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Suda

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[54] **FUEL SUPPLY CONTROL SYSTEM FOR INTERNAL COMBUSTION ENGINES**

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[51] **Int. Cl.** **F02b 3/00,** F02d 31/00

[58] **Field of Search** ....123/32 EA, 32 E, 123/97 B, 97

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[57] **ABSTRACT**

A fuel supply control system for internal combustion engines for controlling the fuel supply controlling electromagnetic valves on the basis of processing electric signals representing respective engine operating parameters such as engine intake manifold negative pressure and engine r.p.m., wherein the electromagnetic valves are rendered inoperative to cut the fuel supply if the engine r.p.m. is above a predetermined value and if the angular speed of the motion of the engine throttle in the direction of closing the engine throttle valve exceeds a predetermined value.

5 Claims, 4 Drawing Figures

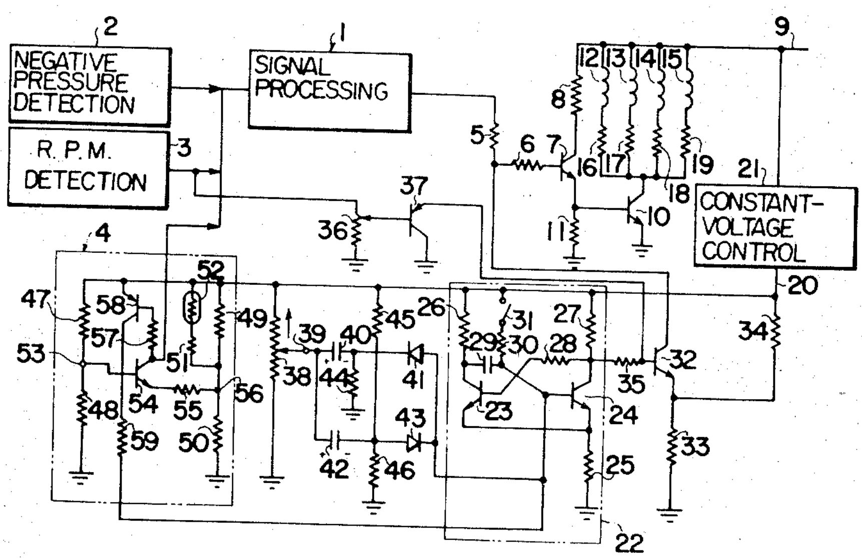


FIG. 1a

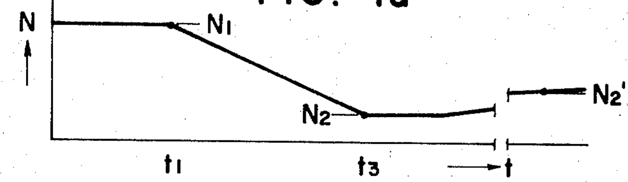


FIG. 1b

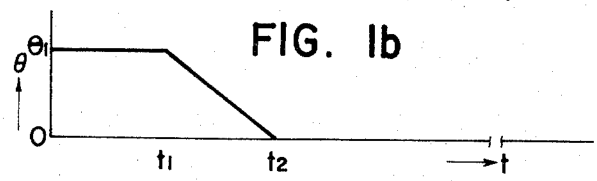


FIG. 1c

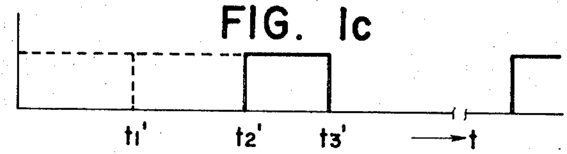
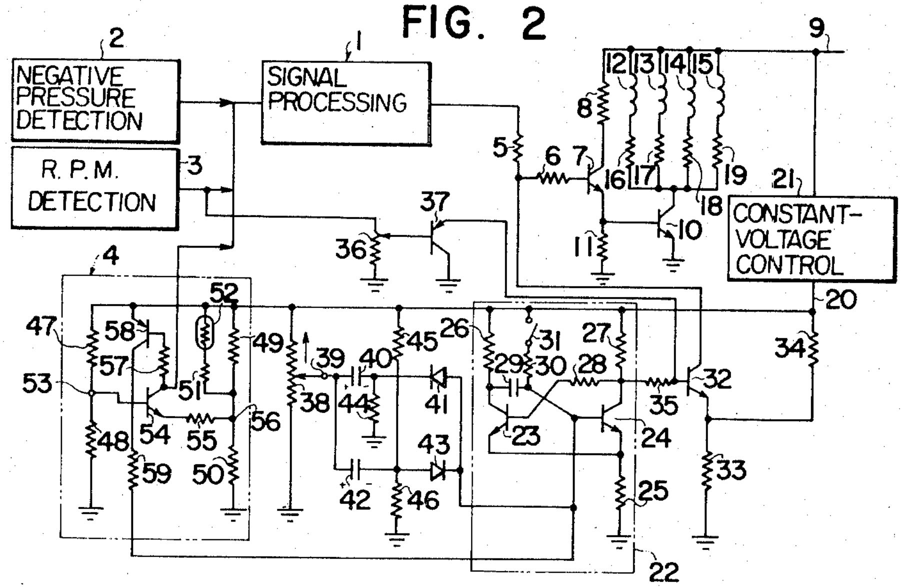


FIG. 2



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FUEL SUPPLY CONTROL SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to fuel supply control systems for internal combustion engines. More particularly, the invention concerns a fuel injection control system in which uncombusted fuel gas resulting in such cases as suddenly closing the engine throttle valve to decelerate the engine is minimized.

2. Description of the Prior Art

It is well known in the art to control the fuel supply to the internal combustion engine by electrically computing the duration during which fuel supply control electromagnetic valves are held operative on the basis of electric signals derived from corresponding engine-operating parameters. A typical example of the fuel supply control system, in which the exact fuel supply is computed from many engine-operating parameters, is disclosed, for instance, in U.S. Pat. No. 2,980,090 (application Ser. No. 637,852, filed on Feb. 4, 1957, assigned to the Bendix Corporation, patented on Apr. 18, 1961).

To the ends of increasing the brake force, reducing the fuel consumption and purification of the exhaust gas, it is extremely advantageous to cut the fuel supply to the fuel supply controlled engine on an automobile or similar vehicle during the coasting of the engine. To these ends, many Venturi type carburetors and fuel injection type fuel control systems are provided with a means to cut fuel during the coasting of the engine. With these prior art fuel supply control systems, however, the fuel supply is cut when two conditions, that the engine throttle valve is closed and that the engine r.p.m. is detected to be above a certain value for the warming-up of the idling engine are satisfied, and it is resumed when the engine r.p.m. is reduced to the afore-said value. Therefore, with these control systems the fuel supply is not cut during the quasi-coasting (during which the engine throttle valve is still not closed) and during the transition period until the closure of the throttle valve, thus reducing the effect of attaining the above ends by cutting the fuel supply that much.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a fuel supply control system, in which the fuel supply is immediately cut when the coasting state of the engine is reached.

Another object of the invention is to provide a fuel supply control system, in which the resumption of the fuel supply is promptly effected at the time of changing of the engine's state from coasting to acceleration.

A further object of the invention is to provide for the reduction of the warming-up period of the engine by such an arrangement as to retain the fuel supply while the engine is being warmed up.

These and other objects of the invention will become more apparent from the description of the preferred embodiment of the invention.

The features of the invention reside in the provision of a means to control the fuel supply control electromagnetic valves in accordance with the results of electrical computation involving engine-operating parameters determining the fuel supply to the engine and a means to render inoperative the afore-said means to control the electromagnetic valves when the speed of the throttle motion in the direction of closing the throttle valve exceeds a predetermined value while the engine r.p.m. is above a predetermined value.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1*a* is a plot representing engine r.p.m. with respect to time.

FIG. 1*b* is a plot representing throttle angle with respect to time.

FIG. 1*c* is a fuel cut-off characteristic with respect to time.

FIG. 2 is a circuit diagram showing an embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Prior to describing a preferred embodiment of the invention, a fuel cut-off characteristic, which is conventionally attainable, will first be described in connection with FIGS. 1*a*, 1 1*b* and 1*c*.

It is now assumed that the engine r.p.m. N and the throttle angle θ begin to decrease at instant t_1 from their initial values N_1 and θ_1 as shown in FIGS. 1*a* and 1b, and that the throttle angle θ is reduced to zero (corresponding to the idling position of the throttle) at instant t_2. The engine r.p.m. will be reduced to predetermined idling value N_2 at a later instant t_3 due to the momentum. A conventional fuel supply cut-off means operates to cut fuel at the instant t_2, at which the throttle angle θ is reduced to zero, and to resume the fuel supply at an instant t_3' immediately before the engine reaches the r.p.m. to the predetermined idling value N_2, as shown in FIG. 1*c*. If the engine is being warmed up, the engine r.p.m. is increased above the predetermined normal idling speed N_2 at the time of reaching a zero angle of the throttle position, so that it is necessary to preset a higher idling r.p.m. N_2' to cut the fuel supply when the r.p.m. is reduced to N_2' under the warming-up engine condition. This is important from the aspect of providing an increased braking force and minimizing incomplete combustion of the air-fuel mixture. It will aid in advantageously solving the exhaust gas problems. It is also important to serve the object of completing the warming-up of the engine as soon as feasible by cutting the fuel upon reaching as high an r.p.m. as possible.

With the afore-mentioned conventional fuel supply cut-off means, however, the fuel supply is not cut during the time interval from instant t_1 till instant t_2, during which the throttle is moving in the direction of closing the throttle valve, when decelerating the engine. Thus, during this time interval the engine produces output torque. Also, during this interval the engine intake manifold negative pressure is sharply reduced to reduce the amount of air admitted into the engine cylinders, resulting in excessive fuel supply to cause incomplete combustion of the air-fuel mixture. Further, in case of adjusting the idling r.p.m. N_2, the higher idling r.p.m. should also be adjusted at the same time, which is very inconvenient from the standpoint of maintenance.

The above drawbacks are overcome with a novel fuel supply control system according to the invention shown in FIG. 2. Referring now to FIG. 2, numeral **1** designates a signal processing means receiving the electric output signal of a negative pressure detection means **2** representing the engine manifold negative pressure, the electric output signal of an r.p.m. detection means **3** representing the r.p.m. of the engine and the electric output signal of a temperature detection means **4** representing the engine temperature. The signal processing means **1** computes the amount of fuel to be supplied from these electric signals. Its output signal is fed through resistors **5** and **6** to the base of an ampiifying n-p-n transistor **7**. The transistor **7** has its collector connected through a resistor **8** to a power supply lead **9** and its emitter connected through a resistor **11** to ground. The emitter of the transistor **7** is also connected to a control n-p-n transistor **10** having the emitter thereof connected to ground and the collector thereof connected to a parallel circuit, which consists of parallel inductors **12**, **13**, **14** and **15** connected to the common supply lead **9** and in series with respective resistors **16**, **17**, **18** and **19** commonly connected to the emitter of the transistor **10**. The inductors **12**, **13**, **14** and **15** are electromagnetic coils of the associated fuel injection control electromagnetic valve unit. Numeral **20** designates a constant-voltage supply lead leading from a constant-voltage control means **21** connected to the power supply lead **9**. Between the lead **20** and ground is connected a mono-stable multi-vibrator circuit shown as enclosed within a dashed rectangle indicated at **22**. The multi-vibrator circuit **22** includes two n-p-n transistors **23** and **24** having their emitters commonly connected through a resistor **25** to ground. The base of the transistor **23** is connected through a resistor **28** to the collector of the transistor **24**. The base of the transistor **24** is connected through a capacitor **29** to the collector of the transistor **23**. Between the lead **20** and the base of the transistor **24** is inserted a switch **31** in series with a resistor **30**. The switch **31** is opened when the throttle angle is reduced to zero (upon reaching of the idling position of the throttle). The connection between the resistors **5** and **6** is connected to the collector of an n-p-n transistor **32**, which has its emitter connected through a resistor **33** to ground and through a resistor **34** to the lead **20** and its base connected through a resistor **35** to the collector of the transistor **24** in the multi-vibrator circuit **22**. The transistor **32** serves to ground the connection between the resistors **5** and **6** so as to prevent the output signal of the signal processing means **1** from being impressed on the base of the transistor **7**. The output terminal of the r.p.m. detection means **3** is connected to one end of a potentiometer type resistor **36** grounded at the other end, so that a voltage proportional to the engine r.p.m. may be applied across the resistor **36**. The movable tap of the resistor **36** is connected to the base of a p-n-p transistor **37**, which has its collector grounded and its emitter connected to the base of the transistor **32**. Another potentiometer type resistor **38** is connected between the lead **20** and ground. Its movable terminal **39** is moved simultaneously with the engine throttle in accordance with the accelerator pedal position. It is moved in the direction of the arrow when the engine throttle is moved in the direction of opening the throttle valve. It is connected through a capacitor **40** to the cathode of a diode **41** having the anode connected to the base of the transistor **24** in the multi-vibrator circuit **22**. It is also connected through a capacitor **42** to the anode of a diode **43** having the cathode connected to the base of the transistor **24**. The connection between the capacitor **40** and the diode **41** is connected through a discharging resistor **44** to ground. The connection between the capacitor **42** and the diode **43** is connected through a resistor **45** to the lead **20** and through a resistor **46** to ground. The series resistors **45** and **46** constitute a voltage divider to hold the connection point between them at the emitter potential of the transistors **23** and **24** in the multi-vibrator circuit **22**. The temperature detection means **4** consists of a bridge circuit connected between the lead **20** and ground. It comprises resistors **47**, **48**, **49**, **50**, and a thermistor **52** having a positive characteristic connected in parallel with the resistor **49**, in a series connection of a resistor **51**. The connection point **53** between the resistors **47** and **48** is connected to the base of an n-p-n transistor **54** having the emitter thereof connected through a resistor **55** to the connection point **56** between the resistors **49** and **50** and the collector thereof connected to an input terminal of the signal processing means **1**. The collector of the transistor **54** is also connected to the base of a p-n-p transistor **58** having the emitter thereof connected to the lead **20** and the collector thereof connected through a resistor **59** to the base of the transistor **24** in the multi-vibrator circuit **22**. The circuit parameters of the temperature detection means **4** including the series connection of the resistor **51** and the thermistor **52** are set such that the bridge circuit is electrically balanced when the engine is at temperatures requiring no warming-up, and that the transistor **54** is cut off when the balanced state of the bridge circuit is brought about.

In the operation of the construction described above, under normal engine-operating conditions, under which the throttle valve is open, the switch **31** is closed, so that the transistor **24** in the mono-stable multi-vibrator **22** carries current, providing a low collector potential, and hence a low base potential of the transistor **32**, to hold the transistor **32** "off." In this state, the output signal of the signal processing means **1** concerning the amount of fuel to be supplied is fed through the transistor **7** to the base of the transistor **10**, thus effecting the control of the fuel injection control magnetic valve unit by the energization of the electromagnetic coils **12**, **13**, **14** and **15**.

Also in this state, the capacitors **40** and **42** connected to the movable terminal **39** of the potentiometer type resistor **38** are charged to the polarity as illustrated with respect to the movable terminal **39**. If now the throttle angle θ is changed, a voltage corresponding to the time differential of the change in the throttle angle is developed across the resistor **44**. The polarity of the voltage developed across the resistor **44**, if the throttle angle is reduced, that is, if the throttle is moved in the direction of closing the throttle valve (when the movable terminal is moving in the opposite direction to the direction of the arrow), is such as to reversely bias the base-emitter path of the transistor **24** in the multi-vibrator circuit **22**. Thus, the circuit parameters involved may be suitably preset such that the terminal voltage developed across the resistor 44 at the required angular speed of motion of the throttle in the direction of closing the throttle valve is just sufficient to cut off the transistor 24 in the multi-vibrator circuit 22. When the transistor 24 is cut off, its collector potential is increased to trigger the transistor 32, thus grounding the connection between the resistors 5 and 6. In this state, the output signal of the signal processing means 1 is not transmitted to the transistor 7, so that the fuel injection control electromagnetic valves are held closed to effect the cutting-off of the fuel supply to the engine.

Subsequent to the exceeding of the required angular speed of motion of the throttle in the direction of closing the throttle valve to cut the fuel supply, if the throttle is held at an intermediate position, the switch 31 remains closed, so that the fuel supply is resumed after a quasi-stable period ($t = 0.7 \times C29 \times R30$), during which the transistor 24 of the mono-stable multi-vibrator circuit 22 is held "off."

Even during the quasi-stable period, however, the fuel supply will be resumed if the throttle turns to move in the direction of opening the throttle valve. At this time, the voltage on the movable terminal 39 of the potentiometer type resistor 38 increases, causing charging current to flow into the capacitor 42. The charging current passes forward through the diode 43 into the base of the transistor 24 in the mono-stable multi-vibrator circuit 22 to forcibly trigger the transistor 24, thus resuming the fuel supply.

As soon as the throttle angle θ is reduced to zero, the switch 31 is opened, so that the transistor 24 in the mono-stable multi-vibrator circuit 22 continues to be "off" to hold the fuel cut off. However, with decreasing engine r.p.m. N the output voltage of the r.p.m. detection means 3 decreases to decrease the voltage fed through the potentiometer type resistor 36 to the base of the transistor 37. As soon as the base voltage of the transistor 37 gets lower than the emitter potential thereof, the transistor 37 is triggered, grounding the base of the transistor 32 to cut off the transistor 32, so that the fuel supply will be resumed. Thus, by suitably setting the circuit parameters involved such that the base potential of the transistor 37 gets lower than the emitter potential thereof when the engine r.p.m. is reduced to the idling speed N_2, the engine operation will not be stopped.

Under the warming-up condition of the engine (under which the engine temperature is low requiring extra fuel supply), the resistor bridge circuit of the temperature detection means 4 is in the unbalanced state. In this state, the potential at the connection point 56 is lower than the potential at the connection point 53 since the resistance of the thermistor 52 is high, so that the emitter-base path of the transistor 54 is forwardly biased and the transistor 54 carries current. Thus, the collector potential of the transistor 54 changes with change in the engine temperature, giving the corresponding electric output signal to the signal processing means 1. Also, in the above state, base current to the transistor 58 is present and the transistor 58 carries current, giving a sufficient bias voltage to the base of the transistor 24 in the monostable multi-vibrator 22. Thus, in this state even upon reaching the required angular speed of motion of the throttle valve in the direction of closing the throttle valve or even upon reduction of the throttle angle to zero to open the switch 31, the transistor 24 will not be cut off, so that the fuel supply will be maintained.

Under low temperature conditions, the engine operation is unstable, so that it is very advantageous to raise the heat of the engine to the stable engine temperature range as quickly as possible without interrupting the fuel supply in the above manner.

As has been described in the foregoing, according to the invention it is possible to provide a fuel supply control system capable of extremely effectively causing the cutting of the fuel supply to the engine.

I claim:

1. A fuel supply control system for an internal combustion engine having electro-magnetic valves for controlling the quantity of fuel supplied to the engine cylinders comprising:

a first transistor circuit, responsive to an input fuel supply signal, for controlling the activation of said valves to supply fuel to said engine;

a second transistor circuit, connected to said first transistor circuit, which, when activated, prevents said first transistor circuit from being activated by said input fuel supply signal; and

means, responsive to the engine r.p.m. being above a predetermined value and upon the rate of change of the position of the engine throttle in the direction of closing the engine throttle valve exceeding a predetermined rate, for actuating said second transistor circuit, so as to prevent said first transistor circuit from actuating said valves,

wherein said means comprises a first control circuit, coupled to said throttle, for deactivating said second transistor circuit upon the opening of said throttle, and for activating said second transistor circuit for a preselected period of time subsequent to the rate of change of position of said throttle valve, in the direction of closing the throttle valve, exceeding said predetermined rate, when said throttle remains in an intermediate position between the fully closed and fully open position thereof, and

wherein said first control circuit comprises monostable multivibrator circuit means for producing an output for said preselected period of time and having a time constant portion which determines said preselected period of time, the time constant portion of which is switchably coupled to said throttle, having its output coupled to said second transistor circuit.

2. A fuel supply control system according to claim 1, wherein said means further comprises a second control circuit coupled between said throttle and said first control circuit, for terminating the activation of said second transistor circuit by said first control circuit upon said throttle valve being opened during said preselected period of time.

3. A fuel supply control system according to claim 2, wherein said second control circuit comprises a potentiometer providing a voltage output proportional to the degree of opening of said throttle valve and a differentiator circuit connected between the output of said potentiometer and the input of said circuit means.

4. A fuel supply control system according to claim 3, wherein said means further comprises a third transistor

circuit responsive to a signal corresponding to the engine r.p.m. for ensuring the deactivation of said second transistor circuit upon said engine r.p.m. falling below a preset r.p.m.

5. A fuel supply control system according to claim **4**,

further comprising a temperature detector circuit connected to the input of said circuit means, for deactivating said second transistor circuit when the temperature of said engine is below a predetermined minimum.

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