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FUEL INJECTION SYSTEMS

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3 Sheets-Sheet 1

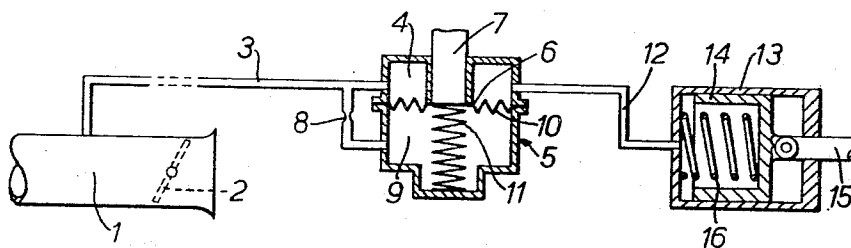


FIG. 1.

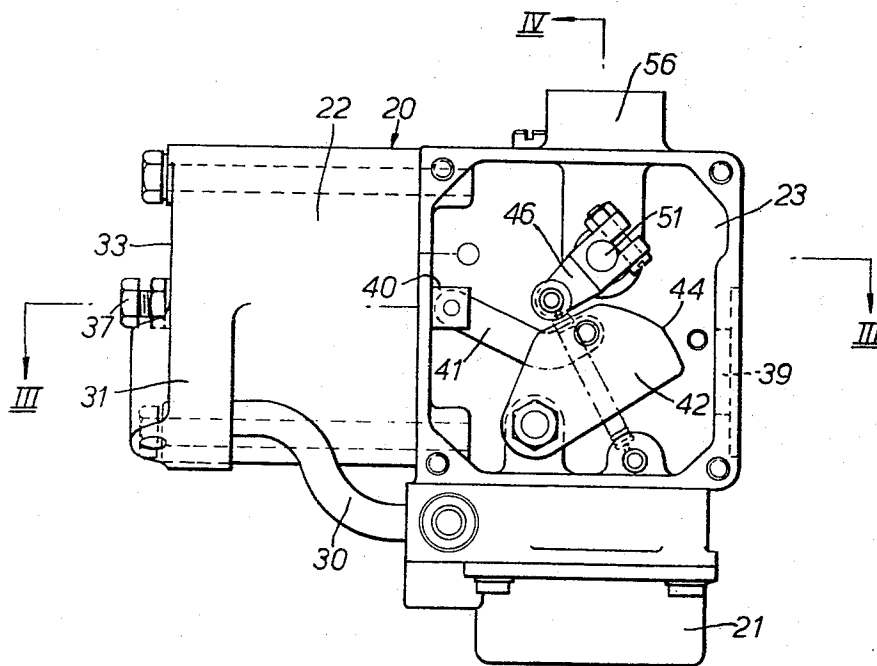


FIG. 2.

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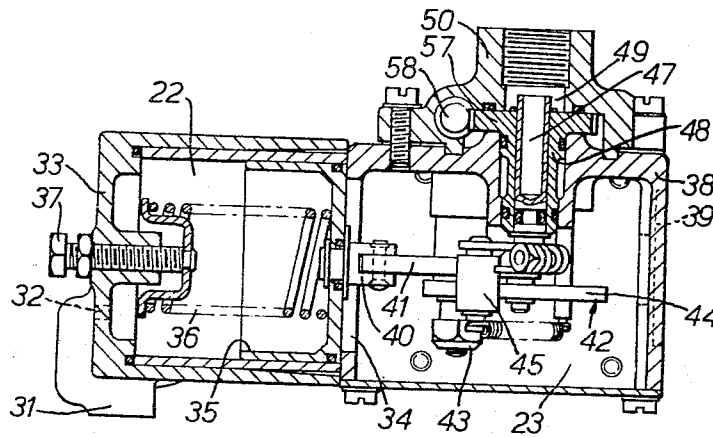


FIG. 3.

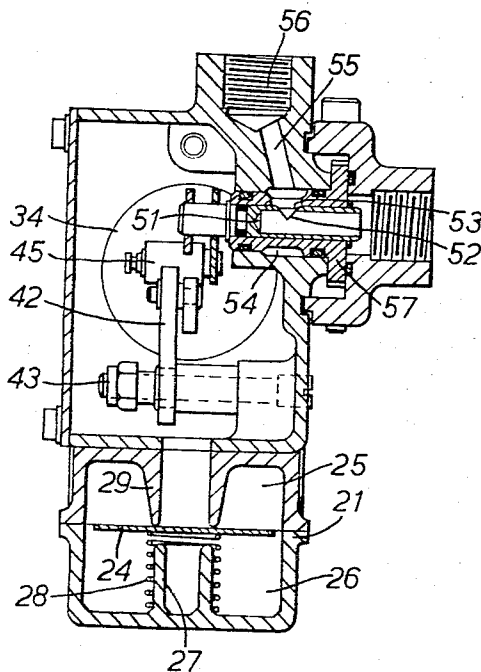


FIG. 4.

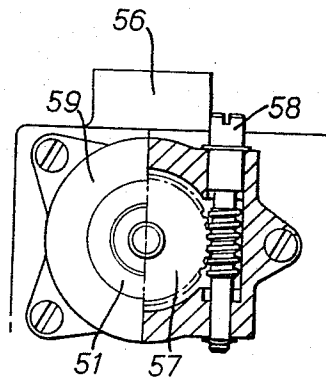


FIG. 5.

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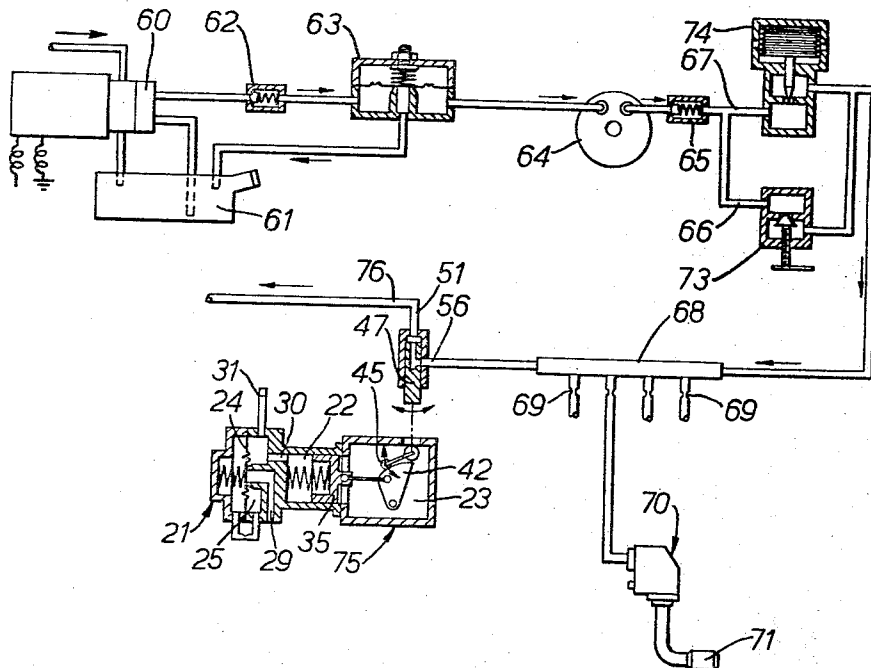


FIG. 6.

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FUEL INJECTION SYSTEMS

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7 Claims. (Cl. 123—32)

This invention relates to valve control devices suitable for use in fuel injection systems for internal combustion engines and in particular to the control of fuel to injection devices in such systems. The invention may be incorporated in low pressure fuel injection systems such as those disclosed in the specifications of my co-pending applications Ser. No. 482,994 filed Aug. 10, 1965, for "Fuel Injection Systems" (a continuation of my earlier applications Ser. Nos. 330,874 filed Dec. 16, 1963, and 434,326 filed Feb. 23, 1965, both now abandoned) and Ser. No. 434,417 filed Feb. 23, 1965, for "Fuel Injection Devices and Systems." However, the use of the present invention is not restricted to such systems and may be incorporated into fuel injection systems of any type.

In fuel injection systems, metering of fuel supply to the injector devices is sometimes adjusted in dependence on engine load by a metering device responsive to the engine inlet manifold vacuum pressure. In such an arrangement the metering device can include a valve operating member exposed to engine inlet manifold vacuum via a pipe connected to the engine inlet manifold. Decreasing inlet manifold pressure (increasing vacuum) causes movement of the operating member against a spring whilst increasing inlet manifold pressure (decreasing vacuum) causes movement of the operating member by the spring. The operating member is coupled to a fuel flow control device so that the fuel supply to the injector devices is adjusted in dependence on the inlet manifold vacuum pressure. This arrangement can be disadvantageous in that if the engine is running with the throttle partly closed and is then suddenly opened, the inlet manifold pressure increases suddenly from a closed and is then suddenly opened, the inlet manifold pressure increases suddenly from a partial vacuum to atmospheric pressure, or nearly so. However, the pipe interconnecting the inlet manifold and the operating member imposes a resistance to air flow so that the pressure change to which the operating member is exposed, lags that in the inlet manifold. Thus, the fuel supply to the injector devices is temporarily deficient. Hence, there is a lag in response of the engine to the sudden throttle opening and a temporary reduction or loss of power which is disadvantageous.

According to the invention, a control device for a valve comprises a fluid pressure controllable valve operating member and a device arranged for response to relatively sudden changes in one sense of the control fluid pressure to expose the operating member directly to an overriding fluid pressure temporarily increasing the effects of the said change.

Such a control device can be used for controlling a fuel metering valve in a fuel injection system for an internal combustion engine. The operating member is normally exposed to engine inlet manifold vacuum pressure but in response to relatively sudden decreases in vacuum, e.g. as when the throttle valve is opened relatively quickly as for engine acceleration, the pressure responsive device operates to expose the valve operating member temporarily to a positive pressure, e.g. atmospheric pressure, temporarily to increase the movement of the operating member in response to the change in manifold vacuum.

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In a particular embodiment, suitable for controlling a fuel metering valve in a fuel injection system, the control fluid responsive device comprises a chamber and a resilient diaphragm defining two compartments within the chamber, one compartment having a vent and communicating with the other compartment via a flow restrictor, the diaphragm normally co-operating with a seating in the vented compartment to close the vent and being unseated by relatively sudden decreases in the inlet manifold vacuum to expose the operating member to atmospheric pressure. The operating member can be a piston slidable in a cylinder and exposed to the engine inlet manifold vacuum via the vented compartment. The piston can be pivotally connected to a cam coupled to a metering valve member so that linear movement of the piston rotates the metering valve member.

By way of example embodiments of the invention will be described in greater detail with reference to the accompanying drawings, of which:

FIG. 1 is a schematic illustration of a control device embodying the invention,

FIG. 2 is a plan view, with a cover plate removed, of a valve incorporating a control device embodying the invention,

FIG. 3 is a section on the line III—III in FIG. 2,

FIG. 4 is a section on the line IV—IV in FIG. 2,

FIG. 5 is a section on the line V—V in FIG. 3, and

FIG. 6 is a schematic illustration of relevant parts of a fuel injection system incorporating a fuel metering valve of the type shown in FIGS. 2-5.

The following description is in relation to a fuel injection system for an engine in which fuel injector devices are supplied with fuel, the fuel being supplied by a metering device which adjusts the fuel flow in response to engine load by response to the engine inlet manifold vacuum pressure.

FIG. 1 illustrates the inlet manifold air intake pipe 1 which incorporates a butterfly valve 2 operable by the engine throttle control to adjust the air flow through into the inlet manifold and hence vary the pressure in the pipe 1. With the engine running the vacuum in the pipe 1 progressively decreases towards atmospheric pressure as the valve 2 is opened.

A tube 3 connects the manifold pipe 1 to the upper compartment 4 of a chamber 5 having a valve seat 6 communicating with a pipe 7 exposed directly to the atmosphere or connected to the engine air cleaner. The tube 3 also is connected via a flow restrictor 8 to a lower compartment 9 of the chamber 5, the compartments 4 and 9 being separated by a resilient diaphragm 10 urged by a spring 11 to seat on the valve seat 6.

The upper compartment 4 is also connected by a short tube 12 to a cylindrical chamber 13 in which a cup-shaped piston 14 is slidably mounted. The piston is connected by a link 15 to the metering valve (not shown) so that sliding movement of the piston adjusts the metering valve to control the fuel supplied to the injector devices in dependence on the inlet manifold vacuum. A spring 16 disposed inside the piston 14 urges the latter towards a position in which the metering valve is open.

With the engine running at any particular position of the butterfly valve 2, steady state conditions exist in which the vacuum pressures in compartments 4 and 9, due to that in the inlet manifold, are equal and the spring 11 maintains the diaphragm 10 seated on the seat 6. Thus, the position of the piston 14 is the chamber 13 is dependent on the pressure in the compartment 4 and hence on the inlet manifold vacuum pressure on the pipe 1.

If now the engine throttle is operated to suddenly open the butterfly valve 2, the pressures in the pipe 1 and the compartment 4 increase (i.e. vacuum decrease) but the

pressure in compartment 9 does not change so quickly due to the flow restrictor 8 and hence remains depressed. The pressure unbalance in the compartments 4 and 9 unseats the diaphragm 10 and the compartment 4 is exposed directly to atmospheric pressure through the pipe 7. Due to the short length of the tube 12, there is a sudden corresponding increase in the pressure in chamber 13 to atmospheric pressure and the piston moves rapidly causing a corresponding increase in the fuel supplied to the injector devices. The engine thus is caused to respond rapidly to sudden openings of the engine throttle. The diaphragm 10 remains unseated until the pressure in compartment 9 has increased sufficiently to allow the spring 11 to reseal the diaphragm 10. This period is dependent on the volume of the compartment 9, the size of the restrictor 8 and the strength of the spring 11. Hence, it can be arranged that, in response to sudden throttle opening, the fuel injector devices are supplied for a predetermined temporary period with a quantity of fuel in excess of that corresponding to the throttle opening.

The arrangement described thus provides for a temporary overriding of the control of the metering means so that the fuel supply to the injector devices increases rapidly in response to sudden throttle opening.

Instead of being connected to the tube 3 the restrictor 8 could be connected directly to the compartment 4.

A metering valve embodying a control device as shown in FIG. 1, is shown in more detail in FIGS. 2-5. The valve has a housing 20 within which are defined chambers 21, 22 and 23.

The chamber 21 is divided by a resilient diaphragm 24 into two compartments 25 and 26. These compartments communicate via a flow restrictor, not shown, and the compartment 26 has an upstanding boss 27 locating a spring 28 bearing against the diaphragm 24, urging it to seat on one end of a tube 29 extending between the compartment 25 and the chamber 23. With the diaphragm 24 seated, there is no communication between compartment 25 and the chamber 23. A pipe 30 extends between the compartment 25 and a port 31 which communicates with the chamber 22 via an aperture 32 in the end wall 33 of the chamber 22. The port 31 is connected, in use of the valve, to the engine inlet manifold (c.f. pipe 3 and manifold pipe 1, FIG. 1).

The chamber 22 is cylindrical and has an aperture 34 in the wall opposite the wall 33 which aperture communicates with the chamber 23. The chamber 22 contains a piston 35 slidable therein and biased towards the aperture 34 by a spring 36 adjustable by a screw 37 projecting from the end wall 33. The piston 35 thus is exposed to inlet manifold vacuum (control pressure) via the aperture 32 and port 31. The wall 38 of the chamber 23, opposite the aperture 34, has a vent to atmosphere 39.

The head of the piston 35 has secured thereto a boss 40 projecting through the aperture 34 into the chamber 23 and pivotally connected by a link 41 to a cam 42 pivoted on a pin 43. The cam 42 has a cam face 44 disposed for co-operation with a cam follower 45 carried by a radial arm 46 secured to one end of a tubular member 47 forming part of the control valve assembly.

The tubular member 47 is rotatable in a sleeve 48 secured in a cylindrical opening 49 in a side wall of the chamber 23 leading to a fuel outlet port 50. The tubular member 47 has a closed end 51 projecting into the chamber 23 and an open end communicating with the port 50. Intermediate its ends the tubular member 47 has a transverse V-notch 52 which can register with a parallel sided aperture 53 in the sleeve 48, the aperture 53 registering with an annular recess 54 surrounding the sleeve and communicating via a passage 55 with a fuel inlet port 56. The sleeve 48 has O-rings disposed either side of the recess 54 and at the end thereof adjacent the port 51 has an integral gear 57. A screw 58, mounted in a cover cap 59 defining the ports 51 and 56, engages with the gear 57 enabling the sleeve to be rotated with respect

to the tubular member 47 to vary the manner of co-operation between the V-notch 52 and the aperture 53 and hence the metering characteristics of the metering valve.

The control valve operates as follows. Under steady engine running conditions, the inlet manifold vacuum communicated to the port 31 is constant and the piston 35 takes up a position dependent on the vacuum level, pivoting the cam 42 so that the cam surface 44 engages the cam follower 45 causing rotation of the tubular member 47. The quantity of fuel passing from the inlet port 56 to the outlet port 51 is thus adjusted in dependence on the area of the V-notch 52 registering with the rectangular aperture 53 and by suitable dimensioning of the notch, and of the cam surface 44, the quantity of fuel flowing through the metering orifice can be suited to engine requirements as determined by inlet manifold vacuum. As the manifold vacuum level changes so will the position of the piston 35 and hence the area of the metering orifice.

Under these steady state conditions and for gradual changes in manifold vacuum, there is no pressure difference across the diaphragm 24 and accordingly it remains seated, closing the tube 29.

However, if the manifold vacuum rapidly decreases towards atmospheric pressure, then there is a delay in communicating the full effects of the change to the port 31 and hence to the piston 35. However, commencement of such a rapid change produces, due to the flow restrictor connecting the compartments 25 and 26 across the diaphragm 24, a sufficient pressure differential across the diaphragm to unseat it and expose the chamber 25 to atmospheric pressure via the tube 29 and the vent 39. This rapidly raises the pressure in the compartment 25 and via the pipe 30, in the chamber 22 to atmospheric pressure. The piston 35 thus moves rapidly towards the aperture 34 pivoting the cam 42 and causing rotation of the tubular member 47 in such a sense as to increase the fuel supply to the injector devices. This may involve closing or opening of the metering orifice as will be explained later with reference to FIG. 6.

As the pressure differential across the diaphragm 24 equalises, due to the flow restrictor connecting the compartments 25 and 26, the diaphragm moves again to a seated position and the inlet manifold vacuum then again takes over as the effective controlling pressure on the piston 35.

Thus, in response to a sudden decrease in inlet manifold vacuum (increasing pressure), the metering valve is operated to provide a corresponding increase in supply of fuel to the injector devices with a minimum lag in response to the change. The duration of the override control, effected by unseating the diaphragm 24, can be varied by variation in the volume of chamber 26, the strength of spring 28 and of the characteristics of the flow restrictor interconnecting compartments 25 and 26.

FIG. 6 shows the relevant portions of a fuel injection system incorporating a metering valve embodying the invention. The injection system is of the type that injects fuel continuously into the engine cylinder intakes at relatively low pressures varying with engine speed, the fuel being metered by a valve controlled by engine inlet manifold vacuum.

FIG. 6 shows an electrically driven fuel pump 60 which supplies fuel from a tank 61 via a check valve 62 and relief valve 63 to an engine driven impeller 64 the latter serving to pressurise fuel in dependence on engine speed. The output from the impeller 64 is supplied via a further check valve 65 and two parallel paths 66 and 67 to a fuel manifold 68. The manifold 68 is connected via flow equalising restrictors 69 to open (i.e. non-valve-controlled) fuel injector devices 70 having discharge nozzles 71 disposed in the respective inlet passages into the engine cylinders. The branches 66 and 67 contain a cold start valve 73 (opened manually or automatically for cold

start-up) and a barometric controlled valve 74, respectively.

The fuel manifold 68 is connected also via a metering valve 75 to a fuel return line 76 connected back to the tank 61. The metering valve 75 is constructed as shown in FIGS. 2-5 and like references have been used. The valve is controlled by engine inlet manifold vacuum so that with increasing manifold vacuum the metering orifice increases, decreasing the fuel supply to the injector devices, and with decreasing vacuum the orifice decreases, increasing the fuel supply to the injector devices.

Instead of being located in the fuel return line, the metering valve 75 could be located upstream of the manifold 68. In this case the valve would be controlled to increase the metering orifice area with decreasing inlet manifold vacuum (increase in pressure) and to decrease the metering orifice area with increasing inlet manifold vacuum.

I claim:

1. A control device for a valve, including a first chamber containing a valve operating member movable in response to changes in fluid pressure, a second chamber having a resilient diaphragm defining vented and non-vented compartments therein, the vented compartment having an inlet for connection to a control vacuum source and directly communicating with the first chamber for exposing the valve operating member to the said source, the vented and non-vented compartments of the second chamber communicating via a flow restriction, the diaphragm normally co-operating with a seating to close the said vent and arranged to be unseated by relatively sudden decreases in vacuum of the said source thereby temporarily exposing the valve operating member to atmospheric pressure and increasing the effect of the said decrease in vacuum.

2. A control device according to claim 1, in which the diaphragm is spring biased towards a seated position.

3. A valve mechanism including a control device according to claim 1, said mechanism having a valve member, and means operably coupling said valve member to the operating member of said control device.

4. A valve mechanism and control device according to claim 3, in which the valve operating member is a linearly movable member and said valve member is a rotary valve member.

5. A valve mechanism and control device according to claim 4, in which the rotary valve member is operably coupled to a pivoted cam member linked to the valve operating member whereby linear movement of the operating member pivots the cam member.

6. A control device for a valve, comprising a fluid pressure responsive valve operating member and a fluid pressure responsive override control device, means for communicating a source of vacuum control pressure with said operating member to control operation thereof, said override control device including a chamber and a resilient diaphragm dividing said chamber into first and second compartments, means including a flow restrictor communicating said first and second compartments, the first compartment having an inlet for communicating said first compartment with a positive pressure source, said diaphragm normally effecting closure of said inlet, and means for communicating said first compartment with said vacuum source and with said operating member to cause movement of said diaphragm in response to a relatively sudden decrease in vacuum of said vacuum source to effect opening of said inlet and thereby communicate said positive pressure to said operating member temporarily to override and increase the effects of said decrease in vacuum on said operating member.

7. A valve mechanism and control device as claimed in claim 3 mounted in a fuel injection system for an internal combustion engine having an air intake manifold structure subject to operation of said engine to vacuum conditions, and fuel supply conduit means connected to supply fuel to fuel injector devices having outlet orifices disposed in said manifold structure, said fuel supply conduit means including said valve mechanism, and means connecting said vented compartment inlet to said air intake manifold structure for movement of said valve operating member in response to vacuum conditions in said structure.

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