United States Patent

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[54] **FUEL CONTROL SYSTEM USING RF CIRCUITS**

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[51] **Int. Cl.** **F02b 3/00,** F02m 39/00

[58] **Field of Search** .....123/32 EA, 139 E

[56] **References Cited**

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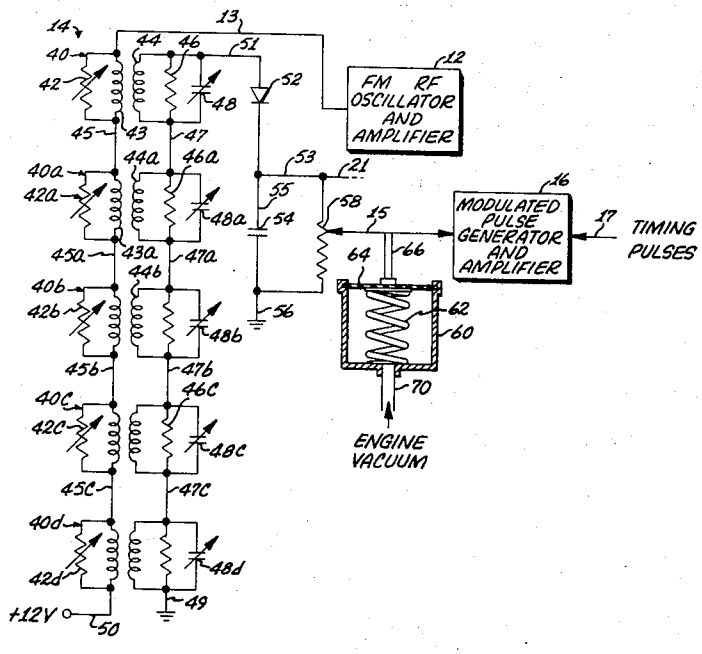
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[57] **ABSTRACT**

Apparatus for controlling the injection of fuel in an internal combustion engine utilizes RF circuits including a tuneable RF detector responsive to the speed of the engine.

18 Claims, 5 Drawing Figures



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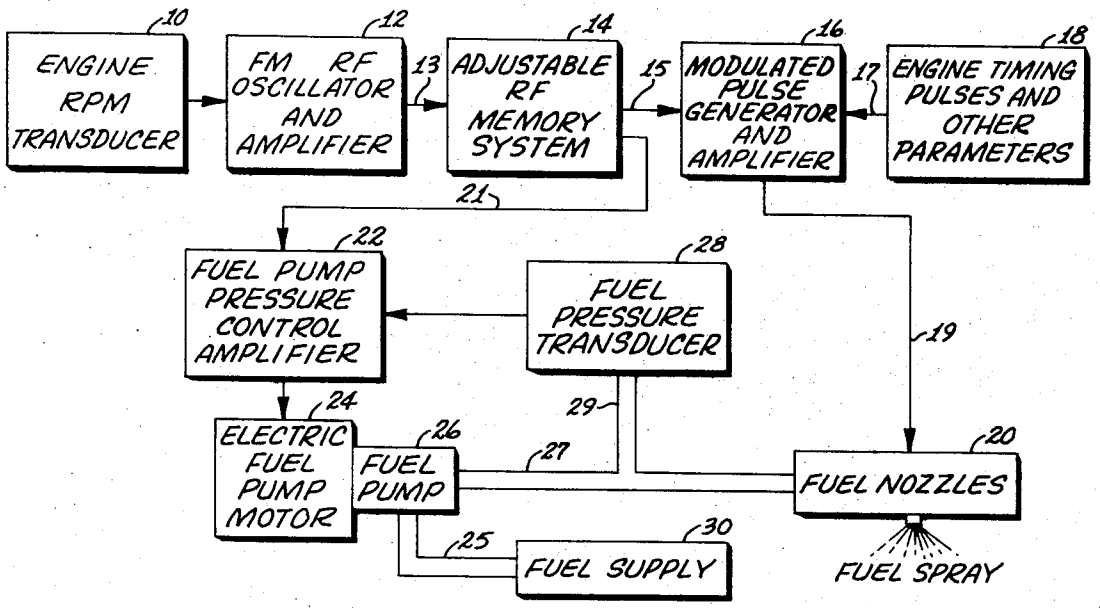


Fig-1

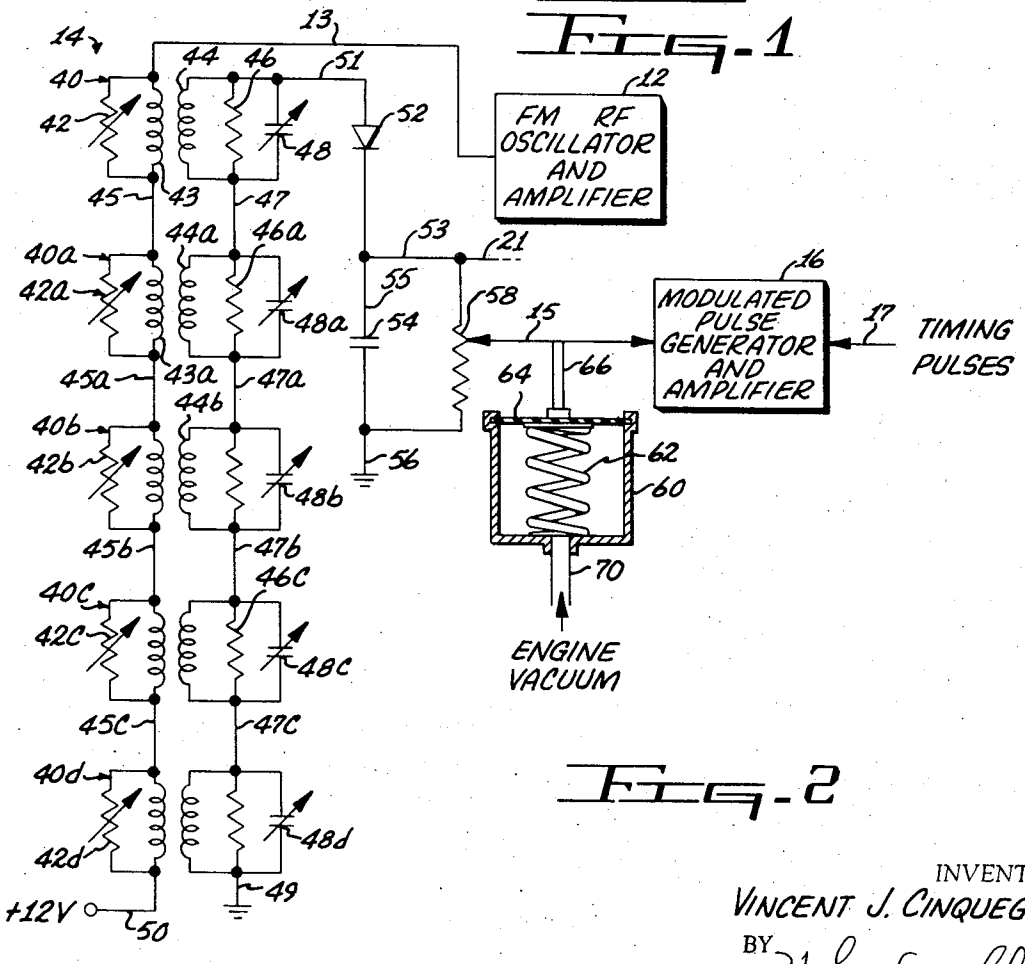


Fig-2

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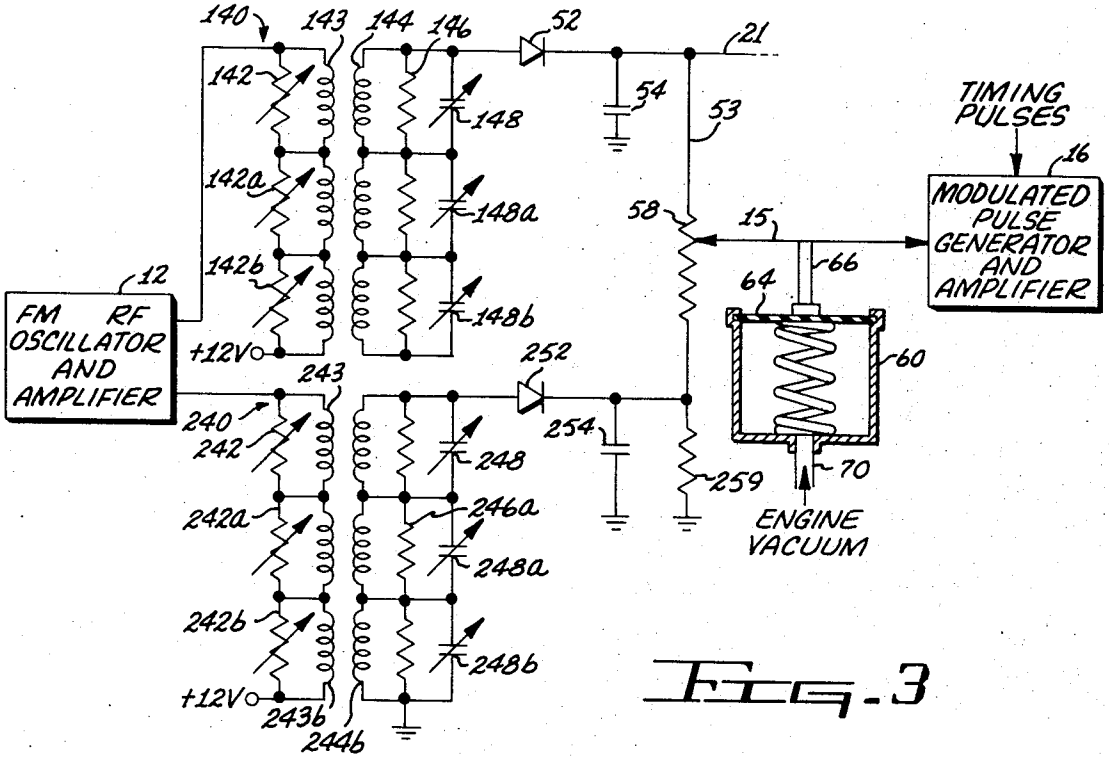


FIG. 3

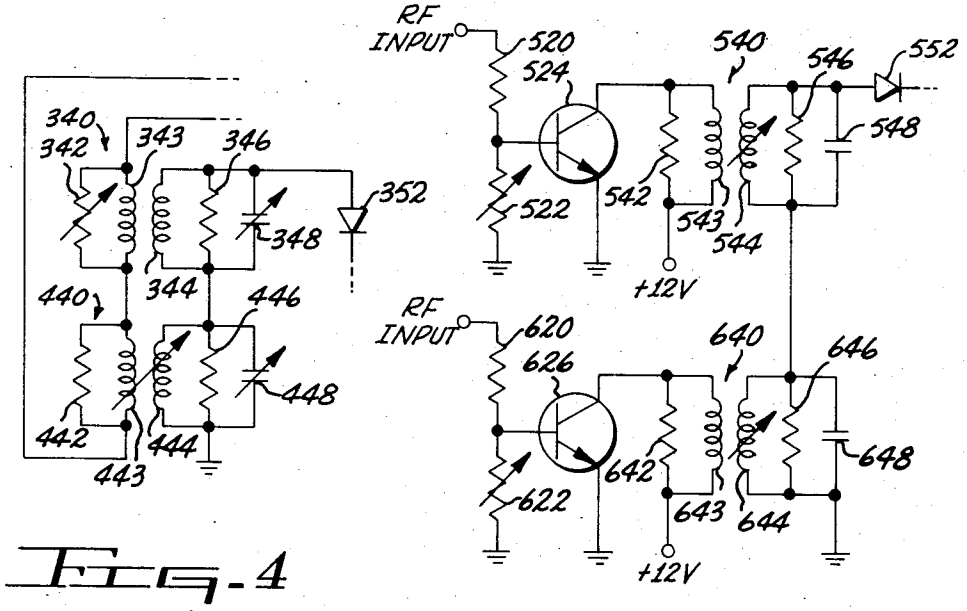


FIG. 4

FIG. 5

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FUEL CONTROL SYSTEM USING RF CIRCUITS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to fuel control systems for internal combustion engines. More particularly, this invention relates to electronic systems for controlling the injection of fuel in internal combustion engines according to the speed of the engine by varying the length of time fuel is admitted into an intake duct or into a combustion chamber and to the control of the pressure of the injected fuel.

2. Description of the Prior Art:

There have been many systems designed for injecting proper quantities of fuel into internal combustion engines. The prior art, with respect to electronic fuel injection systems, includes many different approaches, such as coupled inductor circuits in which current is varied by potentiometers, transistorized multivibrator systems utilizing variable time delays in which the time delay varies according to mechanical linkage associated with the speed of the engine or according to a variable resistance also associated with the speed of the engine, and electronic systems using variable voltage outputs which vary directly with the speed of the engine to control the timing of fuel injectors. Typically, a monostable multivibrator is used in prior art devices. Associated with the monostable vibrator are timing means of various types used to trigger the vibrator and thus control the length of time a fuel injection solenoid is open to allow a flow of fuel therethrough.

Under various operating conditions of an internal combustion engine, among which the primary condition is the speed of the engine, various amounts of fuel are required for optimum efficiency of the engine. Accordingly, it is desired to provide the proper amount of fuel to an engine under any and all operating conditions to which the engine may be subjected. Fuel is typically injected into an intake manifold through an injector nozzle, or, more accurately with respect to a multicylinder engine, through a plurality of injector nozzles or valves, with normally one nozzle or valve per cylinder. The amount of fuel flowing through each nozzle is a function of the pressure of the fuel at the nozzle and the length of time, or duration, that the nozzle is open.

In prior art devices the control of the nozzle opening time duration is by electronic timing signals or pulses which actuate solenoid valves at the nozzles. Such control is accomplished by means of the circuits and devices mentioned above. One of the deficiencies of such prior art devices is their lack of sufficient flexibility to meet required and/or desired conditions. In other words, the fuel control systems, once installed, are usually "fixed" with respect to their response to speed, temperature conditions, and any other parameters which may be used as operating functions.

The control of the pressure of the fuel is typically accomplished in either of two ways, first, a constant fuel pressure may be used, or second, a variable fuel pressure may be used in which the pressure is a direct function of the speed of the engine. Prior art devices do not include means for varying the fuel pressure according to engine requirements with respect to the timing of the fuel injection nozzles.

As indicated above, electronic fuel injection systems of the prior art vary the timing of the fuel at the nozzle. If the fuel pressure is varied, it is varied directly as a function of the speed of the engine. While these systems may be satisfactory under some operating circumstances, under other circumstances, such as the operation of high performance engines under competitive racing conditions, it may be highly desirable to vary both the timing of the injected fuel and the pressure of the injected fuel according to engine requirements. The variation in fuel injection timing and fuel pressure should preferably be responsive to predetermined engine operating parameters.

SUMMARY OF THE INVENTION

The invention herein described and claimed comprises a fuel control system for an internal combustion engine. Tuned RF circuits are used to control the length of time during which fuel is injected into the engine and the pressure at which the fuel is injected.

The following are among the objects of this invention:

to provide a new and useful fuel control system;

to provide a new and useful fuel control system for an internal combustion engine;

to provide a new and useful fuel control system using tuned RF circuits;

to provide a new and useful fuel control system for varying the length of time during which fuel is injected;

to provide a new and useful fuel control system for varying the pressure at which fuel is injected;

to provide a new and useful fuel control system for varying the timing and pressure of fuel as it is injected into an internal combustion engine;

to provide new and useful tuned circuits for fuel control systems;

to provide new and useful electronic circuits for predeterminably controlling the injection of fuel in an internal combustion engine; and

to provide new and useful apparatus for adjustably varying the duration and pressure of injected fuel in an internal combustion engine.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a block diagram of a fuel control system.

FIG. 2 is a schematic diagram of a portion of the fuel control system of FIG. 1.

FIG. 3 is a schematic diagram of another embodiment of a portion of the fuel control system of FIG. 1.

FIG. 4 is a schematic diagram showing variations of tuned circuits.

FIG. 5 is a schematic diagram showing another variation of tuned circuits.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The fuel control system described herein comprises two portions. The first portion is characterized by electronic circuitry and controls for the timing of fuel for injection into an engine through a plurality of fuel nozzles. The second portion is characterized by electronic circuitry cooperating with the fuel supply to provide fuel at the nozzles at a proper, predetermined pressure.

FIG. 1 discloses, in simplified block form, a fuel injection system which uses RF tuned circuits for the timing of fuel injection and for the control of fuel pressure. An engine RPM transducer **10** is shown as the first element of the system. This transducer may comprise any appropriate and well known means for determining the speed of the engine in terms of revolutions per unit of time, such as revolutions per minute. Such transducers may typically be electrically connected to the distributor or the coil, but may also be of a mechanical or any other design, if desired, which includes some form of electronic output corresponding to the speed of the engine.

Engine speed signals from transducer **10** are fed to an FM RF oscillator and amplifier **12**. As with the transducer **10**, the FM RF oscillator and amplifier **12** may be of any state-of-the-art design. The engine speed signals from transducer **10**, normally in the form of an analog voltage, are sent to FM RF oscillator unit **12**. The output of the oscillator is modulated according to the speed of the engine as indicated by the output of transducer **10**. Under present technology, the frequency or frequencies available or practical depend on size and cost limitations, and may be in the range of 25,000 cycles per second (25 KHz) to 250 million cycles per second (250 MHz). Typically, the RF oscillator may operate at a resonant frequency range of between about 1 and 1.3 MHz. It is obvious that any suitable frequency may be used. In the present embodiment, the RF output signal is preferably frequency modulated.

After modulation, the output signal is amplified and transmitted to an adjustable RF detector **14**, which will be discussed in detail below. The adjustable RF detector comprises tuned circuits coupled so as to respond in a predetermined manner to the output of the FM RF oscillator and amplifier **12**. The concepts of the terms "adjustable" and "predetermined" are used to indicate that adjustments may be made on any given or particular engine according to the specific operating characteristics of that engine. Thus, rather than a one-time only factory calibration, the present fuel control system may be calibrated and adjusted on any engine to any desired operating characteristics and parameters. Moreover, the present system may be calibrated to follow a plurality of fuel demand curves of substantial complexity, as compared to prior art devices capacity or ability to follow only simple curves. For example, the present invention can follow full load and part load curves, each different and independent from each other.

The output of the detector **14**, which may also be considered as an adjustable RF memory system, is transmitted to a modulated pulse generator and amplifier **16** and to a fuel pump pressure control amplifier **22**. The modulated pulse generator and amplifier **16** first generates a preferably square wave pulse, the width of which varies according to the input signal from the RF detector **14**. The pulses are then amplified and are in turn used to actuate solenoid valves which control the flow of fuel through fuel nozzles **20**. Each fuel nozzle solenoid valve is held open for a length of time corresponding to the width of the pulse. It will be noted that only one nozzle is schematically illustrated in FIG. **1**, and fuel is illustratively shown as being discharged or sprayed therefrom.

The output pulses of the pulse generator and amplifier **16** are triggered according to engine timing signals, again typically in the form of pulses, which are fed to the generator and amplifier **16** from a source denoted by block **18**. The engine timing pulse preferably may be taken from the distributor or coil in a well known manner.

Other factors may be included within block **18** to modulate or vary the output therefrom. These factors may be taken into consideration to modify the input to the pulse generator and amplifier **16**. These may be any other engine operating parameters, such as engine temperature, ambient temperature, exhaust temperature, barometric pressure, and any other factors which could or should be used to influence the timing of the fuel solenoids with respect to either the determination of when they open or the duration or length of time that they stay open.

Output signals from the adjustable RF memory system **14** are also sent to a fuel pump pressure control amplifier **22** by a conductor **21**. The output of the amplifier **22** varies according in predetermined manner according to the output of the RF memory system **14** and also according to fuel pressure transducer **28**. Fuel from fuel supply **30** flows to fuel pump **26** through fuel line or conduit **25**. Fuel pump **26** is preferably driven by a variable speed electric motor **24**. Fuel is delivered from fuel pump **26** to the fuel nozzles **20** through fuel line or conduit **27**. A fuel pressure line **29** extends from fuel line **27** to fuel pressure transducer **28**. The fuel pressure transducer **28**, which may be of any conventional design, senses the pressure of the fuel and sends its output signal, corresponding to the pressure of the fuel, to the fuel pressure control amplifier **22** as a feedback signal. The output of the fuel pump pressure control amplifier **22** is in turn used to control the speed of the electric fuel motor **24** and ultimately the fuel pressure of the fuel through fuel line **27**.

It may thus be seen that the pressure of the fuel delivered to the nozzles may be controlled according to the speed of the engine as modulated or as responsive to the output of the adjustable RF memory system **14**. The timing of the nozzles, the length of time that each one of them stays open to deliver fuel to a cylinder, is also controlled by, or is responsive to, the output of the adjustable RF memory system **14**, as modulated by engine timing pulses and any other desired parameters, such as atmospheric (barometric) pressure, ambient air temperature, engine temperature, exhaust temperature, and the like.

FIG. **2** shows in detail the circuitry associated with the adjustable RF memory system **14**. A plurality of tuned circuits **40**, **40***a*, **40***b*, **40***c*, and **40***d*, are shown in series. The output from FM RF oscillator and amplifier **12** is sent to the tuned circuits **40***a* – **40***d* through conductor **13**. Each of the tuned circuits **40***a* – **40***d* is typically an inductance-capacitance circuit, comprising a variable resistance **42**, which may typically be a potentiometer, in parallel with an inductor **43**. Another inductor **44**, coupled to inductor **43**, may typically be arranged in parallel with a resistor **46** and a variable capacitor **48**. As illustrated in FIG. **2**, the inductors of the primary of each of the tuned circuits are shown coupled together in series by conductors **45**, **45***a*, **45***b*, and **45***c*, respectively. Supply voltage is typically pro-

vided to the circuits through conductor **50**. The secondary of each of the tuned circuits, that is, the inductor **44**, resistor **46**, and variable capacitor **48**, are, for each circuit, serially connected through conductors **47**, **47***a*, **47***b*, and **47***c*. The secondaries are then terminated to ground through conductor **49**. The tuned circuits include variable capacitors **48**, **48***a*, . . . **48***d* and are tunable to cover the frequency range of the FM RF oscillator **12**.

The tuned circuits are adjustable to cover the frequency range sequentially according to voltage output of the engine RPM transducer as manifested by the RF output of the FM RF oscillator. The output from the tuned circuits responds to RF input according to desired adjustments of the potentiometers **42**, **42***a*, . . . **42***d*. In that manner, any desired curve may be described to follow the required and desired engine demands. While five tuned circuits are shown in FIG. **2**, it will be obvious that the number may vary to only a single tuned circuit, depending on the performance desired. The number shown may provide optimum flexibility and engine performance.

The output from the tuned circuits through conductor **51** is rectified by diode **52** in conductor **51** and appears as a dc voltage through a variable resistor **58**. Variable resistor **58** is connected in parallel by conductor **53** with a filter capacitor **54** in conductor **55** and is terminated to ground through conductor **56**. Conductor **21**, which extends between memory system **14** and fuel pump pressure control amplifier **22**, preferably connects with conductor **53** ahead of variable resistor **58**. Accordingly, the fuel pump pressure is modulated according to the speed of the engine.

The load on the engine, as manifested by engine vacuum through a conduit **70**, is also used to modulate or to determine the output of the adjustable RF detector **14** by modulating the dc output voltage at resistance **58**. A cylinder **60** is connected to engine vacuum conduit **70**. A compression spring **62** within the cylinder **60** biases a diaphragm **64** which closes the cylinder **60** and comprises an end wall for the cylinder opposite that to which conduit **70** is connected. A sensing arm **66** is connected to diaphragm **64** and moves according to the deflection of the diaphragm **64**, which in turn depends on the engine vacuum within cylinder **60**. Conductor **15** is carried by, or is secured to, sensing arm **66**, and extends from variable resistor **58** to the modulated pulse generator and amplifier **16**. Thus the output through the resistor **58** is varied by the engine vacuum as conductor **15** moves according to the deflection of diaphragm **64** and sensing arm **66**. Resistor **58** and conductor **15** comprise simply a load control potentiometer which is varied according to the deflection of sensing arm **66**, which in turn reflects the load on the engine according to manifold vacuum. Also shown in FIG. **2** as an input to the modulated pulse generator and amplifier **16** is conductor **17**, which feeds timing pulses and other parameters into the generator and amplifier **16**. The conductor **21**, which extends between conductor **53** and fuel pump pressure control amplifier **22**, could be connected to conductor **15** and the fuel pressure would accordingly be modulated according to both the engine speed and engine load.

Each of the tuned circuits is adjusted or tuned to respond to different resonant frequencies or signals from the FM RF oscillator and amplifier **12**, which in turn responds to the speed of the engine as detected by the engine RPM transducer **10**. Thus as the speed of the engine changes, the frequency of the FM RF oscillator also varies, and the various circuits of the RF memory respond to give an output to the modulated pulse generator and amplifier which in turn varies the timing, that is, the opening and the closing, of the fuel solenoids and accordingly varies the amount of fuel, at the predetermined pressure, that is discharged through each fuel nozzle. Each tuned circuit may be varied as desired according to the setting of the variable resistor or potentiometer **42**, **42***a*, etc., over the entire speed range of the engine. Since each of the tuned circuits is variable, it may readily be seen that the response of the engine to the proper amount of fuel may be controlled to an extremely finite degree. It has been found that a minimum of one tuned circuit is required, as previously indicated, and that two circuits are needed for good operation. Three, four, or five such tuned circuits are desirable for optimum operation of an engine. For illustrative purposes, five such tuned circuits have been shown in FIG. **2**. It will be noted that each of the tuned circuits is of a well known inductance-capacitance type, in which the resistance is varied to change voltage output, and the capacitance is varied to tune the circuit.

Since each tuned circuit of the RF memory may be adjusted, the unit provides a different and a desired output corresponding to various specific input signals. Or, in other words, in response to a specific input signal, which is determined by the speed of the engine, the output from each tuned circuit of the RF memory system may be adjusted to provide a predetermined output signal. That output signal is in turn used to modulate or vary the width of pulses which determine the opening and the closing and thus the timing of fuel solenoids. The term "memory" is used to denote the ability of the tuned circuits to resonate at predetermined frequencies over a given frequency range according to the speed of the engine and to the specific adjustments for each of the tuned circuits. The output of each tuned circuit accordingly varies as desired in a predetermined manner according to the speed of the engine as manifested by the frequency modulated RF signal from the oscillator **12**. Thus, each circuit may be tuned to a different resonant frequency and the output of each circuit may be varied as desired at that resonant frequency. Once adjusted, the tuned circuits "remember" and respond with a given or specific output according to any given or specific input.

The adjustable RF memory detector system provides a means for varying and thus controlling the amount of fuel provided by the fuel nozzles to the cylinders of an internal combustion engine according to the specific needs of the engine throughout the speed or RPM operating range of the engine. This, of course, comprises the compensation of the engine for the differences in its volumetric efficiency at all operating speeds. The volumetric efficiency of an engine may briefly be defined as the ratio of the volume of the fuel/air charge, inducted into an engine at atmospheric pressure, to the piston displacement of the engine.

Since the volumetric efficiency of an engine varies throughout the speed range of the engine in a predeterminable manner, it is accordingly desirable to compensate for the volumetric efficiency throughout the speed range. With the herein described apparatus, such compensation may be accomplished.

In addition to compensating the engine for volumetric efficiency, the present fuel control system also compensates the engine for load conditions as indicated by manifold vacuum. Resistor **58** and conductor **15** comprise a load control potentiometer varied according to the engine vacuum. The engine vacuum through conduit **70** exerts a force on diaphragm **64** from within cylinder **60** and movement of the diaphragm moves conductor **15** on resistor **58**.

Under no load conditions, which result in high engine vacuum, the diaphragm **64** would be displaced or deflected a maximum amount. This would result in a decrease in the voltage tapped or sensed along resistor **58** by conductor **15** and a decrease in the voltage output from the RF memory system **14** to the modulated pulse generator and amplifier **16**. At high load conditions, which result in low engine vacuum, deflection of diaphragm **64** is minimal, or negligible, and the output from the tuned circuits of the RF memory system is maximum through the load control potentiometer. The output of the tuned circuits through the load control potentiometer may range from 25 percent at no load conditions to 100 percent at fuel load conditions.

The adjustable RF memory system, including the load control potentiometer, may be adjusted to follow a plurality of complex curves required by an engine throughout a wide range of both speed and load variations.

FIG. **3** shows a variation of the adjustable RF circuits of FIG. **2** in which two circuit units, each comprising three stages of tuned circuits, are connected in parallel between the FM RF oscillator **12** to the potentiometer **58** and conductor **15**. A separate input to each of the units from the oscillator **12** is shown, and each of the units has a **12** volt source connected to the primary of each tuned circuit. It will be noted that for simplicity, the variable resistors or potentiometers and inductors in the primary of each tuned circuit stage are shown connected together and each inductor, resistor, and variable capacitor in each stage of the secondary are shown connected together directly, in a manner which is equivalent of that shown in FIG. **2**, rather than by conductors **45**, **45***a*, etc., and conductors **47**, **47***a*, etc. It will also be noted that each unit in FIG. **3** includes a diode **52** and **252**, respectively, and a filter capacitor **54** and **254**, each of which is terminated to ground. The load control potentiometer **58** is terminated to ground through resistor **259**. The first unit **140** comprises the first tuned circuit, which includes potentiometer **142**, primary inductor **143**, secondary inductor **144**, resistor **146**, and variable capacitor **148**, and the second and third "*a*" and "*b*" tuned circuits, comprising, respectively, potentiometers **142***a*, **142***b*, and their respective associated components, some of whose reference numerals have been omitted for convenience and clarity, including the primary and secondary inductors and resistors. The variable capacitors **148***a* and **148***b* are shown. The second unit **240** includes potentiometers **242**, **242***a*, **242***b*, primary inductors **243** – **243***b*, secondary inductors **244** – **244***b*, resistors **246** – **246***b*, and variable capacitors **248** – **248***b*. Note also that some reference numerals have been again omitted for convenience and clarity. The first unit **140** controls from full load conditions of the engine throughout the engine operating speed range and the second unit **240** controls conditions from no load to full load throughout the operating speed range. That is, at no load condition, the second unit **240** has 100 percent effect and at full load condition it has 0 percent effect. The situation is just the opposite for unit **140**, which has 100 percent effect at full load and 0 percent effect at no load. The same resonant frequency of corresponding tuned circuit stages for each unit gives different voltage outputs through the potentiometer **58**. The different voltages then correspond to the load conditions.

FIG. **4** discloses two tuned circuit stages, as from the embodiment of FIG. **2**, and illustrates two different types of tuned circuits, both of which are well known in the art. The first tuned circuit **340** shows the tuned circuit utilized in both FIGS. **2** and **3**, in which a variable resistor or potentiometer **342** is used to vary the output at a particular frequency and a variable capacitor **348** is used to tune the circuit. The primary inductor **343**, secondary inductor **344** and resistor **346** correspond to the respective components in FIGS. **2** and **3**. The second stage of FIG. **4** shows another type of tuned circuit **440** in which the output is controlled by varying the coupling between inductors **443** and **444**, and, accordingly, fixed resistor **442** is used in the primary circuit. While both circuits produce substantially similar results and are therefore the substantial equivalents with respect to the present invention, the type of tuned circuit used in the first stage **340**, utilizing the potentiometer, is preferred. Resistor **446** and variable capacitor **448** correspond to the respective components in FIGS. **2** and **3** and in tuned circuit **340**.

FIG. **5** illustrates another embodiment showing two stages of tuned circuits **540** and **640** which may be utilized in the present invention. Separate amplifiers are shown for each tuned circuit stage. Instead of using one amplifier for all tuned circuits, as illustrated in FIG. **1**, individual amplifiers, such as amplifying transistors **524** and **626**, may be used for each tuned circuit, with separate RF inputs through resistors **520** and **620** to each amplifier. The output of each amplifier is controlled by potentiometers **522** and **622** to the respective amplifiers. Accordingly, the primary of each circuit includes a fixed resistor **542** and **642**, respectively. The circuits are tuned by variable inductors **544** and **644**, respectively, and capacitors **548** and **648** are accordingly of a fixed value. Secondary resistors **546** and **646** are the same as previously illustrated. Each circuit **540** and **640** includes a 12 volt source, and the secondaries are connected together as previously illustrated. The output from the tuned circuits is through diode **552**.

It may thus be seen that the new and useful fuel control system herein described overcomes the deficiencies of the prior art and provides the flexibility desired for optimum efficiency of internal combustion engines. The tuned circuits provide means for compensating for the volumetric efficiency of an engine at all speeds and the load responsive system provides for compensation under all load conditions. The fuel pressure control

system and the fuel timing system combine to provide an effective, efficient, and versatile fuel control system. However, it is obvious that alternatives may be used. For example, the herein described system may be used to control fuel flow by varying the fuel pressure at the fuel pump. Under such circumstances constant width pulses may be used to control the timing of the fuel nozzles. Similarly, continuous flow nozzles may be used, the pulse generator **16** may be eliminated, and the fuel may be entirely controlled by the fuel pump. It is also obvious that one or more tuned circuit units could be added to the embodiment of FIG. **3** with inputs tapped into potentiometer **58** in addition to the inputs at either end of the potentiometer, as shown.

What is claimed is:

1. A fuel control system for an internal combustion engine having a fuel supply and at least a single electromagnetically actuable fuel nozzle connected therewith, comprising, in combination:

means responsive to the speed of the engine for providing an RF signal;

tuned circuit means responsive to the RF signal for providing an output voltage at resonant frequencies; and

a pulse generator responsive to the voltage from the tuned circuit means for generating a pulse to control the electromagnetically actuable fuel nozzle and the flow of fuel therethrough.

2. The fuel control system of claim **1** in which the means responsive to the speed of the engine includes means for sensing the speed of the engine.

3. The fuel control system of claim **2** in which the means responsive to the speed of the engine further includes a frequency modulated radio frequency oscillator.

4. The apparatus of claim **3** in which the RF signal is frequency modulated according to the speed of the engine.

5. The fuel control system of claim **1** in which the tuned circuit means comprises at least a single adjustable tuned circuit for resonating at a predetermined frequency.

6. The apparatus of claim **5** in which the tuned circuit means includes means for varying the output voltage of the circuit.

7. The fuel control system of claim **1** in which the tuned circuit means includes engine load responsive means to modulate the voltage from the tuned circuit means.

8. The apparatus of claim **7** in which the engine load responsive means comprises:

a cylinder;

conduit means connecting the cylinder to a source of engine vacuum;

diaphragm means associated with the cylinder and displaceable in response to engine vacuum within the cylinder;

circuit means for receiving the voltage from the tuned circuit; and

means connecting the diaphragm means to the circuit means for modulating the voltage from the circuit means in response to displacement of the diaphragm means.

9. The apparatus of claim **8** in which the circuit means for receiving the voltage from the tuned circuit comprises a potentiometer.

10. The apparatus of claim **9** in which the tuned circuit means comprises a plurality of tuned circuits, each of which is adjustable as to output and resonant frequency.

11. The apparatus of claim **10** in which the plurality of tuned circuits comprise two units of tuned circuits.

12. The apparatus of claim **11** in which each unit of tuned circuits is separately connected to the potentiometer at opposite ends thereof.

13. The apparatus of claim **1** in which the tuned circuit means includes a plurality of tuned circuits, each of which is tuneable to a different resonant frequency, and the output from each of which is variable, for responding each according to a desired RF signal.

14. The apparatus of claim **13** in which each tuned circuit includes an amplifier.

15. A fuel control system for an internal combustion engine, comprising, in combination:

means for producing a radio frequency signal in response to the speed of the engine;

an adjustable radio frequency memory system responsive to the radio frequency signal for providing a variable voltage;

a pulse generator for providing variable width pulses according to the voltage from the radio frequency memory system;

a fuel supply;

at least a single fuel nozzle connected to the fuel supply and actuable in response to pulses from the pulse generator; and

fuel pressure means responsive to the variable voltage from the radio frequency memory system for controlling the pressure of fuel from the fuel supply to the fuel nozzle.

16. The apparatus of claim **15** in which the pulse generator is also responsive to a plurality of desired engine parameters.

17. The apparatus of claim **15** in which the memory system includes means for varying the voltage therefrom according to the engine vacuum pressure.

18. The apparatus of claim **15** in which the fuel pressure means includes a fuel pump connected to the fuel supply and to the nozzle and a fuel pump pressure control amplifier responsive to the voltage from the memory system for controlling the speed of the fuel pump.

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