

[54] **TEMPERATURE-DEPENDENT TIME-DELAY SWITCH**

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[56]

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[57]

ABSTRACT

A Miller integrator is connected to the output of a circuit the output current of which is dependent on the temperature of a temperature-dependent resistor responsive to engine temperature. A switching stage which controls the current through the starting valve of the engine is turned off when the current in the Miller integrator reaches a predetermined value after a time delay that depends on the temperature of the temperature-dependent resistor.

15 Claims, 2 Drawing Figures

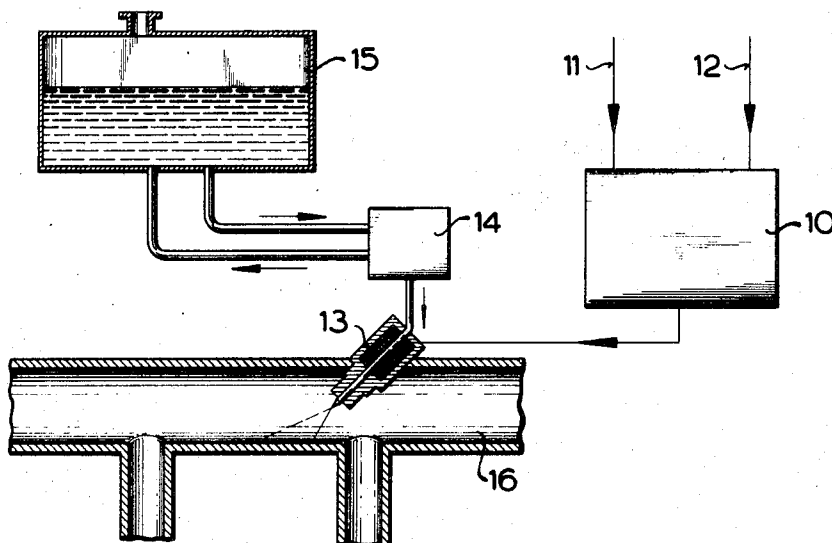


FIG.1

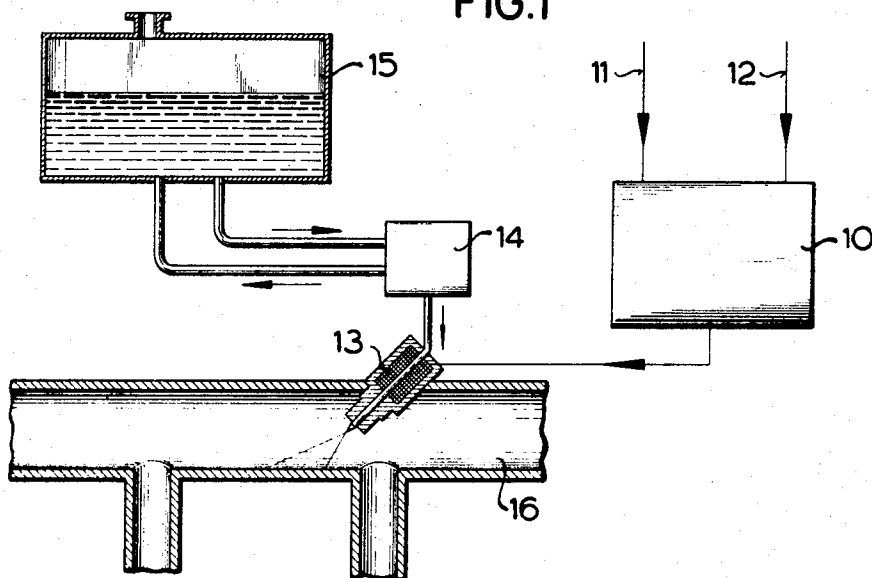
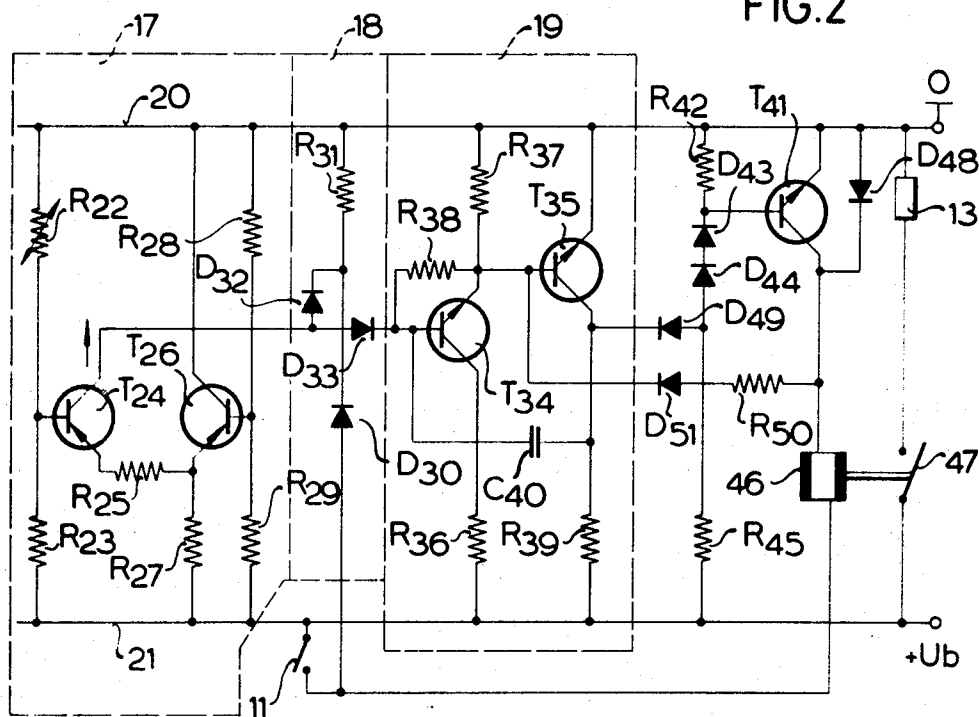


FIG.2



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TEMPERATURE-DEPENDENT TIME-DELAY SWITCH

BACKGROUND OF THE INVENTION

The invention relates to an auxiliary starting arrangement having a time-delay switch, for fuel-injection internal combustion engines, the delay of the time-delay switch being dependent on the temperature of a temperature-dependent resistor.

There are known in the prior art circuits having voltage-dependent resistors in bridge circuits. The voltage is conducted from the bridge diagonal, amplified, and then processed for feeding a meter, for example, or for controlling some device. Also known are electronic time-delay switches incorporating temperature-dependent resistors that compensate for bothersome ambient temperature fluctuations. The combination of known bridge circuits and known time-delay switches into an electronic time-delay switch, and time delay of which is dependent on some temperature, requires a very sophisticated knowledge of electronic circuitry.

SUMMARY OF THE INVENTION

An object of the invention is a simple yet efficacious time-delay arrangement that is reliable in operation and well stabilized against ambient temperature fluctuation.

The arrangement of the invention is fully equal to the demands made on it for operation in motor vehicles.

The arrangement of the invention consists essentially of electrically operated starting valve means having open and closed positions, electric circuit means, and means for simultaneously opening the valve means and energizing the circuit means, the circuit means comprising temperature-dependent resistor means responsive to engine temperature, a first circuit portion having an input and an output, the input being connected to the temperature-dependent resistor means so that the output has an output current that is dependent on the value of the resistor means, a second circuit portion comprising a Miller integrator circuit connected to the output, the Miller integrator circuit having also an output, normally conductive electronic switch means for closing the valve means when non-conductive, the electronic switch means being connected to the Miller integrator circuit output to be rendered non-conductive when the current of that output reaches a predetermined value.

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 schematically shows a use of the invention in an internal combustion engine with fuel injection, and

FIG. 2 shows a circuit diagram of the arrangement of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference to FIG. 1, a time-delay switch 10 is energized by the internal combustion engine starting switch 11, shown in FIG. 1 as a vertical line with an arrow. At 12 a temperature-dependent resistor (R22 in FIG. 2), responsive to the reference temperature, such as the engine temperature, provides for the switch 10 a signal indicative of the reference temperature. The time-delay switch 10 opens, for an interval dependent on the reference temperature, a starting valve 13, to which a pump 14 supplies fuel from a tank 15. As long as the starting valve 13 is open, fuel is furnished to the intake manifold 16 of an internal combustion engine, not shown.

The arrangement operates in the following manner. If a start signal is conducted at 11 to the electronic time-delay switch 10 when the first or starting switch 11 is closed to start up the engine, the switch 10 is triggered to its unstable state. The length of time that the switch remains in this state depends on the reference temperature, the signal of which is conducted to the switch 10 at 12. The output of the time-delay switch 10 is connected to the electrical winding of the starting valve 13, so that the latter is held open during the starting-up period of the engine. During this interval of time fuel is sprayed into the intake manifold 16 through the open valve 13. Once this period of time is up, which period is dependent on the reference temperature, the electronic time-delay switch 10 is triggered to its stable state, and the starting valve 13 is again closed. After starting, for a brief period of time determined by the time-delay switch 10, an additional amount of fuel is added to the engine. The total amount of excess fuel supplied depends, for example, on the temperature of the engine, so that when the latter is hot, a smaller, and when cold, a larger, amount of fuel is sprayed into the intake manifold 16.

A circuit diagram of the time-delay switch 10 is shown in FIG. 2. The circuit comprises temperature-sensing means 17, Miller integrator 19, and actuating means including switch 11, as well as those components to the right (in FIG. 2) of integrator 19. The actuating means has an output at the anode of diode D30. A voltage divider, composed of the temperature-sensitive resistor R22 and a resistor R23 connected in series, is connected between the ground line 20 and the positive battery line 21. The junction between the two resistors R22 and R23 is connected to the base of a first transistor T24, the emitter of which is connected by a resistor R25 to an emitter-follower stage composed of a second transistor T26 and a resistor R27. The emitter follower transistor provides thermal compensation, as explained below. The base of transistor T26 is connected to the tap of a voltage divider composed of the series-connected resistors R28 and R29 connected between the lines 20 and 21. The starting switch 11, connected to the positive supply line 21, is connected to the ground or negative supply line 20 by a first diode D30 connected in series with a resistor R31. Consequently, the anode of the diode D30 is connected to the first or starting switch 11. A second diode D32 is connected conductively between the collector of the transistor T24 and the cathode of diode 30. A third diode D33 is connected conductively between the col-

lector of transistor T24 and the base of a transistor T34. The Miller integrator 19 is composed of transistors T34 and T35. The collector of transistor T34 is connected by resistor R36 to the line 21, and the emitter of this same transistor is connected by a resistor R37 to the line 20. A resistor R38 connects the base of transistor T35 to the base of transistor T34. The emitter of transistor T35 is connected directly to the ground line 20, and the collector is connected through resistor R39 to the positive line 21. An integrating capacitor C40 is connected between the collector of transistor T35 and the base of transistor T34. A second switch or switching stage, comprising the transistor T41, is connected to the Miller integrator 19. The base of transistor T41 is connected by a resistor R42 to the line 20, and by the series-connected diodes D43, D44 and resistor R45 to the line 21. Components R42, D43, D44 and R45 compose a voltage divider. The diodes D43 and D44 are connected to conduct. The emitter of transistor T41 is connected to the line 20, and the collector is connected through a relay 46 to the starting switch 11, the other terminal of which is connected to the line 21. When the starting switch 11 is closed, the relay 46 is connected in the collector circuit of transistor T41, and its operating contact 47 is closed when the transistor T41 conducts. Transistor T41 is protected against high voltage peaks that can appear when the relay 46 opens by a diode D48 shunted across the collector-emitter path of transistor T41, with the polarity of the diode such that the diode conducts in the direction opposite to current flow along this path. The starting valve 13 is connected in series with the relay operating contact 47. The switching amplifier, or switching stage, is connected to the Miller integrator by a diode D49, the cathode of which is connected to the collector of transistor T35, which latter is of an npn-type. To protect transistor T41 against destruction by short-circuit, its collector is connected to the base of transistor T35 by a series-connected resistor R50 and diode D51. The electrical input to the actuating means of FIG. 2 comprises the cathode terminal of diode D49. As explained below, when the input signal furnished by integrator 19 to the electrical input reaches a predetermined value, the aforementioned valve closes, in this embodiment. The actuating means has an output at the anode of D30 and produces there an integrate signal when the valve is opened.

The circuit just described operates in the following manner.

The temperature-dependent resistor R22 is always at the reference temperature and, for example, is contained in a temperature-sensing device that is mounted on the internal combustion engine. At low temperatures the resistor R22 has a high resistance, and at high temperatures a low resistance. The voltage at the base of transistor T24 depends upon the temperature of resistor R22. Since the emitter voltage of transistor T26 is approximately constant, because the voltage divider R28 and R29 keeps the base of this transistor at a fixed voltage, the current flowing through the transistor T24 depends upon the size of the resistor R25 and upon the voltage difference between the emitters of transistors T24 and T26. When the starting switch 11 is closed, the diode-resistor network 18 provides a path for the current of transistor T24 to flow to the Miller integrator

19. If the starting switch 11 is open, the first diode D30 does not conduct, and current from transistor T24 flows through the second diode D32 and the resistor R31 to ground. The resistor R31 is so low in value that the Miller integrator 19 does not conduct. If the starting switch 11 is closed, diode D30 conducts, and the cathode of diode D32 is consequently positive, so that this diode does not conduct. Current from the transistor T24 flows through the de-coupling diode D33 to the base of transistor T34 of the Miller integrator 19. At the same time that the starting switch 11 is closed, the relay 46 is energized, since the transistor T41 is turned on. The closing of the operating contact 47 of the relay 46 connects the starting valve 13 to the battery voltage, thereby opening the valve and admitting additional fuel into the intake manifold 16. In dependence on the amount of current supplied by the transistor T24, the Miller integrator now begins to integrate, the collector potential of transistor T35 falling with a rapidity that depends on the amount of current flowing into the transistor T34 from transistor T24. As soon as the collector potential reaches a value at which the diode D49 becomes conductive, the transistor T41 turns off; the relay 46 is therefore de-energized, and the starting valve 13 is closed.

If there is a change in the ambient temperature in which the unit 17 operates, the characteristics of the two transistors T24 and T26 change in an approximately similar manner, whereby the current furnished by the transistor T24 to the transistor T34 of the Miller integrator 19 is independent of transistor changes associated with the ambient temperature, but is always a function of the value of the temperature-dependent resistor R22. The transistor T26, connected as an emitter-follower, insures in a very simple way a sufficiently accurate temperature compensation of the first circuit portion 17. As against a switch with movable contacts, the resistor-diode network 18 has the advantage that no high peak voltages are conducted to the electronic components, since these latter are easily harmed by excessive voltage. The use of a Miller integrator instead of a multivibrator, comprising a changeable resistor that varies the time of return to the other state, has the advantage that the Miller integrator remains continuously turned hard on after its initial delay period; and the circuit can remain energized without affecting the starting valve 13. The latter, for example, cannot be accidentally operated. Only after the starting switch 11 is re-opened and then re-closed does the time-delay switch 10 of the invention begin to operate anew to actuate the starting valve 13.

The circuit of the invention also has a simple and dependable short-circuit protection. When the engine is started up, the supply voltage for the electrical equipment on the motor vehicle is provided before the closing of the starting switch 11. The base-emitter path of transistor T41 is made conductive through the resistors R42 and R45, as well as through the diodes D44 and D43. If the switch 11 is now closed, the transistor T41 is turned on very quickly, since its base-emitter path is already at the potential necessary for conduction. The time necessary for the path composed of the resistor R50 and the diode D51 to become conductive is therefore greater than the turn-on time of the transistor T41. Once the latter is conductive, the terminal of the re-

sistor R50 connected to its collector is approximately at ground potential. The diode D51 remains non-conductive, and the aforesaid path remains without effect. If a short-circuit occurs in the switching amplifier stage or in the relay 46, the collector of transistor T41, and therefore the aforesaid terminal of resistor R50, is at ground potential. If as a consequence of a short-circuit in relay 46 the collector of transistor T41 is positive, transistor T35 is turned on and transistor T41 is therefore turned off. Only during the time that the former transistor is turning on and the latter transistor is turning off does a short-circuit current flow.

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 circuits differing from the types described above.

While the invention has been illustrated and described as embodied in a temperature-dependent time-delay switch, 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 features of the generic or specific aspects of the 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:

1. In an auxiliary starting arrangement for a fuel-injection internal combustion engine, in combination an electrically operated fuel-injection valve; actuating means having an electrical input, and being operative for opening said valve and therewith generating an integrate signal and for closing said valve when the input signal at said electrical input reaches a predetermined value; temperature-sensing means for producing a temperature signal indicative of a sensed temperature associated with said engine; and integrating circuit means for applying to said electrical input an input signal which has an initial value and which upon generation of said integrate signal departs from said initial value towards said predetermined value in correspondence to the time integral of said temperature signal and reaches said predetermined value after a time interval the length of which is a function of said temperature signal.

2. In an arrangement as defined in claim 1, said temperature sensing means including a temperature-dependent resistor, variations in the resistance of said resistor producing corresponding changes in the value of said temperature signal.

3. In an arrangement as defined in claim 1, said temperature-sensing means including a voltage divider comprising a temperature-dependent resistor and a voltage tap, and further including a first transistor whose base is biased by the tap voltage of said voltage divider, whereby variations in said sensed temperature will produce corresponding variations in the collector current of said first transistor.

4. In an arrangement as defined in claim 2, said temperature sensing means further including thermal compensation means for preventing changes in the value of said temperature signal other than those resulting from variations in said resistance of said temperature-dependent resistor, whereby said temperature signal will constitute an accurate indication of said sensed temperature.

5. In an arrangement as defined in claim 3, said temperature sensing means further including thermal compensation means comprising an emitter-follower transistor in circuit with said first transistor, variations in the base-emitter voltage of said emitter-follower transistor substantially compensating corresponding variations in the base-emitter voltage of said first transistor.

6. In an arrangement as defined in claim 1, wherein said valve has an electrical valve control input; said actuating means including supply means supplying electrical energy, and further including switch means in circuit with said valve control input and supply means, for causing opening and closing of said valve.

7. In an arrangement as defined in claim 6, said switch means including first and second switches connected in circuit, closing of said first switch causing closing of said second switch and opening of said valve for a time interval dependent on said sensed temperature.

8. In an arrangement as defined in claim 7, said second switch being an electronic switch provided with said electrical input, and opening when the signal at said electrical input reaches said predetermined value.

9. In an arrangement as defined in claim 6, said integrating circuit means having an input and said temperature sensing means having an output at which said temperature signal is produced, and said switch means being connected with said output of said temperature sensing means and said input of said integrating circuit means and connecting the same when said valve is opened.

10. In an arrangement as defined in claim 9, said switch means including a diode switching network connecting said output of said sensing means and said input of said integrating circuit means.

11. In an arrangement as defined in claim 1, said integrating circuit means comprising a Miller integrator stage.

12. In an arrangement as defined in claim 11, said temperature sensing means having an output at which is generated said temperature signal, said Miller integrator stage having at its input a diode-resistance network, said diode-resistance network connected with the output of said temperature sensing means and further with said actuating means.

13. In an arrangement as defined in claim 8, said electronic switch comprising a switching transistor whose collector-emitter path is connected in circuit with said valve control input, and said actuating means further including protection means for protecting said switching transistor against damage due to sudden energy changes resulting upon opening and closing of said electrically operated valve.

14. In an arrangement as defined in claim 13, said protection means including current shunt means connected in circuit with said switching transistor for

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shunting excessive currents away from said switching transistor.

15. In an arrangement as defined in claim 13, said protection means including a diode-resistor path connected in circuit with said switching transistor and said integrating circuit means, and causing the latter to

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furnish to said electrical input of said switching transistor an input signal causing said switching transistor to become non-conductive when the collector-emitter voltage thereacross substantially reaches a predetermined undesired value.

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