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Rachel et al.

[11] **3,765,380**

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[54] **ELECTRONIC FUEL CONTROL SYSTEMS WITH NONLINEARIZING CIRCUIT MEANS INTERCONNECTING THE PRESSURE TRANSDUCER WITH THE MAIN COMPUTATION MEANS**

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[52] **U.S. Cl.** ..... **123/32 EA,** 123/119 R

[51] **Int. Cl.** **F02m 51/00**

[58] **Field of Search** ..... 123/32 EA, 119

[56] **References Cited**

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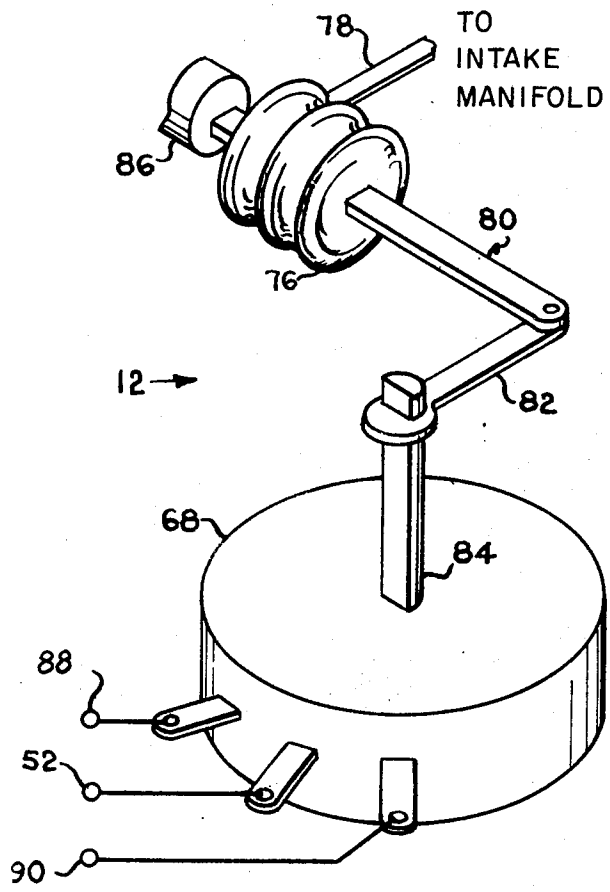
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[57] **ABSTRACT**

In a fuel control system of the type which combines signals indicative of engine speed and engine load to compute a fuel requirement signal, a passive, nonlinearizing circuit is interposed between the intake manifold pressure transducer and the main computing means. The nonlinearizing means is comprised of passive resistive elements in a series-parallel relationship to provide a suitably tailored output signal in response to a manifold pressure input signal.

1 Claim, 6 Drawing Figures



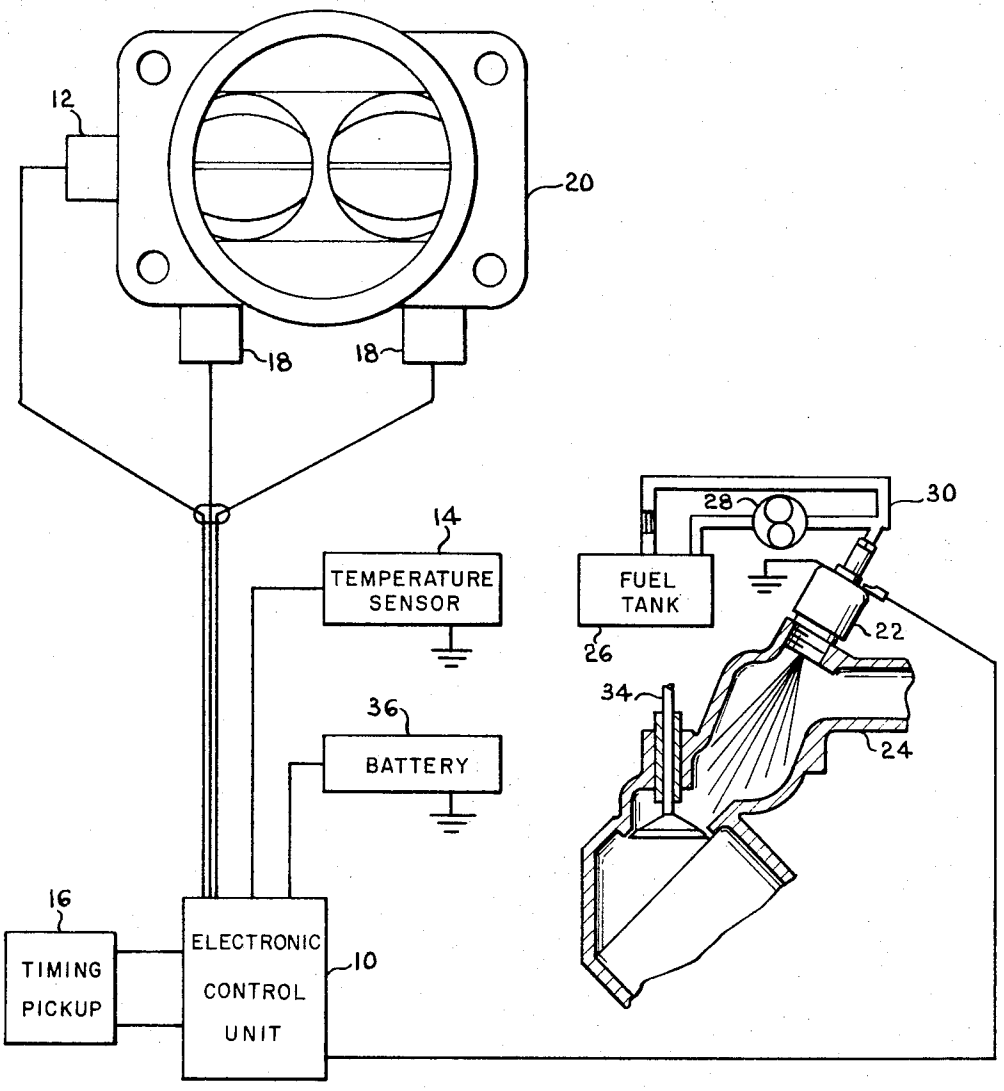


FIGURE 1

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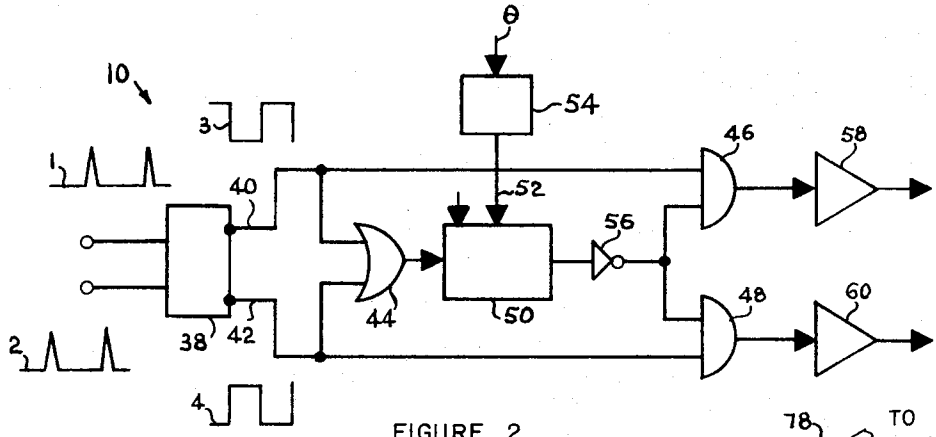


FIGURE 2

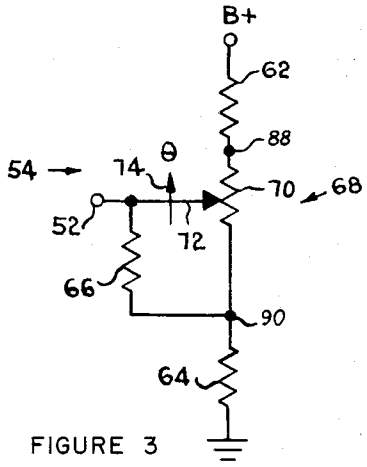


FIGURE 3

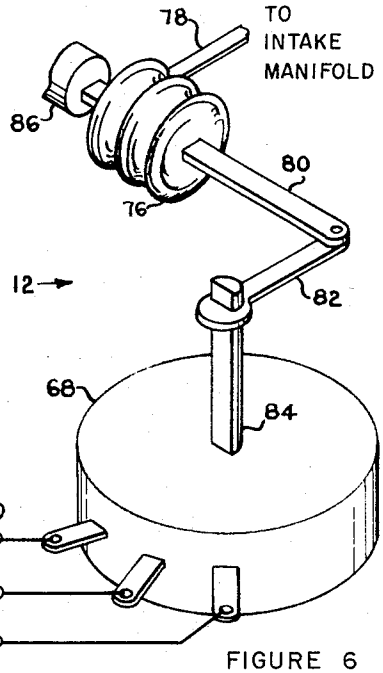


FIGURE 6

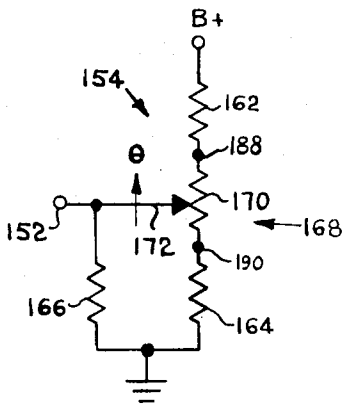


FIGURE 4

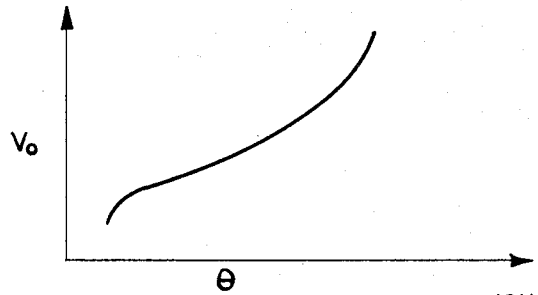


FIGURE 5

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ELECTRONIC FUEL CONTROL SYSTEMS WITH NONLINEARIZING CIRCUIT MEANS INTERCONNECTING THE PRESSURE TRANSDUCER WITH THE MAIN COMPUTATION MEANS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the field of electronic fuel control systems for reciprocating piston internal combustion engines and, more particularly to that portion of the above-described field which relates to the interface of engine sensory elements with the electronic computing means, in particular, to the interface between the intake manifold pressure sensor and the main computing means.

2. Description of the Prior Art

In reciprocating piston internal combustion engines which derive their operating air through an intake manifold, it is known that the fuel requirement is an inverse nonlinear function of the pressure within the intake manifold upstream of the engine valves. The prior art teaches that reactive circuit elements can be combined with mechanical motion producing pressure transducers to provide a reasonably accurate electrical signal indicative of the average air pressure within the intake manifold. In those systems which provide fuel on an intermittent injection basis, capacitive and inductive pressure-to-electric transducers are well known. In addition, it is known that resistive pressure transducers can be provided by suitably tailoring a conventional potentiometer to provide a nonlinear output response with respect to a substantially linear input motion.

Each of the above described known pressure-to-electric transducer mechanisms is disadvantageous because of the high cost involved in fabricating such elements to be suitably nonlinear that their response characteristics closely match the engine fuel requirements at any given manifold air pressure. In addition, the nonlinearized potentiometer used as the pressure-to-electric transducer is known to have relatively short life in the absence of a further increment of expense due to the constant rubbing of the slider (or movable member) over the resistive element. It is an object of the present invention to provide a transducer element and interface mechanism for converting pressure indications of pressure in the intake manifold to a suitably tailored electrical signal for the main computing unit of an electronic fuel control system. In view of the fact that linear response potentiometers having long life are well known in the market place and are available at comparatively slight expense, it is a further object of the present invention to provide a passive circuit interface mechanism which will include a known linear potentiometer to convert a motion which is representative of the intake manifold air pressure to a nonlinearized electrical signal which closely represents the fuel requirement for the engine at any particular intake manifold air pressure.

SUMMARY OF THE INVENTION

The present invention provides a series-parallel circuit configuration which includes a potentiometer having a substantially linear response characteristic for input motion, which circuit is to be connected with a pressure-to-motion transducer which may be of the convention bellows type to provide an electrical output signal having a response characteristic which is directly indicative of the engine fuel requirement at any particular air intake manifold pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic diagram of an electronic fuel control system adapted to a reciprocating piston internal combustion engine.

FIG. 2 shows, in logic diagram form, an electronic fuel control main computing circuit.

FIG. 3 shows one embodiment of a circuit according to the present invention.

FIG. 4 shows an alternative embodiment of a circuit according to the present invention.

FIG. 5 shows a graph of output voltage plotted as a function of angle of rotation of the center top of a potentiometer.

FIG. 6 shows one form of pressure sensor having a linear potentiometer useful with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, an electronic fuel control system is shown in schematic form. The system is comprised of a computing means **10**, a manifold pressure sensor **12**, a temperature sensor **14**, an input timing means **16** and various other sensors denoted as **18**. The manifold pressure sensor **12** and the associated other sensors **18** are mounted on throttle body **20**. The output of the computing means **10** is coupled to an electromagnetic injector valve member **22** mounted in the intake manifold **24** and arranged to provide fuel from tank **26** via pumping means **28** and suitable fuel conduits **30** for delivery to a combustion cylinder **32** of an internal combustion engine, otherwise not shown. While the injector valve member **22** is illustrated as delivering a spray of fuel towards an open intake valve **34**, it will be understood that this representation is merely illustrative and that other delivery arrangements are known and utilized. Furthermore, it is well known in the art of electronic fuel control systems that computing means **10** may control an injector valve means comprised of one or more injector valve members **22** arranged to be actuated singly or in groups of varying numbers in a sequential fashion as well as simultaneously. The computing means **10** is shown here as energized by battery **36** which could be a vehicle battery and/or vehicle charging system as well as a separate battery.

The logic diagram shown in FIG. 2 illustrates the computing means **10** in a nonparticularized manner as applied to a two-group injection system. In FIG. 2, there is shown a switching device **38** capable of producing alternating output signals and receiving as input a signal or signals representative of engine crank angle as from sensor **16**. Mechanically, sensor **16** could be a single lobed cam, driven by the engine and alternately opening and closing a pair of contacts. Since this arrangement could generate spurious signals, as by contact bounce, the switching device **38** will be described and discussed as a flip flop since the flip flop is known to produce a substantially constant level of output at one output location and zero level at the other output location in response to a triggering signal which need only be a spike input but may also be of longer duration and a flip flop may be readily made insensitive to other types of signals. Traces **1** and **2** illustrate the alternating

triggering input signals while traces 3 and 4 illustrate the time relationship of the two output signals. Signals received on the nontriggering input will, of course, have no effect on a flip flop. Outputs **40** and **42** are connected to the inputs of a logic gate **44.** Gate **44** is arranged to give a relatively short duration pulse whenever the flip flop **38** changes state and to produce a constant level d.c. output at all other times. Outputs **40** and **42** are also connected to the inputs of a pair of AND gates with output **40** being connected to one input of AND gate **46** and the output **42** being connected to one input of AND gate **48.** The output of the gate **44** is connected to the input of an adaptive delay means **50** which receives, as control inputs, signals from the various engine parameter sensors, as at **52,** indicative of engine operating conditions and, therefore, of the engine fuel requirement. As will be readily observed, one of the inputs at **52** is derived from signal generator **54** which receives, as its input the angular signal θ, derived from the pressure sensor **12** of FIG. **1.** The output of the adaptive delay means **50** is fed through an inverter **56** and the output of the inverter **56** is connected to a second input of each AND gate **46** and **48.** The output of AND gate **46** is connected to amplifier **58** which, in turn, supplies controlling current to the first injector group. AND gate **48** is connected to amplifier **60** which supplies controlling current to the second injector group.

As will be readily apparent, the presence of an output signal from the flip flop **38** will occur at one output location to the exclusion of the other. This signal will then appear at one input of only one AND gate of only one amplifier. This signal selectively designates an injector or injector group for imminent injection. For the sake of example, we shall assume that the output signal of the flip flop **38** is at output location **40** so that the signal also appears at one input of AND gate **46.** The signal from the output **40** of the flip flop **38** also appears at the gate **44** where, assuming the flip flop **38** has just changed state, a short duration signal is passed to the adaptive delay means **50.** The adaptive delay means **50** is operative to produce an output after the passage of a predetermined amount of time. This time is determined by the values of the sensory inputs applied at **52** to the adaptive delay **50.** During this initial period of time when the output of the adaptive delay **50** is zero, the inverter **56** is producing a full-strength output signal. This signal is applied to one input of each of the AND gates **46** and **48.** Because of the intrinsic nature of AND gates, an output signal is produced only while an input signal is being applied to each and every input. This then dictates that AND gate **46** will produce an output to be amplified by amplifier **58** to open the first injector group since it is receiving an injector selection command directly from the flip flop **38** and an injector control command from the inverter **56.** At the end of the time delay period, adaptive delay means **50** produces a signal which is then inverted from a positive signal to a zero level signal by the inverter **56** so that the injection control command output signal of the inverter **56** is removed from the input to the AND gate **46** and the output of the AND gate **46** goes to zero thereby allowing the first injector group to close. During the period of time the first injector group is open, a metered amount of fuel under pressure is injected by the first injector group.

Referring now to FIG. **3,** the signal generator **54,** according to the present invention, is illustrated as a resistive network interconnecting B+ and ground through a pair of series connected resistors **62, 64** and a parallel resistive combination which includes resistors **66** and potentiometer **68.** As is well known, B+ represents merely a source of electrical energy and may be positive or negative with respect to the ground or common potential. The parallel combination of resistor **66** and potentiometer **68** is operative to interconnect the series resistors **62** and **64.** The potentiometer **68** is illustrated as having the main resistive portion **70** and a movable contact member **72.** Movable contact member **72** is directly coupled to the pressure-to-motion transducer and the motion produced thereby is such that the movable member will follow arrow **74** (counterclockwise with respect to the relative directions illustrated in FIG. **3**) for decreasing pressure within the intake manifold. This will provide at output terminal **52,** which corresponds to the input location similarly numbered on the logic diagram of FIG. **2,** with a voltage signal which is a minimum for zero rotation of the movable member and is a maximum for the maximum amount of rotation of movable member **72.**

Referring now th the diagram of FIG. **5,** the relationship between the output signal at location **52,** V_0, with respect to angular displacement of the movable member is illustrated as θ. As will be observed, the output signal V_0 increases sharply for small movements of the movable member at lower values of V_0 and then increases on a gradual, almost linear, basis up until the region of greatest values of movement of the movable member **72.** This is a result of the fact that potentiometer **68** presents a resistive portion which is in series with resistors **62** and **64** and also presents a portion which is in parallel with resistor **66** and the relative amounts of resistor **70** which are in series and which are in parallel will change as the movable member **72** moves counterclockwise relative to FIG. **3.** The precise shaping of this curve then becomes an exercise in numerical analysis of the relative sizes of resistors **62, 64, 66** and **70** to determine precise values of resistance which should be located in this circuit to provide the desired result. The actual shape of the curve V_0 with respect to θ depends upon the engine type and may be determined empirically for any given engine.

Referring now to FIG. **4,** an alternative embodiment to the circuitry of FIG. **3** is illustrated. In this embodiment, circuit elements which are similar to those illustrated in FIG. **3** will carry similar numeral designations except that they are in the **100** series of numeral designation. In this embodiment, resistor **166** is in parallel with a portion of the potentiometer **168** as well as with resistor **164.** This circuit is also capable of generating the curve illustrated in FIG. **5** and, therefore, represents merely an alternative embodiment which would be used at the choice of the system designer when taking into consideration the specific resistive elements required as contrasted with those which may be commercially or otherwise readily available.

Referring now to FIG. **6,** one form of pressure transducer **12** is illustrated. Transducer **12** is comprised of a pressure-to-motion transducer portion **12M** and a motion-to-electric transducer portion in the form of potentiometer **68.** Pressure-to-motion transducer **12M** is comprised of a conventional bellows system **76** the interior region of which is communicated to the air in-

take manifold by conduit **78.** Lever arm **80** is fixedly attached to one end of bellows and ends in crank lever **82.** The end of crank lever **82** is attached to the rotary shaft **84** of potentiometer **68.** As is the conventional practice, the end of rotary shaft **84** terminates in wiper means not shown which would slide along a resistor located within the interior region of potentiometer **68.** Bellows system **76** is anchored to any convenient structure such as is illustrated at **86.**

Potentiometer **68** is provided with three electrical terminals designated **52, 88** and **90.** These terminals correspond to the similarly designated circuit locations in the FIG. **3** embodiment and to circuit locations **152, 188** and **190** in the FIG. **4** embodiment. With reference to FIGS. **1,2,3** and **6,** the circuit portions of signal generator **54** other than potentiometer **68** could be located within computing means **10** with only the electrical conductors which comprise circuit locations **52, 88** and **90** interconnecting pressure transducer **12** and main computing means **10.**

I claim:

1. An engine control circuit for providing an output signal with a value indicative of the fuel requirement of an internal combustion engine having an air intake manifold and a fuel requirement that increases nonlinearly and monotonically in response to decreasing air pressure in the manifold, said control circuit comprising:

an energy receiving input terminal;

a ground terminal;

an output terminal;

means defining an electrically conductive path between said input and ground terminals and including a first electrically resistive element having an electrical resistance that varies linearly along said element;

a contact member movable along said resistive element in response to changing air pressure within the intake manifold, said contact member connecting said resistive element with said output terminal to provide an output signal at said output terminal; and

means defining a second electrically conductive path connecting said contact member with said ground terminal, said second path including a passive electrical resistance in parallel with one portion of said first resistive element and in series with another portion of said first resistive element, the relative sizes of said portions of said first resistive element being varied by motion of said contact member along said first resistive element to cause that output signal to vary nonlinearly and in accordance with engine fuel requirement.

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