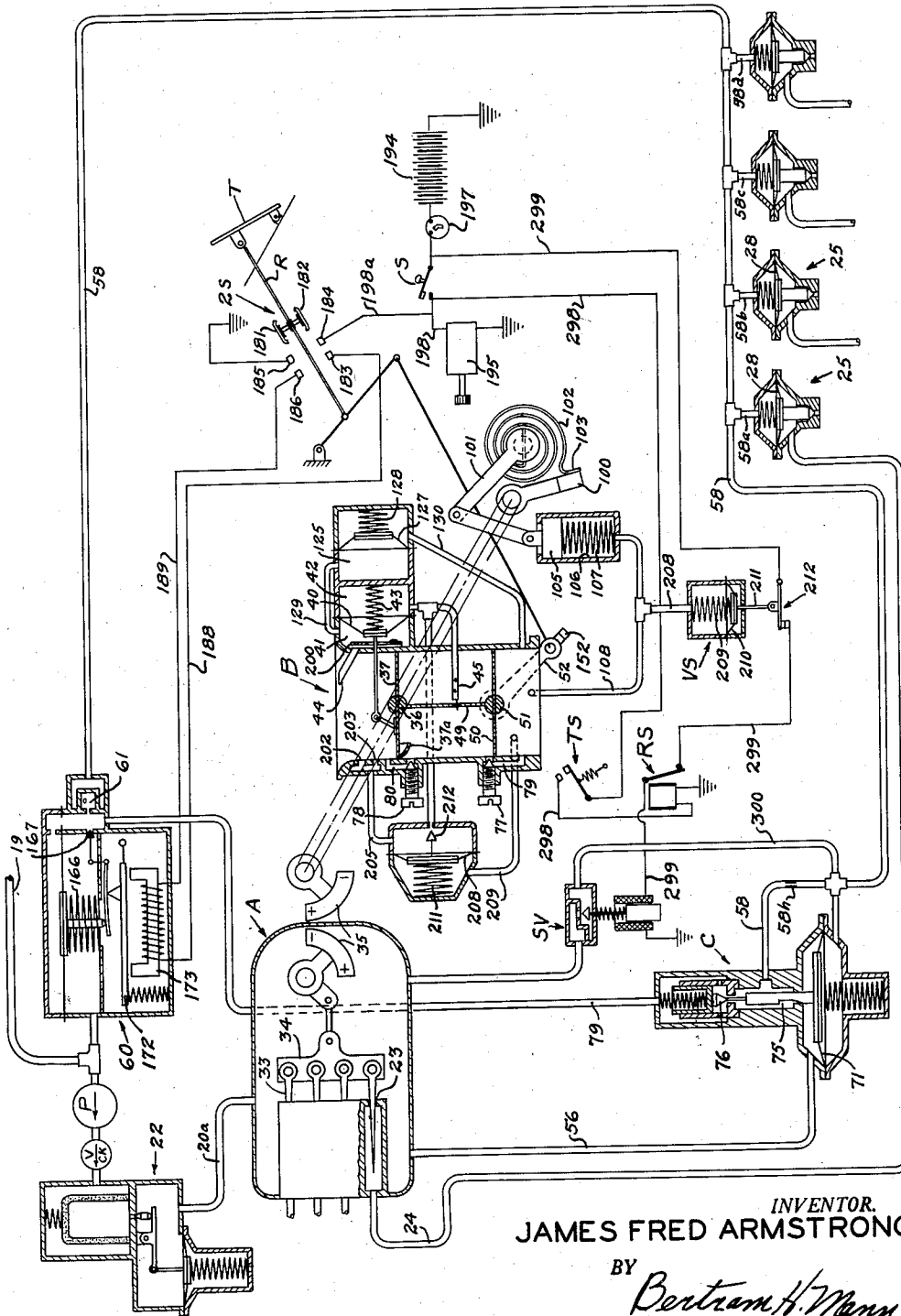


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J. F. ARMSTRONG
FUEL INJECTION SYSTEM
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FUEL INJECTION SYSTEM

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13 Claims. (Cl. 123—179)

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. Such a system is shown in my prior application Serial No. 632,798, filed January 7, 1957, entitled "Fuel Injection System," of which this application is a continuation-in-part.

A more complete understanding of the basic system can be had by reference to my prior applications Serial No. 516,358, filed June 20, 1955, and Serial No. 622,917, filed November 19, 1956.

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

According to this invention, any one of the basic systems above referred to can be modified to shut off the delivery of fuel from the fuel nozzles when the ignition switch for the engine is opened.

According to this invention, the means employed to perform the fuel cut-off is readily adapted to perform other useful functions in the system by modification of the electric circuits which control this means.

Thus it is possible, by including a suction operated switch in addition to the ignition switch in the electric circuits, to adapt this means to the purpose of cutting off the fuel delivery from the nozzles during engine deceleration, such as when the movement of the car is the driving force for the engine. Such a device is referred to in the art as a deceleration fuel cut-off.

In addition to the adaption of the system for the above purpose, it is also possible to modify the electric control circuits for this fuel cut-off means to provide for engine unloading—that is, cutting off the fuel in the open range of throttle positions during engine cranking.

The accompanying drawings are illustrative of a system including this novel form of fuel cut-off and its control circuits, which, together, will carry out the objects of the invention above expressed.

In the single sheet of drawings accompanying this application, the figure is a schematic representation showing the basic elements and their interconnection to form a complete system.

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 my prior identified application, of which this application is a continuation-in-part.

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

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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 37a 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 servomotor. 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 37a 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 opening 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 my copending application, 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 my prior applications. The discharge from the pressure regulator 22 connects with a fuel chamber A by way of a line 20a.

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 58a, 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.

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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 lines 56, and is set to maintain a constant relative pressure in the lines 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 to 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 valve 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 my prior application of which this application is a continuation-in-part. 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 richer mixture during cranking in order to facilitate starting. In an engine equipped with a carburetor, this is accomplished by pressing partway down on the throttle during engine cranking to discharge part of the capacity of the accelerating pump into the manifold. The same function can be built into the present system.

The throttle pedal T is connected with the throttle valve 50 by a suitable linkage R. This linkage may be adapted to operate a switch, such as 2S, having the contact sliders 181 and 182 operating on the contacts 185 and 186, and 183 and 184, respectively, when the throttle is opened partway by pedal T. The usual starter and ignition circuit includes the battery 194 connected to ground and the key switch for the ignition 197, which switch, when closed, energizes a circuit to the starter switch S, which is connected by a lead 198 with the starter motor 195. Switch 2S in the priming control circuit is energized by closing the starter switch, energizing lead 198a connecting with contact 184. Corresponding contact 183 of the switch 2S connects by way of a lead 188 with the winding on the solenoid 173, and the circuit is completed back to contact 186 of the switch 2S by way of a lead 189. Corresponding contact 185 is connected to ground.

Operation of priming circuit

When the engine is being cranked, the starter switch S is closed, energizing contact 184. To prime the engine, throttle pedal T is depressed to close the switch 2S, thereby completing the circuit from the battery 194 to ground, energizing the solenoid 173 and producing a magnetic

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force, attracting the armature 172, to tend to open the valve 167 against the force of the spring 166. The magnetic force modifies the fixed pressure setting of the minimum 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 flow and cause the pressure downstream thereof to drop, so as to lower the datum pressure acting on each of the nozzle diaphragms. When the datum pressure is lowered, the pressure downstream of the metering restrictions 23 is likewise lowered, increasing the pressure drop and the fuel supply to the nozzles to increase the mixture ratio. The priming function is accomplished only with the throttle pedal T partially depressed and the starter switch S closed. When the throttle is closed, or wide open, the switch 2S is not operating.

Deceleration fuel cut-off

Datum pressure regulation is also useful to cut off the fuel when the engine is being driven by the movement of the car. If this feature is deemed desirable, it may readily be incorporated in this system. One manner contemplated is illustrated in the drawings.

In this embodiment, datum line 58 is directly connected with the fuel chamber A by a pressure equalizing line 300, and this connection is controlled by a solenoid operated valve SV, which is spring biased to an open position and closed by energization of the solenoid therein through a circuit connecting with the battery and ground. This circuit includes line 299 which extends from the ignition switch 197 through a vacuum switch VS, a relay RS, to the solenoid of valve SV, and thence to ground. The vacuum switch VS is connected with manifold suction in line 108 by way of a branch 208, which communicates manifold pressure to one side of a diaphragm 210 operating against the pressure of a calibrated spring 209. The switch 212 is connected with the diaphragm 210 by a stem 211 extending through the switch casing from the opposite side of the diaphragm which is vented to atmosphere. The spring 209 may be calibrated so that switch 212 remains closed until manifold suction exceeds the normal range of variations encountered in operating the engine under its own power. In other words, the switch 212 remains closed until manifold suction exceeds twenty-one or twenty-two inches Hg.

Operation of deceleration cut-off

The ignition switch 197 is closed during engine operation, thus energizing the circuit 299 through switch 212 and relay RS to the solenoid valve SV, holding the valve closed tightly, so as to shut off direct communication of pressure from the chamber A to the datum system 58. So long as the switch valve SV remains closed, therefore, the system functions normally in that the pressure regulators C and 60 control the pressure differential between the charging pressure and the datum pressure, so that the mixture ratio remains in calibration. When the vacuum switch VS opens, however, this circuit is de-energized to the solenoid valve SV, which is opened by its spring, thereby connecting the datum pressure line directly to the fuel chamber A to equalize the pressures in the datum system and charging system. When the fuel pressure becomes equal on opposite sides of the diaphragms 28 of the fuel nozzles 25, each nozzle will close immediately by spring pressure, shutting off the fuel from the engine.

It will also be noted that if the ignition switch 197 is shut off or opened to stop the engine, the circuit to the solenoid valve SV is opened, allowing the valve SV to open by spring pressure, shutting off the delivery from the fuel nozzles 25 in the same manner as above described. This feature prevents flow from the nozzles 25 after the ignition is cut off, and during the time that it takes after the engine comes to rest for the fuel pressures to equalize between the charging system and the datum

system. This prevents drip from the nozzles 25, which would leave the intake manifold or valves wet and interfere with restarting of the engine.

Unloading

If, for any reason, the starting mixture is too rich, so that the engine will not fire, it is desirable to provide for engine unloading, so that the excess fuel may be blown from the engine. Under these circumstances, continued delivery of fuel from the fuel nozzles 25 is not desirable. The flexibility of this system adapts it to perform this function in a very simple manner. The circuit 299, above described, contains a relay switch RS, which is normally closed, but may be energized to open by a circuit 298 extending from relay RS to a throttle switch TS and the starter switch S. This circuit is energized by closing the ignition switch 197, starter switch S, and depressing the throttle pedal T to open the throttle 50 wide. This moves arm 152 to a position closing the contacts of switch TS and energizing the relay RS, thereby de-energizing the circuit 299 to open the solenoid valve SV. When the valve SV is opened, as above explained, datum pressure equals charging pressure, and the nozzles 25 close. This allows cranking of the engine without fuel delivery from the nozzles 25, so as to rid the engine of surplus amounts of fuel. Closing of the throttle T or opening of the starter switch S de-energizes the circuit to the relay RS, closing the solenoid valve SV and initiating delivery of fuel from each of the nozzles 25. The datum pressure regulator C then takes over control, so as to maintain the pressure differential between the charging pressure and the datum pressure to give normal operation of the system.

The foregoing describes a structure which performs all the functions and attains all of 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 an engine charge forming device having a system for maintaining the flow of fuel to the engine in one stream proportional to the flow of air to the engine in a separate stream, said device comprising a throttle valve for controlling the flow of air to the engine, means movable in the air stream for measuring the flow of air to the engine past said throttle valve, means movable in the fuel stream for measuring the flow of fuel to the engine, a connection between said movable measuring means to maintain the flow through each stream proportional to the other, means responsive to conditions indicating the engine is being driven, and a connection from said last means with said fuel measuring means for stopping the fuel discharge to the engine.

2. In an engine charge forming device having a system for maintaining the flow of fuel to the engine in one stream proportional to the flow of air to the engine in a separate stream, said device comprising a throttle controlling the flow of air to the engine in said second stream, means movable in the air stream for measuring the flow of air to the engine past said throttle, means movable in the fuel stream for measuring the flow of fuel to the engine, a connection between said movable measuring means to maintain the flow through each stream proportional to the other, means responsive to overspeeding of the engine in the idle range of throttle positions, and a connection between said last means and said fuel measuring means to cut off the flow of fuel to the engine.

3. In an engine charge forming device having a system for maintaining the flow of fuel to the engine in one stream proportional to the flow of air to the engine in a separate stream, said device comprising a throttle in said air stream, means movable in the air stream for measuring the flow of air to the engine in said separate stream past said throttle, means movable in the fuel stream for measuring the flow of fuel to the engine, a connection be-

tween said movable measuring means to maintain the flow through each stream proportional to the other, and means responsive during deceleration of the engine connected with said fuel measuring means to cut off the fuel supply to the engine.

4. In an engine charge forming device having a system for maintaining the flow of fuel to the engine in one stream proportional to the flow of air to the engine in a separate stream, said device comprising, a throttle controlling the flow of air to the engine in said second stream, a variable capacity air metering means for measuring the air flow past said throttle, means for varying the capacity of said air metering means to maintain the rate of air flow there-through within a given range at different engine speeds and throttle openings, a second variable capacity metering means in said fuel stream operated directly by changes in capacity of said variable capacity air metering means whereby the capacity of both metering means is increased or decreased together, means responsive to overspeeding of the engine in the idle range of throttle positions, and a connection between said last means and said metering means in said fuel stream to cut off the fuel flow to the engine.

5. In an engine fuel charging system of the pressure type having 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 nozzle, fuel metering means in said fuel line, a datum pressure system, a connection between said datum pressure system and said fuel line downstream of said metering means for regulating the pressure differential across said metering means, means responsive to conditions indicating the engine is being driven, and a connection between said last means and said fuel line for equalizing the pressures on opposite sides of said metering means to cut off fuel delivery from the engine.

6. In an engine charge forming device having an air conduit with an air inlet and air outlets connected with the combustion chambers of the engine, a throttle valve in said air inlet, a fuel chamber receiving fuel under pressure and delivering fuel under pressure to the combustion chambers of the engine through separate branches, fuel metering means for said separate branches, a fuel nozzle at the outlet of each of said separate branches, a datum pressure system, means establishing a control pressure in said datum system, a connection between said datum system and each of said fuel nozzles for regulating the pressure downstream of each of said metering means, means responsive to overspeeding of the engine in the idle range of throttle positions, and a connection between said last means and said datum system for equalizing the pressures on opposite sides of said metering means to cut off the fuel discharge from said nozzles to the engine.

7. In an engine charge forming device having an air conduit with an air inlet and air outlets connected with the combustion chambers of the engine, a manually controlled throttle in said air inlet, a fuel chamber receiving fuel under pressure and delivering fuel under pressure to the combustion chambers of the engine through separate branches, a fuel metering means for each of said branches, a fuel nozzle at the outlet of each of said branches, a datum pressure system, means establishing a controlled pressure in said datum system, a pressure regulator having a movable wall controlling the nozzle valve in each of said branches, said wall defining opposed expansible chambers connected with said datum system in said fuel line, respectively, whereby the pressure downstream of each of said metering means is held proportional to datum pressure, means responsive to overspeeding of the engine in the idle range of throttle positions, a connection between said means and said datum system for equalizing the pressures on opposite sides of said metering means to cut off fuel flow to the engine through said nozzle valves.

8. In a fuel injection system for an internal combustion

engine having an air induction system with an air inlet, a manual throttle in said air inlet, fuel discharge nozzles communicating with the engine combustion chambers, fuel supply means including passages connecting with said nozzles, a pump for pressurizing said supply means and normally maintaining the fuel under pressure to said nozzles, and means for controlling the fuel pressure upstream and downstream of said fuel metering means, the combination of means responsive to overspeeding of the engine in the idle range of throttle positions, and a connection between said last means and said fuel supply means for equalizing the pressures on opposite sides of said metering means to cut off the fuel flow from said nozzles to the engine.

9. A pressurized fuel charging system for a spark ignition type of internal combustion engine having a source of electric power, an electric circuit from the source to the ignition, and an ignition switch, comprising, in combination, a fuel inlet for said system, a fuel outlet for said system 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 outlet, a pressure regulator having a movable wall controlling a valve at said fuel outlet, a datum pressure system including a by-pass extending around said pump, 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 the said fuel line and said datum pressure system, a normally open, solenoid closed valve in said pressure equalizing line, and an electric circuit energized by operation of said ignition switch connected to said solenoid operated valve to close the valve when the switch is turned on the start the engine, whereby opening of said ignition switch equalizes the pressure between said fuel line and datum system to close said valve at said outlet and cut off the fuel discharged to the engine.

10. A pressurized fuel charging system for a spark ignition type of internal combustion engine having a source of electric power, an electric circuit from the source to the ignition, and an ignition switch, comprising, in combination, a fuel chamber, fuel outlets for discharging fuel to the engine, a pump supplying fuel under pressure to said fuel chamber, a plurality of fuel lines normally pressurized from said pump connecting said chamber and said outlets, a pressure regulator having a movable wall controlling a valve at the outlet of each of said fuel lines, a datum pressure system including a by-pass extending around said pump, opposed expansible chambers separated by each of said movable walls and connected with said datum system and each of said fuel lines, respectively, whereby said regulator maintains the fuel in said fuel lines at a pressure proportional to a controlled pressure in said datum system, means for establishing a control pressure in said datum system at a fixed differential with respect to said chamber pressure, a pressure equalizing passage extending between said chamber and said datum system, a normally open, solenoid operated valve in said pressure equalizing passage, an electric circuit controlled by the ignition switch for connecting said solenoid operated valve with the power source, whereby said solenoid operated valve is closed when the ignition switch is on, a pressure sensitive switch in said electric circuit, and means for operating said pressure sensitive switch by the differential in pressure created in the manifold during engine deceleration to open the switch and equalize the pressure in the datum system and chamber, whereby said nozzle valves are closed and the fuel cut off from discharge to the engine.

11. A pressurized fuel charging system for a spark igni-

tion type of internal combustion engine having a source of electric power, an electric circuit from the source to the ignition, an ignition switch, a starter motor, a starter motor circuit, and a starter switch in the circuit for energizing the starter motor from the power source, comprising, in combination, a fuel inlet, a fuel outlet 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 outlet, a pressure regulator having a movable wall controlling a valve in said outlet, a datum pressure system including a by-pass extending around said pump, 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 control 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, a normally open, solenoid operated valve in said pressure equalizing passage, an electric circuit for energizing said solenoid operated valve controlled by said ignition switch, a normally closed relay in said electric circuit, a second electric circuit extending from the starter switch to said relay, a throttle operated switch in said second circuit closed on full throttle opening to open said relay, whereby said solenoid operated valve can be de-energized by actuation of the throttle and starter switch during engine cranking to equalize the pressures between the chamber and datum system and close the valve at said outlet.

12. A pressurized fuel charging system for a spark ignition type of internal combustion engine having a source of electric power, an electric circuit from the source to the ignition, an ignition switch, a starter motor, a starter motor circuit, and a starter switch in the circuit for energizing the starter motor from the power source, comprising, in combination, a fuel inlet, a fuel outlet 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 outlet, a pressure regulator having a movable wall controlling a valve in said outlet, a datum pressure system including a by-pass extending around said pump, 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 control 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, a normally open, solenoid operated valve in said pressure equalizing passage, an electric circuit for closing said solenoid operated valve controlled by operation of said ignition switch, an engine intake pressure operated suction vacuum switch in said circuit, a normally closed relay in said circuit, a second circuit for energizing said relay controlled by operation of the starter switch, and a normally open switch in said second circuit closed by full operation of the throttle for opening said relay to de-energize said solenoid operated valve during engine cranking to close said valve at said outlet.

13. In an engine charge forming device having a system for maintaining the flow of fuel to the engine in one stream proportional to the flow of air to the engine in a separate stream, said device comprising a throttle valve for controlling the flow of air to the engine, a movable means responsive to changes in the rate of air flow to the engine for measuring the flow of air past said throttle, a fuel flow measuring means including movable means in the fuel stream for metering the rate of fuel flow during engine operation and to cut off the flow of fuel when the engine stops, a source of fuel pressure for said fuel stream connected therewith, means maintaining the fuel in said

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stream under pressure from said source to the engine, a connection between said movable means for measuring air flow and said fuel flow measuring means for operating said means together to maintain the flow through one stream proportional to the other, means responsive to over-speeding of the engine in the idle range of throttle positions, and a connection between said last means and

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one of said measuring means to cut off the flow of fuel to the engine.

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