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Bier

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[54] REMOTE METERING SYSTEM

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[51] **Int. Cl.** **F02m 39/00**

[58] **Field of Search** ..123/32 E, 139 E, 139 AV, 134; 223/385

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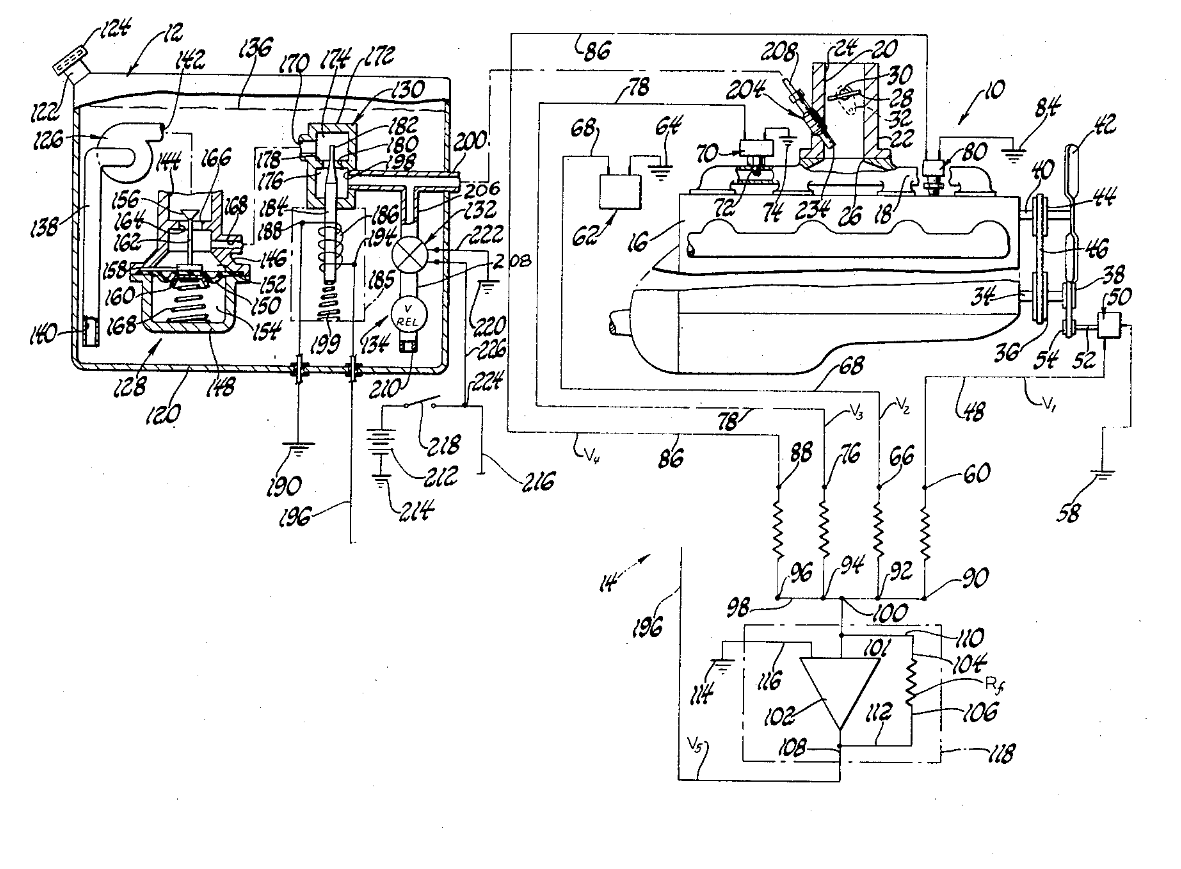
[57] **ABSTRACT**

An internal combustion engine and a fuel supply tank, located remote to the engine, are provided with transducers sensitive and responsive to parameters of engine speed, engine intake manifold pressure, engine temperature and ambient temperature for providing control signals in accordance with such parameters; a fuel supply pump, pressure regulator and fuel metering device are situated within the fuel tank and connected by conduit means to a fuel discharge valve situated for discharging metered fuel to the engine induction passage; and control means responsive to the control signals is operatively connected to the fuel metering device for control thereof in order to thereby meter fuel to the engine in accordance with the demand therefor.

1 Claim, 2 Drawing Figures



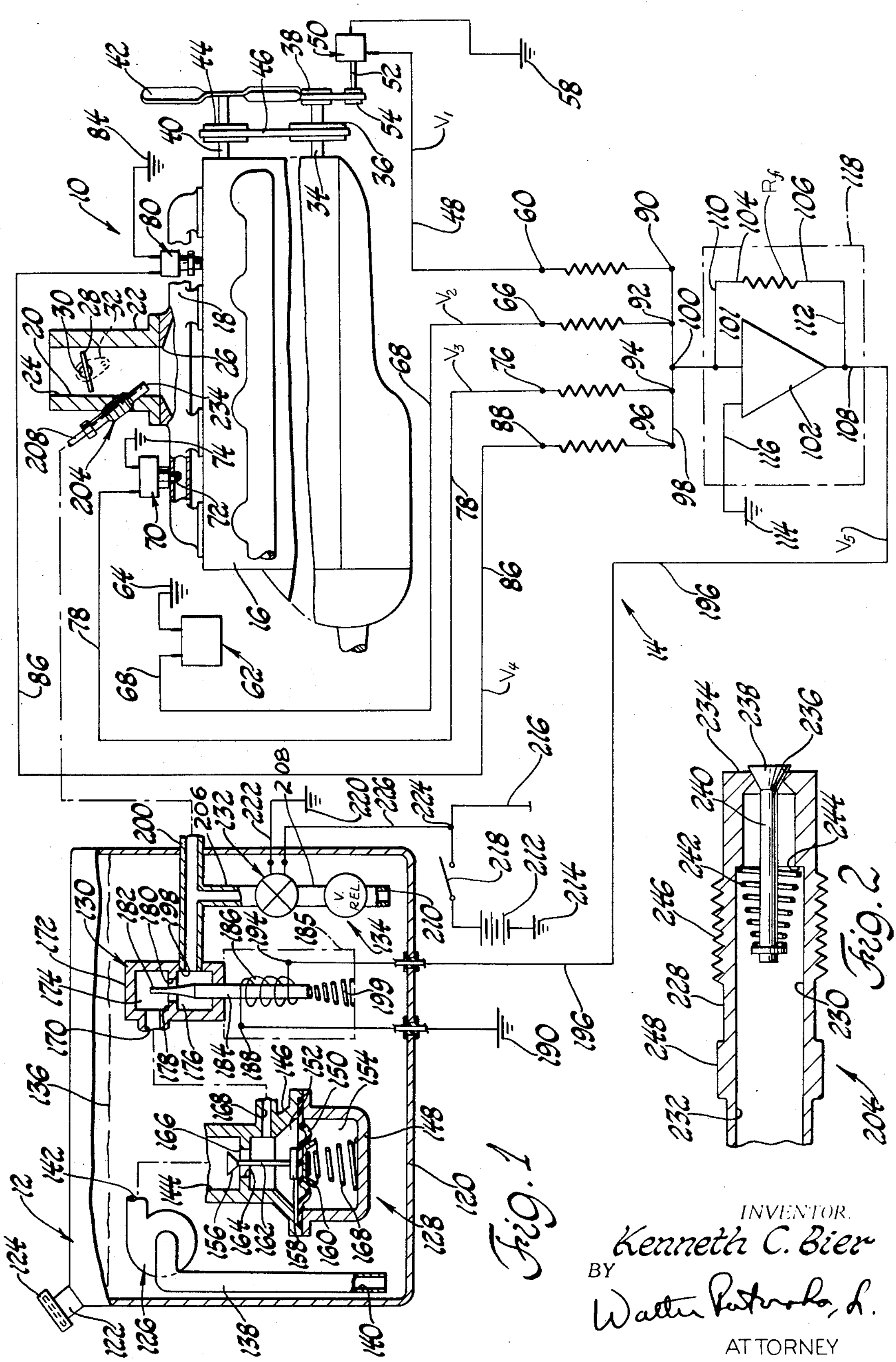


Fig. 1

Fig. 2

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REMOTE METERING SYSTEM

BACKGROUND OF THE INVENTION

In recent time governmental bodies have enacted legislation which limits the amount of contaminants that an automobile engine may discharge into the atmosphere when the vehicle is driven according to a prescribed schedule. In the course of complying with such legislation, the automobile manufacturers have made modifications which have resulted in increased temperatures within the engine compartment. Certain automotive styling trends have further aggravated the problem of increased underhood temperatures and the total problem is still further compounded by the ever increasing volatility of the fuels being marketed. Such conditions often result in problems of starting the engine (when the engine is extremely hot), getting the engine to idle properly (also when the engine is hot), fuel vapor locks in the fuel supply system and evaporative fuel losses to the atmosphere.

Additionally, in order to meet the requirements relating to exhaust emission, it is necessary that the fuel system be sufficiently flexible to provide the optimum quantity of fuel for each of the operating modes of the emission cycle. That is, the quantity of fuel supplied during any given mode of the emission cycle must be adjustable (capable of calibration) independent of each of the other modes of the cycle. The prior art fuel supply systems do not have such characteristics.

Further, when the proper quantity of fuel is supplied to the engine at any operating condition, it is imperative that the atomization and/or vaporization thereof be sufficient to permit optimum ignition or combustion of the fuel-air charge.

Accordingly, the invention as herein disclosed and described is concerned with the solution of the above as well as other related problems.

SUMMARY OF THE INVENTION

According to the invention, a remote fuel metering system for an internal combustion engine and an associated fuel supply tank situated generally remote with respect to said engine, comprises pump means situated within said tank, said pump means including an inlet for admitting said fuel from said tank and an outlet for discharging said fuel under pressure, fuel metering means situated within said fuel supply tank, said fuel metering means including inlet means for receiving said pressurized fuel from said pump means and an outlet for discharging metering fuel, fuel delivery means carried by said engine and operatively connected to said outlet of said fuel metering means, said fuel delivery means being effective for delivering said metered fuel to the engine intake, and additional means responsive to selected engine operating parameters for controlling said fuel metering means in order to thereby achieve a rate of metered fuel flow to said fuel delivery means in accordance with said operating parameters.

DESCRIPTION OF THE DRAWINGS

In the drawings, where in one or more views certain elements may be omitted for purposes of clarity;

FIG. 1 is a somewhat diagrammatic view, with partial electrical circuitry, illustrating a fuel metering system constructed in accordance with the teachings of the invention; and

FIG. 2 is an enlarged fragmentary cross-sectional view of one of the elements shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in greater detail to the drawings, FIG. 1 illustrates a vehicular internal combustion engine **10**, a fuel supply tank **12** situated remote to the engine **10**, as well as electrical circuitry **14** and conduitry operatively interconnecting the fuel tank **12** and the engine **10**.

As generally depicted, the engine **10** may be comprised of an engine block **16**, an intake or induction manifold **18** leading to the inlet valves associated with the pistons and cylinders within the engine block **16**, and an air induction passage **20**, formed within a device **22**, serving to communicate atmospheric air from its intake end **24** to the inlet **26** of the manifold **18**. As shown, a throttle valve **28**, pivotally carried by a variably rotatably positioned throttle shaft **30**, is situated within the induction passage means **20** so as to variably control the rate of air flow therethrough in accordance with operator demands. A throttle actuating lever **32** may be secured to the throttle shaft **30** and operatively connected to suitable control linkage as, for example, the usual foot-operated throttle pedal situated within the passenger compartment of the related vehicle.

A rotatable shaft **34**, which may be, in effect, an extension of the engine crankshaft, is shown as being provided with sheaves **36** and **38** secured thereto for rotation therewith. A second shaft **40**, which may be connected to an engine water (coolant) pump and a fan **42**, fixedly carries a sheave **44** enabling the rotation of such shaft **40** in accordance with the rotation of crankshaft **34** via suitable belt means **46** engaging sheaves **36** and **44**.

As schematically illustrated, a suitable transducer means **50** is provided with a rotatable shaft **52** which fixedly carries a sheaves **54** operatively engaged to the second sheave **38** on crankshaft **34** as by means of a drive belt **56**. The transducer means **50** is shown as having one terminal connected to ground potential as at **58**, while its other terminal is connected to one terminal **60** of a resistor, R_1, via conductor **48**.

A second temperature responsive transducer means **62** is illustrated as being located generally in the ambient atmosphere in which the engine **10** is operating. Transducer **62** is shown having one of its terminals electrically connected to ground as at **64** while its other terminal is connected to one terminal **66** of a second resistor, R_2, by means of conductor **68**.

Similarly, a third pressure responsive transducer means **70** is suitably connected as at **72** so as to be responsive to the pressure within the intake manifold **18**. One terminal of transducer **70** is connected to ground potential as at **74** while the other terminal is electrically connected to one terminal **76** of a third resistor, R_3, via an electrical conductor **78**.

Finally, a fourth transducer means **80**, responsive to temperature, is suitably connected as at **82** so as to be responsive to the temperature of the engine **10**. One terminal of the transducer **80** is connected to ground as at **84** while the other terminal is electrically connected as by conductor means **86** to one terminal **88** of a fourth resistor, R_4.

The other terminals 90, 92, 94 and 96 of resistors R_1, R_2, R_3 and R_4, respectively, are connected by a common electrical conductor 98 which has a juncture point 100 to which one end of a conductor 101, leading to an operational amplifier 102, is connected. A feedback resistor, R_F, is placed in generally parallel relationship with amplifier 102 by having its opposite terminals 104 and 106 respectively connected to input conductor 101 and an output conductor 108 as by conductors 110 and 112. A third terminal of the amplifier 102 is connected to ground 114 as by a conductor 106. As will be seen, the operational amplifier 102 and the feedback resistor R_F comprise an operational amplifier summing system 118.

The fuel tank 12 may be comprised of a general housing 120, provided with filler tube 122 and closure cap 124, containing therein a fuel pump assembly 126, which may be electrically driven, a pressure regulator assembly 128, a main metering valve assembly 130, an on-off type solenoid operated valve assembly 132 and a pressure relief valve assembly 134. As generally depicted, all of the preceding elements may be submerged within the fuel 136 contained in tank housing 120.

As shown, an intake conduit 138, having an open lower end 140, is connected to the inlet of pump assembly 126 which serves to pump such fuel at an elevated pressure through the pump discharge conduit 142 to the inlet conduit portion 144 of the pressure regulator assembly 128.

The regulator assembly 128 may be comprised of housing sections 146 and 148 which peripherally retain therebetween a pressure responsive moveable diaphragm 150 which defines two distinct but generally variable chambers 152 and 154. A valve member 156, secured to the diaphragm 150 as by diaphragm plates 158 and 160, has its stem portion 162 passing through the aperture 164 about which is formed an annular valve seat 166. A compression spring 168, situated within chamber 154, normally urges diaphragm 150 upwardly so as to move valve member 156 away from valve seat 166 in order to open the orifice 164. An outlet conduit 168 communicates with the chamber 152 and serves to direct fuel flow to the inlet conduit portion 170 of the metering valve assembly 130.

The metering valve assembly 130 may be comprised of a housing 172 having formed therein chambers 174 and 176 between which is situated a wall portion 178 provided with a metering orifice 180 formed therethrough. A contoured metering valve portion 182, operatively carried and actuated or positioned as by the armature 184 of a proportional solenoid assembly 185, coacts with the metering orifice 180 in order to determine proper effective flow areas therebetween for achieving the desired rate of fuel flow therethrough. As shown, the proportional solenoid assembly 185, in addition to armature 184, has a winding or field coil 186 having a first terminal 188 connnected to ground 190 as by a conductor 192, and a second terminal 194 connected to one end of a conductor !196 leading to the output conductor 108. Suitable spring means 199 may be provided to normally urge the armature 184 and valve member 182 upwardly thereby tending to more nearly completely close the effective flow area through metering orifice 180.

One end 198 of an outlet conduit 200 is connected to housing 172 so as to be in communication with chamber 176 while its other end 202 is connected to the inlet end of a metered fuel discharge valve assembly 204 which may be threadably carried by the housing of induction device 22, as shown in FIG. 1, so as to have the discharge end thereof in position for discharging metered fuel into the induction passage 20.

A branch conduit 206 serves to connect the inlet of the solenoid operated valve assembly 132 to conduit 200. The outlet of solenoid operated valve assembly 132 is connected via a conduit 208 to the inlet of the pressure relief valve assembly 134 while the outlet thereof is open to the interior of fuel tank housing 120 via conduit 210.

A suitable source of electrical potential 212 has one of its terminals at ground potential, as at 214, while its other terminal is connected to electrical conductor means 216 leading as to, for example, the associated vehicular ignition system (not shown but well known in the art). A convention key-operated ignition switch 218 may be aerially situated in conductor 216. Further, as illustrated, one terminal of the solenoid valve assembly 132 is connected to ground 220 by means of a conductor 222 while its second terminal is connected to conductor 216, at a point 224, as by a second conductor 226. As a consequence of such electrical connections, whenever switch 218 is closed solenoid valve assembly 132 is energized thereby terminating all fluid flow therethrough; whenever switch 218 is open, as shown, solenoid valve assembly 132 is in a de-energized state permitting free flow therethrough from conduit 206 to conduit 208.

Although the fuel discharge valve means may take any suitable form and may in fact be comprised of a plurality of individual valves communicating with the engine induction system at spaced points of discharge, the fuel discharge valve assembly 204, for purposes of illustration, may be comprised of a suitable outer body or housing 228 with an internal passage means 230 having generally an inlet end 232 (for coupling to conduit 200) and an outlet end 234. A discharge aperture 236 is normally closed as by end 238 of a spring-loaded pintle 240 the other end of which is operatively connected to a compression spring 242 seated against an internal shoulder 244. An externally formed threaded portion 246 is provided for operative engagement with, for example, the body of air induction device 22. A suitable tool engaging surface 248 may also be provided for enabling the threadable engagement and disengagement of the valve assembly 204 with respect to the related supporting structure.

OPERATION OF INVENTION

Generally as is well known in the art, a transducer is a device capable of being actuated by power from a first system and capable of, in response thereto, supplying power to a second system different from the first system. Accordingly, as indicated, transducers 50, 62, 70 and 80 are selected as to be responsive to different parameters and to, in turn, produce variable output voltage signals in response thereto.

That is, transducer 50 is made responsive to engine speed and is accordingly effective for producing a variable voltage signal V_1 on conductor 48. The magnitude of voltage signal V_1 generally increases as the speed of the engine increases.

Transducer **62** is responsive to ambient temperature and is set as to produce a voltage signal V_2 on conductor **68**. Generally, the magnitude of voltage signal V_3 decreases as the ambient temperature increases.

Transducer **70** is responsive to manifold vacuum (or pressure) and is set to produce a voltage signal V_3 on conductor **78**. Generally, the magnitude of voltage signal V_3 increases as the pressure in the intake manifold increases (or if considered in terms of vacuum, as the vacuum decreases).

Finally, transducer **80** is responsive to engine temperature and is set to produce a fourth voltage signal V_4 on conductor **86**. Generally, the magnitude of the voltage signal V_4 decreased as the engine temperature increases.

Resistors R_1, R_2, R_3, and R_4 are provided in order to generate a current flow, through each of such resistors, which is proportional to the respective voltage signals generated and applied thereto. Normally, the impedance of the operational amplifier **102** is so high as to preclude any current flow therethrough. Accordingly, point **100** may be considered as a summing point for such current flows regardless of the direction or magnitude of the individual currents I_1, I_2, I_3, and I_4. Since current cannot flow through the operational amplifier, such current passes through the feedback resistor R_F and consequently results in the generation of an output or control voltage V_5 at the terminal **108** and conductor **196**.

As should be evident in view of the preceding, the control voltage V_5 is automatically indicative of the total requirements for fuel flow as sensed by the various transducers responsive to the selected parameters. That is, for example, if engine temperature should rise at any particular engine speed, the value of V_4 will decrease thereby reducing the total value of generated current at summing point **100**. This, in turn, reduces the value or magnitude of V_5.

Accordingly, the normally closed valve **182** and armature **184** are moved downwardly some distance in accordance with the magnitude of the control voltage V_5 applied to the winding **186**. Generally, as the magnitude of control voltage V_5 increases the armature **184** and valve **182** are moved further downwardly thereby producing a greater effective flow area through the metering restriction or orifice **180**.

The rate of metered fuel flow through the metering orifice **180** is, of course, dependent primarily on the effective flow area of the metering orifice **180** and the magnitude of the pressure differential thereacross. However, the factor of the pressure differential is effectively eliminated by the invention. That is, the upstream pressure of the fuel, supplied by the pump assembly, is maintained substantially constant by the pressure regulating or throttling valve assembly **128**. For example, any tendency for an increase in such upstream pressure is sensed by the diaphragm **150** which responds thereto by moving downwardly causing valve member **156** to more nearly close the orifice or passageway **164**, and conversely, as a decrease in upstream pressure is sensed diaphragm **150** is moved upwardly causing valve member **156** further open the orifice or passageway **164**. Consequently, it can be seen that the pressure of the fuel within chamber **174** is maintained substantially constant.

Similarly, the downstream fuel pressure is also maintained substantially constant. That is, the fuel discharger valve assembly **204** is so calibrated so as to permit valve portion **238** to open only upon the attainment of a predetermined fuel pressure within passage means **230**; this being primarily determined by the preload force of spring **242**. Therefore, it can be seen that during normal engine operation, the downstream fuel pressure (downstream of metering orifice **180**) will also be at a substantially constant value but less than the fuel pressure upstream of metering orifice **180**. Therefore, it should be apparent that the volume rate of fuel flow through the metering orifice **180** will be generally in accordance with the position of the metering valve **182** with respect to the metering orifice **180**.

From the preceding it should be apparent that when the engine is cold and initially started the transducer **80** will sense the cold engine temperature and thereby create an output signal V_4 of relatively high magnitude, if the engine remains at idle transducer **70** will sense a relatively high manifold vacuum and in accordance therewith produce an output signal V_3 of relatively high magnitude, and transducer **50** will sense the relatively low engine speed (at idle) and produce in accordance therewith an output signal V_1 of relatively low magnitude. Consequently, the summing point **100** senses a relatively low total current and the feedback resistor, R_F, consequently causes a relatively low control voltage V_5 on conductor **196** causing the metering valve **182** and solenoid armature **184** to be positioned relatively close to the metering restriction **180** reducing the volume rate of metered fuel flow. Of course, it can be seen that with an increase in engine speed, an increase in engine temperature or an increase in engine load, the value of signal V_1 will increase, while in the case of transducers **70** and **80**, the magnitudes of signals V_4 or V_3, as the case may be, will decrease and in accordance therewith alter the total current sensed at summing point **100**.

The disclosure of the invention is intended to be merely exemplary of the many types of arrangement which can be employed within the scope of the inventive concept. To this extent it should be apparent, for example, that various transducers devices could be employed and that, if desired, suitable diodes could be employed within the transducer circuitry shown for providing maximum values of voltage signals generated by the transducers.

From the preceding disclosure, it should also be apparent that the invention provides a fuel metering system responsive to a group of selected parameters wherein the responsiveness of the metering system to any one of the group of selected parameters can be critically tailored or adjusted without in any way influencing the action of the means employed for sensing the remaining parameters of such a group.

Further, as was previously mentioned, during conditions of engine operation, solenoid valve **132** is closed; however, during engine shut-down, solenoid valve **132** is opened so as to permit flow therethrough. The pressure relief valve **134**, may contain suitable spring means, as is well known in the art, which may be set so that the valve **134** will open at a somewhat lower fuel pressure than that at which the delivery valve **204** is set to open. This then provides a discharge or return flow path to the tank **120** in order to accommodate any fuel expansion, due to heat, in the metered fuel supply conduit **200**.

Although only one embodiment of the invention has been disclosed and described, it is apparent that other embodiments and modifications of the invention are possible within the scope of the appended claims.

I claim:

1. A remote fuel metering system for an internal combustion engine and an associated fuel supply tank situated generally remote with respect to said engine, comprising pressure supply means situated within said tank, said pressure supply means including an inlet for admitting said fuel from said tank and an outlet for discharging said fuel under pressure, fuel metering means situated within said fuel supply tank, said fuel metering means including inlet means for receiving said pressurized fuel from said pressure supply means and an outlet for discharging metered fuel, fuel delivery means carried by said engine and operatively connected to said outlet of said fuel metering means, said fuel delivery means being effective for delivering said metered fuel to the intake of said engine, pressure regulating means having an inlet communicating with said outlet of said pressure supply means and an outlet communicating with said inlet of said fuel metering means, said pressure regulating means being enclosed within said tank and effective to regulate the pressure of said fuel entering said inlet of said fuel metering means, and additional means responsive to selected engine operating parameters for controlling said fuel metering means in order to thereby achieve a rate of metered fuel flow to said fuel delivery means in accordance with said operating parameters, said additional means comprising a plurality of individual engine operating parameter sensing means each effective for producing an output signal totally independent of and unaffected by the other of said plurality of sensing means.

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