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DRIVER CIRCUIT FOR FUEL INJECTOR

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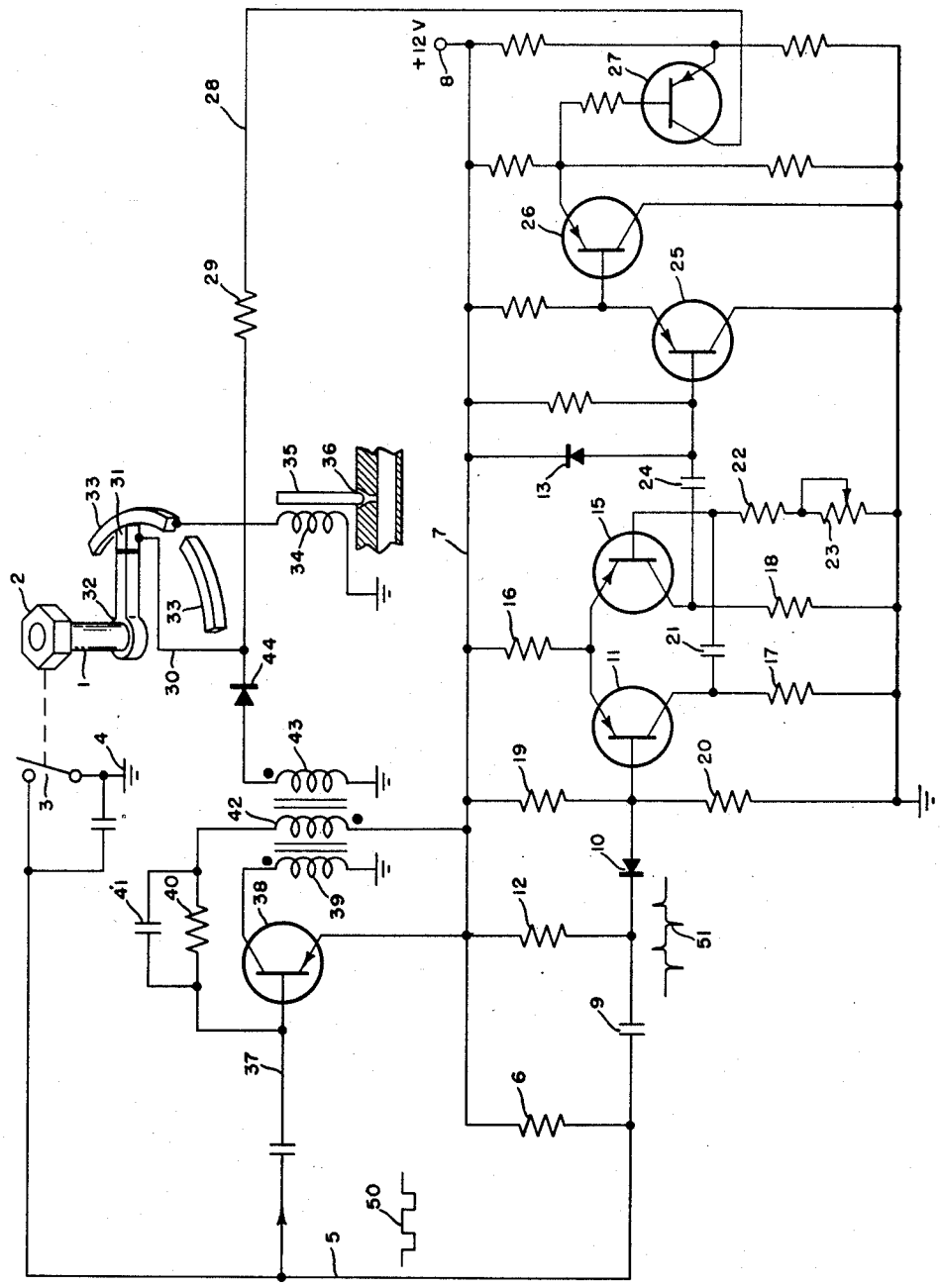

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DRIVER CIRCUIT FOR FUEL INJECTOR

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7 Claims. (Cl. 123—32)

This invention relates to a system for supplying fuel in measured amounts to the individual cylinders of an internal combustion engine in timed relation to engine operation. It relates more specifically to a system conforming to the principles of operation followed by the system disclosed in U.S. patent application Serial No. 567,688, filed February 24, 1956, now abandoned, in the names of Robert W. Sutton et al., for "Fuel Injection System." In that system a magnetically actuated valve for each cylinder is opened for the duration of a pulse of current, the time of occurrence of which is synchronized with engine rotation. The amount of fuel injected is regulated by the duration of the pulse, the pressure on the fuel being constant.

In a system of this type it is necessary to make full utilization of the time available for each valve to remain open. For example, an eight-cylinder engine operating at a speed of fifty-two hundred r.p.m. provides a maximum actual open time for its fuel injection valves of approximately two milliseconds. Since it is desired to maintain a ratio of four-to-one between maximum and minimum open times for the valves, it is apparent that the time required to open each valve must be reduced to a minimum.

In order to open a valve quickly a high voltage must be applied to its operating solenoid so that maximum current flow may be quickly attained. But it is undesirable to continue the application of this high voltage for the duration of the open time since current flow will build up exponentially in the solenoid with resulting wasteful current drain.

It is, accordingly, an object of this invention to provide, in a system as referred to above, a means for causing each pulse of voltage applied to the valve operating solenoids to have an initial peak of high intensity while the remainder of the pulse has an intensity level only sufficient to provide the current necessary to hold the valve open.

It is a further object to provide such a means which is simple and inexpensive.

These and other objects and advantages of the invention are realized in a system in which triggering impulses synchronized with the rotation of the engine are applied both to a monostable multivibrator and to a blocking oscillator, the outputs of both these devices being applied to the solenoids and means being provided to decouple the blocking oscillator from the solenoid at the termination of its high intensity output.

The single figure of the drawing is a schematic circuit diagram of a system embodying the invention.

Referring more particularly to the drawing, there is shown a shaft 1 driven in synchronism with the rotation of the engine and having mounted on it for rotation therewith a cam 2. The cam is shown with six lobes, conforming to a six-cylinder engine. The cam drives a movable contact of a single pole, single throw switch 3, which contact is connected to a voltage reference plane indicated by the grounding symbol 4.

The other contact of the switch 3 is connected by a conductor 5, resistor 6, and conductor 7 to the positive terminal 8 of a voltage source which may, for example, be the twelve volt battery of an automobile.

The junction of resistor 6 and conductor 5 is connected through a serial arrangement of a capacitor 9 and a diode 10 to the base electrode of a transistor 11. The junction of capacitor 9 and diode 10 is connected to conductor 7 through a resistor 12.

The transistor 11 is connected with a second transistor 15 to form a monostable multivibrator. The emitter electrodes are connected together and to the conductor 7 through a resistor 16. The respective collector electrodes are connected to the voltage reference plane through resistors 17 and 18. The base electrode of transistor 11 is connected to conductor 7 through a resistor 19 and to the voltage reference plane through a resistor 20. The collector electrode of transistor 11 is connected to the base electrode of transistor 15 by way of a capacitor 21 and to the voltage reference plane through serially connected resistors 22 and 23. The resistor 23 is variable, the movable tap being driven in accordance with the movement of the throttle of the engine.

The collector electrode of the transistor 15 is connected by a capacitor 24 to the base electrode of a transistor 25. This transistor is connected in cascade with two succeeding transistors 26 and 27 which form a conventional amplifier chain, the connections of which are thus not described in detail. The collector electrode of transistor 27 is connected by way of a conductor 28, a resistor 29, and a conductor 30 to a wiping contact element 31 carried by and insulated from an arm 32. The arm 32 is mounted on shaft 1 for rotation therewith.

The wiping contact 31 makes successive contact with a plurality of contact segments 33, one for each cylinder, of which only two are shown. Each of the contact segments is connected through a respective solenoid 34 to the reference voltage plane. The armature of the solenoid is a valve rod 35 normally seated in a valve seat 36 formed in the intake manifold adjacent one of the engine cylinder intake valves.

The said other contact of switch 3 is also connected by a conductor 37 to the base electrode of a transistor 38 which is connected as a conventional blocking oscillator. The collector electrode is connected to the voltage reference plane through a coil 39. The base electrode is connected by way of a resistor 40, shunted by a capacitor 41, and a coil 42 to the conductor 7. A coil 43 is connected between the voltage reference plane and the plate of a diode 44, the cathode of which is connected to conductor 30. The coils 39, 42 and 43 are coupled to provide a pulse output of high intensity.

In the operation of the circuit described above, the rotation of the shaft 1 in synchronism with engine rotation closes the switch 3 during the time the contact 31 is wiping each of the segments 33. The closing of the switch connects the conductor 5 to the voltage reference plane, while the opening of the switch permits it to come to the potential of the terminal 8. This produces a square waveform as at 50. This waveform is differentiated by the capacitor 9 and resistor 12 as at 51 and the negative-going spike is passed through the low impedance of the diode 10 to the base electrode of transistor 11. The positive spikes are attenuated by the diode. The negative spike triggers the monostable multivibrator composed of transistors 11 and 15 to produce a single square topped pulse of voltage, the duration of which is governed by the position of the movable tap on resistor 23. Since the operation of a multivibrator of this type is described in U.S. patent application Serial No. 612,858, filed September 28, 1956, now Patent 2,859,738, issued Nov. 11,

1958, in the name of Robert R. Campbell, its operation will not be described in detail here.

The output of the multivibrator is a negative-going pulse which is coupled to the base electrode of transistor 25 by capacitor 24. The capacitor charges through the base and emitter electrodes of the transistor which provide a low impedance path for this purpose. Since this path will present a high impedance for the discharge of capacitor 24, a diode 13 is provided to furnish a low impedance path for this purpose.

The output of the final amplifier stage 27 is applied by way of conductor 28, resistor 29 and conductor 30 to the contact element 31 and thence by the segment 33 to the solenoid 34.

The waveform 50 is applied to the base electrode of the transistor 38 concurrently with its application to the capacitor 9. In response to each of the negative-going excursions of the waveform 50, this transistor, by virtue of its connections as a blocking oscillator of known configuration, produces in the coil 43 a pulse of current which provides, at the upper end of the coil, as shown, a pulse of positive voltage. The amplitude of this pulse is much greater than that of the pulse applied to the solenoid by way of resistor 29, and the duration is much shorter. The pulse is applied to the solenoid by way of diode 44, conductor 30, and contact elements 31 and 33.

The diode 44 decouples the blocking oscillator from the multivibrator output at the termination of the pulse output of the blocking oscillator. The blocking oscillator pulse quickly opens the valve and the pulse from the multivibrator holds the valve open for its duration.

What is claimed is:

1. A system for injecting measured amounts of fuel into the cylinders of an internal combustion engine in synchronism with the rotation thereof, comprising: a solenoid controlled valve for each of said cylinders, said valve when open allowing the injection of fuel therethrough, a first electrical circuit operable when triggered to produce a sustained voltage pulse of substantially uniform amplitude, said amplitude being sufficient, when said pulse is applied to one of said solenoids, to maintain the valve associated therewith in its open position, a second electrical circuit, operable when triggered to produce a voltage pulse of greater magnitude and shorter duration than the voltage pulse produced by said first electrical circuit, means combining the outputs of said first and second electrical circuits, means simultaneously and repetitively triggering said first and second electrical circuits in synchronism with the rotation of said engine, and means applying said combined outputs sequentially to said solenoids in synchronism with said triggering action.

2. The system of claim 1, including means decoupling said second electrical circuit from the output of said first electrical circuit at the termination of each of said voltage pulses forming the output of said second electrical circuit.

3. In a system for injecting measured amounts of fuel into the cylinders of an internal combustion engine in synchronism with the rotation thereof in which there is provided an electrical circuit producing, when triggered, a pulse of electrical current, a solenoid controlled valve for each of said cylinders, the solenoid of which is responsive to any of said pulses to open said valve for the duration thereof, and means applying said pulses in sequence to the solenoids of said solenoid controlled valves; means for insuring the rapid opening of said valves comprising: a blocking oscillator, means simultaneosuly triggering said blocking oscillator and said electrical circuit in sychronism with the rotation of said engine and means combining the output of said blocking oscillator with that of said electrical circuit for application to said solenoids.

4. In a system for injecting measured amounts of fuel into the cylinders of an internal combustion engine in synchronism with the rotation thereof in which there is

provided an electrical circuit producing when triggered, a pulse of electrical current, a solenoid controlled valve for each of said cylinders, the solenoid of which is responsive to one of said pulses to open said valve for the duration thereof, and means applying said pulses in sequence to the solenoids of said solenoid controlled valves; means for insuring the rapid opening of said valves comprising: a blocking oscillator, means simultaneously triggering said blocking oscillator and said electrical circuit in synchronism with the rotation of said engine, means combining the output of said blocking oscillator with that of said electrical circuit for application to said solenoids, and means decoupling said blocking oscillator from the output of said electrical circuit at the termination of each voltage pulse comprising the output of said blocking oscillator.

5. Means for the rapid energization of a solenoid comprising control means, a first electrical circuit including said solenoid and operable when triggered to produce a sustained voltage pulse of substantially uniform amplitude, said amplitude being sufficient to maintain said solenoid in an energized state, a second electrical circuit including said solenoid and operable when triggered to produce a voltage pulse of like polarity and of greater amplitude and shorter duration than the voltage pulse produced by said first electrical circuit, means responsive to said control means for simultaneously triggering said first and second electrical circuits and means applying the outputs of both said circuits to said solenoid.

6. Means for the rapid energization of a solenoid comprising control means, a first electrical circuit including said solenoid and operable when triggered to produce a sustained voltage pulse of substantially uniform amplitude, said amplitude being sufficient to maintain said solenoid in an energized state, a second electrical circuit including said solenoid and operable when triggered to produce simultaneously a voltage pulse of like polarity and of greater amplitude and shorter duration than the voltage pulse produced by said first electrical circuit, means responsive to said control means for simultaneously triggering said first and second electrical circuits, means applying the outputs of both said circuits to said solenoid, and means decoupling said second electrical circuit from the output of said first electrical circuit at the termination of the voltage pulse forming the output of said second electrical circuit.

7. Means for the rapid energization of a solenoid comprising a monostable multivibrator electrical circuit including said solenoid and operable when triggered to produce a sustained voltage pulse of substantially uniform amplitude, said amplitude being sufficient to maintain said solenoid in an energized state, a blocking oscillator electrical circuit including said solenoid and triggered to produce a voltage pulse of like polarity and of greater amplitude and shorter duration than said sustained voltage pulse, means simultaneously triggering said oscillator and multivibrator circuits and means applying the outputs of both said circuits to said solenoid.

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