May 5, 1959 D. C. BREEDING ET AL 2,884,915

CONTROL FOR FUEL SUPPLY SYSTEM

Filed Oct. 25, 1956

Fig. 1

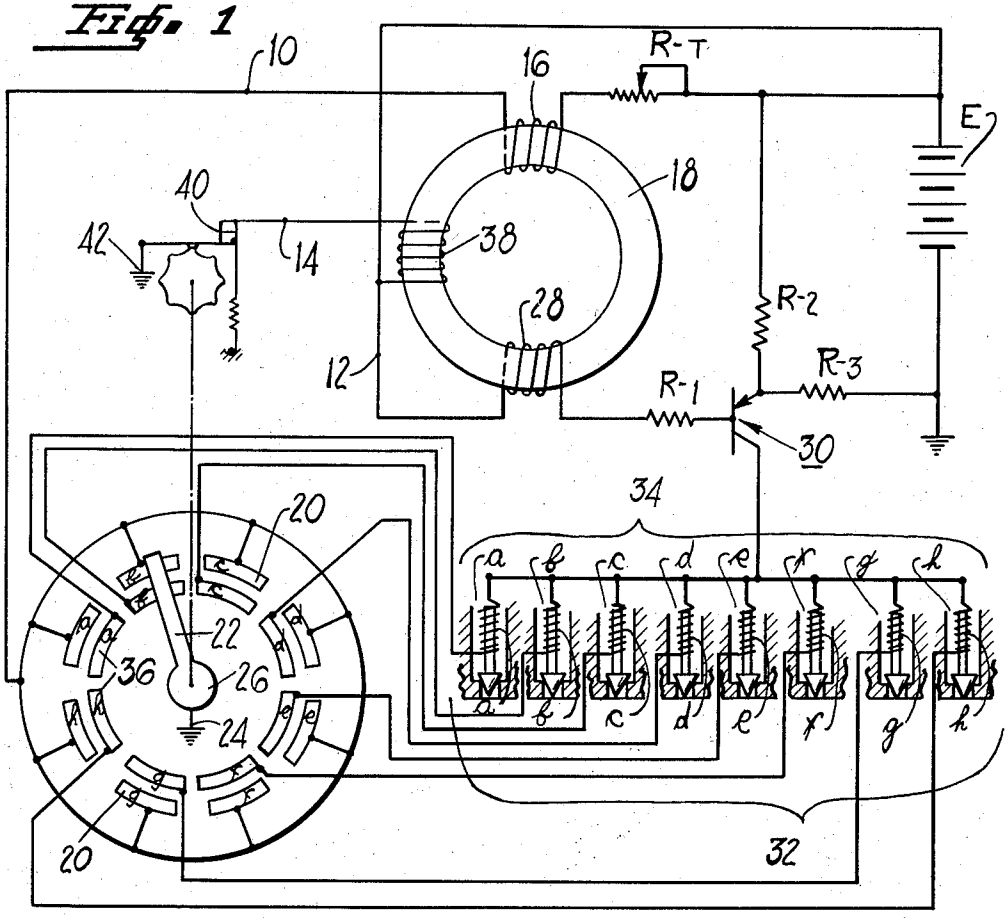


Fig. 2

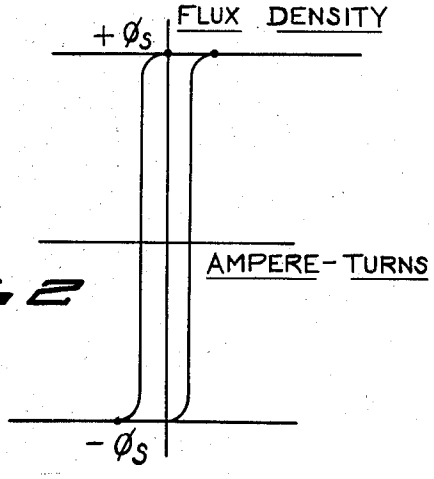
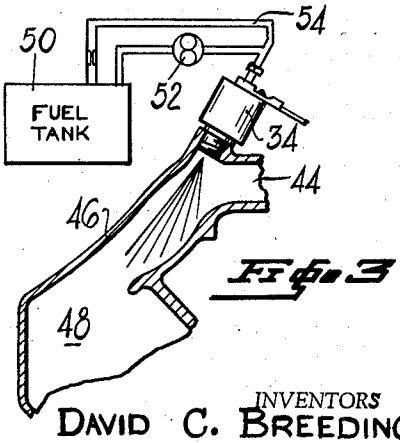


Fig. 3



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CONTROL FOR FUEL SUPPLY SYSTEM

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8 Claims. (Cl. 123—119)

The present invention relates to a control for fuel systems wherein the quantity of fuel supplied by the system to an engine is varied as a function of the time duration of opening of a fuel valve or valves. The time duration of valve opening is controlled as a function of an engine operating condition such as ambient temperature, engine temperature, ambient pressure, relative humidity, induction pressure, exhaust temperature and/or pressure etc.

In an application filed on even date bearing U.S. Serial No. 618,365 in the name of Melvin C. Bartz there is disclosed and claimed a magnetic control for directly energizing a solenoid fuel valve to open the valve for a controlled time duration. In some installations where the source of power is low and the solenoid is not properly matched to the magnetic circuit, the circuit disclosed in the above identified application may be incapable of satisfactorily actuating the valve.

It is an object of the present invention to provide a control having power amplifier means for controlling the quantity of fuel discharged by a fuel supply system.

It is a further object of the invention to provide a rugged, small, light weight and reliable control for a fuel supply system.

Other objects and advantages will be readily apparent from the following detailed description taken in connection with the appended drawings in which:

Figure 1 is a diagrammatic view of a control embodying our invention;

Figure 2 is a characteristic curve of certain operating relationship; and

Figure 3 is a diagrammatic view of fuel valve mounted in operative position in an internal combustion engine.

Referring now to the drawings, primary, secondary and tertiary circuits respectively designated **10**, **12** and **14** connect a source of power E to ground or reference potential. The primary circuit **10** includes a potentiometer R_t which varies the magnitude or intensity of the power or magnetomotive force supplied to a primary inductor **16** which is wound on a relatively high retentivity core **18**. Primary inductor **16** is connected through appropriate wiring harness to a plurality of segmental contacts **20** which are adapted to be successively engaged by a wiper arm **22** which is connected to ground or reference potential at **24**. Arm **22** is mounted on a shaft **26** which is arranged to be rotated as a function of engine speed.

The secondary circuit includes a secondary inductor **28** wound on core **18** connected on one side to source of power E and on the other side to a transistor or power amplifier **30** through a base current limiting resistance R_1. In some installations R_1 may be omitted if desired. Power amplifier **30** is connected to each of the solenoids **32** *a, b, c, d, e, f, g* and *h* respectively located in electrically actuable fuel control members designated **34** *a, b, c, d, e, f, g* and *h*. The number of solenoids or fuel control members may conveniently correspond to the number of combustion chambers in

the engine to which the fuel supply system is adapted to supply fuel. Although it is to be understood that the proportion of fuel control members to combustion chambers may be increased or decreased as desired. Solenoids **32** *a, b, c, d, e, f, g* and *h* are respectively connected by appropriate wiring harness to segmental contacts designated **36** *a, b, c, d, e, f, g* and *h* which are adapted to be successively engaged by a wiper arm **22** for connection to ground or reference potential at **24**. Transistor **30** is normally cut off by voltage divider R_2, R_3. The transistor or power amplifier **30** is rendered conductive when a properly oriented voltage pulse or a voltage pulse of proper polarity is received from secondary inductor **28**.

The tertiary circuit **14** includes source of power E, a tertiary inductor **38** wound on core **18** and reset contacts **40** which are adapted for actuation in timed relation to wiper arm **22** for connecting tertiary inductor **38** to ground or reference potential at **42**.

As shown in the characteristic curve of Figure 2 the tertiary circuit **14** brings the reference flux condition of core **18** to saturation in one direction such as is shown at $-\phi_s$ (ϕ_s=saturation flux). The primary circuit causes the core to become saturated in the opposite direction shown at $+\phi_s$. The time required for flux in core **18** to change from $-\phi_s$ to $+\phi_s$ is controlled by the magnitude of the voltage or magnetomotive force in the primary inductor **16**. It is also to be noted in Figure 2 that when wiper arm **22** breaks contact with a segment **20** and the current is reduced to zero that there is substantially no change in flux and therefore no undesirable surge of current in the inductor.

Figure 3 shows a nozzle or fuel control member **34** installed in the induction passage **44** of an internal combustion engine **46** having a combustion chamber **48**. As shown, fuel from the supply tank **50** is placed under pressure by pump **52** and is delivered to the member **34**. Fuel supplied to the member **34** in excess of the amount injected into the engine is returned to the supply tank via restricted conduit **54**.

In operation the voltage or magnetomotive force supplied to the primary inductors **16** is varied by potentiometer R_t. R_t is variable in response to changes in engine operating conditions such as induction passage pressure, ambient pressure, relative humidity, engine temperature, ambient temperature, exhaust temperature and/or pressure or combinations thereof. The voltage supplied to primary inductors **16** is sufficient to drive core **18** into saturation. The magnitude of the voltage supplied to primary inductors **16** varies the time required for the flux to reach saturation in accordance with the following formula:

$$Et=2BAN10^{-8}$$

Where:

B=flux density
A=core area
N=number of turns

In a given installation B, A and N are constant therefore:

$$Et=K$$

$$t=\frac{K}{E}$$

indicating voltage E and time t to be inversely proportional. Thus when the primary circuit is opened and closed by the wiper arm **22** successively engaging segmental contacts **20** the time required during each energization of the circuit for the flux to build up from a reference condition to a saturated condition is controllable by varying R_t. To provide for a reference condition in the core, the tertiary circuit is energized in

timed relation to the energization of the primary circuit to saturate the core in the opposite direction from the direction of saturation produced by the primary inductor. Therefore, upon each engagement of wiper arm with a segmental contact **20** the build up of flux in core **18** is from a reference condition of saturation to saturation in the opposite direction whereby the current induced in the secondary inductor **28** by the primary inductor is always in the same direction so as to produce a properly oriented or polarized voltage pulse for causing transistor or power amplifier **30** to become conductive. The time duration of conductivity of power amplifier **30** is controlled by the time required for core **18** to be saturated by the primary inductor **16** from a reference core flux condition. Wiper arm **22** through successive engagement with contacts **36***a* to *h* completes the circuit to the appropriate solenoid whereby actuation of the fuel control members occurs in timed relation to engine operation.

As may be seen the control of our invention requires relatively few parts and may be assembled in a small, light weight package and is of such a nature as to be extremely rugged and reliable in operation. The control, with little or no adjustment, can be used with a variety of electrically actuable fuel members having a variety of electrical characteristics.

While only one embodiment of our invention has been described it will be readily apparent to those skilled in the art that various changes and arrangements can be made to obtain the objects of the invention without departing from the spirit thereof.

We claim:

1. A control for a fuel system having an electrically actuable fuel control member comprising: a primary inductor, a variable source of power, means for connecting said source with said primary inductor, a secondary inductor coupled to said primary inductor, a power amplifier connected to said secondary inductor, and means connecting said amplifier to said member.

2. A control for a fuel system for an engine having an electrically actuable fuel control member comprising: a primary inductor, a variable source of power, a circuit connecting said inductor to said source, means responsive to engine speed for periodically opening and closing said circuit, a secondary inductor coupled to said primary inductor, means for controlling the direction of induced current in said secondary inductor, a power amplifier, means connecting said secondary inductor to said amplifier, and means connecting said amplifier to said member.

3. A control for a fuel system having an electrically actuable fuel control member comprising: a core, primary, secondary and tertiary inductors mounted on said core, means for periodically supplying a voltage to said primary inductor sufficient to saturate said core in one direction, means for periodically supplying a magnetomotive force to said tertiary inductors sufficient to saturate said core in a direction opposite said one direction, means for amplifying the current in said secondary inductor, and means connecting said last mentioned means to said member.

4. A control for a fuel system having an electrically actuable fuel control member comprising: a core, primary, secondary and tertiary inductors mounted on said core, means for periodically supplying a voltage to said primary inductor sufficient to saturate said core in one direction, means for varying the magnitude of said force to vary the time required to saturate said core by said primary inductor, means for periodically supplying a magnetomotive force to said tertiary inductors sufficient to saturate said core in a direction opposite to said one direction, means for amplifying the current in said secondary inductor, and means connecting said last mentioned means to said member.

5. A control for a fuel system having a plurality of solenoid actuated valves comprising: a primary inductor, a secondary inductor, means for inducing a current in said second inductor for a controllable time duration, means for orienting the direction of induced current, and means for successively connecting said secondary inductor to said solenoids.

6. A control for a fuel system having a plurality of solenoid actuated valves comprising: a primary inductor, a secondary inductor, means for inducing a current in said second inductor for a controllable time duration, means for orienting the direction of induced current, a power amplifier connected to said secondary inductor, and means for successively connecting said amplifier to said solenoids.

7. A control for a fuel supply system having an electrically actuable fuel control member comprising: a first circuit, a source of power, a primary inductor in said circuit, means connecting said first circuit to said source, means for periodically opening and closing said circuit, a second circuit, a secondary inductor coupled to said primary inductor, means for connecting said secondary inductor to said member, a tertiary inductor in said circuit, means for periodically opening and closing said tertiary circuit in time relation to said last mentioned means, and means connecting said tertiary circuit to said source of power.

8. A control for a fuel supply system having a plurality of electrically actuable fuel valves comprising: a core, primary, secondary and tertiary inductors mounted on said core, primary, secondary and tertiary circuits respectively connected to said inductors, a source of power connected to each of said circuits, means for periodically opening and closing said primary circuit to saturate said core in one direction, means in said primary circuit for varying the intensity of the power applied to said primary inductor to vary the time required to saturate said core, means for periodically opening and closing said secondary circuit in timed relation to said first mentioned means to saturate said core in a direction opposite said one direction, a normally non-conducting power amplifier in said tertiary circuit, said amplifier being rendered conductive by the voltage induced in said tertiary inductor by said primary inductor, means connecting said amplifier to said valves, and means for successively connecting said valve to a reference potential in timed relation to said first mentioned means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,468,917	Booth	May 3, 1949

FOREIGN PATENTS

198,796	Switzerland	Oct. 1, 1938
971,274	France	July 5, 1950