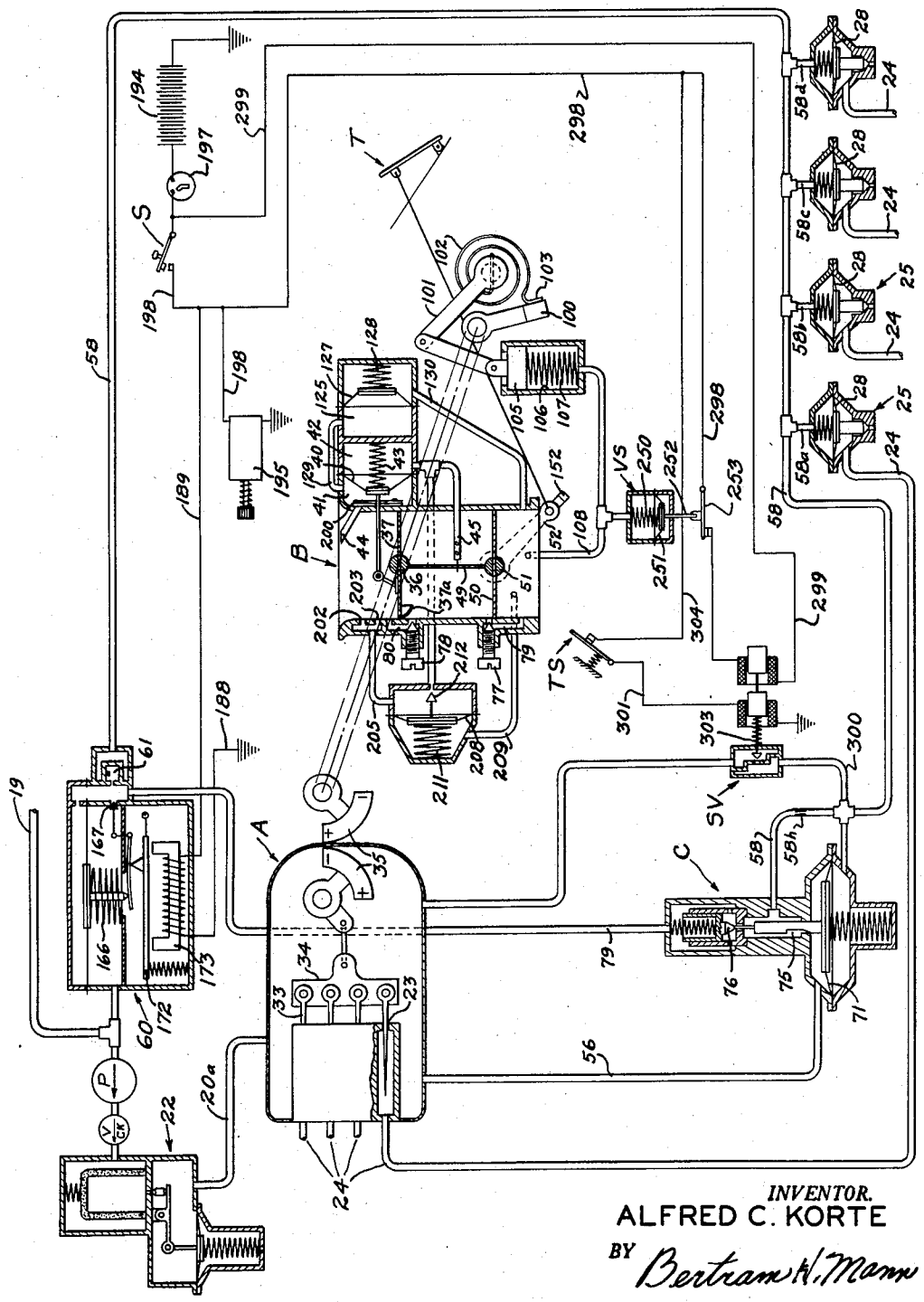
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FUEL INJECTION SYSTEM

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FUEL INJECTION SYSTEM

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This invention is an engine fuel charging device operating as a continuous flow system adapted for intake port injection, in which system the fuel is pressurized, measured under pressure in accordance with engine requirements, and distributed under pressure to points adjacent the intake valves of the several cylinders or combustion chambers of the engine. This application shows an improvement applicable to the basic system shown in the prior patent to James Fred Armstrong, No. 2,785,669, dated March 19, 1957, entitled "Injection Carburetion."

A more complete understanding of the invention herein disclosed will be had by reference to prior applications of James Fred Armstrong, Serial No. 632,798, filed January 7, 1957, for "Fuel Injection System," and Serial No. 646,062, filed March 14, 1957, for "Fuel Injection System," now Patent No. 2,846,994.

The improvement disclosed herein may be applied to any of these prior inventions, as well as others which function on similar principles.

This application is specifically directed to features including a fuel delivery cut-off operated by the ignition switch, an engine load operated means for shutting off the fuel during deceleration of the engine from high speeds, and a control for changing the fuel delivery from the nozzles during engine cranking, which normally increases the flow to prime the engine, or, on full throttle opening, cuts off the fuel flow completely.

These features are all disclosed in the last-mentioned application by James Fred Armstrong, and the improvement here includes electrical circuits for performing the same functions which are simpler and eliminate the need for certain electrical relays and switches.

Further advantages and objects of the invention will become apparent from a reading of the accompanying detailed description taken in connection with the drawing illustrating one form of the invention, in which the figure is a schematic representation showing the basic elements of the injection system with electric controls.

In the detailed description of the invention which follows, the same reference characters will be used, where possible, to indicate the same elements in this system which correspond with those in Patent No. 2,846,994.

DESCRIPTION

Air flow metering

The air metering or measuring part of this system, indicated as B in Fig. 1, may be placed anywhere near the engine and connected with the inlet of the engine intake manifold, which has several branches (not shown) leading to the separate intake ports of the engine. This air measuring or metering part, termed the air horn, has a tubular body constructed for connection at its lower or outlet end to the intake manifold of the engine. The outlet of the air horn is controlled by a suitable throttle **50** mounted on a throttle shaft **51**, and controlled by a throttle arm **52** actuated by a linkage R from the throttle pedal T.

Above the throttle is a balanced air valve **37** mounted

on a suitable shaft **36** journaled in the walls of the air horn B. On the lower leading edge of the air valve **37** is a deflector **37***a* which produces an aerodynamic unbalance tending to close the valve at openings above 55°. The valve **37** is moved in the opening direction by a servo-motor which has a diaphragm **40** operating against a calibrated spring **43** and a connection **39** with the air valve **37**. The servo-motor is powered by the pressure drop across the air valve **37** as sensed by two Pitot tubes **44** and **45** upstream and downstream of the air valve **37**, respectively. A slotted baffle **49** extends between the air valve shaft **36** and the throttle shaft **51** in a manner to eliminate aerodynamic interference of the flow around the throttle **50** with displacements of the air valve **37**.

A by-pass **79** extends around the edge of the throttle **50** when in the closed position, and has a needle valve **77** for adjusting the by-passed air to control the idle speed of the engine.

A by-pass **80** extends around the edge of the air valve and has a metering screw **78** for adjusting the amount of air by-passing the air valve **37** in the idle range of displacements of this valve so as to adjust the mixture ratio at idle.

The air valve **37** is displaced by the power operated servo-motor so that it takes up an angular position indicating the rate of air flow past the throttle **50** to the engine. Shaft **36**, upon which it is mounted, is in turn connected to the fuel metering part A by means of a magnetic clutch **35** to control the displacement of a plurality of tapered fuel metering rods which are calibrated to flow fuel at a rate to give the full throttle power mixture throughout the range of angular displacement of the air measuring valve **37**.

To get a part throttle economy mixture, the response of air valve **37** to air flow is modified to produce a decrease in angular displacement of the air valve **37** for the same rate of air flow as at full throttle. The metering rod displacement likewise is affected, and the rate of fuel delivery is reduced to give an economy mixture for road load operation of the engine.

Part throttle mixture

Air valve response is modified for the above purpose by an air bleed connection **205** in the air horn B which connects the plurality of ports **202** and **203** above the air valve **37** to the suction side **42** of the servo-motor. In this connection is a diaphragm operated valve **212** which is held open against the closing force of the spring **211** by suction connection **209** extending posterior of the throttle valve **50**. When the throttle is open far enough so that manifold depression is less than six inches Hg, for example, valve **212** is closed by the spring **211** against the force of suction acting on the diaphragm **208**, thus cutting off the air bleed **205** from communication with the suction side **42** of the servo-motor. The response of the air valve **37** is thus changed to increase its opening and the displacement of the fuel metering rods to increase the fuel delivery rate to a full rich mixture.

If, on the other hand, engine speed increases in the part throttle range of engine operation, angular air valve displacement is decreased for the same rate of air flow, giving a lesser displacement to the metering rods **33** so as to lean out the mixture for part throttle operation. As engine speed increases, however, angular air valve displacements will also increase as a result of increasing air flow, so that the edge of the air valve **37** and deflector **37***a* swings over the ports **202** and **203**. This places the ports **202** and **203** in a zone of decreasing air pressure due to high velocity flow to reduce the effectiveness of the air bleed on the action of the servo-motor. Air valve response is accordingly modified to increase air valve open-

ing and, consequently, the rate of fuel flow to the engine, giving a richer mixture at higher engine speeds to eliminate the possibility of part throttle detonation.

Mixture control for acceleration

If the particular engine requires a richer mixture on sudden throttle opening, some kind of a connection may be desirable between the throttle and the fuel metering rods to increase the fuel flow temporarily. In this device, it is more convenient to use an equivalent structure which operates the air valve in an opening direction upon opening of the throttle. For example, the air horn B has a pump with a diaphragm **127** spring-powered by a suitable coil spring **128**, and held in operative position with the spring **128** compressed by a connection **130** to the suction side of the air horn below or downstream of the throttle valve **50**. The pressure side of the pump **125** is connected by a passage **129** with the pressure side **41** of the servo-motor. A leaf type of check valve **200** controls the escape of pressure from the Pitot tube 44.

During operation of the engine at idle speeds, suction compresses the spring **128**, but on throttle opening this suction force largely disappears, allowing the spring **128** to expand, pumping air into the chamber **41** of the servo-motor to displace the valve **37** in an opening direction, thus withdrawing the metering rods **33** to increase the fuel mixture ratio temporarily.

Starting mixture enrichment

At low engine temperatures, fuel flow should be increased for starting and engine warm-up. This result is accomplished in the instant device by modification of the response of the air valve **37** instead of by direct connection with the fuel metering rods **33** which is, of course, possible. As illustrated schematically herein, the air horn B mounts a thermostatic spring **102** concentric with respect to one end of the air valve shaft **36**. One end of the spring **102** is held fast in a slot in a pivoted lever **101**, which in turn is angularly movable by a suction operated piston **105** in a cylinder **106** against the force of a calibrated spring **107**. Suction is communicated to the cylinder **106** through a line **108** communicating with the manifold downstream of the throttle **50**. The free end of the thermostat **102**, indicated as **103**, abuts a lever **100** fast on one end of the shaft **36**, and, as the engine cools, the thermostat **102** winds up, exerting a force in a clockwise direction on the lever **100** to urge the valve **37** toward an open position. The force of the thermostat depends upon the temperature, but at temperatures below those encountered in normal operation of the engine this force either actually opens the air valve **37** or decreases the force necessary to open the valve, so that the servo-motor produces a greater degree of valve opening and metering rod movement for increasing the fuel flow to the engine during cranking. As soon as the engine starts, suction rotates the arm **101** to decrease this opening force exerted by the thermostat spring **102** on the arm **100**. Less air valve and metering valve displacements will occur for the same rate of air flow, so that the mixture is leaned out after the engine starts. As engine temperature increases, so does the temperature of the thermostat **102**, thus decreasing the force exerted by the spring **102** on the arm **100** until, at normal engine operating temperature, end **103** backs away from the arm **100** entirely.

Fast idle control

The actual structure for producing a fast idle by cracking the throttle **50** at low engine temperatures is shown in a copending application of James Fred Armstrong, Serial No. 622,917, filed November 19, 1956, and entitled "Fuel Injection System." Figs. 25 and 26 of this application illustrate the fast idle control mechanism. The same structure can be used here, although it is not shown, since it forms no part of this invention.

Fuel metering system

This part of the injection system may be conveniently described as having a fuel charging circuit and a datum pressure circuit. Both circuits are supplied with fuel under pressure from a pump P connected with a fuel tank by the line **19**. The output side of the pump P connects by way of a check valve to a combined filter and pressure regulator **22** of the type shown and described in the prior applications of James Fred Armstrong above mentioned. The discharge from the pressure regulator **22** connects with a fuel chamber A by way of a line **20***a*.

The engine charging circuit includes the pressure chamber A and a plurality of discharge lines **24** connecting the chamber with individual nozzles **25** which discharge adjacent the intake valves of the engine in the branches of the manifold. The inlet of each fuel line **24** is supplied with fuel at the same pressure from the fuel chamber A through separate fuel metering jets or orifices **23**, one for each of the fuel lines **24**. Each metering jet or orifice is variable in area by an individual, tapered metering rod **33**, all supported on a common carrier **34** for moving all of the rods in or out of the jets in unison.

Angular movements of the air valve **37** are mechanically transmitted from the shaft **36** outside the chamber A to move the common carrier **34** inside the chamber A by means of a magnetic clutch having elements **35** disposed inside and outside of the fuel chamber A. Movement of the rods in unison varies the area of all of the fuel metering orifices **23** simultaneously and equally.

Each of the fuel nozzles **25** is, in effect, a pressure regulating type of valve with an operating diaphragm **28** exposed to the action of the pressure downstream of each metering jet **23** in the separate lines **24**. Fuel pressure in each line **24** acts on the diaphragm of the valve in a valve opening direction.

The datum pressure circuit

The opposite side of each of the diaphragms **28** of each nozzle **25** is connected to a by-pass fuel passage **56**, **58** having the branches **58***a*, *b*, *c*, and *d* connecting with the individual fuel nozzles **25**. The datum circuit is maintained under a pressure which bears a constant relation to the chamber pressure (about a half to one-and-a-half pounds gauge lower during operation). Since all of the nozzles are connected with the by-pass **58**, the pressure on the diaphragms **28** resisting valve opening is equal in all of the nozzle valves. When the pump and engine are in operation, each nozzle valve will open until the pressures on opposite sides of each diaphragm balance, or, stated another way, each nozzle valve **25** maintains the pressure downstream of each metering jet **23** equal to datum pressure. The pressure downstream of each metering jet is thereby maintained equal in all the lines **24** by interconnection of all the nozzle valves **25** to the datum system. Each jet is likewise exposed to the same pressure in the common supply chamber A, so that equal division of the flow through the branches is obtained with jets of equal area operating at equal pressure drop.

In the datum pressure system is a pressure regulator C which controls the pressure upstream of the small metering orifice **61** at the by-pass outlet from the line **58**. Between the orifice **61** and the pump inlet is a second pressure regulator **60**.

Regulator C is supplied with fuel through a connection to the fuel chamber A by line **56**, and is set to maintain a constant relative pressure in the line **58** (about one-half to one-and-a-half pounds gauge) below the pressure of fuel in the chamber A, whatever that pressure may be. The regulator **60** is set to maintain a certain minimum pressure in the datum line or by-pass, about twenty to twenty-two pounds. Together, these two regulators maintain a small, continuous flow through the by-pass or datum circuit and out orifice **61** to the pump. This

flow insures circulation in the entire fuel metering system.

When fuel flow increases through the jets **23** in lines **24**, the nozzle valves must open. In order to avoid lag in fuel delivery as the metering rods **33** are withdrawn from the jets **23**, some provision must be made to accommodate the fuel displaced into the datum system circuit by movement of the diaphragms **28** of each nozzle **25**. This movement will be accompanied with a slight pressure increase in the datum circuit **58**, causing diaphragm **71** of pressure regulator C to respond, closing inlet valve **75** and opening outlet vavle **76**, allowing the fuel to escape through a line **79** downstream of the metering restriction **61**.

The preferred details of construction for the pressure regulators C and **60** have been described in the prior applications of James Fred Armstrong above mentioned. A further description here would be repetitious and serve no useful purpose, since the construction is not a feature of this invention.

Engine priming circuit

In this system, the mixture ratio furnished may not only be affected by modifying the response of the air valve, as above described, but also by varying the pressure drop across the metering restrictions **23**, and since this pressure drop or pressure differential is controlled directly by datum pressure, the mixture ratio can be varied one way or the other, rich to lean, by changes in the datum pressure regulation. Because of this inherent characteristic of the system, it is possible to add to it the many desirable auxiliary features necessary to adapt the system to the needs of the engine.

For example, the particular engine might require a rich mixture during cranking in order to facilitate engine starting. This function can be built into the present system by a control which acts upon datum pressure. The following detailed description is explanatory.

The usual starter and ignition circuit for the engine includes the battery **194** connected at one terminal to ground, and at the other terminal to the ignition key switch **197**, which switch, when closed, energizes a circuit to the starter switch S, which is connected, in turn, by a lead **198** with the starter motor **195**. Connected with the lead **198** is a second lead **189** extending to the winding on solenoid **173** in the pressure regulator **60** and to ground through the lead **188**.

Operation of priming circuit

To crank the engine, both the ignition switch **197** and the starter switch S are closed, so as to complete the circuit to the engine starter motor **195**. This circuit, in turn, energizes the circuit through the solenoid **173** by way of the leads **189** and **188**, energizing the solenoid **173** and producing a magnetic force attracting the armature **172**. The force of the solenoid **173** tends to open the valve **167** against the force of spring **166**, and thus change the minimum pressure setting of the pressure regulator **60**, so as to lower the pressure downstream of the metering orifice **61** and increase the flow through the datum system **58**. This brings into operation the effect of the metering restriction **58H** to restrict the fuel flow in the datum system upstream of the metering restriction **61**. The increase in flow through the datum system creates a pressure drop between the restriction **58H** and the metering restriction **61**, thus lowering the datum pressure acting on each of the nozzle diaphragms of the nozzles **25**. When the datum pressure is lowered, the pressure downstream of the metering restrictions **23** is likewise lowered, increasing the pressure drop and the fuel flow past the metering rods **33** to the nozzles at any particular position of the rods **33**. This priming function is accomplished only when both the ignition switch and the starter switch are closed.

Ignition switch fuel cut-off circuit

In this system, the datum circuit forms a remote control for the discharge from the nozzles. When the pressures between the charging system and datum system are equalized, the fuel discharge from the nozzles is effectively cut off. One manner contemplated for utilizing this inherent feature is illustrated in Fig. 1.

In this particular embodiment, datum line **58** is directly connected with the fuel chamber A by a pressure equalizing line **300**. Communication through the line **300** is in turn controlled by a solenoid operated valve SV, which is spring-biased to an open position and closed by energization from either of two electric circuits connected with separate windings in the solenoid valve SV.

The first of these circuits comprises a line **299** connected with the ignition switch **197** and extending to one of the solenoid windings of the switch SV. The lead **298** connects the same winding to the opposite side of the starter switch S. In this circuit is a vacuum operated switch VS, which is held closed by spring pressure from the spring **250** under normal engine operating conditions.

Operation of ignition switch controlled fuel cut-off

In the following discussion of the operation of the above-described circuit, the function of the vacuum operated switch VS will be ignored.

The ignition switch **197** controls the energization of the lead **299**, which in turn, when closed, furnishes the necessary current to one of the windings in the solenoid valve SV to close the valve against the resistance of the spring **303**, which tends to maintain the valve open. If the starter switch is open, as would be the case when the engine is running, then this circuit is grounded through the starter motor **195** by way of the leads **298** and **198**. With the ignition switch **197** closed, therefore, solenoid operated valve SV is energized and closed by the circuit grounding through the starter motor, as described, and the pressure equalizing passage **300** is inoperative. It will be understood that the current flowing through this circuit is necessarily very small, due to the resistance of the solenoid winding, so that it has no effect upon the operation of the starter motor **195**. It requires a much greater amperage to operate the starter motor **195** than it does to operate the small solenoid operated valve SV.

When the ignition switch **197** is open, however, the circuit through the leads **299** and **298** is de-energized, allowing spring **303** to open the solenoid operated valve SV. This equalizes the pressure between the fuel chamber A and the datum line **58**, so that each of the valves in the fuel nozzles **25** closes and discharge of fuel immediately ceases.

Conversely, when the ignition switch **197** is turned on, valve SV closes.

Operation of deceleration fuel cut-off

In the circuit above described is a switch VS operated in response to a negative load on the engine for opening the circuit **299—298**. Preferably, the switch VS has a diaphragm **251** connected through a rod **252** to the switch. The diaphragm **251** is subject to atmospheric pressure on one side, tending to open the switch, and to manifold pressure on its opposite side through the line **108**. A spring **250** may be calibrated so that the switch **253** remains closed until manifold suction exceeds the normal range of variations encountered in operating the engine under its own power. In other words, switch **253** remains closed until manifold suction exceeds 21 or 22 inches Hg. When this occurs, the force of spring **250** is overcome, opening the switch **253** and de-energizing the circuit **299** and **298** to the solenoid operated valve SV. Spring **303** opens the valve, equalizing the pressure between the chamber A and the datum line **58**, so that fuel discharge from the nozzles **25** is effectively cut off.

Unloading

If, for any reason, the starting mixture is too rich so that the engine will not fire during cranking, it is necessary to provide for some means to unload the engine of fuel. Under these circumstances, continued delivery of fuel from the fuel nozzles **25** is not desirable. Here, again, datum pressure regulation forms a convenient manner for remote control of the discharge from the fuel nozzles **25**.

When the ignition switch **197** and starter switch S are closed, the circuit **299** and **298** is short-circuited, so that it becomes inoperative and the current flows directly from the switch S to the starter motor **195** through the line **198**.

The unloading circuit connects with the line **198**, which is energized under these conditions, through lines **298** and **304** to the switch TS, and from thence through the line **301** through a second winding on the solenoid valve SV to ground. Thus, normally, the valve SV is maintained closed, even though the circuit **298—299** is inoperative.

Operation of unloader

With both ignition switch **197** and starter switch S closed, the engine is cranked due to the energization of the starter motor **195**. As above explained, circuit **188** and **189** is also energized at this time to effect priming by lowering the datum pressure in the line **58**. The circuit **198**, **298**, **304** and **301** through the second winding on the solenoid valve SV is likewise energized, maintaining the pressure equalizing passage closed, so that the priming system remains in operation until the throttle is opened wide. This movement of the throttle engages the lug **152** on the throttle arm **52** with the throttle operated switch TS, which opens the circuit between line **304**, which is energized, and line **301**, which extends to the winding on the valve SV. Spring **303** then opens pressure equalizing passage **300**, and the pressure in the charging and datum circuits becomes equalized, closing the nozzle valves **25** to shut off the discharge of fuel to the engine.

As above explained, the starter switch S short-circuits the electric circuit through the lines **298** and **299**, so that there is no closing force exerted against the spring **303**, and the valve remains open while the throttle is held wide open and the starter switch remains closed.

The foregoing describes a structure which performs all the functions and attains all the results set forth above, but it is contemplated that other modifications will occur to those skilled in the art which come within the terms of the appended claims.

I claim:

1. In a pressurized fuel charging system for a spark ignition type of internal combustion engine having a source of electric power and an electric circuit from the source to the ignition and to the engine starter motor including an ignition switch and a starter switch, said system including a fuel inlet, a fuel nozzle discharging fuel to the engine, a pump supplying fuel under pressure to said fuel inlet, a fuel line normally pressurized from said pump connecting said inlet and said fuel nozzle, a pressure regulator having a movable wall controlling a valve in said fuel nozzle, a datum pressure system, opposed expansible chambers separated by said movable wall and connected with said datum system and said fuel line, respectively, whereby said regulator maintains the fuel in said fuel line at a pressure proportional to the controlled pressure in said datum system, means for establishing a controlled pressure in said datum system at a fixed differential with respect to said pump supply pressure, a pressure equalizing line extending between said fuel line and said datum pressure system and a normally open, solenoid closed valve in said pressure equalizing chamber; the combination therewith comprising a pair of windings on said solenoid controlled valve, an electric

circuit extending from said ignition switch for energizing one of said windings, and a second circuit energized by said starter switch for energizing the other of said windings.

2. In a pressurized fuel charging system for a spark ignition type of internal combustion engine having a source of electric power, an electric circuit from said source to the ignition, an ignition switch, a starter motor, a starter motor circuit, and a starter switch in said starter motor circuit for energizing the starter motor from the power source, said system including a fuel inlet, a fuel nozzle for discharging fuel to the engine, a pump supplying fuel under pressure to said inlet, a fuel line normally pressurized from said pump connecting said inlet and said fuel nozzle, a pressure regulator having a movable wall controlling a valve in said nozzle, a datum pressure system, opposed expansible chambers separated by said movable wall and connected with said datum system and said fuel line, respectively, whereby said regulator maintains the fuel in said fuel line at a pressure proportional to the control pressure in said datum system, means for establishing a controlled pressure in said datum system at a fixed differential with respect to said pump supply pressure, a pressure equalizing passage, and a normally open, solenoid closed valve in said pressure equalizing passage; the combination therewith comprising a pair of windings in said solenoid for operating said valve, an electric circuit energized by operation of said ignition switch connected with one of said windings, an electric circuit energized by said starter switch connected to the other of said windings, and a connection for short-circuiting said first circuit on operation of said starter switch.

3. In a pressurized fuel charging system for a spark ignition type of internal combustion engine having a battery and a starter-ignition system including an ignition switch and a starter switch in series between the battery and the starter motor, said system including a fuel inlet, a fuel nozzle for discharging fuel to the engine, a pump supplying fuel under pressure to said inlet, a fuel line normally pressurized from said pump connecting said inlet and said fuel nozzle, a pressure regulator having a movable wall controlling a valve in said nozzle, a datum pressure system, opposed expansible chambers separated by said movable wall and connected with said datum system and said fuel line, respectively, whereby said regulator maintains the fuel in said fuel line at a pressure proportional to the control pressure in said datum system, means for establishing a controlled pressure in said datum system at a fixed differential with respect to said pump supply pressure, a pressure equalizing passage between said fuel inlet and said datum system, and a normally open, solenoid operated valve in said pressure equalizing passage; the combination therewith comprising a pair of windings for said solenoid operated valve, a first electric circuit energized from said ignition switch and connected to ground through one of said windings and said starter motor whereby said circuit is energized only during operation of the engine but not during cranking, a switch in said first circuit responsive to negative load on the engine to open said circuit, and a second circuit energized from said starter switch and connected to ground through said second solenoid winding for retaining said pressure equalizing passage closed during operation of the starter motor.

4. In a pressurized fuel charging system for a spark ignition type of internal combustion engine having a throttle controlled air inlet, a battery and an ignition switch and starter switch connected in series in an electric circuit extending from the battery to the starter motor, said system including a fuel inlet, a fuel nozzle for discharging fuel to the engine, a pump supplying fuel under pressure to said inlet, a fuel line normally pressurized from said pump connecting said inlet and said fuel nozzle, a pressure regulator having a movable wall controlling a valve in said nozzle, a datum pressure system, opposed

expansible chambers separated by said movable wall and connected with said datum system and said fuel line, respectively, whereby said regulator maintains the fuel in said fuel line at a pressure proportional to the control pressure in said datum system, means for establishing a controlled pressure in said datum system at a fixed differential with respect to said pump supply pressure, a pressure equalizing passage between said fuel inlet and said datum system, and a normally open, solenoid operated valve in said pressure equalizing passage; the combination therewith comprising a pair of windings in said solenoid operated valve, a first circuit energized from said ignition switch and extending to ground through one of said windings and said starter motor whereby said circuit is short-circuited during operation of said starter switch, a second circuit energized by closing of said starter switch and extending to ground through said second winding, and a switch in said second circuit operated by full opening movement of the throttle for de-energizing said second circuit during cranking of the engine.

5. In a pressurized fuel charging system for a spark ignition type of internal combustion engine having a throttle controlled air inlet, a battery, an electric circuit extending from the battery to a starter motor, and an ignition switch and starter switch in series in said circuit, said system including a fuel inlet, a fuel nozzle for discharging fuel to the engine, a pump supplying fuel under pressure to said inlet, a fuel line normally pressurized

from said pump connecting said inlet and said fuel nozzle, a pressure regulator having a movable wall controlling a valve in said nozzle, a datum pressure system, exposed expansible chambers separated by said movable wall and connected with said datum system and said fuel line, respectively, whereby said regulator maintains the fuel in said fuel line at a pressure proportional to the control pressure in said datum system, means for establishing a controlled pressure in said datum system at a fixed differential with respect to said pump supply pressure, a pressure equalizing passage between said fuel inlet and said datum system, and a normally open, solenoid operated valve in said pressure equalizing passage; the combination therewith comprising a pair of windings in said solenoid operated valve, a first circuit energized by said ignition switch and extending to ground through one of said windings and said starter motor, a switch in said circuit opened in response to negative load on the engine, a second circuit energized by said starter switch and extending to ground through said second winding, and a switch in said second circuit operated upon movement of said throttle to the wide-open position for de-energizing said second circuit.

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