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FUEL INJECTION SYSTEM

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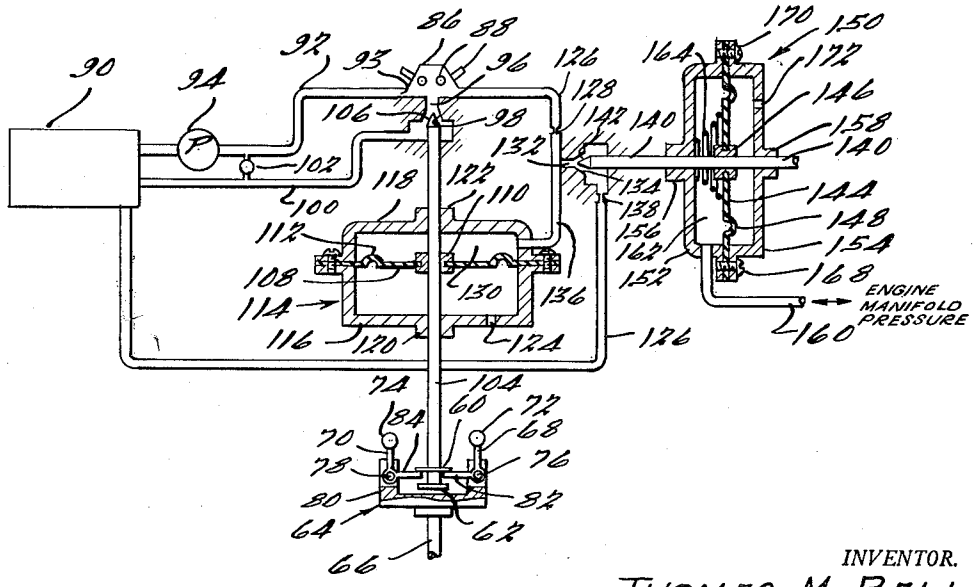

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FUEL INJECTION SYSTEM

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This invention relates to a fuel injection system and in particular to means for metering fuel to the cylinders of an internal combustion engine in amounts determined by engine operating conditions.

Although the invention is concerned mainly with automotive engines, it is anticipated that the disclosed type of fuel metering system may be used on other types of internal combustion engines.

It is conventional in fuel injection systems to supply fuel under pump pressure to a metering system which regulates the fuel flow to a number of fuel injection nozzles in accordance with the engine speed and load requirements. In such systems it is common to meter the fuel to the nozzles through one or more needle valve controlled metering orifices which are subject to regulation by various atmospheric and engine operating parameters, including speed and load as aforesaid. Among the problems encountered by such systems is the pressure drop across the metering system which often results in fuel vaporization and cavitation on the downstream side of the system, particularly on hot days during conditions of comparatively light load and fuel flow. In consequence of vapor formation and of comparatively low pressure downstream of the metering system, uneven fuel flow to the nozzles and poor nozzle efficiency results.

It is accordingly an object of this invention to provide an improved fuel distributing system which utilizes the principle of supplying fuel at optimum pump pressure in parallelism with both a fuel metering system and the fuel injection nozzles of an internal combustion engine and for returning the excess fuel to the fuel tank via conduit means downstream of the metering system, thereby to maintain an optimum fuel pressure downstream of said metering system and also to assure an optimum flow of fresh fuel through said metering system particularly at light loads, whereby over heating of the fuel and vapor formation downstream of the metering system is minimized.

It is another object of this invention to provide a fuel distributing system which returns excess fuel to the fuel tank in accordance with the engine requirements as transmitted to the fuel distributing system by the speed of rotation of the engine crankshaft and the pressure of the gases in the intake manifold of the engine.

It is still another object of this invention to provide a fuel distributing system wherein the amount of fuel returned to the fuel tank is a function of two return flow metering needles one of which acts in accordance with engine speed and the other of which acts independently and in accordance with the manifold pressure.

It is another object of this invention to provide a fuel distributing system wherein vapor formed in the fuel tank or feed conduit and carried by the feed fuel is purged from said fuel by continuously returning a large portion of said fuel back to the fuel source.

For the purpose of particularly describing the principal features of the invention, reference will be made to the accompanying drawing wherein:

The FIGURE is a schematic representation of the fuel circulatory system showing the speed and load sensory mechanism.

Referring to the drawing, 86 represents a fuel distribution chamber or rosette having fuel outlets 88 thereon

and is connected to a fuel tank 90 by a feed conduit 92 communicating with said chamber through inlet 93. A constant delivery fuel pump 94 supplies fuel under pressure to chamber 86. A primary return flow outlet 96 having a tapered orifice 98 connects chamber 86 with a primary fuel return flow conduit 100 which communicates with fuel tank 90. A pressure regulator 102 connecting conduits 92 and 100 returns some excess fuel to the tank and eliminates a building up of excessive pressure in chamber 86.

A primary return flow metering needle 104 has a tapered end 106 shaped to fit snugly into orifice 98 of port 96. A flexible diaphragm 108 of corrosion resistant material is secured to needle 104 by bushing 110. An expansion rib 112 may be provided on diaphragm 108. A housing 114 comprised of two sections 116 and 118 slidably receive needle 104 in bushings 120 and 122 respectively. Housing 114 is secured against movement relative to chamber 86. Vent 124 opens one side of diaphragm 108 to atmosphere to prevent compressed air resistance to movement of diaphragm 108. A secondary return flow conduit 126 having a constriction 128 therein connects chamber 86 to chamber 130 in housing 114 through a branch 136 of conduit 126 and allows a substantial portion of the pressure in said chamber to act on diaphragm 108.

A secondary return flow outlet 132 opens into conduit 126 and is provided with tapered orifice 134. Constriction 138 in conduit 126 is interposed between said secondary outlet and the fuel tank. A secondary return flow metering means or needle 140 having tapered end 142 which is shaped to fit snugly into orifice 134 is secured to flexible diaphragm 144 by bushing 146. Diaphragm 144 may be provided with expansion rib 148. A housing 150 having portions 152 and 154 slidably receive needle 140 in bushings 156 and 158 respectively and vents one side of diaphragm 144 to the atmosphere through aperture 172 to again prevent air resistance. A manifold pressure conduit 160 opens into chamber 162 in housing 150 and is connected at its other end to the low pressure portion of an intake manifold of an internal combustion engine to transmit pressure signals in the manifold to the chamber 162 to exert a force on diaphragm 144 proportional to the manifold pressure. A spring 164 may be interposed between diaphragm 144 and housing portion 152 to provide a slight resistance against movement of diaphragm 144 toward port 132. Suitable means such as screws 168 and 170 are provided to clamp housing portions 152 and 154 together.

Opposite the tapered end 106 metering needle 104 is provided with a pair of collars 60 and 62. A speed sensor generally designated at 64 is secured to the engine crankshaft 66 to rotate therewith. A pair of arms 68 and 70 having flyweights 72 and 74 respectively are pivotally mounted at 76 and 78 on the speed sensor housing 80. Arms 82 and 84 integral with arms 68 and 70 are loosely fitted between collars 60 and 62 and abut collar 60 during the normal operation of the engine. Since arms 68 and 70 are integral with arms 82 and 84 respectively, they are also pivotal about points 76 and 78 respectively.

In the operation of the fuel distributing system, pump 94 supplies a constant amount of fuel to chamber 86 when the engine is started. Portions of this fuel will be returned to the tank through outlets 96 and 132. Another portion of said fuel will flow through conduit 126 to chamber 130 wherein it will exert a force on diaphragm 108 and urge needle 104 away from orifice 98. However, as the engine is being cranked and as the first portions of fuel ignite in the cylinders, the speed sensor 64 will produce a force on needle 104 tending to urge it toward orifice 98. As the engine approaches its idling

speed the force on needle **104** produced by the speed sensor **64** on collar **60** slightly exceeds the force on said needle produced by the fuel pressure on diaphragm **108**. However, simultaneously with the application of these forces to the needle **104**, the intake manifold pressure decreases and the greater atmospheric pressure on diaphragm **144** urges needle **140** toward outlet **132**. As the return flow through outlet **132** decreases, the fuel pressure in chamber **130** builds up sufficiently to maintain needle **104** the correct distance from outlet **96** to allow the engine to idle.

As the engine throttle is opened, a pressure increase occurs on the manifold side of diaphragm **144** tending to urge needle **140** to an open position to allow the return of fuel through outlet **132**. Upon the return of a portion of the fuel through outlet **132** which fuel normally flows to chamber **130**, the pressure on the fuel side of diaphragm **108** decreases and allows the speed sensor **64** to urge needle **104** closer to orifice **98** which causes more fuel to be retained in chamber **86** and consequently greater fuel flow to the cylinders. As the pressure in chamber **130** gradually attains the pressure in chamber **86** the needle **104** becomes stationary at a closer distance to the orifice **98**. Any further opening of the engine throttle will again provide a pressure drop between chambers **86** and **130** and again cause the needle **104** to be urged closer to orifice **98**.

As the throttle is closed or partially closed, a pressure decrease occurs in chamber **162** of the load sensor and causes needle **140** to move closer to orifice **134** and retard the flow of return fuel through outlet **132**. As this occurs, the pressure in chamber **130** will increase and cause needle **104** to move further away from orifice **98** and allow more fuel to return to the tank which will result in a decreased fuel supply to the cylinders and a deceleration of the engine. Restrictions **128** and **138** are provided in conduits **126** and **136** respectively and provide a slower rate of fuel flow in the vicinity of outlet **132** to allow small changes in manifold pressure to effectively vary the flow of return fuel through outlet **132**. These restrictions are desirable to produce a greater range of more accurate pressure variations on diaphragm **108** with a smaller degree of travel of the needle **140**. Restriction **138** also insures a limit to the amount of fuel that can be returned to the tank through outlet **132** in the event that needle **140** should override a desirable distance from outlet **132**.

The structural details herein disclosed for the purpose of illustrating my invention may be widely varied without departing from the substance of the invention, or sacrificing the advantages thereof, and hence I do not limit my invention to the specific structure disclosed, except to the extent clearly indicated in specific claims, but reserve all such variations, modifications and equivalents as fall within the spirit and purview of the claims.

I claim:

1. In a return flow fuel metering system for an internal combustion engine, a fuel distributing chamber having a fuel inlet connected with a fuel source and a plurality of fuel outlets adapted to be operatively connected with said engine, a return flow conduit connecting said chamber with said source, a return flow valve for regulating the flow of return fuel in said return flow conduit from said chamber to said source, engine speed responsive means operatively connected with said valve for progressively closing the latter with increasing speed, fuel pressure responsive means operatively connected with said valve for progressively opening the latter with increasing fuel pressure applied to said pressure responsive means, duct means connecting said pressure responsive means with said chamber for applying the pressure at the latter to said pressure responsive means, said duct means having a restriction therein, and means for controlling the pressure applied to said pressure actuated means by said duct means comprising a second duct means in communication with the first named duct means at a location between said restriction and said pressure responsive means and being in communication with said source, a second valve for regulating the flow of fuel from said location to said source, and engine load responsive means operatively connected with said second valve for progressively opening the latter with increasing load, thereby to decrease the pressure applied to said pressure actuated means with increasing load.

2. In a return flow fuel metering system on an internal combustion engine, a fuel distributing chamber having a fuel inlet connected with a fuel source and a plurality of fuel outlets adapted to be operatively connected with said engine, a return flow conduit connecting said chamber with said source, a return flow valve for regulating the flow of return fuel in said return flow conduit from said chamber to said source, engine speed responsive means operatively connected with said valve and operable at a speed proportional to the speed of said engine for progressively closing said valve with increasing speed, fuel pressure responsive means operatively connected with said valve for progressively opening the latter with increasing fuel pressure applied to said pressure responsive means, duct means connecting said pressure responsive means with said chamber for applying the pressure at the latter to said pressure responsive means, said duct means having a restriction therein, and means for controlling the pressure applied to said pressure actuated means by said duct means comprising a second duct means in communication with the first named duct means at a location between said restriction and said pressure responsive means and being in communication with said source, a second valve for regulating the flow of fuel from said location to said source, and engine load responsive means operatively connected with said second valve and being in communication with the intake manifold pressure of said engine and responsive thereto for progressively opening said second valve with increasing load on said engine, thereby to decrease the pressure applied to said pressure actuated means with increasing load.

3. In a return flow fuel metering system for an internal combustion engine, a fuel distributing chamber having a fuel inlet connected with a fuel source and a plurality of fuel outlets adapted to be operatively connected with said engine, means for supplying fuel under pressure from said source to said chamber through said inlet, a return flow conduit connecting said chamber with said source, a return flow valve for regulating the flow of return fuel in said return flow conduit from said chamber to said source, engine speed responsive means operatively connected with said valve for progressively closing the latter with increasing speed throughout the operating speed range of said engine, fuel pressure responsive means operatively connected with said valve for progressively opening the latter with increasing fuel pressure applied to said pressure responsive means, duct means connecting said pressure responsive means with said chamber for applying the pressure at the latter to said pressure responsive means, said duct means having a restriction therein, and means for controlling the pressure applied to said pressure actuated means by said duct means comprising a second duct means in communication with the first named duct means at a location between said restriction and said pressure responsive means and being in communication with said source, a second valve for regulating the flow of fuel from said location to said source, and engine load responsive means operatively connected with said second valve for progressively opening the latter with increasing load, thereby to decrease the pressure applied to said pressure actuated means with increasing load.

4. In a return flow fuel metering system for an internal combustion engine, a fuel distributing chamber having a fuel inlet connected with a fuel source and a plurality of fuel outlets adapted to be operatively connected with

said engine, means for supplying fuel under pressure from said source to said chamber through said inlet, a return flow conduit connecting said chamber with said source, a return flow valve for regulating the flow of return fuel in said return flow conduit from said chamber to said source, engine speed responsive means operatively connected with said valve for progressively closing the latter with increasing speed throughout the operating speed range of said engine, fuel pressure responsive means operatively connected with said valve for progressively adjusting the latter with increasing fuel pressure applied to said pressure responsive means, duct means connecting said pressure responsive means with said chamber for applying the pressure at the latter to said pressure responsive means, said duct means having a restriction therein, a second duct means in communication with the first named duct means at a location between said restriction and said pressure responsive means and being in communication with said source, a second valve for regulating the flow of fuel from said location to said source, and engine load responsive means operatively connected with said second valve for adjusting the latter to control the pressure applied to said pressure actuated means to close the first named valve progressively with increasing engine load.

5. In a return flow fuel metering system on an internal combustion engine, a fuel distributing chamber having a fuel inlet connected with a fuel source and a plurality of fuel outlets adapted to be operatively connected with said engine, means for supplying fuel under pressure from said source to said chamber through said inlet, a return flow conduit connecting said chamber with said source, a return flow valve for regulating the flow of return fuel in said return flow conduit from said chamber to said source, engine speed responsive means operatively connected with said valve for progressively closing the latter with increasing speed throughout the operating speed range of said engine, fuel pressure responsive means operatively connected with said valve for progressively adjusting the latter with increasing fuel pressure applied to said pressure responsive means, duct means connecting said pressure responsive means with said chamber for applying the pressure at the latter to said pressure responsive means, said duct means having a restriction therein, a second duct means in communication with the first named duct means at a location between said restriction and said pressure responsive means and being in communication with said source, a second valve for regulating the flow of fuel from said location to said source, and engine load responsive means operatively connected with said second valve and being in communication with the

intake manifold pressure of said engine and responsive thereto for adjusting said second valve to control the pressure applied to said pressure actuated means to progressively close the first named valve with increasing engine load, thereby to decrease the pressure applied to said pressure actuated means with increasing load.

6. In a return flow fuel metering system on an internal combustion engine, a fuel distributing chamber having a fuel inlet connected with a fuel source and a plurality of fuel outlets adapted to be operatively connected with said engine, means for supplying fuel under pressure from said source to said chamber through said inlet, a return flow conduit connecting said chamber with said source, a return flow valve for regulating the flow of return fuel in said return flow conduit from said chamber to said source, engine speed responsive means operatively connected with said valve and operable at a speed proportional to the speed of said engine for progressively closing said valve with increasing speed throughout the operating speed range of said engine, fuel pressure responsive means operatively connected with said valve for progressively adjusting the latter with increasing fuel pressure applied to said pressure responsive means, duct means connecting said pressure responsive means with said chamber for applying the pressure at the latter to said pressure responsive means, said duct means having a restriction therein, a second duct means in communication with the first named duct means at a location between said restriction and said pressure responsive means and being in communication with said source, a second valve for regulating the flow of fuel from said location to said source, and engine load responsive means operatively connected with said second valve for adjusting the latter to control the pressure applied to said pressure actuated means to close the first named valve progressively with increasing engine load.

7. In the combination according to claim 6, said load responsive means comprising pressure responsive means responsive to the intake manifold pressure of said engine.

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