

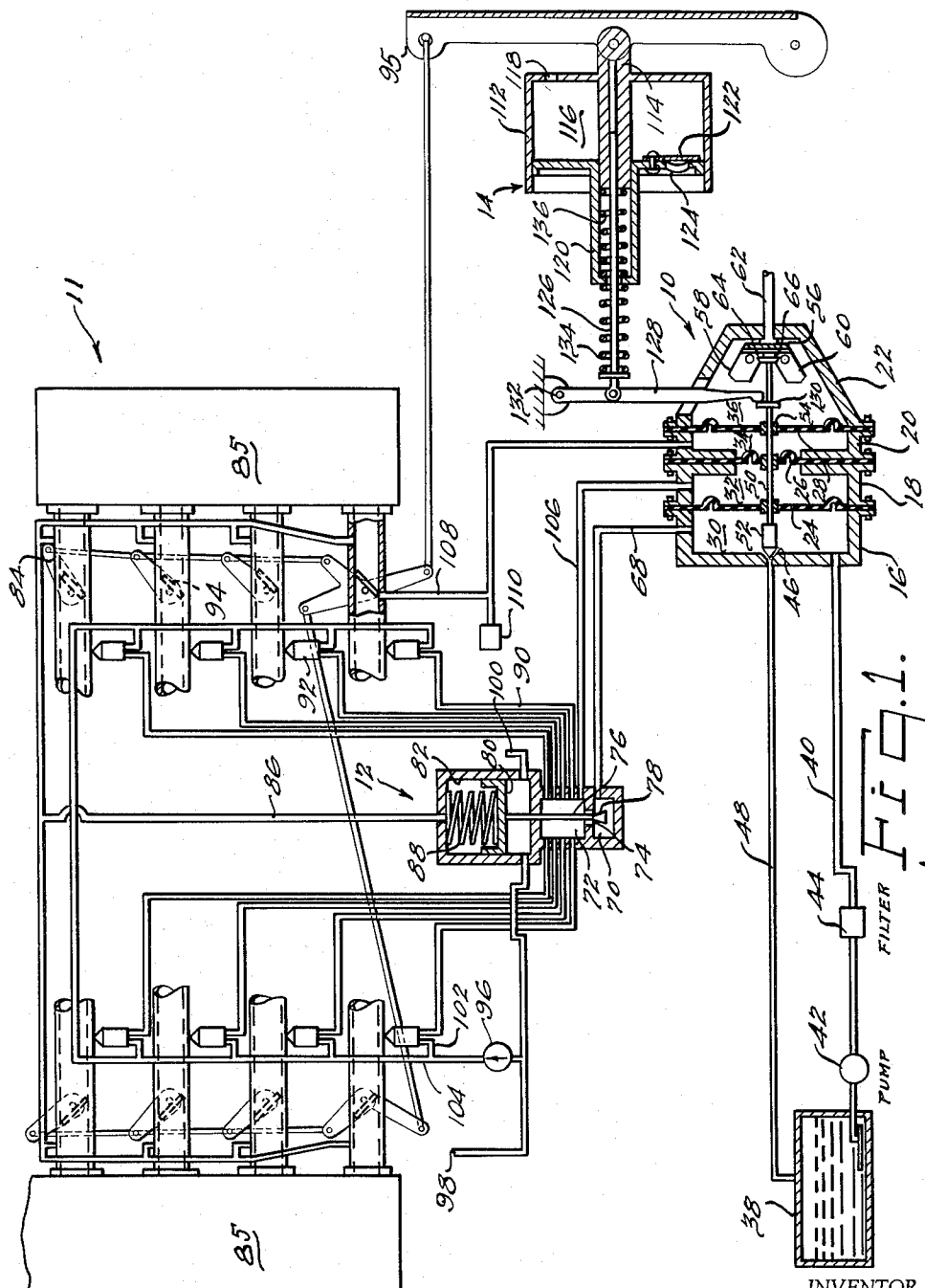
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2,997,036

FUEL INJECTION SYSTEM

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1

2,997,036

FUEL INJECTION SYSTEM

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This invention relates to a fuel injection system of the type disclosed in the related copending application of Thomas M. Ball et al., Serial No. 751,999, filed July 30, 1958 and assigned to applicant's assignee, and relates in particular to an acceleration fuel booster therefor.

The present invention is concerned with fuel injection systems of the type employed on automotive internal combustion engines wherein manually operated means are provided for accelerating said engines. In one type of fuel injection system, a fuel metering unit is conventionally connected to a throttle valve controlled intake manifold of the engines so that any movement of the throttle valve caused by movement of an accelerator pedal will transmit a pressure signal to the fuel metering unit which will re-adjust the flow of fuel to the engine according to the direction and magnitude of the signal.

It is found in such systems that the response of the metering unit to such a signal is not sufficiently rapid to obtain a smooth and instantaneous acceleration of the vehicle particularly when the throttle valve is suddenly opened.

An object of the present invention therefore is to provide improvements in a fuel injection system of the above type which avoids the latter difficulty by supplementing the normal accelerating rate of the fuel metering unit by means of a direct application of force thereto.

Another object is to provide an acceleration booster that can be used in conjunction with direct inlet metering and also with return flow metering systems.

Another object is to provide said acceleration booster with means to allow said booster to provide a fading fuel pulse to the engine.

Another object is to provide said acceleration booster with means to allow rapid recovery thereof in response to de-actuation of the accelerator pedal.

Another object is to provide said acceleration booster with a means to prevent overloading the metering unit with direct mechanical force through the actuation of the accelerator.

These objects are accomplished by linking the metering mechanism to a dashpot or piston type air compression acceleration booster which is in turn connected to the accelerator pedal of the engine. When the pedal is depressed, the booster applies a direct force to the metering mechanism which immediately provides an increased flow of fuel to the engine. Since the normal reaction of the metering unit to the opening of the throttle valve will ordinarily increase the fuel flow to the desired value within a relatively short time, the booster which is designed to provide only instantaneous fuel, is provided with a bleed aperture to cause a fading of force developed by the booster. The booster is also provided with a flapper type bleed valve which allows rapid recovery of the booster upon retraction of the accelerator.

Further objects and advantages will become apparent from the following specifications and drawings, in which:

FIGURE 1 is a schematic view partly in section of a fuel injection system and acceleration booster.

Referring to the drawing, a fuel injection metering system for an internal combustion engine 11 is shown comprising a speed sensor 10, a load sensor 12, and an acceleration booster 14. The speed sensor is provided with four housing portions 16, 18, 20, and 22 separated

2

from each other by diaphragms 24, 26, and 28 respectively to provide chambers 30, 32, 34, and 36. Chamber 30 communicates with a fuel tank 38 through inlet conduit 40. A fuel pump 42 in conduit 40 supplies a constant volume of fuel through filter 44 to chamber 30 during the operation of the engine regardless of its load or speed. A return flow metering orifice 46 in housing portion 16 connects chamber 30 with a return flow conduit 48 which communicates with the fuel tank 38. A return flow metering needle 50 having a tapered end 52 is secured to each of said diaphragms 24, 26, and 28 by suitable grommets 54.

A flyweight support 56 pivotally supports flyweights 58 and 60 and is secured to a flexible shaft 62 which is operatively connected to the engine to rotate at a speed directly proportional to engine speed. Flyweights 58 and 60 have projections 64 and 66 respectively which abut the end of needle 50 when the flyweights pivot outwardly in response to rotation of shaft 62, thereby to urge needle 50 toward orifice 46 against the force applied in the opposite direction against diaphragm 24 by the fuel in chamber 30.

A conduit 68 connects chamber 30 to the upstream chamber 70 of the load sensor which upstream chamber communicates with a downstream fuel distribution chamber 72 of the load sensor across a load metering orifice 74. A load metering needle 76 having a reversely tapered end 78 positioned in orifice 74 is operatively connected to piston 80 reciprocally mounted in cylinder 82, which cylinder operatively communicates with the low pressure portions of each intake manifold 84 on heads 85 through conduit 86. The degree of taper of end 78, the length of the stroke of piston 80, and the size of orifice 74 are interrelated and are specifically predetermined. These dimensions must be such that the flow of fuel across orifice 74 can always be adjusted by the load sensor to be substantially linear with respect to the total air flow to the engine as measured by the load sensor. Low pressure transmitted through conduit 86 will cause piston 80 to be drawn upwardly against the force of spring 88 thereby to urge the flared end of needle 76 into closer proximity to the sides of orifice 74. Conversely high pressure in the intake manifolds will tend to urge needle 76 to a more open position with respect to orifice 74.

A plurality of nozzle fuel feed conduits 90 extend from chamber 72 of the load sensor to an equal number of fuel injection nozzles 92 located upstream of the throttle valves 94 of the individual intake manifold sections 84. Throttle valves 94 are linked to the accelerator pedal 95 of the engine and are simultaneously moved to an open position upon actuation of the accelerator pedal. It is obvious that all of the separate manifold branches 84 could be brought together into a single plenum chamber provided with a single throttle body which structure is conventional as shown, for example in Patents 2,673,556, 2,419,171, and 2,136,959. The atomizing air supply to the nozzles 92 is obtained from pump 96 through intakes 98 and 100 and is transmitted to the branch air conduits 102 of said nozzles by header 104. Chamber 72 of the load sensor is connected to chamber 32 of the speed sensor by conduit 106 to provide an adjustment of the return flow metering needle 50 with respect to orifice 46 based on the pressure differential existing across orifice 74 of the load sensor.

An idle boost conduit 108 communicates with one of said manifold sections 84 at a point adjacent the edge of the throttle valve 94 of that section and with the chamber 34 of the speed sensor. An air bleed valve 110 in conduit 108 is provided to regulate the pressure transmitted to idle boost vacuum chamber 34 from said manifold section during idling of the engine in order to regulate

thereby the speed of the engine at idling. Under normal idling conditions the pressure in chamber 34 is lower than in chamber 36 which is vented to the atmosphere and said pressure in chamber 36 tends to urge the needle 50 toward orifice 46 to retard the flow of return fuel therethrough and provide a sufficient fuel supply for idling. The requirement of this additional boost to needle 50 is due to the fact that at slow engine speed the centrifugal force of the flyweights is not sufficient to negate completely the frictional resistance of the needle 50 to movement.

Acceleration booster 14 is provided with a housing or cylinder 112 having a shaft or thrust member 114 adapted to be connected to the accelerator of the engine, which accelerator is operatively connected to said throttle valves 92 and operative to open the latter upon being actuated to increase engine power. A cavity 116 in member 112 is vented to the atmosphere through bleed hole 118 and slidably contains reaction member or plunger 120. A flapper valve 122 is secured to member 120 and is adapted to close bleed aperture 124 when pressure is developed in cavity 116. A shaft 126 slidably mounted in shaft 114 and member 120 is pivotally attached to a pressure arm 128 which is pivotally and conveniently attached at a point 132 to a stationary portion of the speed sensor 10. Arm 128 abuts a shoulder 130 on needle 50 and exerts a longitudinal force on said needle in response to being pivoted clockwise around point 132. An overload spring 134 interposed between member 120 and arm 128 prevents the exertion of an excessive force on needle 50 as the engine accelerator is depressed to its maximum stroke. A spring 136 urges members 120 and 112 apart to allow cavity 116 to expand when the accelerator is in its undepressed position.

The operation of the fuel injection metering system will be described in relation to a change in static engine operating conditions, that is, constant engine speed and load. Under said static operating conditions, the combined forces exerted by flyweights 58 and 60 and the fuel in metered fuel pressure chamber 32 is balanced by the force exerted by the fuel in fuel supply pressure chamber 30, and the return flow metering needle 50 is maintained stationary at a distance away from orifice 46. In this static condition, the amount of fuel delivered to the distribution chamber 72 is constant and is equal to the constant amount of fuel being delivered to the system by the pump less the constant amount of fuel being returned to the fuel tank through the return flow conduit 48. This static condition represents the engine during normal driving speed and the pressure in chamber 36 has no noticeable effect on the operation of the unit. It is only during idling and very low engine speeds that the pressure differential across diaphragm 28 becomes significant.

As the throttle valves 94 are moved to a more open position by operation of the engine accelerator 95, an increase in manifold pressure transmitted to the load sensor piston through conduit 86 moves said piston down and thereby moves the load metering needle 76 to a more open position with respect to the load metering orifice 74. The pressure differential existing across orifice 74 is consequently decreased as more fuel is allowed to flow into chamber 72, the pressure in the latter chamber and the fuel flow to the nozzles being consequently increased. This decrease in pressure differential causes the flow through orifice 74 to deviate from the desirable flow which is substantially directly proportional to engine speed. To correct this condition and bring the pressure differential across said orifice up to a value where the flow of fuel therethrough is substantially directly proportional to engine speed, the fuel pressure in fuel supply pressure chamber 30 and the load sensor upstream chamber 70 communicating therewith is increased. This increase in pressure is accomplished by moving the return flow metering needle 52 closer to orifice 46 so as to restrict the return flow in line 48. The closing move-

ment of needle 50 results from the increased force transmitted by the flyweights 58 and 60 as the increased fuel flow to the nozzles increases and from the increased pressure in chamber 32 caused by the increased flow of fuel into the downstream chamber 72 of the load sensor. When the forces transmitted by the flyweights and the fuel in chamber 32 once again balance the force transmitted in the opposite direction by the fuel in chamber 30, the flow of fuel through orifice 74 will be substantially directly proportional to the speed of the engine and will correspond to the flow of air into the intake manifold.

When rapid acceleration of the engine is desired acceleration booster 14 comes into play as shown in FIGURE 1. The rapid depression of the accelerator will cause the attached thrust member 114 to be urged to the left, which will compress the air in cavity 116 and exert a force on reaction member 120. This force will be transmitted to needle 50 through spring 134, shaft 126, and arm 128 to restrict the flow of return fuel through orifice 46 and increase the fuel pressure in chambers 30 and 70. This increased pressure will result in an increase in fuel flow across orifice 74 and to the engine. Simultaneously, however, with the compression of air in cavity 116, the air trapped therein begins to bleed out through bleed hole 118, whereby spring 134 begins to force member 120 to the right and relieves the boost pressure on arm 128 and needle 50. The time required for a complete retraction of member 120 may be conveniently regulated by varying the size of hole 118. It is noted that spring 134 is stronger than spring 136 and easily overpowers it to effectively reduce the volume of cavity 116. As the accelerator and attached thrust member 112 are suddenly retracted to the right, flapper valve 122 opens to allow a rush of air through aperture 124 to avoid dragging member 120 excessively far to the right against the light tension of spring 136.

I claim:

1. In a fuel injection system for an internal combustion engine, fuel metering means connected with a fuel source for supplying fuel to said engine, an accelerator operatively connected with said fuel metering means for increasing the fuel supply to said engine, fuel booster means operatively connected with said accelerator and fuel metering means, and responsive to rapid actuation of said accelerator to adjust said fuel metering means to supply additional accelerating fuel to said engine, and means on said booster means effective to rapidly reduce the accelerating effect of said booster means.

2. In a fuel injection system for an internal combustion engine, fuel metering means connected with a fuel source for supplying fuel to said engine, an accelerator operatively connected with said fuel metering means for increasing the fuel supply to said engine, fuel booster means operatively connected with said accelerator and fuel metering means, and responsive to rapid actuation of said accelerator for transmitting an adjusting force to said fuel metering means to adjust the latter to supply additional accelerating fuel to said engine, and means associated with said booster means for rapidly dissipating said adjusting force to reduce the accelerating effect of said booster means.

3. In a fuel injection system for an internal combustion engine having an accelerator and an intake manifold, fuel metering means connected with a fuel source for supplying fuel to said engine, said means comprising a fuel metering orifice and a fuel metering member shiftable with respect to said orifice to regulate fuel flow therethrough, fuel booster means having a thrust member operatively connected to said accelerator, said thrust member carrying an air cylinder, a plunger mounted in said cylinder for reciprocation and operatively linked to said fuel metering member, said thrust member being responsive to rapid actuation of said accelerator to adjust said metering member with respect to said orifice to sup-

ply additional accelerating fuel to the engine, bleed means on said cylinder operable to rapidly reduce the accelerating effect of said booster means, and valve means on said cylinder for facilitating the rapid recovery of said booster means upon deactuation of said accelerator.

4. In a fuel injection system for an internal combustion engine having an accelerator and an intake manifold communicating with the engine combustion chambers, a speed metering unit having a fuel supply pressure chamber, conduit means connecting said chamber to said manifold, a fuel source communicating with said chamber through a fuel conduit, a fuel return flow conduit connecting said chamber with said source, fuel return flow control means having a shiftable member, engine speed governor means connected with said member to shift the same in response to thrust developed by said governor means to regulate the flow of return fuel through said orifice, dashpot means on said accelerator, said dashpot means being operatively linked to said member for imparting a direct thrust thereto in response to actuation of said accelerator, bleed means on said dashpot means effecting automatic and rapid fading of said thrust to zero value to cause a temporary increased fuel flow to said engine for facilitating rapid engine acceleration.

5. In a fuel injection system for an internal combustion engine having an accelerator and an intake manifold communicating with the engine combustion chambers, a speed metering unit having a fuel supply pressure chamber, conduit means connecting said chamber to said manifold, a return flow metering orifice in said chamber, a fuel source communicating with said chamber through a fuel feed conduit, and also communicating with said chamber through said return flow metering orifice, a return flow metering member in said unit connected to a speed governor means and shiftable with respect to said orifice in response to thrust developed by said governor means to regulate the flow of return fuel through said orifice, dashpot means on said accelerator, said dashpot means being operatively linked to said return flow metering member for imparting a direct thrust thereto in response to actuation of said accelerator, bleed means on said dashpot means effecting automatic and rapid fading of said thrust to zero value to cause a temporary increased fuel flow to said engine for facilitating rapid engine acceleration.

6. In a fuel injection system for an internal combustion engine, fuel metering means connected with a fuel source and including adjustable valve means having a member adjustable for regulating the fuel supply to said engine, an accelerator operatively connected with said fuel metering means for increasing the fuel supply to said engine, fuel booster means operatively connected with said accelerator and member and responsive to rapid actuation of said accelerator to adjust said member to supply additional accelerating fuel to said engine, and means on said booster means effective to rapidly reduce the accelerating effect of said booster means.

7. In a fuel injection system for an internal combustion engine having an accelerator and an intake manifold communicating with the engine combustion chambers, a speed metering unit having a fuel supply pressure chamber, a return flow metering orifice opening into said chamber, a fuel source communicating with said chamber through a fuel feed conduit and also communicating with said chamber through said return flow metering orifice, said chamber adapted to communicate with said engine through conduit means, engine speed responsive governor means, a return flow metering member in said unit connected to said speed governor means and shiftable with respect to said orifice in response to thrust developed by said governor means to regulate the flow of return fuel through said orifice, dashpot means comprising relatively movable cylinder and plunger elements operative to effect a fluid pressure therebetween and having bleed means for effecting controlled dissipation of said pres-

sure, one of said members being operatively connected to said accelerator for effecting said pressure upon rapid actuation of said accelerator, resilient linkage means, the other of said elements being operatively connected to said metering member through said linkage means and responsive to said fluid pressure to exert a thrust on said metering member to retard the flow of fuel through said return flow metering orifice.

8. In a fuel injection system for an internal combustion engine, fuel metering means connected with a fuel source for supplying fuel to said engine, an accelerator operatively connected with said fuel metering means for increasing the fuel supply to said engine, means responsive to rapid actuation of said accelerator to adjust said fuel metering means to supply additional accelerating fuel to said engine comprising a dashpot having relatively movable elements, one of said elements being operatively connected with said accelerator to be shifted thereby to exert an adjusting force by dashpot action on the other of said elements, said other element being operatively connected with said fuel metering means, said dashpot having a bleed orifice for rapidly dissipating fluid pressure from between said elements.

9. In a fuel injection system for an internal combustion engine having an accelerator and an intake manifold communicating with the engine combustion chambers, a speed metering unit communicating with a fuel supply, a load metering unit connected to said speed metering unit and communicating with said intake manifold, shiftable fuel metering means in said speed metering unit for regulating the flow of fuel to said load metering unit, and fuel booster means connected to said accelerator and to said shiftable fuel metering means and responsive to sudden actuations of said accelerator to adjust the position of said shiftable fuel metering means in said speed metering unit for increasing the flow of fuel to said load metering unit.

10. In a fuel injection system for an internal combustion engine having an accelerator and an intake manifold communicating with the engine combustion chambers, a speed metering unit communicating with a fuel supply, a load metering unit connected to said speed metering unit and communicating with said intake manifold, said load metering unit having means therein responsive to changes in intake manifold pressure to regulate the flow of fuel to said manifold, shiftable fuel metering means in said speed metering unit for regulating the flow of fuel to said load metering unit, and fuel booster means connected to said accelerator and to said shiftable fuel metering means and responsive to sudden actuations of said accelerator to adjust the position of said shiftable means in said speed metering unit for increasing the flow of fuel to said load metering unit.

11. In a fuel injection system for an internal combustion engine having an accelerator and an intake manifold communicating with the engine combustion chambers, a speed metering unit having a fuel supply pressure chamber, a return flow metering orifice forming a fuel outlet from said chamber to a fuel source, a fuel feed conduit connecting said chamber to said fuel source, a load metering unit having a load metering orifice communicating with said engine and with said chamber and having a pressure responsive load metering member positioned in said load metering orifice and communicating with said manifold, said member being responsive to manifold pressure to regulate the flow of fuel through said load metering orifice to said engine, a return flow metering member in said speed metering unit, an engine speed responsive governor means connected to said return flow metering member for shifting the same with respect to said return flow metering orifice in response to thrust developed by said governor means to adjust the flow of return fuel through said return flow metering orifice and to said load metering unit in accordance with engine speed, dashpot means on said accelerator having a thrust member, said thrust member being operatively connected to said accel-

erator and having a fluid cylinder thereon, a plunger member reciprocally mounted in said cylinder and movable in response to pressure developed therein, said plunger member being operatively connected to said return flow metering member through resilient linkage means, resilient means reacting between said thrust member and said plunger member urging them to their inoperative positions, bleed means communicating with said cylinder to bleed off fluid pressurized therein by actuation of said accelerator, and valve means communicating with said cylinder to facilitate the recovery of said dashpot means.

12. In a fuel injection system for an internal combustion engine having an accelerator and an intake manifold communicating with the engine combustion chambers, a speed metering unit having a fuel supply pressure chamber, a return flow metering orifice forming a fuel outlet from said chamber to a fuel source, a fuel feed conduit connecting said chamber to said fuel source, a load metering unit having a load metering orifice communicating with said engine and with said chamber and having a pressure responsive load metering member positioned in said load metering orifice and communicating with said manifold, said member being responsive to manifold pressure to regulate the flow of fuel through said load metering orifice to said engine, a return flow metering member in said speed metering unit, an engine speed responsive governor means connected to said return flow metering member for shifting the same with respect to said return flow metering orifice in response to thrust developed by said governor means to adjust the flow of return fuel through said return flow metering orifice and to said load metering unit in accordance with engine speed, dashpot means having a variable volume fluid chamber defined by two relatively movable elements, one of said elements being connected to said accelerator and the other of said elements being resiliently connected to said return flow metering member, resilient means reacting between said elements urging separation thereof, bleed means communicating with said fluid chamber to bleed fluid under pressure therefrom, and one way valve means communicating with said fluid chamber and effective to allow the rapid flow of fluid therein upon separation of said elements.

13. In a fuel injection system for an internal combustion engine, a speed metering unit having a fuel supply pressure chamber, a return flow outlet from said chamber to a fuel source, fuel inlet means connecting said source and said fuel supply pressure chamber, engine speed responsive means, a return flow metering member carried by said speed responsive means for controlling the return fuel flow from said fuel supply pressure chamber through said outlet to said source, fuel conduit means connecting said fuel supply pressure chamber and engine to supply fuel to the latter, engine load responsive means for controlling the fuel flow through said conduit means to said engine, dashpot means on said accelerator having a thrust member operatively connected to said accelerator and having a fluid cylinder thereon, a plunger member reciprocally mounted in said cylinder and movable in response to pressure developed therein, said plunger member being operatively connected to said return flow metering member through resilient linkage means, resilient means reacting between said thrust member and said plunger member urging them to their inoperative positions, bleed means communicating with said cylinder to

bleed off fluid pressurized therein by actuation of said accelerator, and valve means communicating with said cylinder to facilitate the recovery of said dashpot means.

14. In a fuel injection system for an internal combustion engine, a speed metering unit having a fuel supply pressure chamber, a return flow outlet from said chamber to a fuel source, fuel inlet means connecting said source and said fuel supply pressure chamber, engine speed responsive means, a return flow metering member carried by said speed responsive means for controlling the return fuel flow from said fuel supply pressure chamber through said outlet to said source, fuel conduit means connecting said fuel supply pressure chamber and engine to supply fuel to the latter, engine load responsive means for controlling the fuel flow through said conduit means to said engine, dashpot means having a variable volume fluid chamber defined by two relatively movable elements, one of said elements being connected to said accelerator, means for actuating said metering member and for preventing sudden overloading thereof by sudden actuation of said accelerator comprising a resiliently yieldable connection between the other of said elements and said metering member, bleed means communicating with said fluid chamber to bleed fluid under pressure therefrom, and one way valve means communicating with said fluid chamber for effecting rapid flow of fluid therein upon rapid separation of said elements.

15. In a fuel injection system for an internal combustion engine, a fuel supply, a speed metering unit having a fuel supply pressure chamber and a metered fuel pressure chamber, a movable wall separating said chambers, said wall being responsive to pressure differences in said chambers to shift toward the chamber of lower pressure, a return flow outlet from said fuel supply pressure chamber connected to said fuel source, fuel inlet means connecting said source and said fuel supply pressure chamber, engine speed responsive means, a return flow metering member carried by said speed responsive means for controlling the return fuel flow from said fuel supply pressure chamber through said outlet to said source, said return flow metering member being connected to said wall to shift therewith, fuel conduit means connecting said fuel supply pressure chamber and engine to supply fuel to the latter, engine load responsive means for controlling the fuel flow through said fuel conduit means to said engine, metered fuel conduit means connecting said fuel conduit means at a location downstream of said engine load responsive means with said metered fuel pressure chamber, dashpot means having a variable volume fluid chamber defined by two relatively movable elements, one of said elements being connected to said accelerator, means for actuating said metering member and for preventing sudden overloading thereof by sudden actuation of said accelerator comprising a resiliently yieldable connection between the other of said elements and said metering member, bleed means communicating with said fluid chamber to bleed fluid under pressure therefrom, and one way valve means communicating with said fluid chamber for effecting rapid flow of fluid therein upon rapid separation of said elements.

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