# United States Patent

[11] 3,612,013


[72] Inventor **Charles C. Gambill**
**Kokomo, Ind.**



[21] Appl. No. **879,122**
[22] Filed **Nov. 24, 1969**
[45] Patented **Oct. 12, 1971**
[73] Assignee **General Motors Corporation**
**Detroit, Mich.**


[54] **FUEL SUPPLY CONTROL SYSTEM FOR AN INTERNAL COMBUSTION ENGINE**
**2 Claims, 1 Drawing Fig.**


[52] **U.S. Cl.** ..... **123/32 EA,** 123/97 B, 123/119, 123/139 E
[51] **Int. Cl.** ..... **F02m 51/00**
[50] **Field of Search** ..... 123/32, 32 EA, 119 R, 97 B, 139 E



[56] **References Cited**

UNITED STATES PATENTS

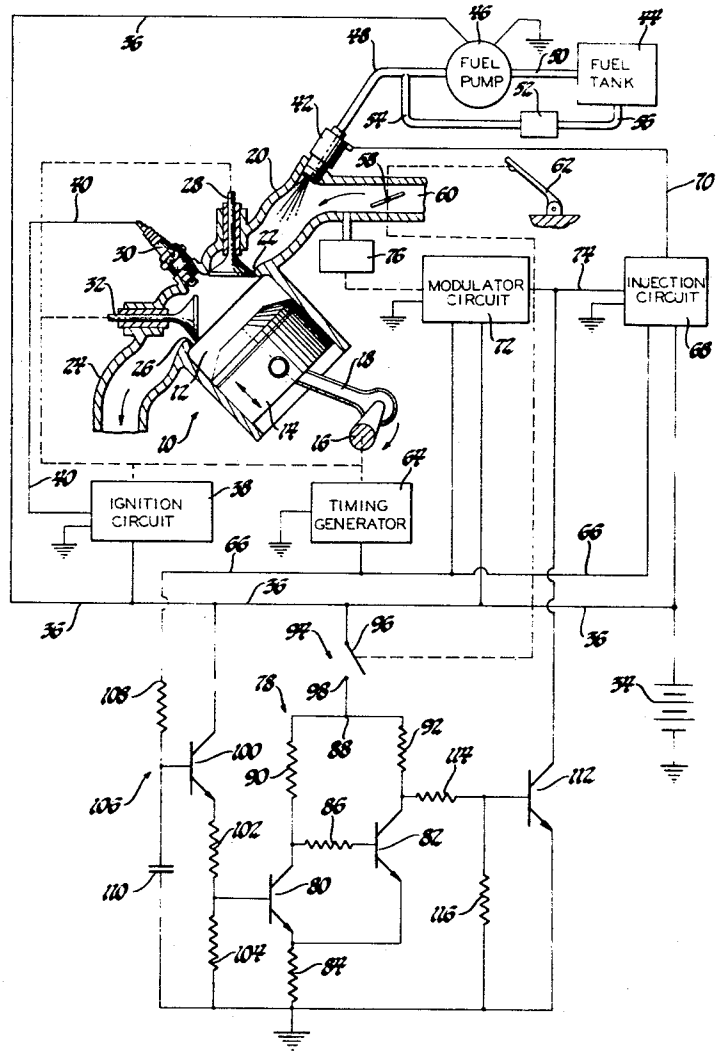
| | | | |
|---|---|---|---|
| 3,463,130 | 8/1969 | Reichardt et al. ..... | 123/32 EA |
| 3,515,104 | 6/1970 | Reichardt ..... | 123/32 |

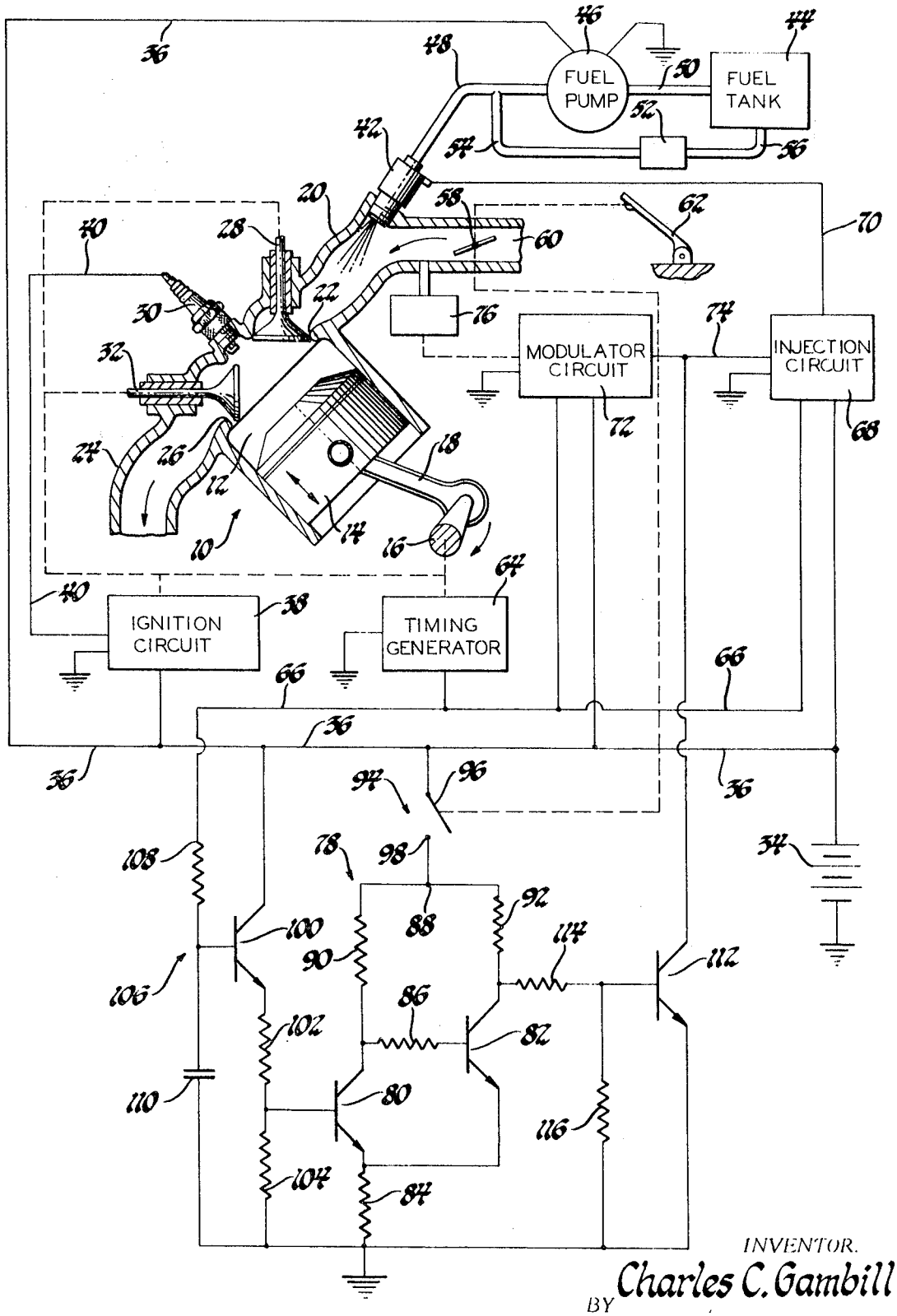


*Primary Examiner*—Laurence M. Goodridge
*Attorneys*—E. W. Christen, C. R. Meland and Tim G. Jagodzinski



**ABSTRACT:** A fuel supply control system for an internal combustion engine includes a trigger circuit which is switchable between first and second states. The application of fuel to the engine is permitted when the trigger circuit is in the first state and is prohibited when the trigger circuit is in the second state. An energizing voltage is produced in response to deceleration of the engine. The trigger circuit is responsive to the presence of the energizing voltage to normally switch to the first state in which a feedback signal is developed. A control signal is generated having an amplitude proportional to the speed of the engine so that the amplitude of the control signal is at a trigger level when the engine speed is at a reference magnitude. The trigger circuit is responsive to the absence of the feedback signal to switch to the second state when the amplitude of the control signal exceeds the trigger level. Further, the trigger circuit is responsive to the presence of the feedback signal to remain in the first state when the amplitude of the control signal exceeds the trigger level due to an increase in the speed of the engine produced by the application of fuel to the engine as the engine speed initially decreases below the reference magnitude during deceleration of the engine.




INVENTOR.
Charles C. Gambill
BY
Jim G. Jagodzinski
ATTORNEY

# FUEL SUPPLY CONTROL SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

The present invention relates to a fuel supply control system for an internal combustion engine. More particularly, the invention relates to an electronic fuel injection control system for prohibiting the application of fuel to an internal combustion engine during deceleration of the engine.

According to one aspect of the invention, the application of fuel to the engine is prohibited in response to deceleration of the engine when the engine speed exceeds a reference magnitude. This feature conserves fuel and reduces exhaust emissions during engine deceleration.

In another aspect of the invention, the application of fuel to the engine is permitted when the engine speed decreases below the reference magnitude as the engine decelerates. This feature facilitates operation of the engine at an idle speed.

According to a further aspect of the invention, the application of fuel to the engine is continuously permitted even though the engine speed increases briefly above the reference magnitude as fuel is reapplied to the engine when the engine speed initially decreases below the reference magnitude. This feature prevents oscillation of the engine speed about the reference magnitude.

In a general embodiment of the invention, a trigger circuit is switchable between first and second states. The application of fuel to the engine is permitted when the trigger circuit is in the first state and is prohibited when the trigger circuit is in the second state. An energizing voltage is produced in response to deceleration of the engine. The trigger circuit is responsive to the presence of the energizing voltage to normally switch to the first state in which a feedback signal is developed. A control signal is generated having an amplitude proportional to the engine speed so that the amplitude of the control signal is at a trigger level when the engine speed is at the reference magnitude. The trigger circuit is responsive to the absence of the feedback signal to switch to the second state when the amplitude of the control signal exceeds the trigger level. Further, the trigger circuit is responsive to the presence of the feedback signal to remain in the first state when the amplitude of the control signal exceeds the trigger level due to the increase in the speed of the engine produced by the application of fuel to the engine as the engine speed initially decreases below the reference magnitude.

In a more specific embodiment of the invention, the trigger circuit includes first and second transistors which are each switchable between first and second conductive conditions. The first and second transistors are interconnected so that when the first transistor is switched to one of the first and second conductive conditions, the second transistor is switched to the other one of the first and second conductive conditions. The application of fuel to the engine is permitted when the second transistor is in the first conductive condition and is prohibited when the second transistor is in the second conductive condition. The second transistor is normally switched to the first conductive condition in response to the energizing voltage. In addition, the trigger circuit includes a resistor. The resistor is connected with the first and second transistors for developing a feedback signal when the second transistor is in the first conductive condition. The first transistor is responsive to the absence of the feedback signal to switch to the second conductive condition when the amplitude of the control signal exceeds the trigger level. Further, the first transistor is responsive to the presence of the feedback signal to remain in the first conductive condition when the amplitude of the control signal exceeds the trigger level due to the increase in the speed of the engine produced by the application of fuel to the engine as the engine speed initially decreases below the reference magnitude.

These and other aspects and features of the invention may be best understood by reference to the following detailed description of a preferred embodiment when considered in conjunction with the accompanying drawing in which the sole FIGURE illustrates a fuel supply control system for an internal combustion engine incorporating the principles of the invention.



Referring to the drawing, an internal combustion engine **10** for an automotive vehicle includes a combustion chamber **12**. A piston **14** is mounted for reciprocation within the combustion chamber **12**. A crankshaft **16** is mounted for rotation within the engine **10**. A connecting rod **18** is pivotally connected with the piston **14** and with the crankshaft **16** for rotating the crankshaft **16** when the piston **14** is reciprocated within the combustion chamber **12**.

An intake manifold **20** is connected with the combustion chamber **12** through an intake port **22**. An exhaust manifold **24** is connected with the combustion chamber **12** through an exhaust port **26**. An intake valve **28** is slidably mounted within the combustion chamber **12** in cooperation with the intake port **22** for regulating the entry of combustion ingredients into the combustion chamber **12** from the intake manifold **20**. A spark plug **30** is mounted in the top of the combustion chamber **12** for igniting the combustion ingredients within the combustion chamber **12** when the spark plug **30** is energized. An exhaust valve **32** is slidably mounted within the combustion chamber **12** in cooperation with the exhaust port **26** for regulating the exit of combustion products from the combustion chamber **12** to the exhaust manifold **24**. The intake valve **28** and the exhaust valve **32** are driven through a suitable linkage (not shown) from the crankshaft **16** of the engine **10**. Conventionally, this linkage includes rocker arms, lifters and a cam shaft.

An electrical power supply is provided by the vehicle battery **34** which energizes a power line **36**. A conventional ignition circuit **38** is connected to the power line **36** and is coupled with the crankshaft **16**. Further, the ignition circuit **38** is connected through a spark line **40** to the spark plug **30**. In a conventional manner, the ignition circuit **38** energizes the spark plug **30** in synchronization with the operation of the engine **10**. Hence, the ignition circuit **38** combines with the spark plug **30** to form an ignition system.

A fuel injector valve **42** is mounted on the intake manifold **20** for injecting fuel into the intake manifold **20** at a constant rate when the injector valve **42** is energized. As an example, the fuel injector valve **42** may include a plunger which is movable to a fully opened position against a bias spring in response to energization of a coil, and which is movable to a fully closed position by the bias spring when the coil is deenergized. However, it is to be understood that the fuel injector valve **42** may be virtually any suitable constant rate injector valve.

A fuel reservoir is provided by the vehicle fuel tank **44**. A fuel pump **46** is connected to the fuel injector valve **42** by a conduit **48** and is connected to the fuel tank **44** by a conduit **50** for pumping fuel from the fuel tank **44** to the injector valve **42**. Preferably, the fuel pump **46** is connected to the power line **36** to be electrically driven by the vehicle battery **34**. Alternately, the fuel pump **46** could be connected to the crankshaft **16** to be mechanically driven by the engine **10**. A pressure regulator **52** is connected to the conduit **48** behind the fuel pump **46** by a conduit **54** and is connected to the fuel tank **44** by a conduit **56** for determining the pressure of the fuel supplied to the injector valve **42**. Thus, the fuel injector valve **42** combines with the fuel tank **44**, the fuel pump **46**, and the pressure regulator **52** to form a fuel supply system.

A throttle plate **58** is rotatably mounted within the intake manifold **20** for regulating the flow of air into the intake manifold **20** through a passage **60** in accordance with the position of the throttle plate **58**. The throttle plate **58** is connected through a suitable linkage (not shown) with the vehicle accelerator pedal **62**. Consequently, as the accelerator pedal **62** is depressed by the vehicle operator, the throttle plate **58** is opened to increase the flow of air into the intake manifold **20**. Conversely, as the accelerator pedal **62** is released by the vehicle operator, the throttle plate **58** is closed to decrease the flow of air into the intake manifold **20**.

In operation, fuel and air are combined within the intake manifold 20 to form an air-fuel mixture. The fuel is injected into the intake manifold 20 by the fuel injector valve 42 in response to energization. The precise amount of fuel deposited into the intake manifold 20 is regulated by a fuel supply control system which will be described hereinafter. The air enters the intake manifold through the passage 60 from an air intake system (not shown) which conventionally includes an air filter. The precise amount of air admitted into the intake manifold 20 is determined by the position of the throttle plate 58 with respect to the inner wall of the passage 60. As previously described, movement of the accelerator pedal 62 controls the position of the throttle plate 58. Hence, the richness or leanness of the air-fuel mixture within the intake manifold 20 is regulated by movement of the accelerator pedal 62.

As the piston 14 initially moves downward within the combustion chamber 12 on the intake stroke, the intake valve 28 is opened away from the intake port 22 and the exhaust valve 32 is closed against the exhaust port 26. Consequently, combustion ingredients in the form of the air-fuel mixture within the intake manifold 20 are drawn by negative pressure through the intake port 22 into the combustion chamber 12. As the piston 14 subsequently moves upward within the combustion chamber 12 on the compression stroke, the intake valve 28 is closed against the intake port 22 so that the air-fuel mixture is compressed between the piston 14 and the top of the combustion chamber 12. When the piston 14 reaches the end of its upward travel on the compression stroke, the spark plug 30 is energized to ignite the air-fuel mixture and initiate the combustion reaction which drives the piston 14 downward within the combustion chamber 12 on the power stroke. As the piston again moves upward within the combustion chamber 12 on the exhaust stroke, the exhaust valve 32 is opened away from the exhaust port 26. Accordingly, the combustion products in the form of hot exhaust gases are pushed by positive pressure out of the combustion chamber 12 through the exhaust port 26 into the exhaust manifold 24. The exhaust gases pass out of the exhaust manifold 24 into the exhaust system (not shown) which conventionally includes a muffler and an exhaust pipe.

Although the structure and operation of only a single combustion chamber 12 has been described, it will be readily appreciated that the illustrated internal combustion engine 10 may include additional combustion chambers 12 as desired. Similarly, additional fuel injector valves 42 may be provided as required. However, as long as the fuel injector valves 42 are mounted on the intake manifold 20, the number of additional fuel injector valves 42 need not necessarily bear any fixed relation to the number of additional combustion chambers 12. Alternately, the fuel injector valve 42 could be mounted right on the combustion chamber 12 so as to inject fuel directly into the combustion chamber 12. In such case, the number of additional fuel injector valves 42 would necessarily equal the number of additional combustion chambers 12. Further, it is to be understood that the illustrated internal combustion engine 10, together with all its associated equipment, is shown only to facilitate a more complete understanding of the inventive fuel supply control system which will now be presented.

A timing generator 64 is coupled with the crankshaft 16 for developing timing pulses having a frequency which is proportional to and synchronized with the rotating speed of the crankshaft 16. The timing pulses are applied to a timing line 66. Preferably, the timing generator 64 is some type of inductive speed transducer, as for example a rotary permanent magnet cooperating with a stationary sensing coil. However, the timing generator 64 may be virtually any suitable pulse producing device, such as a multiple contact rotary switch or a capacitive speed transducer.

An injection circuit 68 is connected to the power line 36 and to the timing line 66. Further, the injection circuit is connected through an injection line 70 to the fuel injector valve 42. As energized from the vehicle battery 34, the injection circuit 68 is responsive to the timing pulses produced by the timing generator 64 to energize the fuel injector valve 42 in synchronization with the rotating speed of the crankshaft 16 in much the same manner as the ignition circuit 38 energizes the spark plug 30. The length of time for which the fuel injection valve 42 is energized by the injection circuit 68 is determined by the width or time duration of drive pulses produced by a modulator circuit 72 which will be more fully described later. The drive pulses are applied by the modulator circuit 72 to the injection circuit 68 via a drive line 74 in synchronization with the timing pulses produced by the timing generator 64. In other words, the injection circuit 68 is responsive to the coincidence of a timing pulse and a drive pulse to energize the fuel injector valve 42 for the time duration or width of the drive pulse.

The injection circuit 68 may be virtually any electrical circuit capable of logically executing the desired coincident pulse operation, as for example some type of AND gate circuit. However, where additional fuel injector valves 42 are provided, it may be necessary that the injection circuit 68 also select which one or ones of the fuel injector valves 42 are to be energized on each timing pulse. As an example, where the fuel injector valves 42 are mounted on the intake manifold 20, they may be divided into two separate groups which are alternately energized on each successive one of the timing pulses. Conversely, where the fuel injector valves 42 are mounted directly on the additional combustion chambers 12, the timing pulses may be applied to operate a counter which individually selects the fuel injector valves 42 for energization.

The modulator circuit 72 is connected to the power line 36 and to the timing line 66. As energized from the vehicle battery 34, the modulator circuit 72 is responsive to the timing pulses produced by the timing generator 64 to develop corresponding drive pulses on the drive line 74. The width or time duration of the drive pulses is modulated by the modulator circuit 72 in accordance with one or more operating parameters of the engine 10. As an example, a vacuum sensor 76 is connected with the intake manifold 20. The modulator circuit 72 is connected with the vacuum sensor 76 for modulating the width of the drive pulses in accordance with variations in the negative pressure within the intake manifold 20. As the vacuum within the intake manifold 20 decreases, the width of the drive pulses produced by the modulator circuit 72 increases, and vice versa.

In one well known type of fuel supply control system, the modulator circuit 72 includes a monostable multivibrator or blocking oscillator cooperating with an inductive vacuum sensor 76 for varying the feedback of the blocking oscillator in response to variations in the negative pressure within the intake manifold 20. However, it is to be understood that the modulator circuit 72 may also be responsive to other operating parameters of the engine 10, such as fuel temperature, air temperature, engine temperature, engine speed, engine acceleration and others. Hence, the timing generator 64, the injection circuit 68 and the modulator circuit 72 combine to form the basic components of a fuel supply control system.

As previously described, the fuel injector valve 42 is energized to inject fuel into the intake manifold 20 at a constant rate for a time duration determined by the width of the drive pulses produced by the modulator circuit 72. However, since the width of the drive pulses is inversely proportional to the vacuum within the intake manifold 20 as monitored by the vacuum sensor 76, the amount of fuel injected into the intake manifold 20 by the fuel injector valve 42 is likewise directly related to the negative pressure within the intake manifold 20. Further, since the vacuum within the intake manifold 20 is defined by the position of the throttle plate 48 as regulated by movement of the accelerator pedal 62, the amount of fuel injected into the intake manifold 20 is similarly regulated by movement of the accelerator pedal 62.

During deceleration of the engine 10, the fuel consumed within the combustion chamber 12 is largely wasted since the automotive vehicle is actually driving the engine 10 rather than vice versa. In addition it has been found that during

deceleration of the engine **10**, the exhaust gases expelled from the combustion chamber **12** contain a higher proportion of deleterious exhaust emissions that at other times. Since the vehicle accelerator pedal **62** is released during deceleration of the engine **10**, the throttle plate **48** is rotated to a closed or idle position so as to sharply decrease the flow of air into the intake manifold **20**. It is thought that the inordinate increase in the amount of exhaust emissions produced during deceleration of the engine **10** is primarily caused by an incomplete burning of the air-fuel mixture within the combustion chamber **12** due to a general lack of air within the intake manifold **20**. Hence, it is desirable to deenergize the fuel injector **42** to prohibit the injection of fuel into the intake manifold **20** during deceleration of the engine **10**. Accordingly, the illustrated fuel supply control system includes a deceleration override circuit for accomplishing this result.

In the deceleration override apparatus, a trigger circuit **78** includes first and second transistors **80** and **82**, each having base, emitter and collector electrodes. The emitter electrodes of the transistors **80** and **82** are connected through a feedback resistor **84** to ground. The collector electrode of the transistor **80** is connected through a biasing resistor **86** to the base electrode of the transistor **82**. The collector electrode of the transistor **80** is also connected to a junction **88** through a biasing resistor **90**. Similarly, the collector electrode of the transistor **82** is connected to the junction **88** through a biasing resistor **92**.

The trigger circuit **78** is switchable between first and second states. In the first state, the first transistor **80** is turned off or switched to a fully nonconductive condition and the second transistor **82** is turned on or switched to a fully conductive condition. Conversely, in the second state, the first transistor **80** is turned on or switched to a fully conductive condition and the second transistor **82** is turned on or switched to a fully nonconductive condition.

A throttle switch **94** includes a contact arm **96** connected to the power line **36** and a contact **98** connected to the junction **88** of the trigger circuit **78**. Further, the contact arm **78** is connected through a suitable linkage (not shown) to the throttle plate **58** in such a manner that the switch **94** is closed when the throttle plate **58** is closed. With the throttle switch **94** closed, the contact arm **96** engages the terminal **98** to apply an energizing voltage from the vehicle battery **34** to the junction **88** to energize the trigger circuit **78**. Thus, the throttle switch **94** combines with the throttle plate **58** to form a deceleration sensor for applying an energizing voltage to the trigger circuit **78** in response to deceleration of the engine **10**.

An input transistor **100** includes base, emitter and collector electrodes. The emitter electrode of the transistor **100** is connected through a pair of output resistors **102** and **104** to ground. The base electrode of the first transistor **80** in the trigger circuit **78** is connected to the junction between the resistors **102** and **104**. The collector electrode of the transistor **100** is connected directly to the power line **36**. An integrating network **106** includes a resistor **108** and a capacitor **110** connected in series between the timing line **66** and ground. The base electrode of the transistor **100** is connected to the junction between the resistor **108** and the capacitor **110**.

The timing pulses produced by the timing generator **64** are applied to the integrator **106** via the timing line **66**. The timing pulses are integrated by the resistor **108** and the capacitor **110** to provide an integrated signal at the base electrode of the transistor **100**. The transistor **100** is operated as an emitter follower for amplifying the integrated signal to develop a control signal across the output resistor **104** at the base electrode of the first transistor **80** in the trigger circuit **78**. The amplitude of the control signal is a direct function of the frequency of the timing pulses. However, since the frequency of the timing pulses is proportional to the rotating speed of the crankshaft **16**, the amplitude of the control signal is similarly proportional to the speed of the crankshaft **16**. Hence, the input transistor **100** and the integrator **106** combine with the timing generator **64** to form a speed sensor for developing a control signal having an amplitude proportional to the speed of the engine **10**.

An output transistor **112** includes base, emitter and collector electrodes. The emitter electrode of the transistor **112** is connected directly to ground. The collector electrode of the transistor **112** is connected to the drive line **74** between the injection circuit **68** and the modulator circuit **72**. The base electrode of the transistor **112** is connected through a biasing resistor **114** to the collector electrode of the second transistor **82** in the trigger circuit **78**. The base electrode of the transistor **112** is also connected through a biasing resistor **116** to ground.

The transistor **112** is turned off or switched to a fully nonconductive condition when the transistor **82** is turned on or switched to a fully conductive condition. Conversely, the transistor **112** is turned on or switched to a fully conductive condition when the transistor **82** is turned off or switched to a fully nonconductive condition. In the fully conductive condition, the transistor **112** shunts drive pulses from the drive line **74** to ground. Consequently, the injection circuit **68** is disabled so as to prohibit the energization of the fuel injection valve **42**. However, in the fully nonconductive condition, the transistor **112** does not shunt drive pulses from the drive line **74** to ground. Accordingly, the injection circuit **68** is enabled to permit the energization of the fuel injector valve **42**. Thus, the transistor **112** combines with the injection circuit **68** and the fuel supply system, including the fuel injector valve **42**, to provide a fuel injection system for applying fuel to the engine **10** when enabled and for not applying fuel to the engine **10** when disabled.

In operation, the control signal is applied to the base electrode of the first transistor **80** in the trigger circuit **78** by the integrator **106** and the input transistor **100**. However, assuming the vehicle accelerator pedal **62** is depressed, the throttle plate **58** is opened to operate the engine **10** in the normal manner. Similarly, the throttle switch **94** is opened so that the trigger circuit **78** is deenergized. Consequently, the first and second transistors **80** and **82** are in the fully nonconductive condition and no feedback voltage is developed across the feedback resistor **84**. Further, the transistor **112** is also in the fully nonconductive condition so that the injection circuit **68** is enabled to energize the fuel injector valve **42** as previously described.

When the vehicle accelerator pedal **62** is subsequently released, the throttle plate **48** is closed to initiate deceleration of the engine **10**. As a result, the throttle switch **94** is also closed so that an energizing voltage is applied to the junction **88** to energize the trigger circuit **78**. Since the trigger circuit **78** was previously deenergized, no feedback voltage initially exists across the feedback resistor **84**. In this situation, the bias voltage across the base and emitter electrodes of the transistor **80** is sufficient to turn on the transistor **80** when the amplitude of the control signal applied to the base electrode of the transistor **80** exceeds a trigger level. For reasons which will become more fully apparent later, the resistors **102** and **104** are selected so that the amplitude of the control signal exceeds the trigger level when the speed of the engine **10** exceeds a reference magnitude which is slightly greater than the desired idle speed of the engine **10**.

Assuming the speed of the engine **10** exceeds the reference magnitude, the transistor **80** is turned on. With the transistor **80** in the fully conductive condition, the bias voltage applied across the base and emitter electrodes of the transistor **82** by the resistors **84**, **86** and **90** is insufficient to turn on the transistor **82**. With the transistor **82** in the fully nonconductive condition, the bias voltage applied across the base and emitter electrodes of the transistor **112** by the resistors **92**, **114** and **116** is sufficient to turn on the transistor **112**. In the fully conductive condition, the transistor **112** disables the injection circuit **68** to prohibit the application of fuel to the engine **10**. This action conserves fuel and reduces exhaust emissions.

During deceleration, the speed of the engine **10** gradually decreases until it eventually falls below the reference magnitude. Correspondingly, the amplitude of the control signal applied to the base electrode of the transistor **80** drops below the trigger level. When this happens, the bias voltage applied

across the base and emitter electrodes of the transistor **80** is insufficient to maintain the transistor **80** in the fully conductive condition. Accordingly, the transistor **80** is turned off. With the transistor **80** in the fully nonconductive condition, the bias voltage applied across the base and emitter electrodes of the transistor **82** by the resistors **84**, **86** and **90** is sufficient to turn on the transistor **82** so that a feedback voltage is developed across the feedback resistor **84**. Further, with the transistor **82** in the fully conductive condition, the bias voltage applied across the base and emitter electrodes of the transistor **112** by the resistors **84**, **92**, **114** and **116** is insufficient to maintain the transistor **112** in the fully conductive condition. Hence, the transistor **112** is turned off. In the fully nonconductive condition, the transistor **112** enables the injection circuit **68** to permit the application of fuel to the engine **10**. Since the reference magnitude of the engine **10** is slightly greater than the desired idle speed, this action facilitates operation of the engine **10** at the idle speed by reapplying fuel to the engine **10** just before the engine speed decreases to the idle speed.

As fuel is initially reapplied to the engine **10**, the engine speed rises briefly above the reference magnitude and then settles down to the idle speed. Correspondingly, the amplitude of the control signal rises briefly above the trigger level and then drops down below the trigger level again. However, since the transistor **82** is in the fully conductive condition, a feedback voltage exists across the feedback resistor **84** in opposition to the control signal applied to the base electrode of the transistor **80**. As a result, the bias voltage applied across the base and emitter electrodes of the transistor **80** is insufficient to turn on the transistor **80**. Therefore, the transistor **80** remains in the fully nonconductive condition. Accordingly, the transistor **112** also remains in the fully nonconductive condition to permit the continued application of fuel to the engine **10**. Were it not for this action, the speed of the engine would alternately rise above and fall below the reference magnitude as the application of fuel to the engine **10** was repeatedly permitted and prohibited. Thus, the speed of the engine **10** is prevented from oscillating about the reference magnitude.

When the accelerator pedal **62** is once more depressed, the throttle plate **58** is opened to operate the engine **10** in the normal manner. Consequently, the throttle switch **94** is opened so that the energizing voltage is removed from the junction **88** to deenergize the trigger circuit **78**. Thereafter, when the accelerator pedal **62** is again released, the previously described operating cycle of the deceleration override circuit is repeated. It is to be noted that fuel is applied to the engine **10** whenever the throttle switch **94** is opened regardless of the speed of the engine **10**.

Although the transistors **80**, **82**, **100** and **112** are shown to be of the NPN conductivity type, it is to be understood that they may also be of the PNP conductivity type, or they could be field effect transistors rather than junction transistors. Further, it will be readily appreciated that various alterations and modifications may be made to the illustrated fuel supply control system without departing from the spirit and scope of the invention. As an example, one or more conventional diodes could be connected in series with the output resistor **104** so as to temperature compensate the deceleration override circuit.

In a fuel injection control system constructed in accordance with the drawing, the following components were utilized in the deceleration override circuit and were found to yield satisfactory results:

| | |
|---|---|
| Battery 34 | 12 volts |
| Transistors 80, 82, 100 and 112 | Delco Radio DS-67 |
| Capacitor 110 | 6.8 microfarads |
| Resistor 84 | 220 ohms |
| Resistor 86 | 4,700 ohms |
| Resistor 90 | 1,200 ohms |
| Resistor 92 | 910 ohms |
| Resistor 102 | 10,000 ohms |
| Resistor 104 | 9,100 ohms |
| Resistor 108 | 39,000 ohms |
| Resistor 114 | 20,000 ohms |
| Resistor 116 | 3,300 ohms |

It will now be apparent that the previously described fuel supply control system provides three distinctive features. First, it prohibits the application of fuel to the engine when the engine speed exceeds a reference magnitude and the engine is decelerated. This feature conserves fuel and reduces exhaust emissions. Second, it subsequently permits the application of fuel to the engine when the engine speed decreases below a reference magnitude as the engine continues to decelerate. This feature facilitates operation of the engine at an idle speed. Third, it thereafter permits the application of fuel to the engine even though the engine speed increases briefly above the reference magnitude as fuel is again applied to the engine when the engine speed initially decreases below the reference magnitude. This feature prevents oscillation of the engine speed about the reference magnitude.

I claim:

1. A fuel supply system for an internal combustion engine, comprising: a trigger circuit switchable between first and second states when energized, the trigger circuit including means for developing a feedback signal in the first state, fuel supply means connected with the engine for applying fuel to the engine when enabled and for withholding fuel from the engine when disabled, the trigger circuit connected with the fuel supply means for enabling the fuel supply means to permit the application of fuel to the engine when the trigger circuit is either deenergized or in the first state and for disabling the fuel supply means to prohibit the application of fuel to the engine when the trigger circuit is in the second state, deceleration sensing means connected with the engine for providing an energizing voltage in response to deceleration of the engine, the trigger circuit connected with the deceleration sensing means to be energized by the energizing voltage, speed sensing means connected with the engine for generating a control signal having an amplitude proportional to the speed of the engine so that the control signal is at a trigger level when the engine speed is at a reference magnitude, the trigger circuit connected with the speed sensing means for switching to the second state to withhold fuel from the engine in response to energization when the control signal is above the trigger level and the feedback signal is absent at the onset of engine deceleration, the trigger circuit further connected with the speed sensing means for switching to the first state to reapply fuel to the engine and to develop the feedback signal when the control signal falls below the trigger level due to a decrease in the engine speed below the reference magnitude during engine deceleration, and the trigger circuit also connected with the speed sensing means for remaining in the first state to maintain the application of fuel to the engine in response to the presence of the feedback signal even though the control signal rises above the trigger level due to an increase in the engine speed above the reference magnitude as fuel is reapplied to the engine.

2. A fuel supply control system for an internal combustion engine, comprising: a trigger circuit including first and second transistors and a resistor, the first and second transistors each switchable between first and second conductive conditions, the resistor connected with the first and second transistors for developing a feedback signal when the second transistor is in the first conductive condition, the first and second transistors interconnected so that when the first transistor is switched to one of the first and second conductive conditions the second transistor is switched to the other one of the first and second conductive conditions when the trigger circuit is energized, the first and second transistors normally residing in the second conductive condition when the trigger circuit is deenergized, fuel injection means connected with the engine for applying fuel to the engine when enabled and for withholding fuel from the engine when disabled, the second transistor connected with the fuel injection means for enabling the fuel injection means to permit the application of fuel to the engine when the second transistor is in the first conductive condition and for disabling the fuel injection means to prohibit the application of fuel to the engine when the second transistor is in the second conductive condition, deceleration sensing means including a control switch connected with the engine for opera-

tion from a first position to a second position in response to deceleration of the engine, the trigger circuit connected with the deceleration sensing means for deenergization when the control switch is in the first position and for energization when the control switch is in the second position, speed sensing means connected with the engine for generating a control signal having an amplitude proportional to the speed of the engine so that the amplitude of the control signal is above a trigger level when the engine speed is above a reference magnitude and so that the amplitude of the control signal is below the trigger level when the engine speed is below the reference magnitude, the first transistor connected with the speed sensing means to switch to the first conductive condition in response to energization of the trigger circuit when the control signal is above the trigger level in the absence of the feedback signal at the onset of engine deceleration thereby to switch the second transistor to the second conductive condition to withhold fuel from the engine, the first transistor further connected with the speed sensing means to switch to the second conductive condition when the control signal falls below the trigger level as the engine speed decreases below the reference magnitude during engine deceleration thereby to switch the second transistor to the first conductive condition to reapply fuel to the engine and to develop the feedback signal and the first transistor also connected with the speed sensing means to remain in the second conductive condition in response to the presence of the feedback signal even though the control signal rises above the trigger level due to an increase in the engine speed above the reference magnitude as fuel is reapplied to the engine thereby to retain the second transistor in the first conductive condition to maintain the application of fuel to the engine.