cylinder of the engine. The solenoids are activated by having applied thereto in sequence the output pulses of a monostable multivibrator triggered in synchronism with the operation of the engine. The duration of each valve opening is controlled by the air throttle.

For cold starting of the engine it is desirable to increase the amount of fuel fed to the cylinder above the range of amounts fed in normal running, to compensate for the low rate of vaporization of the fuel at low temperatures. The present invention offers a means of doubling the number of output pulses of the multivibrator for a given input signal coincident with the activation of the starter circuit.

It is an object of the invention to provide a means by which a monostable multivibrator may have its output frequency doubled at will.

It is another object of the invention to provide a fuel injection system for internal combustion engines in which the number of fuel injection valve openings for a given rate of engine rotation may be doubled at will for cold starting.

These and other objects and advantages of the invention are realized by an arrangement in which there is incorporated a triggering circuit responsive to alternate terminal edges of the square wave input signal and a second triggering circuit responsive to the remaining terminal edges. The latter triggering circuit is normally biased to a non-conductive state and is activated by the closing of the starter switch.

In the drawing the single figure is a schematic diagram of a fuel injection system incorporating the invention.

Referring more particularly to the drawing there is a shaft 1 which may be the distributor shaft of the engine rotating in synchronism with the operation thereof. Mounted on the shaft 1 for rotation therewith is a lobed cam 2 having one lobe for each cylinder of the engine. The cam 2 drives one contact element of a breaker switch 4 by means of a mechanical linkage 3. The driven contact element of the switch 4 is connected by way of a resistor 5 to the positive terminal 6 of a voltage supply source which may be the battery of an automobile. The remaining contact element is connected to a voltage reference plane indicated as the ground 7.

A monostable multivibrator is formed of a pair of transistors 8 and 10. The emitters of these transistors are

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joined and connected by way of a resistor 11 to the terminal 6. The base of transistor 8 is connected to the driven contact element of switch 4 by way of a series arrangement of capacitor 12, diode 13 and capacitor 14. The collectors of transistors 8 and 10 are connected by way of respective resistors 15 and 16 to a conductor 17 which, by way of a resistor 18 and a capacitor 20, in series, is connected to the driven contact element of switch 4. The base of transistor 10 is connected to conductor 17 by resistor 21. The base of transistor 8 is connected to terminal 6 by resistor 22 and to conductor 17 by resistor 23. The terminal 6 is connected to the junction of capacitor 14 and diode 13 by resistor 24.

The starter motor control relay coil 25 of the automobile is connected by a conductor 27 to the movable contact element of the starter switch 26, which element is actuated by a button 28. The fixed contact element of this switch is connected to the terminal 6. The remaining terminal of solenoid 25 is connected to the voltage reference plane at 7. The first mentioned terminal of the solenoid is connected to the junction of capacitor 12 and diode 13 by way of a resistor 29. The junction of resistor 18 and capacitor 20 is connected by way of a diode 30 and capacitor 41 to the collector of transistor 8, which is also connected to the base of transistor 10 by a capacitor 31.

The output of the multivibrator is taken at the collector of transistor 10 and applied by way of a conductor 32 to an amplifier 33. The output of this amplifier is applied by a conductor 33a to a wiping contact element 34, carried by and insulated from an arm 35 mounted on the shaft 1 for rotation therewith. The element 34 makes successive contact with a plurality of commutator segments 36, one of which is provided for each cylinder of the engine. Connected to each segment 36 is one terminal of a respective solenoid 37, the other terminal of which is grounded. Each solenoid actuates the valve stem 38 of a fuel injection valve seating in a seat formed in the intake manifold 39 of the engine near the intake port of a respective cylinder. Fuel under pressure is supplied to these valves by means not shown.

In the operation of the above system, the rotation of the shaft 1 causes the cam 2 to open and close the switch 4 once while the element 34 is making contact with each of the segments 36. As the switch opens the voltage at the lower terminal of resistor 5 rises to the 12 volt level and when the switch closes the voltage falls to ground level resulting in a square wave as indicated by the graph 40.

Prior to triggering of the multivibrator the transistor 10 is conducting. This is insured by the fact that the value of resistor 16 is less than that of resistor 15, so that current flow through transistor 10 is heavier than that through transistor 8. The voltage drop across resistor 11 and the bias on transistor 8 due to the voltage divider 22, 23 maintains this transistor in a cut off state.

The square wave 40 is differentiated by capacitor 14 and resistor 24 and by capacitor 20 and resistor 18. During engine operation the switch 26 is open. The upper terminal of coil 25 and the junction of capacitor 12 and diode 13 are thus at ground potential. The diode 13 is, therefore, not conducting to any portion of the differentiated version of waveform 40.

The diode 30 is, on the other hand, so poled as to pass the positive-going spikes of the differentiated wave. These are coupled by capacitors 41 and 31 to the base of transistor 10, cutting it off, which action, in accordance with the known multivibrator mode of operation causes transistor 8 to be rendered conductive. This state exists until the capacitor 31 discharges sufficiently to cause the multivibrator to return to its stable state.

The output of the multivibrator, taken at the collector of transistor 10, is applied by conductor 32 to the

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amplifier 33 and thence to the element 34 to be applied to the segment 36 being wiped. It thus activates the solenoid 37 connected to this segment, lifting the valve 38 for the duration of one output pulse of the multivibrator for each rotation of the engine.

This provides sufficient fuel for normal running. But in starting the engine when cold, in which condition the fuel does not readily vaporize, additional fuel is needed for the starting operation. This the invention provides by triggering the multivibrator coincident with the trailing edge as well as the leading edge of each positive-going excursion of the waveform 40.

The pressing of the starting button 28 closes the switch 26, bringing the upper terminal of the coil 25 to 12 volts. This voltage is applied to the junction of diode 13 and capacitor 12, rendering the diode conductive to the negative spikes derived from waveform 40 by the differentiating action of capacitor 14 and resistor 24. Each negative spike, coupled to the base of transistor 8, renders that transistor conductive, driving the multivibrator into its unstable state. By this means each valve 38 will be lifted twice during each dwell of the element 34 on the segment 36 to which it is connected. This action will, of course, cease with the release of the starter button.

The action of the double triggering arrangement, being analogous to that of a choke in an engine employing carburetion, may be made effective or ineffective at will by the same manual or automatic arrangements normally employed in connection with a choke, which have not been shown herein.

What is claimed is:

1. In a system for injecting measured amounts of fuel into the cylinders of an internal combustion engine in synchronism with the operation thereof, in which fuel is supplied under pressure to a respective solenoid operated valve for each cylinder, a square wave of electrical energy is generated in synchronism with engine rotation, said wave undergoing a number of cyclic variations related to the number of cylinders of said engine during each rotation of said engine, a monostable multivibrator is triggered in synchronism with a corresponding terminal edge of each cycle of variation of said wave, the pulses in the output of said multivibrator are applied by way of a commutating device to the solenoids of said valves to actuate the same, and a starting circuit for said engine is provided, said starting circuit comprising a starting solenoid, a source of electrical energy, a circuit for applying energy from said source to said starting solenoid, said circuit normally being interrupted, and a switch for completing said circuit at will, the improvement which comprises: means responsive to the occurrence of a second terminal edge of each of said cycles of variation of said wave to trigger said multivibrator into its unstable state, the last named means being normally inoperative and means responsive to the completion of said starting circuit to render said last named means operative.

2. In a system for injecting measured amounts of fuel into the cylinders of an internal combustion engine in synchronism with the operation thereof, in which fuel is supplied under pressure to a respective solenoid operated valve for each cylinder, a square wave of electrical energy is generated in synchronism with engine rotation, said wave undergoing a number of cyclic variations related to the number of cylinders of said engine during each rotation of said engine, a monostable multivibrator is triggered in synchronism with a corresponding terminal edge of each cycle of variation of said wave, the pulses in the output of said multivibrator are applied by way of a commutating device to the solenoids of said valves to actuate the same, and a starting circuit for said engine is provided, said starting circuit comprising a starting solenoid, a source of electrical energy, a circuit for applying energy from said source to said starting

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solenoid, said circuit normally being interrupted, and a switch for completing said circuit at will, the improvement which comprises: means responsive to the occurrence of a second terminal edge of each of said cycles of variation of said wave to trigger said multivibrator into its unstable state, and means applying the voltage across said starting solenoid to the last named means as biasing voltage, whereby said last named means is rendered operative only when said circuit is completed.

3. In a system for injecting measured amounts of fuel into the cylinders of an internal combustion engine in synchronism with the operation thereof, in which fuel is supplied under pressure to a respective solenoid operated valve for each cylinder, a square wave of electrical energy is generated in synchronism with engine rotation, said wave undergoing a number of cyclic variations related to the number of cylinders of said engine during each rotation of said engine, a monostable multivibrator is triggered in synchronism with a corresponding terminal edge of each cycle of variation of said wave, the pulses in the output of said multivibrator are applied by way of a commutating device to the solenoids of said valves to actuate the same, and a starting circuit for said engine is provided, said starting circuit comprising a starting solenoid, a source of electrical energy, a circuit for applying energy from said source to said starting solenoid, said circuit normally being interrupted, and a switch for completing said circuit at will, the improvement which comprises: means responsive to the occurrence of a second terminal edge of each of said cycles of variation of said wave to trigger said multivibrator into its unstable state, the last named means comprising means generating a pulse coincident with said second terminal edge, means including a diode coupling said pulse to said multivibrator in a manner to trigger the latter, and means responsive to the voltage across said starting solenoid to bias said diode to non-conduction when said starting circuit is open and to remove said bias when said starting circuit is complete.

4. A system for injecting measured amounts of fuel into the cylinders of an internal combustion engine in synchronism with the operation thereof, comprising: means driven in accordance with engine rotation and generating a voltage having a square waveform which undergoes a number of cyclic variations related to the number of cylinders of the engine during each rotation thereof, a monostable multivibrator, a solenoid operated fuel injection valve for each cylinder of said engine, means applying the output of said multivibrator to the solenoids of said solenoid operated valves sequentially in synchronism with the rotation of said engine, a starting circuit for said engine including a starting solenoid, a source of electrical energy, means connecting said source to said starting solenoid, and a starter switch normally interrupting said connecting means, a pair of triggering circuits for said multivibrator, each responsive to a respective terminal edge of each of the cyclic variations of said waveform to trigger said multivibrator, and biasing means for one of said triggering circuits, said biasing means operating when said starting circuit is interrupted to render said one triggering circuit inoperative.

5. A system for injecting measured amounts of fuel into the cylinders of an internal combustion engine in synchronism with the operation thereof, comprising: means driven in accordance with engine rotation and generating a voltage having a square waveform which undergoes a number of cyclic variations related to the number of cylinders of the engine during each rotation thereof, a monostable multivibrator, a solenoid operated fuel injection valve for each cylinder of said engine, means applying the output of said multivibrator to the solenoids of said solenoid operated valves sequentially in synchronism with the rotation of said engine, a start-

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ing circuit for said engine including a starting solenoid, a source of electrical energy, means connecting said source to said starting solenoid, and a starter switch normally interrupting said connecting means, a pair of triggering circuits for said multivibrator, each responsive to a respective terminal edge of each of the cyclic variations of said waveform to trigger said multivibrator, and

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biasing means for one of said triggering circuits, and biasing means comprising means impressing the voltage across said starting solenoid on said one triggering circuit, whereby said one triggering circuit is rendered operative only by the completion of said starting circuit.

No references cited.