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FUEL INJECTION PUMP

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2 Sheets-Sheet 1

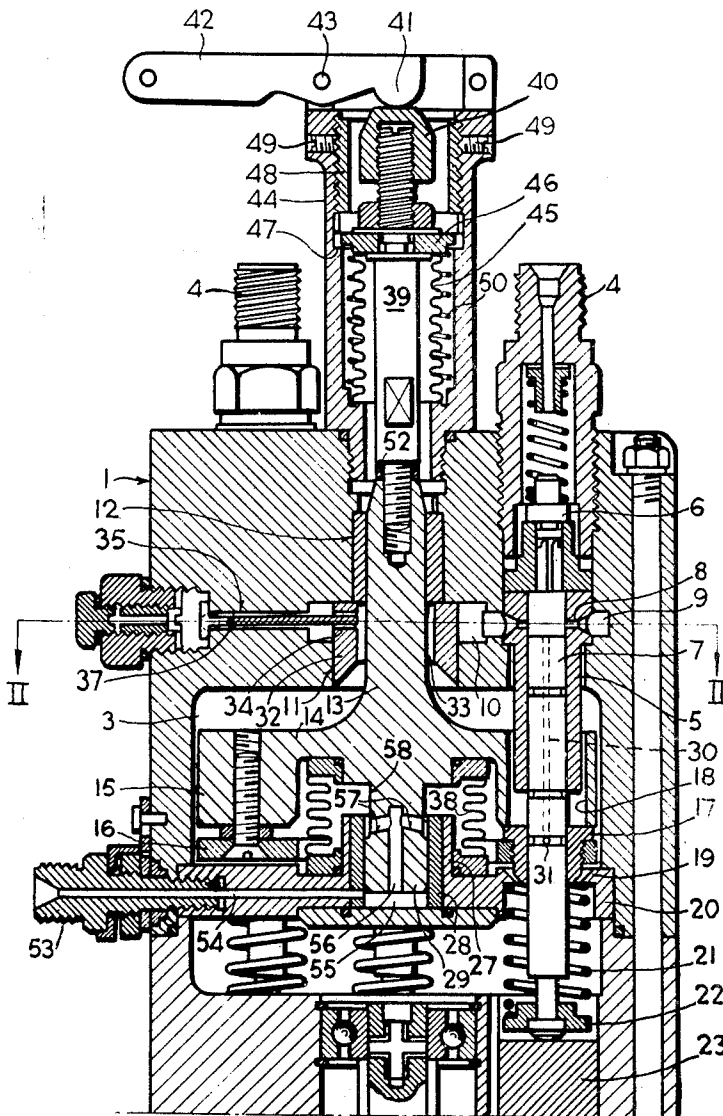


FIG. 1A

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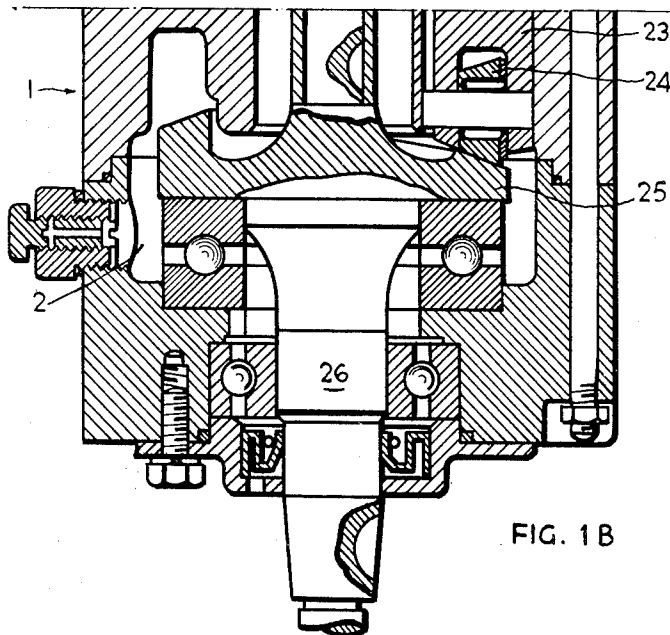
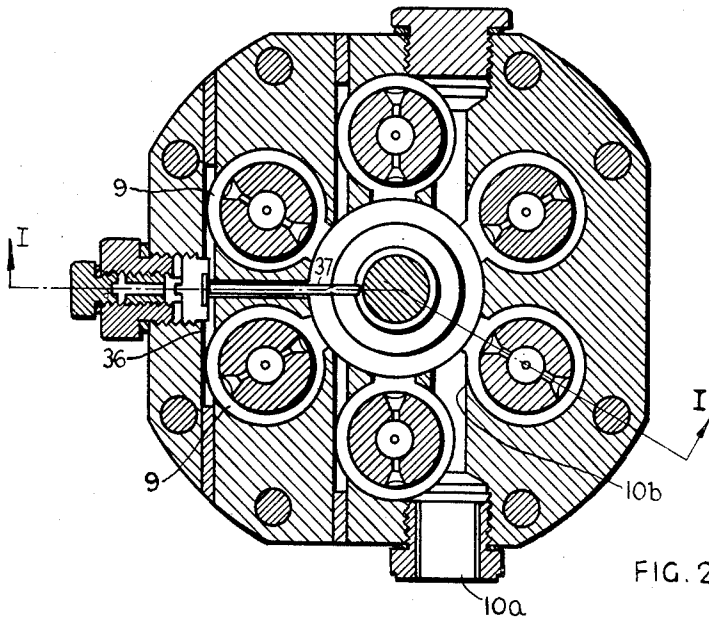
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UNITED STATES PATENT OFFICE

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FUEL INJECTION PUMP

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Application June 15, 1950, Serial No. 168,359

Claims priority, application Great Britain
June 17, 1949

10 Claims. (Cl. 103—41)

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This invention relates to fuel injection pumps for internal combustion engines, particularly though not exclusively, compression-ignition engines. It is concerned with improvements in pumps of the kind (hereinafter referred to as "the kind specified") in which the effective length of the delivery strokes of the respective pistons is similarly controlled simultaneously for all the pump cylinders by actuation of a common regulating member which adjusts, for each cylinder, the position of an element which determines at what point in the delivery stroke fuel will be spilled from the cylinder into a chamber or passage in communication with the inlet side of the pump, the fuel tank or a like low-pressure region.

Various proposals have heretofore been made for controlling the delivery of pumps of the kind specified automatically in accordance with the speed and loading of the engines supplied thereby, so that a certain speed governing action will be secured which will prevent the engine speed from varying to any substantial extent from the value thereof corresponding to the setting for the time being of the manual or other control normally employed for actuating the common regulating member.

The object of the present invention is to provide an improved automatic delivery-controlling device for a pump of the kind specified which shall be sensitive, efficient and of relatively simple construction.

According to the invention, in a pump of the kind specified, the chamber or passage receiving the spilled fuel is placed in communication with the low-pressure region by way of a constriction so that a pressure will build up in the chamber or passage of a value which is a function of the speed and loading of the engine supplied by the pump, pressure-responsive means is exposed to the pressure within the chamber, and means is provided for transmitting the movements of the pressure-responsive means to the common regulating member in the sense for reducing the delivery of the pump as the engine speed increases.

It is preferred, furthermore, also to utilise the pressure prevailing in the intake manifold of the engine (or in the exhaust manifold in the case of supercharged engines) for producing a similar effect upon the common regulating member. This may be achieved, in some cases, by causing the prevailing pressure in the manifold to act upon the pressure-responsive device which is also subjected to the action of the pressure of the spilled fuel, and, in other cases, by providing an

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additional pressure-responsive device to be acted upon by the manifold pressure.

In order that the nature of the invention may be clearly understood, an example of the way in which it may be carried into effect will now be described in greater detail with reference to the accompanying drawings.

In this example, the pump chosen for illustrative purposes is constructed substantially in accordance with the invention forming the subject matter of application Serial Number 687,368, filed July 31, 1946, by Haut et al., now Patent No. 2,517,483, issued Aug. 1, 1950, but the present invention may be applied also to other constructions of pumps of the kind specified above without difficulty.

In the drawings:—

Fig. 1A is the upper part of a section taken on the line I—I of Fig. 2,

Fig. 1B is the lower part of this section, and

Fig. 2 is a section taken on the line II—II of Fig. 1A.

The pump, as shown in Fig. 1A, comprises a generally cylindrical housing 1 having a cam chamber 2 (Fig. 1B) at one end, a spill chamber 3 intermediate its length and a series of delivery connections 4 at its other end which are each connected to the fuel injection device of the respective engine cylinder. At this end of the housing there are the appropriate pump cylinders 5 disposed around and parallel with the axis of the housing and each communicating through a delivery valve 6 with the corresponding delivery connection 4. The cylinders 5 and the respective pistons or plungers 7 are all identical and only one set of these parts need be described here. The cylinder wall is formed with radial bores 8 near its outer end and is surrounded at this location by an annular fuel supply passage 9. This is in permanent communication with a central annular chamber 10 (supplied from an inlet 10a through a bore 10b formed by a recess in the cylindrical wall of the enlarged inner end 11 of an axial bore 12 in the housing 1 provided to admit the passage of a stem 13 attached to a common regulating member 14 located in the spill chamber 3. The regulating member 14 is of disc form with a thickened edge 15 on to which is clamped a ring 16 serving to position controlling sleeves 17 which are a close sliding fit on the pistons 7 working in the cylinders 5. Each piston 7 is a close sliding fit in its cylinder 5 which projects, with play, part-way into an aperture 18 in the thickened edge 15 of the regulating member, the corresponding controlling sleeve being mounted

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on the latter in such manner that it may move laterally (e. g. radially or circumferentially of the member) without being capable of any appreciable motion relative to the member in the axial direction.

The piston 7 continues beyond the sleeve 17, through an over-size hole 19 in a partition member 20 secured transversely of the spill chamber 3, to be surrounded by a compression spring 21 bearing at its ends upon the partition member 20 and upon a collar 22 secured on the end of the piston, respectively. This end of the piston 7 bears upon one end of a reciprocable push rod 23 the other end of which (see Fig. 1B) carries a roller 24 co-operating with a face cam 25 rotatable within the cam member 2 by means of a shaft 26 extending axially through the end of the housing 1 to be driven from the engine crankshaft at an appropriate speed.

Centrally of the partition member 20 (see Fig. 1A) is formed an axially extending cylindrical wall 27 surrounding a liner 28 within which slides a spigot part 29 secured on the regulating member 14. Axial adjustment of this member varies the position of the controlling sleeves 17 relative to the length of the pistons 7 which are formed with axial bores 30 leading from their operative end faces to radial bores 31 the opening of which occurs as they move out of the controlling sleeves 17 during the delivery strokes of the respective pistons.

The pump thus far described operates in exactly the same manner as that described in application Serial Number 687,368, rotation of the face cam 25 causing reciprocation of the pistons 7 and the consequent delivery, per working stroke, of a quantity of fuel determined by the spacing for the time being of the controlling sleeves 17 from the cylinders 5.

While the pump is operating, a certain proportion of the fuel initially drawn into each cylinder 5 is spilled into the chamber 3 containing the regulating member 14, the proportion thus spilled increasing as the quantity of fuel supplied to the engine per stroke of each piston decreases.

In the example of the present invention which is illustrated use is made of this fact for producing automatic variation of the delivery of the pump in accordance with the speed and loading of the engine.

To this end, see Figs. 1A and 2, the enlarged inner end 11 of the bore 12 in the housing 1 has tightly fitted therein a sleeve 32 which leaves between its inner cylindrical surface and the stem 13 of the common regulating member 14 a relatively narrow annular passage 33, the outer cylindrical surface of the sleeve 32 forming the inner wall of the central annular chamber 10 referred to above. At a suitable location, a small bore 34 is formed radially through the sleeve 32 to establish communication between the narrow annular passage 33 and the central annular chamber 10 and a radial bore 35 of about the same diameter is formed through the pump housing 1 in axial alignment with the bore 34 in the sleeve wall. At its outer end the bore 35 is placed in communication with the annular fuel supply passages 9 surrounding the cylinders 5, by way of a bore 36 formed in the housing 1 as shown in Fig. 2, these passages being supplied with fuel at low pressure, through the inlet 10a, from a fuel tank or the like. Within the bore 35 in the housing 1 is fitted a restrictor pin 37 which leaves a free annular passage of a predetermined radial width, the free end of the pin 37 projecting into the

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radial bore 34 in the sleeve 32. Alternatively, the pin 37 can be tapered and spring loaded, or parallel and spring loaded, or can be manually controlled, in order in each case to vary the resistance to the flow of fuel through the bore 34 and thereby vary the speed-load characteristics of the engine.

It will be seen that a restricted outlet is thus provided for the fuel spilled into the spill chamber 3 so that a pressure will build up in the latter which will be the higher the more fuel is spilled into the chamber in a unit of time.

Within the annular space which is defined between the thickened edge 15 of the regulating member 14 and the cylindrical wall 27 on the partition member 20 is disposed a flexible metallic bellows 38 having its ends attached in a fluid-tight manner to the partition member 20 and to the regulating member 14, respectively.

Consequently, assuming for the moment that the bellows 38 is filled with gas under a given pressure, when the pressure in the spill chamber 3 increases (for a predetermined setting of the regulating member 14) the bellows 38 is collapsed to a smaller axial length and allows the regulating member 14 to move towards the partition member 20. This has the effect of moving the controlling sleeves 17 away from the pump cylinders 5 so that the spill passages 31 in the pistons 7 are uncovered at an earlier stage in the working strokes of the pistons. This results in a smaller delivery of fuel to the engine so that the speed of the latter falls. Should the load on the engine now increase, the speed of the latter will tend to fall still further and, in consequence, the quantity of fuel spilled into the chamber 3 in a unit of time will tend to decrease. The consequent fall in the pressure in this chamber will allow the bellows 38 to expand again, assisted if necessary by a suitable spring, referred to below, so that the regulating member 14 will then move in the direction for increasing the supply of fuel to the engine.

The restrictor pin 37 may be replaced by another of different diameter in order to pre-set the pump to suit the engine concerned and the pressure of the spring provided to ensure movement of the regulating member when the bellows expands may also be varied (as indicated below) for the same purpose.

In order that the regulating member 14 may normally be adjusted by hand or other means, particularly for the purposes of stopping the engine and determining the maximum delivery of fuel, the stem 13 thereof is extended by a screwed-on rod 39 which carries at its free end a head 40 adapted to be contacted by one arm 41 of a two-armed actuating lever 41, 42 pivoted at 43 on a tubular extension 44 secured on the pump housing 1. The rod 39 is sealed in the housing by means of a flexible bellows 45 connected at one end to the wall of the passage through the extension 44 and at the other end to a collar 46 secured on the rod. This collar 46 also serves to limit the movement of the regulating member 14 by working between two stops, the inner one of which is constituted by a shoulder 47 formed in the extension 44 and the outer one of which is the inner end of a sleeve 48 adjustably screwed into the outer end of the extension 44 and locked in position by grub screws 49. The collar 46 also acts as an abutment for one end of a compression spring 50 the other end of which bears against a shoulder 51 in the passage through the extension 44. This spring is provided to oppose the movement of the control member 14 towards the minimum de-

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livery position in order to reduce erratic variations of idling speed. It will be seen that the bellows which responds to the pressure variations in the spill chamber may nevertheless act to reduce the supply of fuel to the engine at any setting of the actuating lever 41, 42.

The pressure of the spring 50 acting on the regulating member 14 may be varied to suit requirements by interposing spacing collars or washers 52 between the stem 13 of the member and the screwed-on rod 39 which forms the extension thereof.

It is preferred to combine with the hydraulic governing action described above a pneumatic governing action in which use is made of the pressure variations in the intake or exhaust manifolds of the engine. The arrangement to be described is the subject-matter of co-pending application Serial No. 168,508 of even date herewith.

The same pressure-responsive bellows 38 is employed, a connection from the engine manifold being made at 53 to a radial bore 54 formed in the partition member 20 in the spill chamber 3, this bore opening through the liner 28 to the space 55 bounded by the latter within the cylindrical wall 27 on the partition member. The spigot portion 29 on the regulating member 14 is itself formed with an axial bore 56 (from its free end) which communicates with substantially radial bores 57 formed in the spigot portion and normally having their mouths just covered by the free edge of the liner 28. The spigot portion 29 is however slightly reduced in diameter at this location (as shown at 58) so that pressure variations in the engine manifold can act upon the interior of the pressure-responsive bellows 38. It will be understood that an increase in the suction in the manifold due to an increase of engine speed will result in a reduction in the delivery of fuel to the engine. The required engine speed is selected by varying the free orifice of the engine manifold with the air of a butterfly valve in accordance with known practice.

It is found that the devices according to the invention are particularly sensitive in operation, especially the combined hydraulic/pneumatic system, the hydraulic action being particularly effective in controlling maximum speeds and the pneumatic action in controlling idling speeds.

With advantage, the sleeve 32 fitted in the larger diameter inner end 11 of the axial bore 12 in the housing 1 is constructed from a metal having a low coefficient of expansion whereas the restrictor pin 37 is made from a metal having a relatively high coefficient of expansion. In this way, some automatic compensation is secured for the reduction in the viscosity of the fuel at higher temperature.

What I claim is:

1. A fuel injection pump comprising a pump housing, a fuel inlet connection on the exterior of said housing, a plurality of pump cylinders located within the housing with their axes parallel to each other, a fuel passage connecting said fuel inlet connection to said cylinders, a pump plunger reciprocable in each cylinder, a cam for reciprocating the plungers, a spill passage in each plunger, a spill chamber formed in the housing, an element slidable on each plunger in a direction parallel to said axes to determine the point in the stroke of the plunger at which the spill passage therein will be placed in communication with the spill chamber, a regulating member operatively connected to each of the slid-

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able elements and mounted within the spill chamber for displacement in said direction, an abutment fixedly mounted within the spill chamber, a flexible bellows disposed within the chamber and operatively connected at one end to the regulating member and at the other end to said abutment, a passage connecting said fuel passage to said chamber and a restrictor element adapted to reduce the effective cross-sectional area of said connecting passage to control the flow of fuel from the spill chamber through the connecting passage to the fuel passage to produce a back pressure within the spill chamber proportional to the amount of fuel spilled therein.

2. A fuel injection pump comprising a pump housing, a fuel inlet connection on the exterior of said housing, a plurality of pump cylinders located within the housing with their axes parallel to each other, a fuel passage connecting said cylinders to said fuel inlet connection, a pump plunger reciprocable in each cylinder, a cam for reciprocating the plungers, a spill passage in each plunger, a spill chamber formed in the housing, an element slidable on each plunger in a direction parallel to said axes to determine the point in the stroke of the plunger at which the spill passage therein will be placed in communication with the spill chamber, a regulating member operatively connected to each of the slidable elements and mounted within the spill chamber for displacement in said direction, an abutment fixedly mounted within the spill chamber, a flexible wall disposed between the fixed abutment and the regulating member and so connected to each that it isolates a space within the spill chamber from the remainder of the said chamber, any pressure variation in the remainder of the chamber tending to cause flexing of said wall for moving the regulating member in said direction, a pressure-conducting connection from said space to the exterior of the pump-housing, a passage connecting said spill chamber to said fuel passage and a restrictor element adapted to limit the effective cross-sectional area of the connecting passage in order to present a predetermined resistance to the flow of fuel from the spill chamber through said connecting passage to the fuel passage and thereby produce a pressure within said spill chamber which is proportional to the amount of fuel spilled thereinto.

3. A fuel injection pump for an internal combustion engine comprising a pump housing, a fuel inlet connection on the exterior of said housing, a plurality of fuel delivery conduits, a plurality of pump cylinders located within the housing with their axes parallel to each other and with their one ends adjacent one end of the housing, a fuel supply passage connecting said cylinders to said fuel-inlet connection, a valve-controlled connection from said one end of each cylinder to a respective delivery conduit, a piston reciprocable within each cylinder, a cam for reciprocating the pistons, a spill passage in each piston, a spill chamber located within the housing entirely between said ends of the cylinders and said cam for receiving fuel ejected through the spill passages, an element associated with each piston for determining the point in the delivery stroke of the piston at which the spill passage therein will be placed in communication with the spill chamber, a common regulating member displaceable within said chamber in a direction parallel to the direction of length of said axes, a partition member fixedly mounted within and transversely of the spill chamber, a flexible bellows located en-

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tiely within the spill chamber to define a secondary chamber and connecting the common regulating member to the said partition member, a pressure conducting connection from the exterior of the housing to said secondary chamber and a restricted passage extending between said spill chamber and said fuel supply passage to control the pressure built up within said spill chamber.

4. A fuel injection pump for an internal combustion engine comprising a pump housing, a fuel inlet connection on the exterior of the housing, a chamber within the housing, a plurality of pumping assemblies arranged with their axes parallel to each other a spill passage included in each of said assemblies, a fuel passage for supplying fuel from said fuel inlet connection to said pumping assemblies, an element associated with each assembly for determining at what point in each delivery of fuel the respective spill passage shall be opened to said chamber, a common regulating member displaceable within said chamber in a direction parallel to the direction of length of said axes for adjusting all said elements simultaneously, a passage connecting said chamber to said fuel passage, a restrictor element adapted to limit the effective cross-sectional area of said connecting passage in order to control the flow of fuel from said chamber through said connecting passage to said fuel passage and thereby produce a pressure within the chamber proportional to the amount of fuel spilt therein, an abutment fixedly mounted within said chamber and a pressure responsive element operatively connected between said abutment and said regulating member to displace said regulating member in said direction in accordance with the pressure built up in said chamber.

5. A fuel injection pump comprising a housing, a plurality of outlet connections on the housing, a fuel inlet connection on the housing, a plurality of pump cylinders located within the housing with their axes parallel to each other and with their one ends adjacent one end of the housing, a valve controlled connection from said end of each cylinder to its respective outlet connection, a bore through each cylinder wall, a fuel passage within the housing communicating at one end with the fuel inlet connection and at the other end with each said bore, a pump plunger reciprocable in each cylinder, a common cam for reciprocating the plungers, a spill passage in each plunger having an outlet end, a spill chamber located entirely within the housing between said cylinder ends and said common cam such that the outlet ends of the spill passages will be moved through the chamber by reciprocation of the plungers, an element slidable on each plunger in a direction parallel to said axes to determine for what proportion of each stroke of the respective plunger the outlet end of the spill passage thereof will be in communication with the spill chamber, a common regulating member mounted within the spill chamber and displaceable in said direction, operative connections between said member and the elements slidable on the plungers for causing these elements to move in said direction in unison with the regulating member, a passage of restricted cross-sectional area connecting said spill chamber with said fuel passage, the rate of flow of fuel from said spill chamber through said connecting passage to said fuel passage being such as to produce a back pressure within said spill chamber proportional to the amount of fuel spilled therein, a partition member fixedly

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mounted within and transversely of said spill chamber and a flexible bellows entirely located within the spill chamber and responsive to pressure variations in said spill chamber, said bellows being directly connected at one end to the regulating member and at the other end to the partition member to cause movement of the regulating member in said direction in accordance with variation in the pressure within the spill chamber.

6. A fuel injection pump comprising a housing, a plurality of outlet connections on the housing, a fuel inlet connection on the housing, a plurality of pump cylinders located within the housing with their axes parallel to each other and with their one ends adjacent to one end of the housing, a valve controlled connection from said end of each cylinder to its respective outlet connection, a bore through each cylinder wall, a fuel passage within the housing communicating at one end with the fuel inlet connection and at the other end with said bore, a pump plunger reciprocable in each cylinder, a common cam for reciprocating the plungers, a spill chamber located entirely in the housing between the said cylinder ends and said common cam such that the outlet ends of the spill passages will be moved through the chamber by reciprocation of the plungers, an element slidable on each plunger in a direction parallel to said axes to determine for what proportion of each stroke of the respective plunger the outlet end of the spill passage thereof will be in communication with the spill chamber, a common regulating member mounted within the spill chamber and displaceable in said direction, operative connections between said member and the elements slidable on the plungers for causing these elements to move in unison with the regulating member in said direction, a passage connecting said spill chamber with said fuel passage, a restrictor element adapted to reduce the effective cross-sectional area of said connecting passage to control the rate of flow of fuel from said spill chamber through said connecting passage to said fuel passage to produce a back pressure within said spill chamber proportional to the amount of fuel spilled therein, a partition member fixedly mounted within and transversely of said spill chamber, a flexible bellows entirely located within the spill chamber and responsive to pressure variations in said spill chamber, said bellows being directly connected at one end to the regulating member and at the other end to the partition member to cause movement of the regulating member in said direction corresponding to the response produced in the bellows by the variation in the pressure within the spill chamber, said flexible bellows defining a secondary chamber located entirely within the spill chamber, a fluid inlet connection on the exterior of the housing and a radial bore through said partition member connected at one end to the fluid inlet connection and at the other end to said secondary chamber for maintaining a fluid pressure within the secondary chamber.

7. A fuel injection pump comprising a housing, a plurality of pumping assemblies within said housing arranged with their axes parallel to and equally spaced from a common axis, means for supplying fuel to said pumping assemblies, a spill chamber located in said housing, means for spilling fuel from said pumping assemblies into said spill chamber, a pump-delivery varying member mounted within said spill chamber and displaceable in a direction parallel to said common axis to vary the rate at which fuel is spilled from said

pumping assemblies into said spill chamber, a restricted passage for permitting fuel to return from said spill chamber to said fuel supply means at a rate such that the pressure in said spill chamber will vary with the rate of spill and pressure-responsive means located within said spill chamber and operatively connected to said pump-delivery varying member in order to displace the same in said direction in accordance with the pressure produced in said chamber.

8. A fuel injection pump comprising a pump housing, a fuel inlet connection on the exterior of said housing, a plurality of pump cylinders located within the housing with their axes parallel to and equally spaced from a common axis, a fuel passage connecting said fuel inlet connection to said cylinders, a pump plunger reciprocable in each cylinder, a cam for reciprocating the plungers, a spill passage in each plunger, a spill chamber formed in the housing, an element slidable on each plunger in a direction parallel to said common axis to determine the point in the stroke of the plunger at which the spill passage therein will be placed in communication with the spill chamber, a regulating member operatively connected to each of the slidable elements and mounted within the spill chamber for displacement in said direction, an abutment fixedly mounted within the spill chamber, a flexible bellows disposed within the chamber and operatively connected at one end to the regulating member and at the other end to said abutment, a passage connecting said fuel passage to said chamber and a restrictor element adapted to reduce the effective cross-sectional area of said connecting passage to control the flow of fuel from the spill chamber through the connecting passage to the fuel passage to produce a back pressure within the spill chamber proportional to the amount of fuel spilled therein.

9. A fuel injection pump comprising a pump housing, a fuel inlet connection on the exterior of said housing, a plurality of pump cylinders located within the housing with their axes parallel to and equally spaced from a common axis, a fuel passage connecting said fuel inlet connection to said cylinders, a pump plunger reciprocable in each cylinder, a cam for reciprocating the plungers, a spill passage in each plunger, a spill chamber formed in the housing, an element slidable on each plunger in a direction parallel to said common axis to determine the point in the stroke of the plunger at which the spill passage therein will be placed in communication with the spill chamber, a disc-like regulating member mounted within the spill chamber co-axially with said common axis and displaceable in a direction parallel thereto, an abutment fixedly mounted within the spill chamber, a flexible bellows disposed within the spill chamber co-axially with said common axis and operatively connected at one end to the regulating member and at the other end to said abutment, a passage connecting said fuel passage to said chamber and a restrictor element adapted to reduce the effective cross-sectional area of said connecting passage to control the flow of fuel from the spill chamber through the connecting passage to the fuel pas-

sage to produce a back pressure within the spill chamber proportional to the amount of fuel spilled therein.

10. A fuel injection pump comprising a housing, a plurality of outlet connections on the housing, a fuel inlet connection on the housing, a plurality of pump cylinders located within the housing with their axes parallel to and equally spaced from a common axis and with their one ends adjacent one end of the housing, a valve controlled connection from said end of each cylinder to its respective outlet connection, a bore through each cylinder wall, a fuel passage within the housing communicating at one end with the fuel inlet connection and at the other end with each said bore, a pump plunger reciprocable in each cylinder, a common cam for reciprocating the plungers, a spill passage in each plunger having an outlet end opening into the curved surface of the plunger, a spill chamber located entirely within the housing such that said outlet ends of said spill passages will be moved through said chamber by reciprocation of said plungers, an element slidable on each plunger in a direction parallel to said common axis to determine by its axial position relative to said plunger that proportion of each stroke of the respective plunger for which the outlet end of the spill passage thereof will be in communication with the spill chamber, a disc-like common regulating member mounted within the spill chamber co-axially with said common axis and displaceable in a direction parallel thereto, operative connections between said member and the elements slidable on the plungers for causing these elements to move in said direction in unison with the regulating member, a passage of restricted cross-sectional area connecting said spill chamber with said fuel passage, the rate of flow of fuel from said spill chamber through said connecting passage to said fuel passage being such as to produce a back pressure within said spill chamber proportional to the amount of fuel spilled therein, a partition member fixedly mounted within and transversely of said spill chamber and a flexible bellows located entirely within the spill chamber co-axially with said common axis and responsive to pressure variations in said spill chamber, said bellows being directly connected at one end to the regulating member and at the other end to the partition member to cause movement of the regulating member in said direction in accordance with variation in the pressure within the spill chamber.

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