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FUEL INJECTION PUMP CONTROL SYSTEM

3 Sheets-Sheet 1

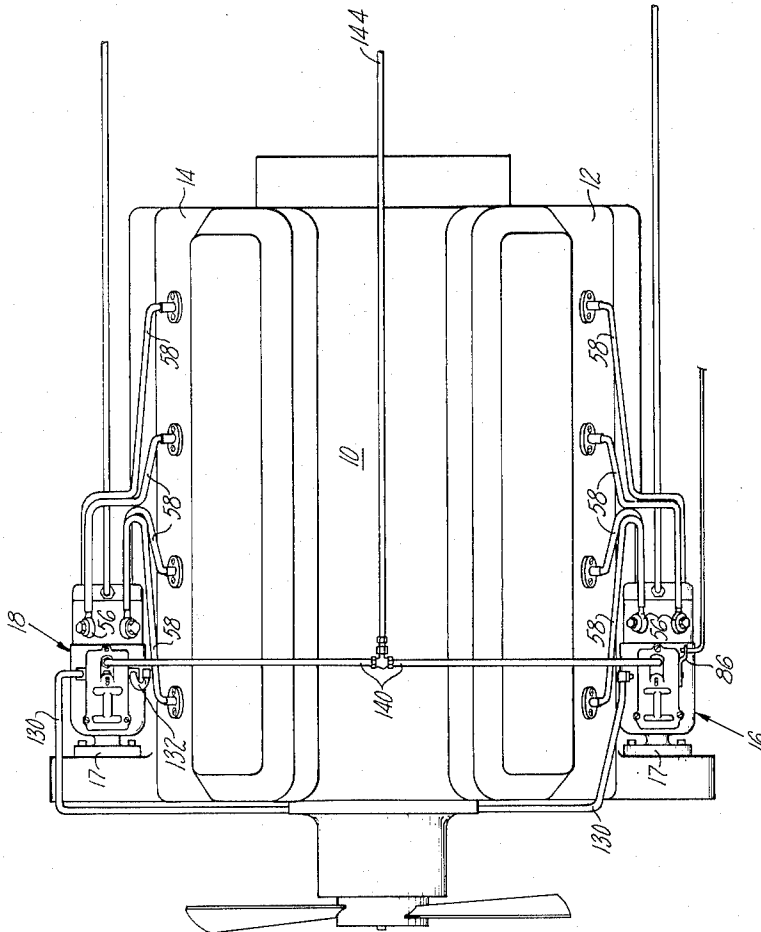


FIG. 1

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April 26, 1966

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3,247,799

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3 Sheets-Sheet 2

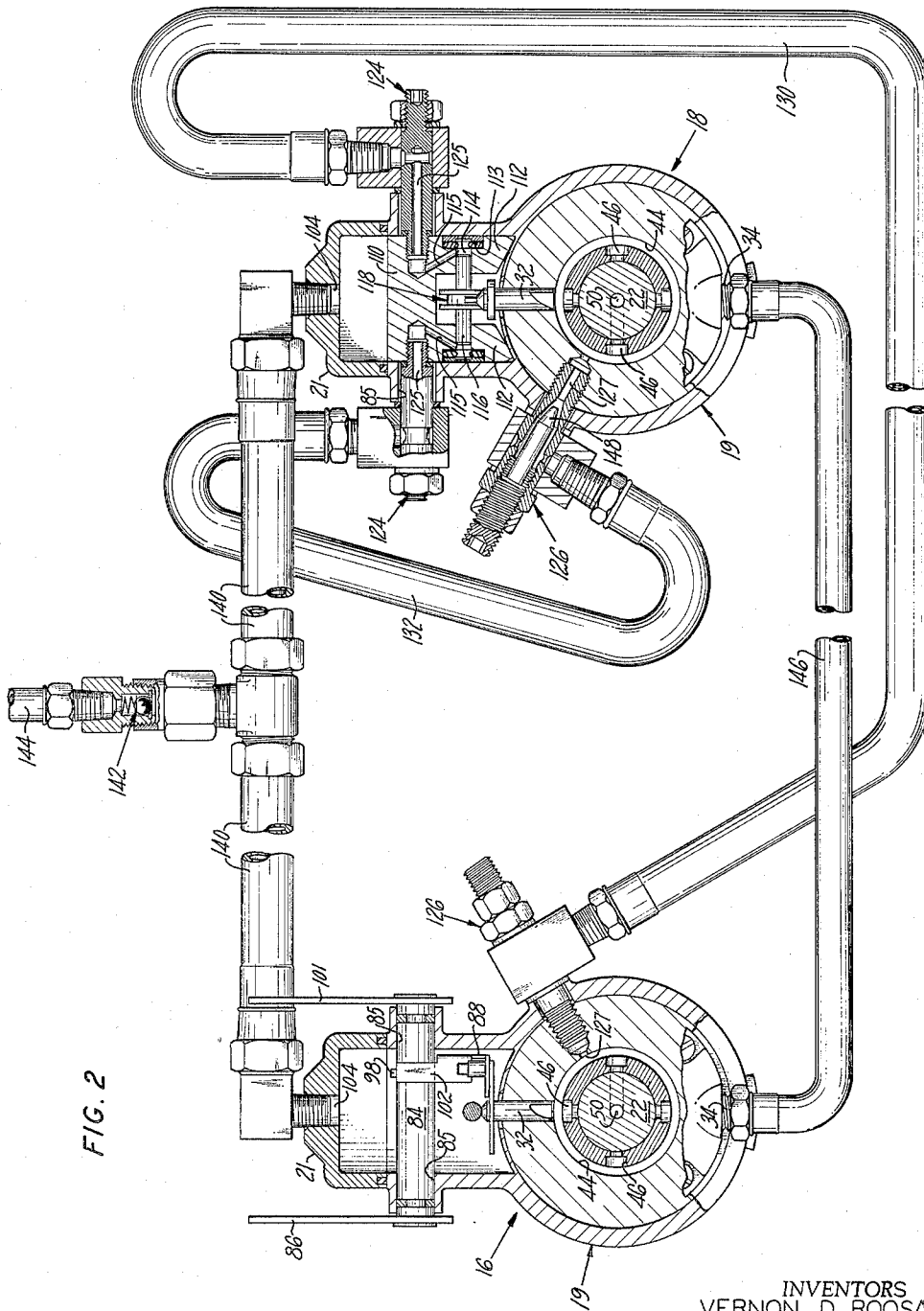


FIG. 2

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3 Sheets-Sheet 3

FIG. 3

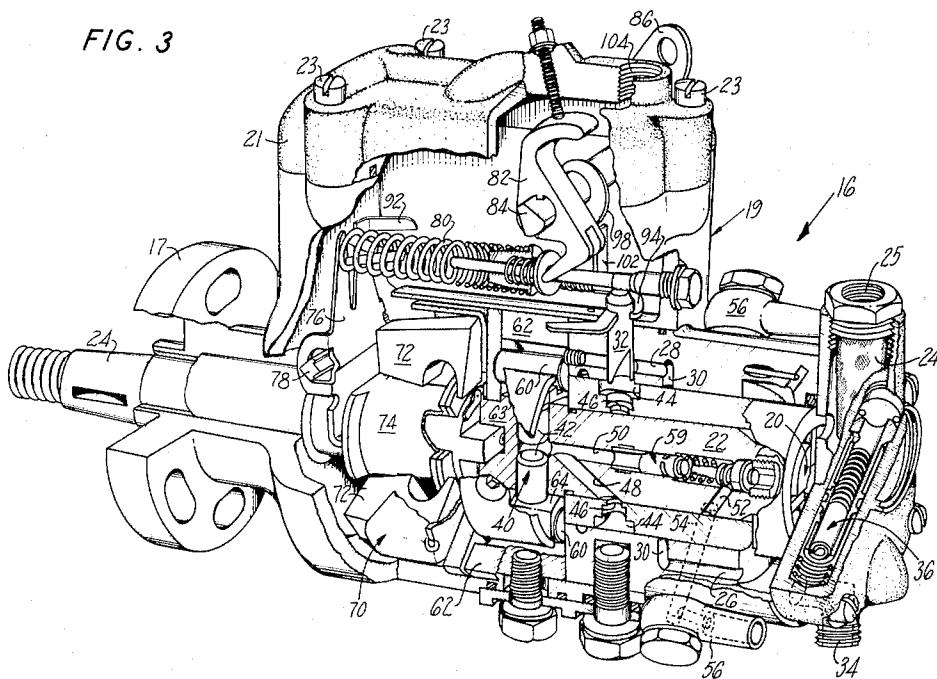


FIG. 4

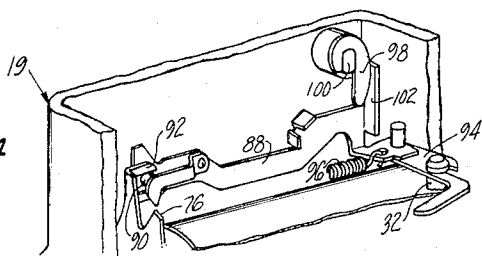
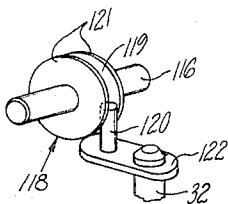


FIG. 5



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FUEL INJECTION PUMP CONTROL SYSTEM

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7 Claims. (Cl. 103—11)

The present invention relates to pumps of the type conventionally employed in fuel injection systems for delivering measured charges of fuel to the cylinders of an internal combustion engine, and more particularly to an arrangement for regulating the quantity of the charge delivered by a secondary or slave pump in correlation with the quantity of the charge delivered by a primary or master pump.

It is a primary aim of the present invention to provide a new and improved slave pump control of the type described which is responsive to minute changes in the measure of the charge of the master pump and which accurately regulates the measure of the charge of the slave pump in correlation therewith.

It is another aim of the present invention to provide an hydraulically operated slave pump control which precludes the necessity of having a mechanical connection between the master and slave pumps.

It is a further aim of the present invention to provide a new and improved pump installation for an engine requiring fuel charges at uneven intervals.

It is another aim of the present invention to provide a new and improved master pump and slave pump installation of the type described in which the master pump is governor-controlled for maintaining a selected engine speed under varying loads and the slave pump is regulated for operation in correlation with the operation of the master pump.

Other objects will be in part obvious and in-part pointed out more in detail hereinafter.

The invention accordingly consists in the features of construction, combination of elements and arrangement of parts which will be exemplified in the construction hereafter set forth, and the scope of the application of which will be indicated in the appended claims.

In the drawings:

FIG. 1 is a top plan view, partly broken away, of an internal combustion engine employing a master fuel pump controlled in a conventional manner and a slave fuel pump controlled in accordance with the present invention;

FIG. 2 is an enlarged transverse section view, partly broken away and partly diagrammatic, of the master and slave pump installation of FIG. 1;

FIG. 3 is a perspective view, partly broken away and partly in section, of the master pump;

FIG. 4 is a perspective view, partly broken away and partly in section, showing a portion of the master pump control mechanism; and

FIG. 5 is a perspective view, partly broken away and partly in section, showing a portion of the slave pump control mechanism.

Referring now to the drawings in detail in which like characters represent like parts, FIG. 1 shows a conventional V-8 engine 10 having two banks 12, 14 of cylinders of four cylinders each. A master fuel injection pump 16 and slave fuel injection pump 18 installation exemplifying the present invention is employed for providing measured fuel charges to the eight cylinders of the engine, the master and slave pumps being provided with apertured flanges 17 for installing the pumps on the engine and being driven by the engine by suitable gearing (not shown). As installed, the master pump 16 delivers fuel to the four

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cylinders of the bank 12 and the slave pump 18 delivers fuel to the four cylinders of the bank 14.

Referring now to FIG. 3, the master fuel pump 16 is of conventional design and, as illustrated, is generally similar in operation to the pump disclosed in U.S. Patent No. 2,641,238 entitled, "Fuel Pump" issued June 9, 1953. The pump 16 comprises a pump housing 19, with a housing cap 21 secured thereto by fasteners 23, in which is mounted a pump rotor 22 and a connected drive shaft 24 having a tapered end for receiving a driving gear (not shown) to which the shaft is keyed. The rotor 22 drives at one end thereof a vane-type fuel transfer pump 20 which receives fuel from a fuel tank via a filter 24 in the pump inlet 25 and supplies fuel under pressure via axial conduits 26, 28 and an annular conduit 30 to a pump metering valve 32. The axial conduit 26 communicates with a pump outlet 34 in the pump housing 19 and with a pressure regulator valve, generally denoted by the numeral 36, adapted to bypass fuel to the pump inlet 25. In the well-known manner, the regulator valve 36 regulates the transfer pump outlet pressure in accordance with the fuel requirements of the engine and conventionally maintains the transfer pump outlet fuel at a pressure which increases with the speed of the rotor 22 and therefore with the speed of the engine 10.

A charge pump 40 driven by the rotor 22 comprises a pair of diametrically opposed plungers 42 reciprocally mounted in a radial bore of the rotor 22. The charge pump 40 receives fuel from the metering valve 32 via an annulus 44, a plurality of angularly spaced radial passages 46, and a diagonal inlet passage 48 in the rotor. High pressure fuel is delivered from the charge pump 40 via an axial bore 50 to a radial distributor passage 52 which communicates with a plurality of angularly spaced distributor passages 54 appropriately connected by means of the connectors 56 and conduits 58 (FIG. 1) to the individual cylinder fuel nozzles. A spring-biased delivery valve 59 in the bore 50 provides in a known manner for achieving sharp fuel cutoff to the fuel nozzles to eliminate fuel dribble to the engine combustion chambers. It should be apparent that inasmuch as the master pump provides fuel to four cylinders, four radial inlet passages 46 and four distributor passages 54 are provided with the angular positions of these passages being such as to ensure registration of the passages 46 with the diagonal inlet passage 48 during the intake stroke of the charge pump plungers 42 and to ensure registration of the distributor passages 54 with the radial distributor passage 52 during the discharge stroke of the plungers 42.

The plungers 42 of the charge pump are actuated inwardly by a pair of rollers 60 positioned intermediate the plungers 42 and an annular internal cam 62 having four pairs of diametrically opposed camming lobes engageable by the rollers. An annular carrier 63 driven by the rotor 22 supports the rollers 60 and a pair of roller shoes 64 slidably mounted in radial slots in the carrier and engageable with the plungers 42. The cam 62 is seated in an annular recess and is angularly controlled by a suitable timing mechanism which relates the distributor discharge with the engine speed.

A governor, generally denoted by the numeral 70, has a plurality of flyweights 72 which act through a sleeve 74 to urge a governor plate 76 in one pivotal direction, clockwise as seen in FIG. 3, about a fulcrum provided by a supporting rod 78. The governor plate 76 is urged in the opposite pivotal direction by a compression spring 80 having a bias controllable by an operating lever 82. The lever 82 is fixed to a throttle control shaft 84 rotatably mounted in one of the opposed openings 85 in the housing and is suitably connected to the engine throttle by means of a lever 86.

Referring to FIG. 4, the master pump governor plate 76 is connected to the metering valve 32 for angular control of the metering valve and therefore control of the pressure of the metered fuel in the annulus 44. This connection comprises an elongated link 88 supporting a roller 90 at one end thereof received within the bifurcated projection 92 of the governor plate and pivotally connected at its opposite end to a valve control arm 94 fixed to the metering valve. A tension spring 96 attached to the governor plate 76 and to the control arm 94 normally maintains the link 88 in operative engagement with the governor plate. A shut-off cam 98 mounted on a control shaft 100 mounted in a housing opening 85, is operated by control linkage suitably connected to a lever 101. Pivotal movement of the lever effectuates cam engagement with an upstanding tab 102 of the link 88 to move the link against the bias of the tension spring 96 and pivot the valve control arm 94, clockwise as seen from above the pump, for shutting off fuel flow to the charge pump.

Fuel leaking into the housing cavity from the operative parts of the pump is bled from the top of the pump through a pump outlet opening 104 in the housing cap 21, the housing cavity being preferably maintained full of fuel for improved pump operation.

The slave pump 18 is illustrated to be identical with the master pump 16 with the exception that the regulation of the metering valve 32 of the slave pump is modified in accordance with the present invention. Referring to FIGS. 2 and 5, there is inserted within the upper portion of the housing 19 of the slave pump 18 a block 110 having a pair of depending leg portions 112 snugly received within the pump housing. The block legs 112 have aligned bores 114 in which a valve operating plunger 116 is reciprocably mounted. A collar 118 defining an annulus 119 between collar end discs 121 is fixed centrally on the plunger 116 and an upstanding pin 120 fixed to a valve control arm 122 secured to the metering valve 32 is received within the annulus 119. Accordingly, upon reciprocable movement of the plunger 116 the metering valve is angularly displaced, with movement of the plunger 116 to the right, as seen in FIG. 2, reducing the effective opening of the metering valve and thereby reducing the fluid pressure in the annulus 44. The outer ends of the bore 114 are suitably sealed by caps 113 and the block 110 is provided with passages 115 communicating with the fluid chambers at the ends of the plunger 116. Connector assemblies 124 received within the opposed housing openings 85 are threaded to the block 110 and are provided with passages 125 communicating with the passages 115.

The metering valve 32 of the slave pump 18 is controlled in correlation with the control of the valve 32 of the master pump 16 by connecting the annulus 44 of the master pump with the right end of the plunger 116, as seen in FIG. 2, and by connecting the annulus 44 of the slave pump 18 with the left end of the plunger 116, for which purposes there are provided, respectively, a pair of conduits 130, 132 between the connector assemblies 124 and a pair of connector assemblies 126 mounted on the pump housings and providing passageways 127 communicating with the annulus 44. Consequently, when the pressure in the annulus 44 of the slave pump is less than that in the annulus 44 of the master pump, the plunger 116 will be shifted to the left, as seen in FIG. 2, to increase the effective area of the slave pump metering valve 32. Similarly, if the pressure in the annulus 44 of the slave pump is greater than the fluid pressure in annulus 44 of the master pump, the plunger 116 will shift to the right to decrease the effective area of the slave pump metering valve 32.

The measure or quantity of the charge distributed to the engine cylinders is dependent upon the inlet fluid pressure of the charge pump as measured, for example, by the fluid pressure in the annulus 44, and upon the pres-

sure of the fluid within the pump housing cavity providing a back pressure on the plungers 42 which urges them inwardly. Of these, the measure of the charge distributed to the engine is most effectively controlled by controlling the charge pump inlet pressure as performed by the metering valves 32.

The metering valve 32 of the master pump is regulated by the pump governor with the bias on the governor and therefore the engine speed being controlled by the engine throttle. Consequently, for any given throttle setting the governor will control the metering valve 32 to maintain a substantially constant engine speed under varying engine loads. It should be readily appreciated that in the exemplary embodiment of the present invention described, it is desirable that the fuel charge of the slave pump be the same quantity or measure as that of the master pump. In order to obtain more accurate control of the quantity or measure of the slave pump fuel charge, the charge pump back pressures or fluid pressures within the pump housing are equalized by connecting the housing cavity outlets 104. For this purpose a conduit 140 is provided which preferably incorporates a spring-biased ball pressure relief valve 142 for maintaining a pressure of approximately 3 to 5 p.s.i. in the pump housings and for returning excess fuel to the engine fuel tank via a conduit 144.

Additionally, the control of the fuel pressure in the annulus 44 of the slave pump can be enhanced by equalizing the transfer pump outlet pressures in the slave and master pumps. This is provided by connecting the transfer pump outlets of the master and slave pumps and suitably accomplished by a conduit 146 threaded to the housing openings 34. Consequently, with the master and slave pumps in a stable operating condition, the metered pressure in the annulus 44 of the slave pump will be equal to the metered pressure in the annulus 44 of the master pump, and the metering valves 32 will be in the same angular metering positions. Any subsequent angular adjustment of the metering valve 32 of the master pump effected by the master pump governor will be accompanied by an equal adjustment of the metering valve 32 of the slave pump. This accurate control of the valve 32 of the slave pump will remain effective notwithstanding the use in the pump installation of master and slave pumps having a different history and therefore different pump operating characteristics.

To aid the stabilization of the operation of the valve operating plunger 116 of the slave pump and to reduce hunting of the plunger 116, particularly at idle or low engine r.p.m., adjustable metering valves 148 are provided in the connector assemblies 126 in the fluid passages connecting the annulus 44 of the slave and master pumps with the valve operating plunger 116. These metering valves 148 provide a restricted orifice limiting the fluid flow to the plunger 116 and may be adjusted in accordance with each installation of the pumps.

One use of the master and slave pump installation is shown in FIG. 1 where each pump supplies fuel to one of the banks of cylinders of a V-type engine. This use of the present invention has particular value where the engine cylinders require fuel charges at uneven intervals but where each bank of cylinders requires fuel charges at even intervals. Accordingly, there can be installed in the engine for each bank of cylinders a pump with a more simply constructed charge pump cam providing fuel charges at constant angular intervals of pump rotor rotation.

Thus, the slave pump control of the present invention provides for accurately controlling the slave pump in a master and slave pump installation without the necessity of having a mechanical connection between the pumps. Additionally, the slave pump control system is not only sensitive to minute changes in the measure of the charge provided by the master pump, but effectively adjusts the metering valve of the slave pump to correlate

the measure of the charge of the slave pump with that of the master pump. Further, the master and slave fuel pump installation readily allows for providing fuel charges at irregular intervals as may be required in a V-8 engine.

As will be apparent to persons skilled in the art, various modifications and adaptations of the structure above described will become readily apparent without departure from the spirit and scope of the invention, the scope of which is defined in the appended claims.

We claim:

1. In a fuel injection system of master and slave fuel pumps in which each pump has a charge pump providing fuel charges with a measure dependent upon the fuel pressure in the charge pump inlet and a charge pump back pressure, and a metering valve having an inlet connected to a fuel source and an outlet connected to the charge pump inlet controllable for varying the fuel pressure in the charge pump inlet, a slave pump control comprising, conduit means providing open communication between the master and slave pumps for equalizing the charge pump back pressures of the master and slave pumps, means for equalizing the fuel pressures in the metering valve inlets of the master and slave pumps, and means for controlling the slave pump valve operable by opposing forces related to the fuel pressures in the charge pump inlets of the master and slave pumps.

2. In a fuel injection system of master and slave fuel pumps in which each pump has a charge pump providing fuel charges with a measure dependent upon the fuel pressure in the charge pump inlet and a charge pump back pressure, and a valve having an inlet connected to a fuel source and an outlet connected to the charge pump inlet controllable for varying the fuel pressure in the charge pump inlet, a slave pump control comprising, first conduit means providing open communication between the master and slave pumps for equalizing the charge pump back pressures of the master and slave pumps, second conduit means connecting the valve inlets of the master and slave pumps for equalizing the fuel pressures therein, and valve operating means for controlling the slave pump valve for equalizing the fuel charges of the master and slave pumps, said valve operating means being operable by opposing forces related to the fuel pressures in the charge pump inlets of the master and slave pumps.

3. The slave pump control of claim 2 further comprising pressure relief means in said first conduit means.

4. In a fuel injection system of master and slave fuel pumps in which each pump has a charge pump providing fuel charges with a measure dependent upon the fuel pressure in the charge pump inlet, and a valve controllable for varying the fuel pressure in the charge pump inlet, a slave pump control comprising, a valve actuator operatively connected to the slave pump valve for control

thereof, said valve actuator being movable in opposite directions for increasing and decreasing the fuel pressure in the slave charge pump inlet, first conduit means connecting the master charge pump inlet with the valve actuator for urging the actuator in one direction for increasing the fuel pressure in the slave charge pump inlet, and second conduit means connecting the slave charge pump inlet with the valve actuator for urging the actuator in the opposite direction for decreasing the fuel pressure in the slave charge pump inlet, and third conduit means providing unrestricted communication between the housings of said master and slave pumps for equalizing the charge pump back pressures of the same.

5. The slave pump control of claim 4 further comprising flow restriction means in at least one of said first and second conduit means.

6. In a fuel injection system of master and slave fuel pumps in which each pump has a housing containing a charge pump providing fuel charges with a measure dependent upon the fuel pressure in the charge pump inlet and a charge pump back pressure, and a metering valve having an inlet connected to a fuel source and an outlet connected to the charge pump inlet controllable for varying the fuel pressure in the charge pump inlet, a slave pump control comprising first conduit means providing open communication between the housings of said master and slave pumps for equalizing the charge pump back pressures of the master and slave pumps, conduit means connecting the metering valve inlets of the master and slave pumps for equalizing the fuel pressures therein, a reciprocally mounted valve actuator operatively connected to the metering valve of the slave pump for increasing and decreasing the fuel pressure in the slave charge pump inlet, second conduit means connecting the master charge pump inlet with the valve actuator for urging the actuator in one reciprocable direction for increasing the fuel pressure in the slave charge pump inlet, and third conduit means connecting the slave charge pump inlet with the valve actuator for urging the actuator in the opposite reciprocable direction for decreasing the fuel pressure in the slave charge pump inlet.

7. The slave pump control of claim 6 further comprising flow restriction means in each of the second and third conduit means.

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