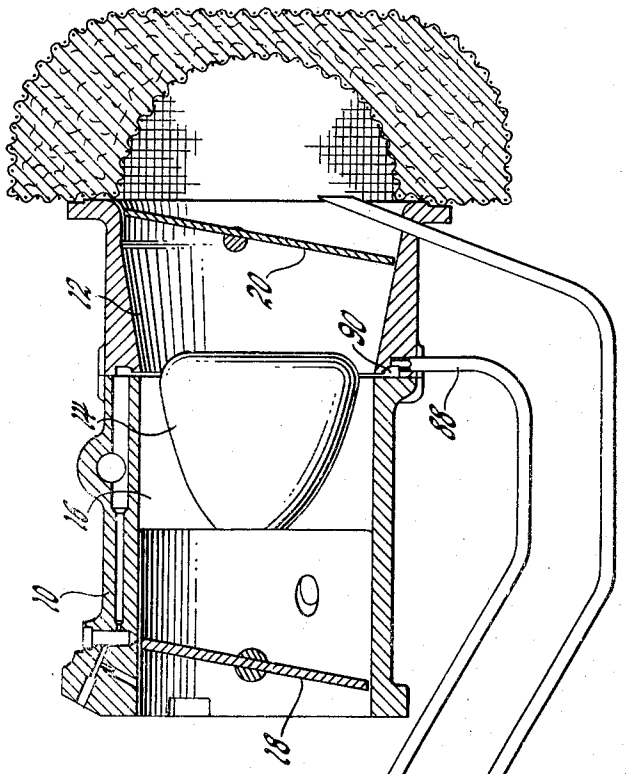
Sept. 27, 1960 S. H. MICK 2,954,019

FUEL CUT-OFF MECHANISM FOR FUEL INJECTION SYSTEM

Filed May 1, 1957 2 Sheets-Sheet 1



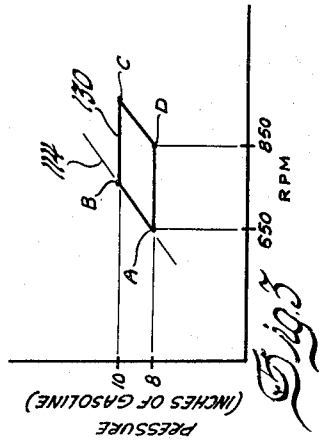


Fig. 3

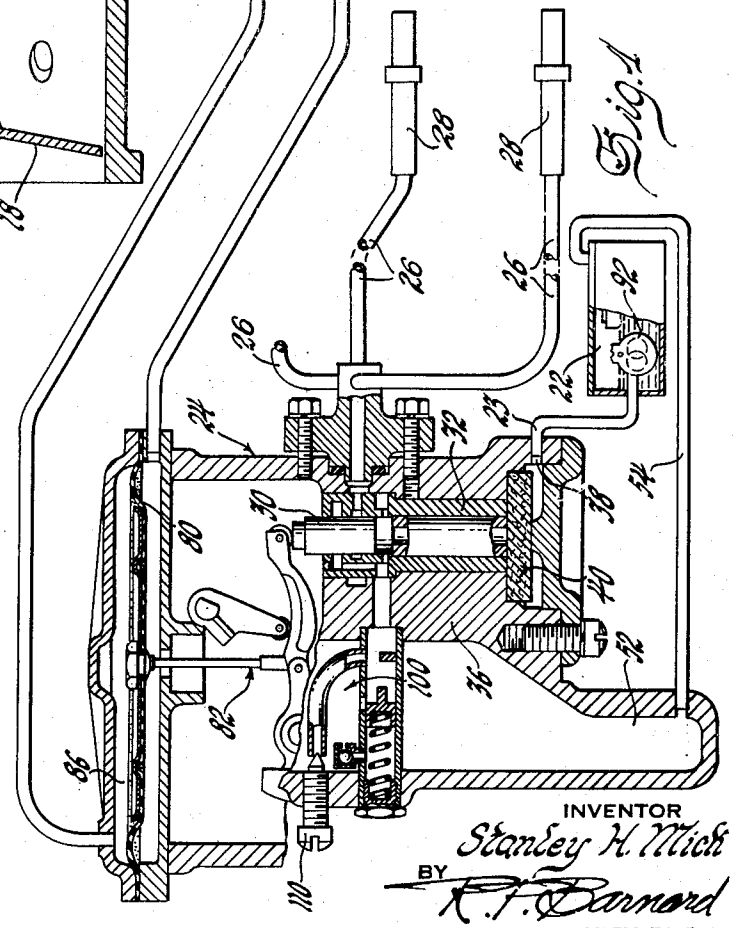


Fig. 4

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FUEL CUT-OFF MECHANISM FOR FUEL INJECTION SYSTEM

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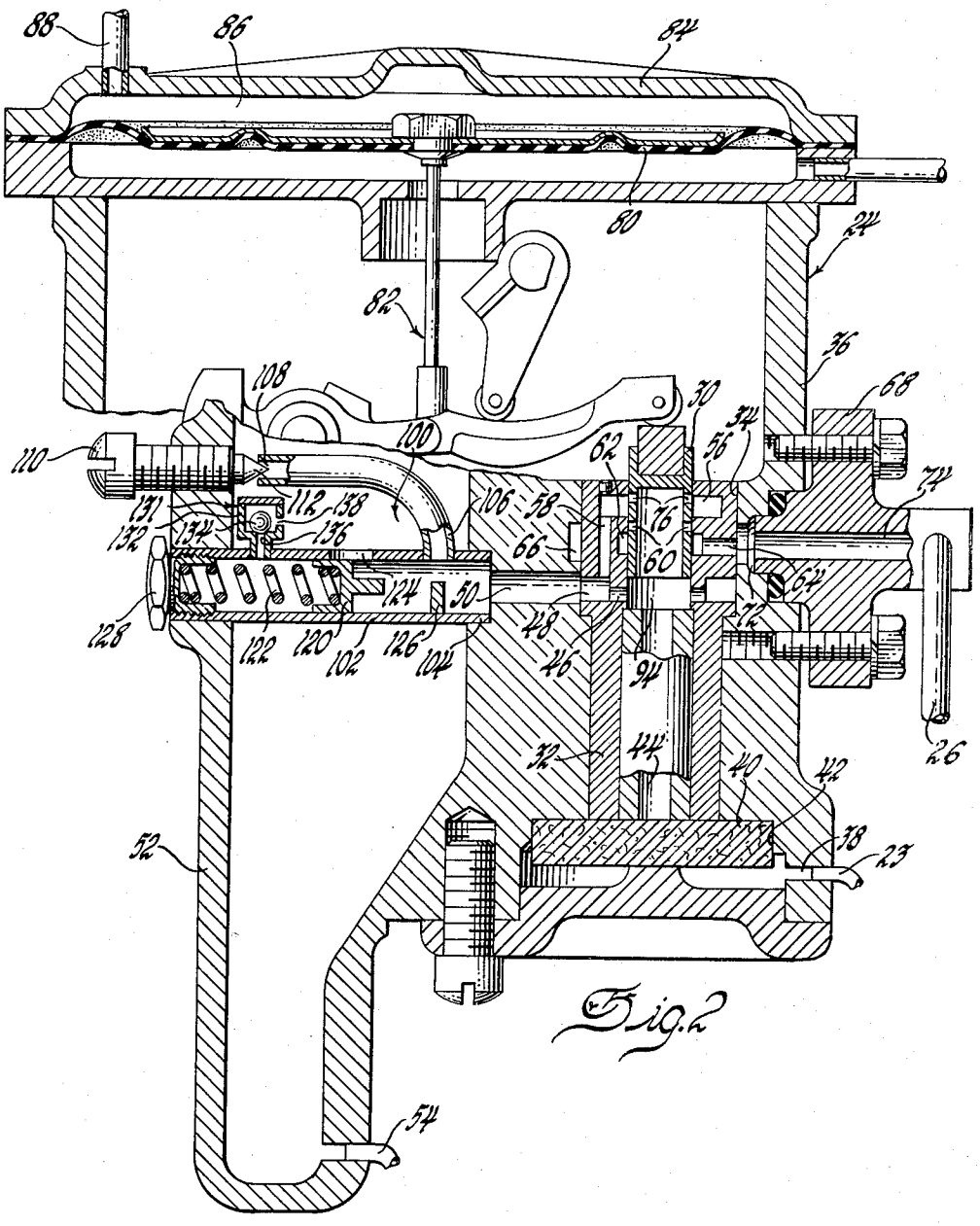


Fig. 2

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United States Patent Office 2,954,019
Patented Sept. 27, 1960

2,954,019

FUEL CUT-OFF MECHANISM FOR FUEL INJECTION SYSTEM

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Filed May 1, 1957, Ser. No. 656,431

10 Claims. (Cl. 123—119)

The present invention relates to a fuel injection system in which means is provided for cutting off the flow of fuel under engine decelerating conditions. This device is an improvement over the coasting fuel shut-off mechanism shown in copending application Serial No. 608,853 Dolza, filed September 10, 1956, now Patent No. 2,843,098 granted July 15, 1958.

The present device represents a greatly simplified construction for a coasting or deceleration fuel cut-off mechanism which in addition to the greater economy of manufacture is functionally more effective than the corresponding mechanism of the aforenoted copending application. In the coasting fuel shut-off mechanism of the Dolza application, the fuel flow was stopped under decelerating conditions by an increase in manifold depression. It is apparent that with such a mechanism changes in altitude may seriously affect the operation of the device to the extent of rendering it completely inoperative. In the present improved coasting fuel shut-off mechanism manifold depression is eliminated as a control force and thus the fuel cut-off function takes place equally well irrespective of ambient pressure variations.

A detailed description of the present invention as well as other objects and advantages is set forth in the detailed description which follows.

In the drawings:

Figure 1 discloses a fuel injection system embodying the present invention;

Figure 2 is an enlarged sectional view of a portion of Figure 1; and

Figure 3 is a graphic representation of the functioning of the subject invention.

The present invention has been illustrated on a fuel injection system which is in general the same as that shown in copending application Serial No. 658,091 Dolza et al., filed May 9, 1957, now Patent No. 2,914,051 granted Nov. 24, 1959. The fuel injection system will be described only insofar as is necessary to provide an adequate environment for the present invention. An air intake casing 10 includes an induction passage 12 and a tapered plug 14 disposed therein which cooperates with the induction passage 12 to form an annular venturi 16. A throttle valve 18 is disposed posteriorly of the annular venturi 16 and is adapted to control the quantity of air flow through the passage. A signal modifier valve 20 is also disposed in the induction passage 12 anteriorly of the venturi 16 and is in general controlled by a temperature responsive mechanism shown and described in Patent No. 2,914,051. A source of fuel under a pressure is shown generally at 22 and is adapted to supply a quantity of fuel proportional to engine speed through conduit 23 to a metering valve device indicated generally at 24 from whence a metered quantity of fuel is supplied to individual fuel conduits 26 terminating in nozzles 28 adapted to supply fuel to the individual cylinders of the engine as described in the latter copending application.

The fuel metering mechanism 24 includes a metering valve 30 slidably disposed in a sleeve 32 fixed within a bore 34 of casing 36. Fuel from source 22 and conduit 23 enters casing 36 through a port 38 and flows upwardly through a filter element 40 within a counterbored portion 42 of casing 36 and is directed to longitudinal passage 44 in sleeve 32 and thence to the interior of the slidable metering valve 30.

Sleeve 32 includes a plurality of sets of radial ports for variously dispensing the fuel supplied continuously thereto from source 22. A first set of radial sleeve spill ports 46 communicates with an annular chamber 48 formed in the sleeve and which passage in turn communicates with a passage 50 formed in casing 36. Passage 50 leads to a fuel bypass reservoir 52. Fuel in reservoir 52 returns to the fuel source 22 through a conduit 54. An annular spill passage 56 is formed in sleeve 32 in axially spaced relation to spill ports 46. Spill passage 56 communicates with annual passage 48 through a longitudinal passage 58.

The slidable valve member 30 also includes a plurality of axially spaced sets of radial ports. The first set of valve ports 60 are adapted to slidably coact with an annular passage 62 formed in sleeve 32 and which passage communicates through a passage 64 with an annular chamber 66. A fitting 68 is suitably fixed within opening 72 in casing 36. Fitting 68 includes a passage 74 communicating with fuel outlet chamber 66 and one or more of the fuel conduits 26. An additional set of radial ports 76 is formed in valve member 30 and is adapted to communicate with annular spill passage 56.

As the valve member 30 slides axially within the sleeve 32 the fuel therewithin will be variously distributed between the outlet or cylinder supply passage 64 and the bypass or spill passages 46 and 56 depending on the needs of the engine.

The axial position of the metering valve 30 within sleeve 32 is determined in part by a vacuum actuated diaphragm member 80 which is operatively connected to the valve member 30 through a control linkage indicated generally at 82. The diaphragm 80 and a casing member 84 define a vacuum chamber 86 which communicates through a conduit 88 with an annular chamber 90 formed in the induction casing 10. Annular chamber 90 communicates with the venturi 16 so that as the quantity of air flow through the venturi increases a vacuum force proportional to a square of such flow is created in chamber 90 and transmitted to the diaphragm 80.

Fuel source 22 includes an engine speed responsive pump 92, therefore, the quantity of fuel in the metering cavity 94 varies in accordance with engine speed and acts in opposition to the vacuum in chamber 90 in positioning valve 30. Thus the position of valve 30 is differentially determined by air flow and the quantity of fuel in cavity 94.

Under normal operating conditions the fuel source 22 supplies fuel to the metering valve 30 in excess of the needs of the engine and therefore a continuous quantity of fuel is being bypassed around the metering valve through spill passage 46 and 56. The quantity of fuel actually supplied to the cylinders from passage 64 is controlled by air flow which, as described, determines the extent of registry between radial valve ports 76 and the annular sleeve passage 56 as well as by the extent to which the lower end of valve 30 uncovers spill ports 46. During normal idling conditions the vacuum in chamber 86 will be such as to maintain a small amount of fuel flow to the cylinder supply passage 64 with the main quantity of fuel supplied to the metering valve being bypassed to the reservoir 52. During decelerating conditions, however, it has been found that various engine operating conditions tend to cause excess or unneeded fuel flow through the engine cylinders, albeit the flow is quantitatively the same as occurs during normal idling. The deceleration fuel excess is passed in an unburned state

into the atmosphere. Obviously this condition is undesirable both from the point of view of fuel economy and the general contamination or fouling of the atmosphere. Accordingly, the present invention is directed to an improved mechanism for cutting off fuel flow under engine decelerating conditions.

Under decelerating conditions the vacuum in annular chamber **90** and hence in diaphragm chamber **86** is the same as that which occurs under normal idling conditions. However, inasmuch as pump **92** is responsive to engine speed the quantity of fuel in the metering valve cavity **94** increases under decelerating conditions and acts on the valve member **30** to move the latter upwardly moving the radial ports **60** out of communication with annular passage **62** cutting off all fuel flow to the cylinder supply passage **64** and bypassing all the fuel back to reservoir **52** and in so doing endeavoring to maintain the cavity **94** at idle fuel pressure.

In order to achieve this type of fuel cut-off by the metering valve **30**, it is necessary to provide means which will insure the cut-off of fuel when the fuel pressure in metering cavity **94** exceeds that desired for normal idling operation. The fuel cut-off operation presupposes that the throttle valve **18** is closed under which condition the vacuum force acting on diaphragm **80** is no greater than at idle.

To achieve the appropriate fuel cut-off operation, a mechanism indicated generally at **100** is provided. Mechanism **100** includes a tubular sleeve member **102** mounted in casing **36** and communicating at its inner end **104** with spill passage **50**. A conduit member **106** extends from sleeve member **102** and is open at end **108** to communication with the reservoir **52**. An adjustable needle valve member **110** is rotatably mounted in casing **36** and has a tapered end **112** which communicates with the open end **108** of conduit **106**. Thus, the needle valve **110** may be threaded into or out of the open end of conduit **106** to vary the engine speed at which the fuel under pressure in metering cavity **94** will cause the metering valve **30** to cut off the fuel flow to fuel outlet passage **64**. As the needle valve is adjusted to close the open end **108** of conduit **106** the engine speed at which the coasting fuel shut-off takes place decreases. Correspondingly as the needle valve moves to open end **108** of tube **106**, the r.p.m. at which fuel is cut off during coasting operation is increased.

Referring to the curves of Figures 3, a pressure-speed curve is shown at **114** which would obtain if the spill ports were kept open, i.e., no signal on the diaphragm, and the plunger or valve had no weight. This curve indicates that the pressure within the metering cavity **94** increases as a square of engine r.p.m. as plotted on a logarithmic scale. It has been found satisfactory for fuel cut-off operation to adjust the needle valve **110** in relation to the open end **108** of conduit **106** to achieve a minimum pressure head equal to approximately eight inches of gasoline in the metering cavity **94**. This fuel cut-off point is shown at A on the graph of Figure 3, which indicates a metering cavity pressure of eight inches of gasoline at approximately **650** r.p.m. Thus the restriction of end **108** of conduit **106** sets the minimum fuel pressure obtainable in the metering cavity at each speed.

The mechanism as thus far described is adequate to provide coasting fuel shut-off operation at moderate speeds, however, for a smooth tip-in when coasting at high speeds, it is necessary that the minimum fuel rate be near the idle fuel rate. To accomplish this the pressure in the metering cavity **94** cannot be excessively higher than idle fuel pressure.

Accordingly, a relief valve mechanism is provided in tube **102** and comprises a slidable valve member **120** normally biased by a spring **122** to a position closing off an exhaust port **124** formed in tube **102**. The limit of outward travel of the slidable member **120** is limited by a stop **126** suitably disposed within tube **102**. The spring **122** seats in a plug **128** adjustably mounted within the tube **102** such that the rate of the spring and hence the operation of the slidable member **120** may be adjusted in accordance with desired operating characteristics of the engine. It has been found that satisfactory tip-in operation will take place if the relief valve **120** is adjusted to open exhaust port **124** when the metering cavity pressure reaches a head of approximately ten inches of gasoline as shown at B on the curve **114** of Figure 3. In other words, after the metering cavity pressure has reached ten inches there can be no further increase in pressure as indicated by the straight line portion **130** of the curve. Thereafter if at any time the operator again desires to accelerate the vehicle the pressure in the metering cavity **94** has been maintained only slightly above that obtaining during normal idling, supra. Thus a small amount of throttle opening will create a vacuum force sufficient to balance the fuel pressure and resume fuel flow to the cylinders.

An additional problem arises in a continuous fuel flow system when utilizing a coasting fuel shut-off mechanism. This problem is due to the fact that the fuel flow required to fire or ignite a particular engine cylinder is accumulated during two revolutions of the engine. Thus, when the coasting fuel shut-off operation is completed and the plunger or slidable valve member **30** resumes its normal metering position, there will be two engine revolutions before the first cylinder receives sufficient fuel to ignite. Under moderate engine decelerations the engine will be turning at a sufficient speed to supply fuel before the engine is likely to stall. However, during rapid deceleration the engine speed may be reduced so quickly that insufficient quantity of fuel will have been supplied to the cylinders or the engine speed may be reduced to an extent preventing ignition of the fuel, in either event resulting in engine stalling.

The present invention provides means which precludes engine stalling during conditions of rapid deceleration. To this end, a dashpot mechanism indicated generally at **131** is provided which is effective during rapid deceleration to in effect raise the engine r.p.m. at which coasting fuel shut-off takes place or, in other terms, at which fuel flow resumes. Mechanism **130** includes a casing **132** in communication with that portion of tube **102** between the slidable relief valve member **120** and adjustable spring plug **128**. Thus, as the relief valve member **120** is moved to open the relief port **124** fluid behind the valve member will move a ball check member **134** from its seat **136** permitting the fluid to escape through a port **138** into the reservoir **52**. On the other hand, during conditions of rapid deceleration the action of relief valve member **120**, which would normally close relief port **124** rapidly, is delayed by the reseating of ball check member **134**. With the ball check member seated the valve **120** will slowly close port **124** as the fluid leaks between the valve and tube **102** which has the effect of causing the pressure in the metering cavity **94** to drop from a point C on the ten inch curve to the point D on the eight inch curve and which latter point represents an engine speed of approximately 850 r.p.m.. In this way under rapid decelerating conditions the engine r.p.m. will still be of a sufficiently high value when fuel flow resumes to insure at least two revolutions of the engine and sufficient fuel to prevent the engine stalling.

The clearance between relief valve **120** and sleeve **102** is such that during normal decelerating conditions the leakage of fluid around the valve is enough to cause the dashpot mechanism **131** to have essentially no effect and the pressure-speed curve which would be followed would be represented by C, B, A in returning to normal idling operation. Under rapid deceleration conditions, on the other hand, the curve represented by C, D, A would be followed in returning to normal idling operation.

The pressure values utilized in illustrating the operation of this invention as well as the mechanism itself while representing an operative system are merely illustrative insofar as the principle of the subject invention is

concerned and structural and numerical variations are possible within the intended scope of this invention.

I claim:

1. A fuel injection system for an internal combustion engine comprising an air induction passage, a source of fuel under pressure the quantity of which is proportional to engine speed, conduit means for delivering fuel to the individual cylinders of the engine, a valve for metering the quantity of fuel flow to the individual cylinders in accordance with the mass of air flow through said induction passage, means for bypassing a portion of the fuel supplied to said metering valve back to the fuel source, said metering valve being constructed and arranged to completely cut off the flow of fuel to said cylinder supply conduit means in accordance with an increase of fuel pressure beyond a given value, valve means for adjusting the engine speed at which the metering valve will cut off the flow of fuel to the cylinders, and an additional valve means for limiting the maximum pressure of the bypass fuel.

2. A fuel injection system for an internal combustion engine comprising an air induction passage, a source of fuel under pressure the quantity of which is proportional to engine speed, conduit means for delivering fuel to the individual cylinders of the engine, a valve for metering the quantity of fuel flow to the individual cylinders in accordance with the mass of air flow through said induction passage, means for bypassing a portion of the fuel supplied to said metering valve back to the fuel source, said metering valve being constructed and arranged to cut off the flow of fuel to said cylinder supply conduit means in accordance with an increase of fuel pressure beyond a given value, valve means for adjusting the engine speed at which the metering valve will cut off the flow of fuel to the cylinders, an additional valve means for limiting the maximum pressure of the bypass fuel, and means for changing the engine speed at which the fuel shut-off mechanism becomes effective under rapid engine decelerating conditions.

3. A fuel injection system for an internal combustion engine comprising an air induction passage, a source of fuel under pressure the quantity of which is proportional to engine speed, conduit means for delivering fuel to the individual cylinders of the engine, a valve for metering the quantity of fuel flow to the individual cylinders in accordance with the mass of air flow through said induction passage, said metering valve being constructed and arranged to cut off the flow of fuel to said cylinder supply conduit means in accordance with an increase of fuel pressure beyond a given value, means for bypassing a portion of the fuel supplied to said metering valve, passage means for conducting the bypassed fuel to said fuel source, a first valve cooperating with the passage means for controlling the rate of flow therethrough and hence the engine speed at which the metering valve will cut off fuel flow to the cylinders, and a second valve associated with the passage means, said second valve being responsive to bypass fuel pressure to limit the maximum pressure of the bypass fuel.

4. A fuel injection system for an internal combustion engine comprising an air induction passage, a source of fuel under pressure the quantity of which is proportional to engine speed, conduit means for delivering fuel to the individual cylinders of the engine, a valve for metering the quantity of fuel flow to the individual cylinders in accordance with the mass of air flow through said induction passage, said metering valve being constructed and arranged to cut off the flow of fuel to said cylinder supply conduit means in accordance with an increase of fuel pressure beyond a given value, means for bypassing a portion of the fuel supplied to said metering valve, passage means for conducting the bypassed fuel to said fuel source, a first valve cooperating with the passage means for controlling the rate of flow therethrough and hence the engine speed at which the metering valve will cut off fuel flow to the cylinders, and a second valve associated with the passage means, said second valve being responsive to bypass fuel pressure to limit the maximum pressure of the bypass fuel, and dashpot means for changing the rate of actuation of said second valve under rapid engine decelerating conditions.

5. A fuel injection system as set forth in claim 2 in which said fuel bypass passage means includes a first conduit continuously open to return fuel to the fuel source, and a second conduit, said first valve coacting with the first conduit to control the rate of flow therethrough, said second valve coacting with the second conduit and blocking fuel flow therethrough under normal idling conditions, said second valve being adapted to permit fuel flow through the second conduit when the idling fuel pressure is exceeded by a given amount to limit the maximum pressure of the bypass fuel.

6. A fuel injection system for an internal combustion engine comprising an air induction passage, a source of fuel under pressure the quantity of which is proportional to engine speed, conduit means for delivering fuel to the individual cylinders of the engine, a valve for metering the quantity of fuel flow to the individual cylinders in accordance with the mass of air flow through said induction passage, said metering valve being constructed and arranged to cut off the flow of fuel to said cylinder supply conduit means in accordance with an increase of fuel pressure beyond a given value, means for bypassing a portion of the fuel supplied to said metering valve, passage means for returning the bypassed fuel to said fuel source, said bypass passage means including a continuously open first conduit, a second conduit, a first valve coacting with the first conduit to control the rate of flow therethrough, a second valve coacting with the second conduit and blocking fuel flow therethrough under normal idling conditions, said second valve being adapted to permit fuel flow through the second conduit when the idling fuel pressure is exceeded by a given amount to limit the maximum pressure of the bypass fuel, and dashpot means for changing the rate of actuation of said second valve under rapid engine decelerating conditions.

7. A deceleration fuel cut-off mechanism for a fuel injection system comprising a metering valve, means for continuously supplying said metering valve with fuel under pressure the quantity of which is proportional to engine speed, means operatively connected to said metering valve and adapted to control the quantity of fuel flowing through said valve in accordance with the mass of air flowing through said system, said fuel under pressure being adapted to cut off the flow of fuel through the metering valve under engine decelerating conditions, and means for returning fuel to said source when the flow through said metering valve is cut off, said fuel return means including a first valve for determining the rate of return fuel and thereby the minimum fuel pressure acting on the metering valve, and a second valve means for limiting the maximum pressure of said return fuel.

8. A deceleration fuel cut-off mechanism for a fuel injection system comprising a metering valve, means for continuously supplying said metering valve with fuel under a pressure proportional to engine speed, control means operatively connected to said metering valve and adapted to control the quantity of fuel flowing through said valve in accordance with the mass of air flowing through said system, said fuel under pressure being adapted to cut off the flow of fuel through the metering valve under engine decelerating conditions, and means for returning fuel to said source when the flow through said metering valve is cut off, said fuel return means including a first valve for determining the rate of return fuel flow and thereby the minimum fuel pressure acting on the metering valve, and a second valve means for limiting the maximum pressure of said return fuel, and dashpot means for changing the engine speed at which

the fuel shut-off mechanism becomes effective under rapid engine decelerating conditions.

9. A fuel injection system as set forth in claim 6 in which said second conduit includes a relief port, said second valve slidably disposed in the second conduit and responsive to the fuel pressure therein, spring means biasing the second valve to a position normally closing said relief port, fluid pressure being adapted to shift said

second valve to open said relief port to limit the maximum pressure of the bypass fuel.

10. A fuel injection system as set forth in claim 9 in which the dashpot includes a check valve associated with the second conduit for delaying the movement of the second valve in closing the relief port.

No references cited.