

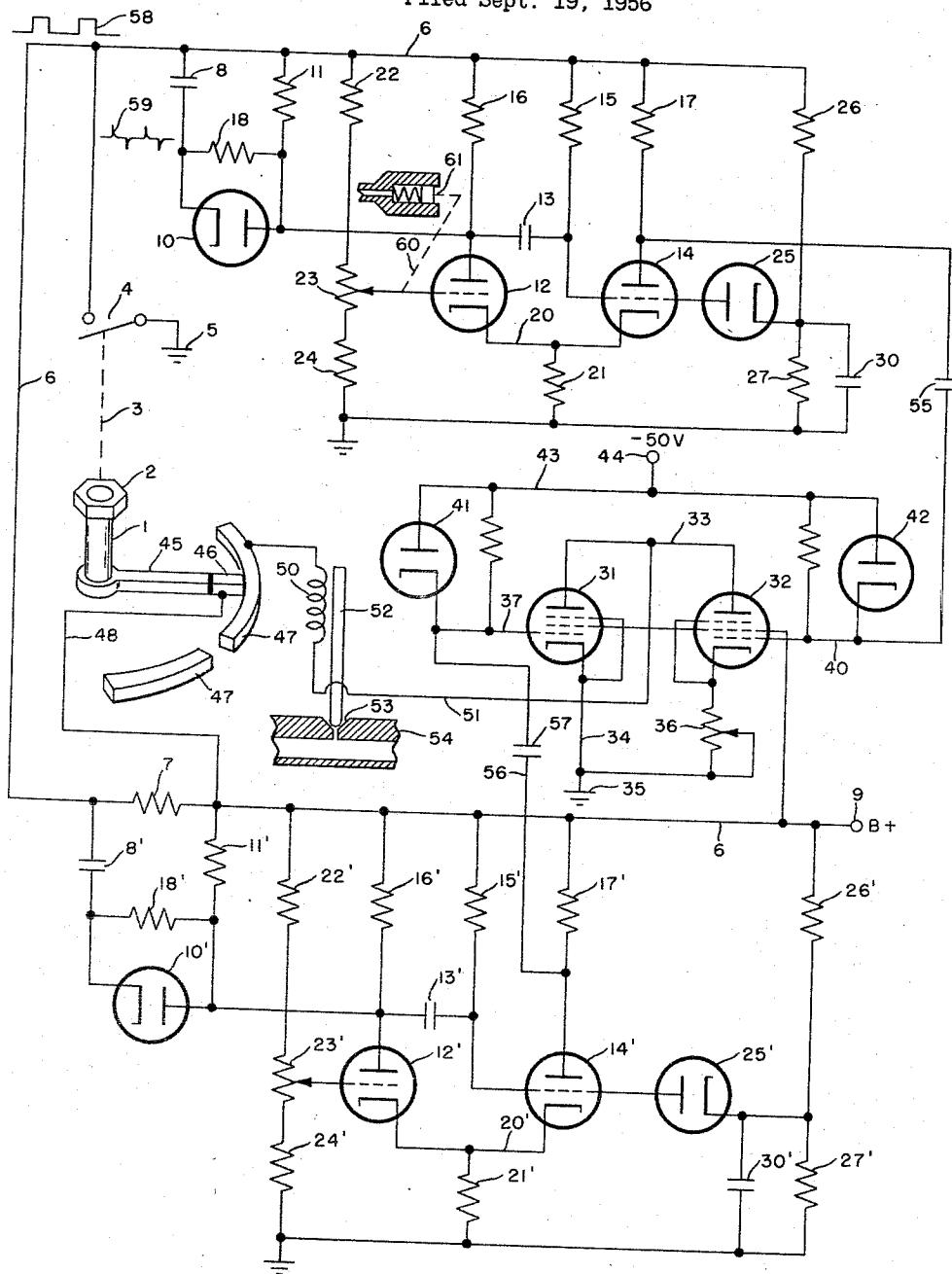
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FUEL INJECTION CONTROL SYSTEM

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FUEL INJECTION CONTROL SYSTEM

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2 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. application Serial No. 567,688, filed February 24, 1956, 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 a resulting wasteful current drain.

It is also desirable to provide a pulse duration control for use during engine idling which is separate from the control of pulse duration in response to throttle opening which takes place in normal operation.

It is an object of this invention to provide, in a system as referred to above, a means for causing each pulse 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 a means for independently varying the duration of each portion of the pulse.

It is another object to provide a means for controlling pulse duration during the idling of the engine which is independent of the control of pulse duration during operation in response to throttle opening.

These and other objects and advantages of the invention are realized in a system in which two multivibrators are simultaneously triggered in synchronism with engine operation. One of the multivibrators has an output of short duration, high amplitude pulses, while the other has an output of longer duration, lower amplitude pulses. The outputs of these multivibrators are combined and applied to the valve solenoids. Means are provided for separately controlling the duration of the pulses of each output.

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In the drawing, the single figure is a schematic diagram of a circuit embodying the invention.

Referring more particularly to the drawing, there is shown a shaft 1 which rotates in synchronism with engine operation and may, for example, be the distributor shaft. Mounted on the shaft for rotation therewith is a lobed cam 2, having one lobe for each engine cylinder. The cam drives, through a mechanical linkage 3, one contact of a single pole, single throw switch 4, which contact is connected to a voltage reference plane indicated as ground at 5. The other contact is connected by a conductor 6 through a resistor 7 to the positive terminal 9 of a source of supply voltage.

The said other contact is also connected through a capacitor 8 to the cathode of a diode 10 and through a resistor 11 to the plate of the same diode. The diode is shunted by a resistor 18. The plate of the diode is also connected to the plate of a triode 12 and by a capacitor 13 to the control grid of a triode 14, which grid is also connected to the conductor 6 by way of a resistor 15. The plates of tubes 12 and 14 are connected by respective resistors 16 and 17 to the conductor 6 and their cathodes are directly connected by a conductor 20 and are connected by way of a resistor 21 to ground.

Three resistors 22, 23 and 24 form a voltage divider between conductor 6 and ground, a movable tap on resistor 23 being connected to the grid of tube 12. The grid of tube 14 is connected to the plate of a diode 25, the cathode of which is connected to the junction of a pair of resistors 26 and 27 connected in series between the conductor 6 and ground. The resistor 27 is shunted by a capacitor 30.

The elements 7, 8, 10, 11 and 18 form a trigger circuit for a monostable multivibrator composed of the tubes 12 and 14 and their associated components. A second and identical trigger circuit and multivibrator combination is shown on the lower part of the drawing. The reference numerals applied to the respective components of this combination are the same as those applied to the corresponding components of the combination just described, the numbers being primed.

There are also shown a pair of tubes 31, 32 of the pentode type, having their plates interconnected by a conductor 33. Their cathodes are also interconnected by a conductor 34 which is grounded at 35. Between the ground connection and the cathode of tube 32 is a variable resistor 36. The control grids of tubes 31 and 32 are connected by respective conductors 37 and 40 to the cathodes of diodes 41 and 42, the plates of which are connected by a conductor 43 to the negative terminal 44 of a source of bias voltage.

The shaft 1 also carries, for rotation therewith, an arm 45, which terminates in a contact element 46 insulated therefrom. The element 46 makes sequential wiping contact with a plurality of contact segments 47, one for each engine cylinder, of which only two have been shown. Each of the elements 47 is connected to one terminal of a respective coil 50, only one of which has been shown. The remaining terminals of all the coils 50 are connected by a conductor 51 to the conductor 33 and the plates of tubes 31, 32. The element 46 is connected by a conductor 48 to the conductor 6.

The coils 50 are solenoids each operating one of the fuel injection valves. The mechanism of one valve is schematically indicated adjacent coil 50 as a valve rod 52 which is the armature of the solenoid. The lower end of the rod seats in a seat 53 formed in the manifold 54 adjacent one of the engine cylinders. Fuel under constant pressure is supplied to each valve by means not shown and is admitted through the valve only when the rod is raised by action of the solenoid.

The output of the multivibrator consisting of tubes 12, 14 is applied by way of conductor 40 and a coupling capacitor 55 to the control grid of tube 32. Likewise the output of the multivibrator 12', 14' is applied by conductor 56, capacitor 57 and conductor 37 to the control grid of tube 31.

In the operation of the system described above, the operation of the switch 4 alternates the voltage on the conductor 6 between that existing at the reference plane 5 and terminal 9 resulting in a voltage of square waveform as at 58. This waveform is differentiated by the capacitor 8 and the resistor 18 to produce a waveform as indicated at 59. The negative-going spikes of this waveform are passed by the low impedance of the diode 10, the positive spikes being attenuated.

In the multivibrator formed by tubes 12, 14, the tube 14 is normally conducting with the tube 12 biased to cut-off due to the common connection of the cathodes. When the negative spike of the waveform 59 is applied to the control electrode of tube 14 its conduction is decreased and there is inaugurated a regenerative action through the tube 12 which rapidly places that tube in conduction and cuts off the tube 14, in a manner well known to those skilled in the art. In this process the capacitor 13 becomes charged and the resulting condition of conduction and cut-off in the tubes 12 and 14 is maintained thereby for a length of time depending on the position of the movable contact on the variable resistor 23. The diode 25 and the resistors 26 and 27 set an upper limit to the positive level of voltage on the grid of tube 14.

As a result of this operation, the multivibrator 12, 14 generates a square topped voltage pulse in response to each negative spike of waveform 59. This output is applied by way of conductor 40 and capacitor 55 to the control grid of tube 32.

The trigger circuit and multivibrator in the lower portion of the drawing operate in the same manner as the portion of the system just described. The output of the multivibrator 12', 14' is applied by way of conductor 56, capacitor 57 and conductor 37 to the control grid of tube 31. The diodes 41, 42 provide low impedance paths for the discharge of the capacitors 55 and 57 at the termination of the positive output pulses of the multivibrators.

The fact that the two multivibrators are simultaneously triggered insures that the leading edges of their output pulses are coincident. Their respective durations are governed by the positions of the movable contacts of the variable resistors 23 and 23'. To provide separate control for idling one of these may be driven by a linkage connected with the throttle as a function of throttle opening and the other by a manual control means as a control for the idling speed of the engine.

In the circuit, as shown, the throttle controlled resistor would be 23, shown connected by a mechanical linkage 60 to a manifold vacuum controlled piston 61.

The resistor 23' would be manually controlled to provide for a duration of the output pulse of multivibrator 12', 14' which is of the order of, but greater than the minimum duration of the output of multivibrator 12, 14.

The amplitude of the response of the amplifier 32 to the output of multivibrator 12, 14 is controlled by the variable resistor 36 in its cathode circuit. The amplitude of this response is kept just sufficient to maintain the valve in its open position. The amplitude of the response of the tube 31 is made sufficiently high to insure quick opening of the valves.

The outputs of both tubes 31 and 32 are combined and applied by conductor 51 to the various solenoids in sequence, the circuit being completed through the segment 47, contact element 46, conductor 48, conductor 6 and the supply source.

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 operated valve for each of said cylinders, said valve when open allowing the injection of fuel there-through, a pair of multivibrator circuits each operable when triggered to produce a sustained voltage pulse of substantially uniform amplitude, means simultaneously and repetitively triggering said multivibrator circuits in synchronism with the operation of said engine, means controlling the duration of each pulse of the output of one of said multivibrators in accordance with the position of the throttle of said engine, means causing the duration of the pulses in the output of the other of said multivibrators to be at least as great as the minimum duration of said pulses in the output of said one multivibrator, means causing the amplitude of said pulses in the output of said one multivibrator to be less than that of said pulses in the output of said other multivibrator, means combining said outputs and means applying said outputs sequentially to the solenoids of said valves as energizing voltage.
2. 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 operated valve for each of said cylinders, said valve when open allowing the injection of fuel there-through, a pair of pulse producing circuits each operable when triggered to produce a sustained voltage pulse of substantially uniform amplitude, means simultaneously and repetitively triggering said pulse producing circuits in synchronism with the operation of said engine, means controlling the duration of each pulse of the output of one of said pulse producing circuits in accordance with the position of the throttle of said engine, means causing the duration of the pulses in the output of the other of said pulse producing circuits to be at least as great as the minimum duration of said pulses in the output of said one pulse producing circuit, means causing the amplitude of said pulses in the output of said one pulse producing circuit to be less than that of said pulses in the output of said other pulse producing circuit, means combining said outputs and means applying said outputs sequentially to the solenoids of said valves as energizing voltage.

No references cited.