July 17, 1962 T. M. BALL 3,044,457

FUEL INJECTION SYSTEM

Filed May 11, 1959 2 Sheets-Sheet 1

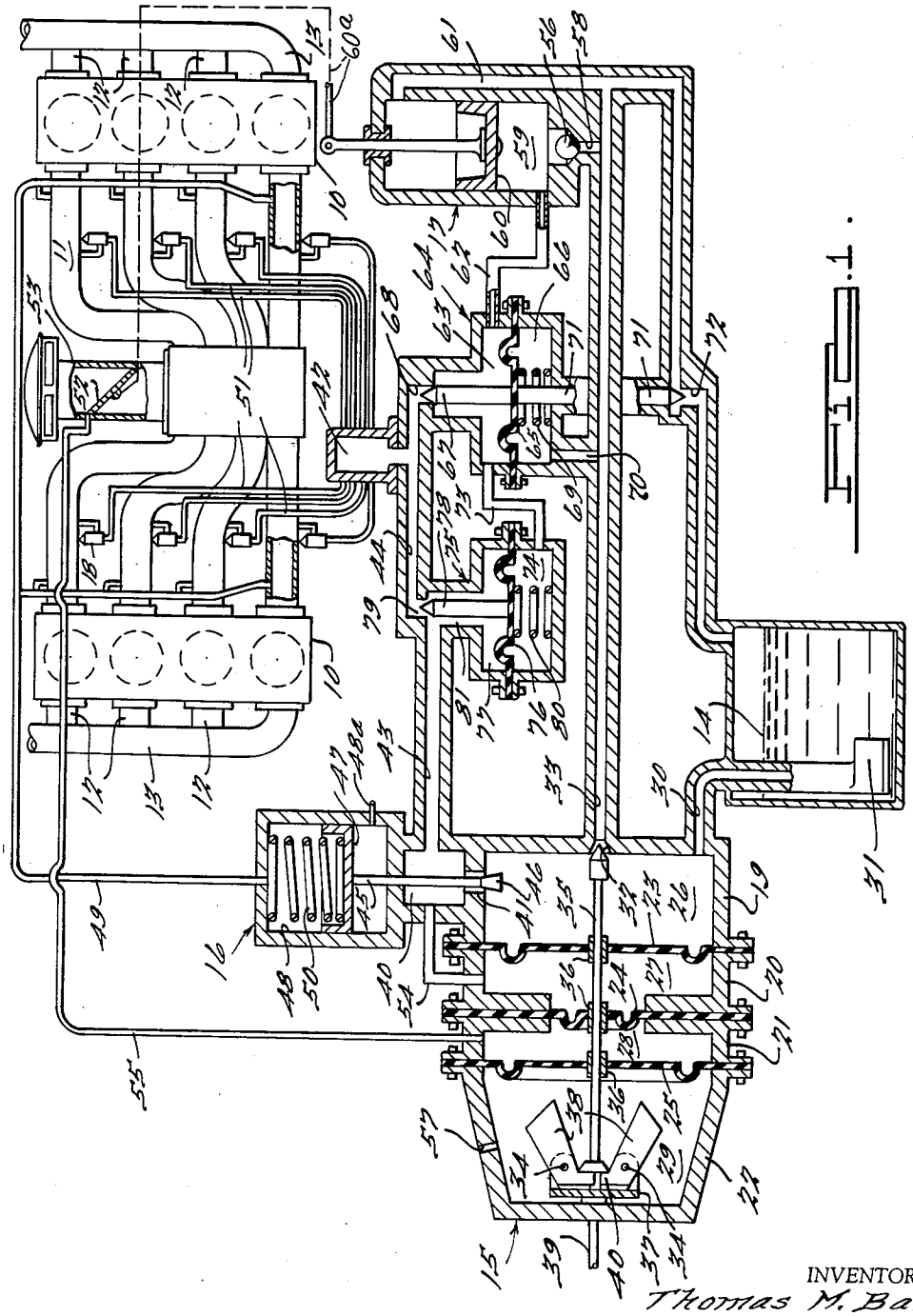


FIG. 1.

INVENTOR.
Thomas M. Ball.

BY Harness & Harris

ATTORNEYS.

July 17, 1962 T. M. BALL 3,044,457

FUEL INJECTION SYSTEM

Filed May 11, 1959 2 Sheets-Sheet 2

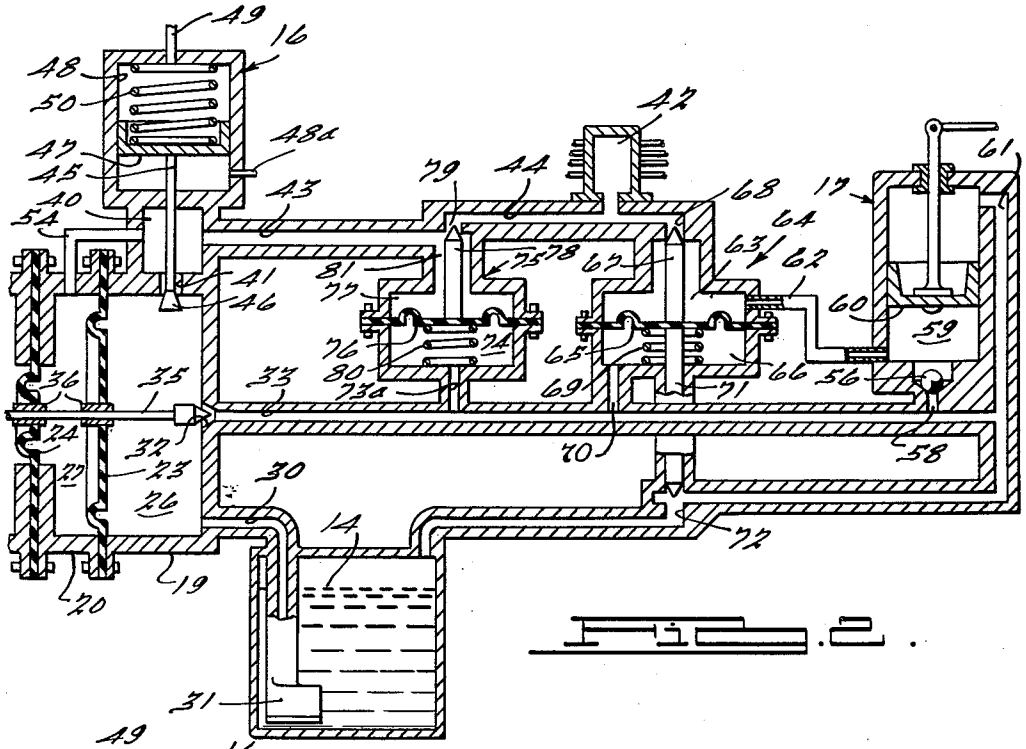


Fig. 2.

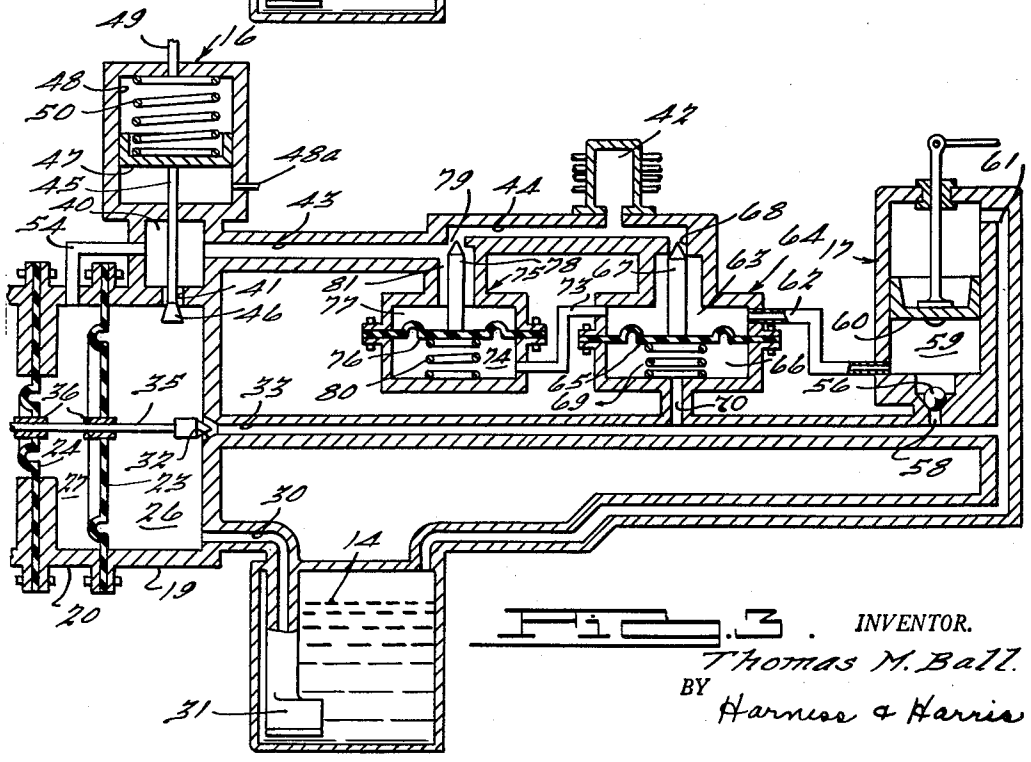


Fig. 3.

INVENTOR.
Thomas M. Ball.
BY
Harness & Harris
ATTORNEYS.

United States Patent Office 3,044,457 Patented July 17, 1962

3,044,457

FUEL INJECTION SYSTEM

Thomas M. Ball, Bloomfield Hills, Mich., assignor to Chrysler Corporation, Highland Park, Mich., a corporation of Delaware

Filed May 11, 1959, Ser. No. 812,508
20 Claims. (Cl. 123—119)

This invention relates to a fuel injection system particularly suited for use in an automotive internal combustion engine.

An object of the present invention is to provide an improved return flow fuel injection system of the above type wherein pressurized fuel from a fuel pump is supplied by a fluid conduit to the engine through a load metering valve operable in response to variations in engine load, as for example in response to changes in engine air intake manifold pressure. Upstream of the load metering valve, the feed conduit branches into a fuel return flow conduit which conveys fuel in excess of engine requirements back to a fuel tank and thence to the pump. An engine speed responsive metering valve is associated with the return flow conduit to control the fuel flow therein inversely with engine speed, thereby to influence fuel pressure upstream of the load metering valve as a function of engine speed and to cooperate with the load metering valve to supply fuel to the engine in accordance with its speed and load requirements.

Another object is to provide improved, simple, and highly effective pressure increasing valve means for maintaining a predetermined pressure differential between the fuel pressure in the return flow conduit downstream of the speed metering valve and the fuel pressure in the feed conduit downstream of the load metering valve, thereby to maintain predetermined pressure differentials across the metering valves and to assure their reliable operation in accordance with desired performance curves regardless of variations in pump pressure or in the return flow conduit pressure. In consequence, the tolerances for the fuel pump as well as for the dimensions of the conduit system can be relaxed materially with resulting cost savings and without affecting critical pressure relation across the metering valves.

Other objects are to provide such a fuel injection system including an accelerator pump which can be linked with the customary accelerator pedal and personally operated to inject a burst of pressurized fuel into the feed conduit at a location downstream of the load metering valve for accelerating the engine, and to provide an operable fluid connection between the accelerator pump and the pressure increasing valve means so as to actuate the latter to close the fuel feed conduit between said location and the load metering valve to prevent back flow of the accelerator pressure to the metering mechanism.

Another object is to provide an improved pressure increasing valve means which performs its desired function of maintaining the fuel pressure in the feed conduit at a predetermined level above the fuel pressure in the return flow conduit and in addition serves to prevent back flow of the accelerator pressure to the fuel metering valves and thus to prevent momentary upsetting of the dynamic pressure relationship across these valves during operation of the accelerator pump.

Another object is to provide back-flow check valve means operable independently of the pressure increasing valve means and immediately in response to operation of the accelerator pump to close the return fuel conduit and thereby prevent back flow of the accelerator pressure to the fuel tank.

Still another object is to provide such a back-flow check valve operable conjointly with the pressure increasing

valve to prevent back flow of accelerator fuel pressure, the back-flow check valve being normally effective to operate immediately in response to operation of the accelerator pump. Thus in the event of vapor bubble formation in the comparatively low pressure region of the return flow conduit downstream of the speed metering valve for example, any resulting delay in the effectiveness of the back-flow check valve in preventing back flow of accelerator pump pressure is ameliorated by operation of the pressure increasing valve.

Other objects of this invention will appear in the following description and appended claims, reference being had to the accompanying drawings forming a part of this specification wherein like reference characters designate corresponding parts in the several views.

FIGURE 1 is a fragmentary schematic view of a fuel injection system embodying the present invention.

FIGURE 2 is a view similar to FIGURE 1, showing a modified form of the invention.

FIGURE 3 is a view similar to FIGURE 1, showing still another modified form of the invention.

It is to be understood that the invention is not limited in its application to the details of construction and arrangement of parts illustrated in the accompanying drawings, since the invention is capable of other embodiments and of being practiced or carried out in various ways. Also it is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

FIGURE 1 shows a fuel injection system embodying the present invention for use with an internal combustion engine having separate cylinder banks **10**, air intake manifold conduits **11**, exhaust manifold conduits **12**, and exhaust manifolds **13**. The system comprises a fuel supply tank **14**, an engine operated speed sensor **15**, an engine load sensor **16**, an accelerator pump **17**, and fuel injection nozzles **18**. The speed sensor is provided with four housing portions **19**, **20**, **21**, and **22** separated from each other by diaphragms **23**, **24**, and **25** to provide four chambers **26**, **27**, **28**, and **29**. Chamber **26** communicates with fuel tank **14** through conduit **30** and by means of fuel pump **31** submerged in tank **14** is supplied with fuel in adequate volume and pressure to exceed the maximum requirements of the engine regardless of the engine load or speed. A return flow metering orifice **32** in housing portion **19** connects chamber **26** with a return flow conduit **33** which extends to fuel tank **14** to return excess fuel thereto. A return flow metering needle **35** having a tapered end registering with the upstream side of orifice **32** is secured to each of the diaphragms **23**, **24**, and **25** by suitable grommets **36**.

A flyweight support **37** pivotally supports flyweights **38** at **34** and is secured to a flexible shaft **39** which is operatively connected to the engine to rotate at a speed directly proportional to engine speed. The flyweights **38** have projections **40** which abut an end portion of needle **35** when the flyweights pivot outwardly in response to rotation of shaft **39**, thereby to urge needle **35** toward orifice **32** against the opposite force of the fuel pressure in chamber **26** applied to diaphragm **23**. Thus as engine speed increases or decreases respectively, needle valve **35** is moved toward or away from metering orifice **32** to restrict or increase the latter's opening.

Chamber **26** is connected with a downstream chamber **40** via load metering orifice **41** and thence with a downstream fuel distribution chamber or rosette **42** via fuel supply conduits **43** and **44** in series. A load metering needle **45** extends through orifice **41** and terminates in a reversely tapered end portion **46** registering with the upstream side of orifice **41**. Needle **45** is operatively connected to a piston **47** reciprocable in cylinder **48**, which

in turn is connected with the low pressure portions of each intake manifold 11 of said engine by conduit 49. Low pressure transmitted through conduit 49 causes piston 47 to move upwardly against the force of spring 50 and to urge the tapered needle 46 into closer proximity with the sides of orifice 41 to progressively restrict the latter. Conversely, with increasing pressure in the intake manifolds, as for example with increasing load, spring 50 urges piston 46 downwardly to increase the opening of orifice 41. Vent duct 48*a* in the lower portion of cylinder 48 prevents entrapment of air below piston 47.

A separate nozzle feed conduit 51 extends from chamber 42 to each of the fuel injection nozzles 18 located downstream of the throttle valve 52 in the air intake manifold 53. Chamber 40 is also connected to chamber 27 of the speed sensor unit by conduit 54 to provide an adjustment of the fuel pressure differential across the metering orifice 41, as explained below.

An idle boost conduit 55 communicates with manifold 53 at a point adjacent the edge of throttle valve 52 and with the chamber 28 of the speed sensor unit in order to augment operation of the flyweights 38 urging rightward movement of needle valve 35 when the engine is idling. By virtue of duct 55, the pressure in chamber 28 during idling is lower than in chamber 29 which is vented to the atmosphere by vent 57. The pressure in chamber 29 urges needle 35 toward orifice 32 to retard the flow of return fuel therethrough and provide an enrichment of the engine fuel supply for idling.

The accelerator pump 17 has an inlet duct 58 in communication with return flow conduit 33 via ball check valve 56 and receives fuel into the lower portion of cylinder 59 upon upward movement of the accelerator piston 60, which may be personally operated in accordance with customary practice, as for example by linkage 60*a* operably connected with throttle valve 52 as schematically indicated in FIGURE 1. Depression of the accelerator piston 60 forces fuel from cylinder 59 into the engine to accelerate the latter as described below. Bleed duct 61 connects cylinder 59 above piston 60 with return conduit 33 to facilitate operation of piston 60 and to prevent entrapment of fuel in the upper portion of cylinder 59.

The acceleration fuel discharged from cylinder 59 upon downward movement of piston 60 is directed through conduit 62 to the upper chamber 63 of fluid-containing pressure operated check valve housing 64 partitioned by a flexible diaphragm 65 into the aforesaid upper chamber 63 and a lower chamber 66. A shiftable needle valve element 67 secured to diaphragm 65 to move therewith has a tapered upper seating end registering with an acceleration orifice 68 to close the latter. Upon downward movement of valve element 67, orifice 68 communicates with conduit 44 and chamber 42. Needle valve 67 is normally maintained in the closed position shown by a biasing coil spring 69 under compression between the under side of diaphragm 65 and a lower portion of the housing 64. Chamber 66 is in communication with return flow conduit 33 via duct 70, whereby excess pressure buildup in chamber 66 is avoided and the return flow pressure in conduit 33 is employed to augment spring 69 in maintaining valve element 67 in the closed position.

Depending from diaphragm 65 and movable therewith is a second needle valve element 71 having a tapered lower seating end registering with an orifice 72 located in return flow conduit 33 downstream of the accelerator fuel inlet 58. By virtue of valve element 71, when the accelerator piston 60 is depressed to discharge fuel from cylinder 59 in an accelerating operation, the acceleration fuel pressure directed to chamber 63 forces diaphragm 65 downwardly against the tension of spring 69, thereby causing valve element 71 to close orifice 72 and causing valve element 67 to open orifice 68. Opening of the latter orifice admits the accelerating fuel to chamber 42 and thence to the nozzles 18 via the various nozzle supply conduits 51. The closing orifice 72 blocks the acceleration fuel pressure upstream of chamber 42 to prevent dissipation of the acceleration pressure into tank 14.

During normal operation, the closure of orifice 72 is immediately responsive to operation of the acceleration pump 17. However, valve 71 and orifice 72 employed by themselves momentarily tend to upset the dynamic balance between the various pressures across the metering orifices 32 and 41 upon operation of fuel pump 17. Also in the event of appreciable vapor bubble formation in the comparatively low pressure conduit 33 upstream of orifice 72, the effect of closing the latter is momentarily delayed until the vapor bubble is compressed. Such a delay may result in an objectionably delayed acceleration of the engine and is avoided by the supplemental pressure increasing means described below.

The upper chamber 63 also communicates via duct 73 with the lower chamber 74 of a fluid containing pressure increasing valve housing 75 partitioned by a flexible diaphragm 76 to provide the aforesaid lower chamber 74 and an upper chamber 77. A needle valve element 78 secured to diaphragm 76 to move therewith extends upwardly to register with a metering orifice 79 which communicates with conduit 44 adjacent its juncture with conduit 43. A biasing spring 80 under compression between the under side of diaphragm 76 and a lower portion of housing 75 urges needle valve element 78 upwardly to maintain a predetermined pressure differential between the fuel pressure in conduit 43 and the fuel pressure in the return flow conduit 33, as described below.

As is apparent from FIGURE 1, chamber 74 is in communication with the return flow fuel pressure of conduit 33 via duct 73, chamber 63, duct 62, cylinder 59, and duct 58. Thus pressure changes in conduit 33 augment the force of spring 80 urging diaphragm 76 and needle valve 78 upwardly in opposition to the pressure in feed conduit 43 urging diaphragm 76 downwardly. Upward or downward movement respectively of valve element 78 progressively restricts or opens orifice 79. In the event of a pressure increase in conduit 33 for any cause, as for example on inclination of the vehicle raising fuel tank 14 with respect to metering orifice 32, the pressure increase is transmitted to the under side of diaphragm 76 to increase the restriction of orifice 79. In consequence the pressure in feed duct 43 increases, thereby to increase the pressure in chamber 27 via conduit 54 and also in chamber 77 via duct 81 connected with feed conduit 43.

The increased pressure in chamber 27 urges diaphragm 23 to the right because of its larger area with respect to the area of diaphragm 24, causing valve 35 to increase the restriction of metering orifice 32. The latter action reduces the pressure in return conduit 33 and also in chamber 74. The resulting reduced upward force on diaphragm 76, augmented by the increased pressure in chamber 77, tends to restore the opening of orifice 79 to the extent predetermined by biasing spring 80. Accordingly, any tendency to increase the pressure in return conduit 33 results in a corresponding tendency to increase the pressure in chambers 26 and 40 and to maintain the desired pressure on conduit 33, so that the pressure differentials across the metering orifices will remain substantially constant for any given engine operating condition.

It is also apparent by reason of the connection between chamber 74 and the accelerating pump cylinder 59 that upon operation of the accelerating pump 17, the pressure in chamber 74 will rise to the level of the accelerating pressure and immediately cause valve element 78 to close orifice 79. This action supplements the action of valve element 71 in preventing back flow of accelerating pressure and also operates to prevent a temporary unbalancing of the dynamic pressure forces across the metering orifices 32 and 41. In the event of a bubble formation in conduit 33 as mentioned above, valve 78 will close orifice 79 almost immediately upon operation of accelerator

pump 17. Inasmuch as the pressure from cylinder 59 to chamber 74 must first depress diaphragm 65, operation of diaphragm 76 responsive to the acceleration pressure will ordinarily follow operation of diaphragm 65 by a slight time differential. For this reason sole reliance upon valve element 78 to close orifice 79 during acceleration is not preferred. It is apparent however that either valve element 71 and orifice 72, or valve element 78 and orifice 79 can be employed solely and independently of the other as illustrated in FIGURES 2 and 3.

The operation of the speed sensor 15 and load sensor 16 will be described in relation to a change in static engine operating conditions, that is, constant engine speed and load. Under static operating conditions, the combined forces exerted by flyweights 38 and the fuel pressure in chamber 27 is balanced by the force exerted by the fuel pressure in chamber 26 to maintain the return flow metering needle 35 stationary at a predetermined distance from orifice 32. In this static condition, the amount of fuel delivered to the rosette 42 is constant and is equal to the amount of fuel delivered to the system by the pump less the amount of fuel being returned to the fuel tank 14 through the return flow conduit 33. During normal driving, the pressure differential across diaphragm 25 has no appreciable effect on the operation of the unit and may be disregarded. It is only during idling and very low engine speeds that the pressure differential across diaphragm 25 becomes significant, as explained above.

As the throttle valve 52 is moved to a more open position by operation of the engine accelerator, an increase in manifold pressure is transmitted to the load sensor piston 47 through conduit 49, enabling spring 50 to move piston 47 downwardly and thereby move the load metering needle valve 46 to a more open position with respect to the metering orifice 41. The pressure differential existing across orifice 41 and therefore across diaphragm 23 consequently tends to decrease as more fuel is allowed to flow into chamber 40. To prevent such a condition and to maintain the pressure differential across orifice 41 at a value where the flow of fuel therethrough will satisfy the increased engine load requirement, the fuel pressure in speed chamber 26 is increased by movement of the return flow metering valve 35 closer to orifice 32 in consequence of the increased pressure in chamber 27 which communicates via duct 54 with chamber 40. Thus the return fuel flow in conduit 33 is decreased and the fuel flow to the engine via conduits 43 and 44 is increased. Similarly, when the engine speed is increased, the flyweights 38 exert increased force on needle valve element 35 urging the latter rightward to restrict orifice 32, with the result of decreasing the return fuel flow in conduit 33 and increasing the flow to the engine via conduits 43 and 44. The converse operation will of course occur in the event of a reduction in engine load or speed.

FIGURE 2 shows a modified form of the present invention wherein valve 71 and orifice 72 are employed solely to prevent back flow of the accelerating fuel pressure. In overall structure, FIGURE 2 is similar to FIGURE 1, so that corresponding parts are numbered the same. The primary difference in the FIGURE 2 structure is that valve element 78 is not responsive to the accelerating fuel pressure to close orifice 79. In other respects, valve element 78 operates as described above to maintain the predetermined pressure differential between the pressures in conduits 33 and 43. To this end, the chamber 74 is connected directly with return flow conduit 33 via conduit 73*a*.

FIGURE 3 shows a modified form of the present invention wherein valve 78 and orifice 79 are employed solely to prevent back flow of accelerating fuel pressure. In FIGURE 3, valve element 71 and orifice 72 have been eliminated. Otherwise, the operation and function of the parts are the same as described above in regard to FIGURE 1.

I claim:

1. In a fuel injection system for an internal combustion engine, a fuel supply, a fuel feed conduit connecting said engine with said fuel supply, a return flow conduit communicating with said fuel feed conduit and said fuel supply, accelerator means in said system adapted to receive fuel therefrom, said accelerator means communicating with said fuel feed conduit and being operative to supply accelerating fuel thereto, and pressure increasing means communicating with said return flow conduit and said accelerator means and responsive to pressure developed by said accelerator means to restrict the flow of fuel through said return flow conduit to said fuel supply.

2. In a fuel injection unit for an internal combustion engine, a fuel conduit system having a fuel feed conduit portion and a return flow conduit portion, said fuel feed conduit portion communicating with a fuel supply and said engine, fuel metering means operatively associated with said system, said return flow conduit portion communicating with said fuel metering means and said fuel supply, said metering means being adjustable to regulate the flow of fuel through said return flow conduit portion to said fuel supply, accelerator means having fuel inlet means in said return flow conduit portion, said accelerator means communicating with said fuel feed conduit portion, pressure responsive valve means in said return flow conduit portion located intermediate said fuel inlet means of said accelerator means and said fuel supply, said valve means communicating with said accelerator means and being responsive to actuation of said accelerator means to stop the flow of fuel through said return flow conduit portion.

3. In a fuel injection unit for an internal combustion engine, a fuel conduit system having a fuel feed conduit portion and a return flow conduit portion, said fuel feed conduit portion communicating with a fuel supply and said engine to receive fuel under pressure from said fuel supply and deliver it in required amounts to said engine, fuel metering means operatively associated with said system, said return flow conduit portion communicating with said fuel metering means and said fuel supply to convey a portion of said fuel back to said fuel supply, said metering means being adjustable to regulate the flow of fuel through said return flow conduit portion to said fuel supply, accelerator means in said return flow conduit portion to receive fuel therefrom and communicating with said fuel feed conduit portion, pressure responsive valve means in said return flow conduit portion located intermediate said accelerator means and said fuel supply, said valve means communicating with said accelerator means and being responsive to actuation thereof to restrict the flow of fuel through said return flow conduit portion.

4. In a fuel injection system for an internal combustion engine, a fuel feed conduit connecting a fuel supply with said engine, a fuel pressure and speed responsive fuel metering means connected to said fuel feed conduit and said engine and adapted to adjust the fuel flow to said engine in accordance with engine fuel requirements, pressure responsive fuel pressure increasing means in said conduit downstream of said fuel metering means and adapted to maintain the fuel pressure within said conduit and metering means above a minimum value, accelerator means in said system downstream of said pressure increasing means and communicating with said pressure increasing means, said pressure increasing means being responsive to a fuel pressure increase in said accelerator means to prevent the flow of accelerator fuel to said fuel metering means.

5. In a fuel injection system for an internal combustion engine, a fuel feed conduit communicating with a fuel supply and said engine, a return flow conduit communicating with said fuel feed conduit and said fuel supply, accelerator means in said return flow conduit and adapted to receive fuel therefrom, said accelerator means communicating with said fuel feed conduit to supply acceler-

ator fuel thereto, first pressure responsive valve means communicating with said return flow conduit and said accelerator means and responsive to pressure developed by said accelerator means to restrict the flow of fuel through said return flow conduit to said fuel supply, and second pressure responsive valve means communicating with said fuel feed conduit and said accelerator means and responsive to pressure developed by said accelerator means to restrict the flow of fuel through a portion of said fuel feed conduit downstream of the location of the communication between said accelerator means and fuel feed conduit.

6. In a fuel injection system for an internal combustion engine having an intake manifold, a fuel feed conduit communicating with a fuel supply and said engine, manifold pressure responsive load metering means in said conduit and connected to said manifold to respond to pressure changes therein to meter fuel to said engine in accordance with engine load, a return flow conduit communicating with said fuel feed conduit upstream of said load metering means and also communicating with said fuel supply, combined fuel pressure and speed responsive metering means in said return flow conduit connected to a drive portion of said engine and communicating with a portion of said fuel feed conduit downstream of said load metering means to adjust the fuel flow through said fuel feed conduit in accordance with engine speed and load metered fuel pressure, accelerator means in said return flow conduit adapted to receive fuel therefrom, said accelerator means communicating with said fuel feed conduit downstream of said load metering means to supply accelerator fuel pulses thereto, first pressure responsive valve means communicating with said return flow conduit and said accelerator means and responsive to pressure developed by said accelerator means to restrict the flow of fuel through said return flow conduit to said fuel supply, and second pressure responsive valve means communicating with said fuel feed conduit at a point intermediate said load metering means and said accelerator means, said second valve means communicating with said accelerator means and responsive to fuel pressure developed thereby to block said fuel feed conduit at said point to prevent said fuel pressure developed by said accelerator means from being transmitted to said combined fuel pressure and speed responsive metering means.

7. In a fuel system for an internal combustion engine, a fuel supply, a fuel feed conduit connecting said engine with said fuel supply, a return flow conduit communicating with said fuel feed conduit and said fuel supply, accelerator means in said system adapted to receive fuel therefrom, said accelerator means communicating with said fuel feed conduit and being operative to supply accelerating fuel thereto, and pressure increasing means operatively coupled with said return flow conduit and accelerator means and responsive to pressure developed by said accelerator means to restrict the flow of fuel through said return flow conduit to said fuel supply.

8. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a supply of fuel and having a return flow conduit portion for returning excess fuel to said supply, fuel metering means associated with said fuel conduit means for regulating the fuel flow in said return conduit portion to said supply, accelerator means operable to supply accelerating fuel to said engine and being in communication with said supply to receive fuel therefrom, and means operatively connected with said accelerator means to retard the fuel flow in said return flow conduit portion upon actuation of said accelerator means to supply fuel to said engine.

9. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a supply of fuel and having a return flow conduit portion for returning excess fuel to said supply, fuel metering means associated with said fuel conduit means for regulating the fuel flow in said return conduit portion to said supply, accelerator means operable to supply accelerating fuel to said engine and being in communication with said supply to receive fuel therefrom, pressure responsive valve means responsive to the fuel pressure at the fuel supply side of said accelerator means and operatively associated with said return flow conduit portion to retard the fuel flow therein upon actuation of said accelerator means to supply fuel to said engine.

10. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a fuel source and having a return flow conduit portion upstream of said engine for returning excess fuel to said source, fuel metering means associated with said conduit portion for controlling the fuel flow therein, accelerator means connected with said conduit portion downstream of said metering means to receive fuel from said conduit portion and being operative to discharge pressurized fuel into said conduit means at a location between said metering means and engine to supply accelerating fuel to the latter, pressure increasing valve means in communication with the fuel in said accelerator means received from said conduit portion and thereby being in communication with the pressure in said conduit portion, said pressure increasing valve means being also in communication with the pressure in said conduit means between said location and metering means and being responsive to the differential between the two pressures to control the fuel flow in said conduit means to said engine at a second location between the first location and said metering means, said pressure increasing valve means being also responsive to the pressure of said pressurized fuel to restrict said conduit means at said second location to retard back flow of fuel in said conduit means upon operation of said accelerator means.

11. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a fuel source and having a return flow conduit portion upstream of said engine for returning excess fuel to said source, fuel metering means associated with said conduit portion for controlling the fuel flow therein, accelerator means connected with said conduit portion downstream of said metering means to receive fuel from said conduit portion and being operative to discharge pressurized fuel into said conduit means at a location between said metering means and engine to supply accelerating fuel to the latter, pressure increasing valve means responsive to the pressure differential between the pressure in said conduit portion downstream of said metering means and the pressure in said conduit means between said location and said metering means to control the fuel flow in said conduit means to said engine at a second location between the first location and said metering means, said pressure increasing valve means being also responsive to the pressure of said pressurized fuel to restrict said conduit means at said second location to retard back flow of fuel in said conduit means upon operation of said accelerator means.

12. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a fuel source and having a return flow conduit portion upstream of said engine for returning excess fuel to said source, fuel metering means associated with said conduit portion for controlling the fuel flow therein, accelerator means connected with said conduit portion downstream of said metering means to receive fuel from said conduit portion and being operative to discharge pressurized fuel into said conduit means at a location between said metering means and engine to supply accelerating fuel to the latter, pressure increasing valve means responsive to the pressure in said conduit portion downstream of said metering means to restrict the fuel flow in said conduit means at a second location between the first location and said metering means, said pressure increasing valve means being also responsive to the pressure in said conduit means between said metering means and first location to de-

crease the restriction in said conduit means at said second location, thereby to effect a balance between the two pressures to control the fuel flow in said conduit means at said second location, said pressure increasing valve means being also responsive to the pressure of said pressurized fuel to restrict said conduit means at said second location to retard back flow of fuel in said conduit means upon operation of said accelerator means.

13. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a fuel source and having a return flow conduit portion upstream of said engine for returning excess fuel to said source, fuel metering means associated with said conduit portion for controlling the fuel flow therein, accelerator means connected with said conduit portion downstream of said metering means to receive fuel from said conduit portion and being operative to discharge pressurized fuel into said conduit means at a location between said metering means and engine to supply accelerating fuel to the latter, pressure increasing valve means responsive to the pressure in said conduit portion downstream of said metering means to restrict the fuel flow in said conduit means at a second location between the first location and said metering means, said pressure increasing valve means being also responsive to the pressure in said conduit means between said metering means and first location to decrease the restriction in said conduit means at said second location, thereby to effect a balance between the two pressures to control the fuel flow in said conduit means at said second location, said pressure increasing valve means being also responsive to the pressure of said pressurized fuel to restrict said conduit means at said second location to retard back flow of fuel in said conduit means upon operation of said accelerator means, and spring means cooperable with said pressure increasing valve means to augment the pressure of said conduit portion acting thereon.

14. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a supply of fuel and having a return flow conduit portion for returning excess fuel to said supply, accelerator means operable to supply accelerating fuel to said engine and being in communication with said supply to receive fuel therefrom, and means operatively connected with said accelerator means and with said conduit means to retard the fuel flow in the latter upstream of the region of communication between said accelerator means and conduit means upon actuation of said accelerator means.

15. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a supply of fuel and having a return flow conduit portion for returning excess fuel to said supply fuel metering means associated with said fuel conduit means for regulating the fuel flow in said return conduit portion to said supply, accelerator means operable to supply accelerating fuel to said conduit means at a location between said engine and return flow conduit portion and being in communication with said conduit portion to receive fuel therefrom, and pressure actuated valve means cooperable with said conduit means to control the fuel flow therein upstream of said location and to restrict the latter flow upon operation of said accelerator means, said valve means being responsive to the pressure in said conduit portion and also to the accelerating fuel pressure upon operation of said accelerator means to urge said valve means in a direction tending to close said conduit means at a second location upstream of the first location, and being responsive to the pressure in said conduit means upstream of said location to urge said valve means in the opposite direction, and a second pressure actuated valve means responsive to the fuel pressure in said conduit means between said metering means and second location to augment said metering means in restricting the fuel flow in said conduit portion, and being responsive to the fuel pressure upstream of said metering means to oppose operation of said metering means in restricting the fuel flow in said conduit portion.

16. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a supply of fuel and having a return flow conduit portion for returning excess fuel to said supply, fuel metering means associated with said fuel conduit means for regulating the fuel flow in said return conduit portion to said supply, accelerator means operable to supply accelerating fuel to said conduit means at a location between said engine and return flow conduit portion and being in communication with said conduit portion to receive fuel therefrom, and pressure actuated valve means cooperable with said conduit means to control the fuel therein upstream of said location and to restrict the latter flow upon operation of said accelerator means, said valve means being responsive to the pressure in said conduit portion and also to the accelerating fuel pressure upon operation of said accelerator means to urge said valve means in a direction tending to close said conduit means at a second location upstream of the first location, and being responsive to the pressure in said conduit means upstream of said location to urge said valve means in the opposite direction, spring means cooperable with said valve means to urge the latter in said direction, and a second pressure actuated valve means responsive to the fuel pressure in said conduit means between said metering means and second location to augment said metering means in restricting the fuel flow in said conduit portion, and being responsive to the fuel pressure upstream of said metering means to oppose operation of said metering means in restricting the fuel flow in said conduit portion.

17. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a fuel source and having a return flow conduit portion upstream of said engine for returning excess fuel to said source, fuel metering means associated with said conduit portion for controlling the fuel flow therein, accelerator means connected with said conduit portion downstream of said metering means to receive fuel from said conduit portion and being operative to discharge pressurized fuel into said conduit means at a location between said metering means and engine to supply accelerating fuel to the latter, pressure increasing valve means responsive to the pressure differential between the pressure in said conduit portion downstream of said metering means and the pressure in said conduit means between said location and said metering means to control the fuel flow in said conduit means to said engine at a second location between the first location and said metering means, said pressure increasing valve means being also responsive to the pressure of said pressurized fuel to restrict said conduit means at said second location to retard back flow of fuel in said conduit means upon operation of said accelerator means and pressure actuated means cooperable with said metering means and being responsive to the pressure differential between the pressure in said conduit means between said second location and said metering means and the pressure in said conduit means upstream of said metering means to control the fuel flow in said conduit portion.

18. In a fuel system for an internal combustion engine, fuel conduit means having a fuel feed portion for connecting said engine with a fuel source and having a return flow conduit portion branching from said fuel feed portion upstream of said engine for returning excess fuel to said source, fuel metering means associated with said fuel feed portion and with said conduit portion for controlling the fuel flow therein, accelerator means connected with said conduit portion downstream of said metering means to receive fuel from said conduit and being operative to discharge pressurized fuel into said conduit means at a location between said metering means and engine to supply accelerating fuel to the latter, pressure increasing valve means responsive to the pressure in said conduit portion downstream of said metering means to urge operation of said pressure increasing valve means in a direction tend-

ing to restrict the fuel flow in said fuel feed portion at a second location between the first location and said metering means, said pressure increasing valve means being responsive to the pressure in said fuel feed portion between said metering means and second location to urge operation of said pressure increasing valve means in the opposite direction, thereby to control the fuel flow in said feed portion at said second location, said pressure increasing valve means being also responsive to the pressure of said pressurized fuel to restrict said conduit means at said second location to retard back flow of fuel in said conduit means upon operation of said accelerator means, and pressure actuated means cooperable with said metering means and being responsive to the pressure in said fuel feed portion between said second location and said metering means to augment operation of said metering means tending to restrict the fuel in said conduit portion, said pressure actuated means being also responsive to the pressure in said feed portion upstream of said metering means to augment operation of the latter tending to increase the fuel flow in said conduit portion.

19. In a fuel system for an internal combustion engine, fuel conduit means having a fuel feed portion for connecting said engine with a fuel source and having a return flow conduit portion branching from said fuel feed portion upstream of said engine for returning excess fuel to said source, fuel metering means associated with said fuel feed portion and with said conduit portion for controlling the fuel flow therein, accelerator means connected with said conduit portion downstream of said metering means to receive fuel from said conduit portion and being operative to discharge pressurized fuel into said conduit

means at a location between said metering means and engine to supply accelerating fuel to the latter, pressure increasing valve means responsive to the pressure in said conduit portion downstream of said metering means to urge operation of said pressure increasing valve means in a direction tending to restrict the fuel flow in said fuel feed portion at a second location between the first location and said metering means, spring means cooperable with said pressure increasing valve means biasing the latter in said direction, said pressure increasing valve means being responsive to the pressure in said fuel feed portion between said metering means and second location to urge operation of said pressure increasing valve means in the opposite direction, thereby to control the fuel flow in said feed portion at said second location.

20. In a fuel system for an internal combustion engine, fuel conduit means for connecting said engine with a supply of fuel, accelerator means in communication with conduit means and operable to supply accelerating fuel to said engine, said accelerator means being also in communication with said supply to receive fuel therefrom, and means operatively connected with said accelerator means and with said conduit means to retard the fuel flow in the latter upstream of the region of communication between said accelerator means and conduit means upon actuation of said accelerator means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,438,663	Greenland	Mar. 30, 1948
2,641,237	Deschamps	June 9, 1953

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

July 17, 1962

Patent No. 3,044,457

Thomas M. Ball

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 9, line 52, after "supply" insert a comma; column 10, line 69, after "conduit" insert -- portion --.

Signed and sealed this 13th day of November 1962.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents