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(54) VACUUM LIMITER FOR A FUEL INJECTION SYSTEM

(71) We, ROBERT BOSCH GMBH. a German Company, of Postfach 50, 7 Stuttgart 1, Federal Republic of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a fuel supply system of a mixture-compressing internal combustion engine using ignition, the system entailing supply of the measured quantity of fuel into the induction pipe, wherein there is arranged a selectively controllable throttle valve, and the induction pipe sections upstream and downstream of the throttle valve are connected by a by-pass the cross-seciton of which can be modified by means of a vacuum limiter, the vacuum limiter comprising a pressure-dependent controlling element which responds to the vacuum prevailing in the induction pipe section downstream of the throttle valve when the vehicle is overrunning the engine.

Vacuum limiters are known already which, in order to influence the fuel-air mixture when the vehicle is overrunning the engine, respond to the pressure drop arising in the induction pipe on sudden closure of the throttle valve and conduct a quantity of air past the closed throttle valve which is sufficient for maintaining combustion in the individual cylinders of the internal combustion engine while the car is overrunning the engine. However, such limiters are not suitable adequately to ensure the metering of combustion air with varying geodetic altitudes, since the increasing altitudes, and consequently diminishing atmospheric pressure, and due to their responding to the pressure difference upstream and downstream of the throttle valve, they open only at too large a value of vacuum downstream of the throttle valve when the car is overrunning the engine.

It is the object of the invention to develop in a fuel supply system of the kind described above, a vacuum limiter by which the metering of combustion air is ensured independently of the prevailing atmospheric pressure (altitude). There is provided by the present invention, a fuel supply system for an internal combustion engine using ignition, the system entailing supply of the metered quantity of fuel to the induction pipe, and comprising a vacuum limiter, a selectively controllable throttle valve installed in the induction pipe and a by-pass connecting the sections of the induction pipe upstream and downstream of the throttle valve, the cross-section of which by-pass can be varied by means of the vacuum limiter, and the vacuum limiter comprising a control valve for controlling the variation of the by-pass cross-section and a pressure-dependent controlling element which responds to the vacuum prevailing in the induction pipe section downstream of the throttle valve when the vehicle is overrunning the engine to actuate the control valve; wherein the pressure dependent controlling element is formed by a pressure box, namely, a hollow box having walls which are resiliently deflectable according to the pressure differential between the inside and outside of the box, the pressure box along with the control valve is housed in the chamber of an advance control box, and the by-pass is in the form of a by-pass control box comprising a valve to vary the by-pass cross-section in response to actuation of said control valve.

A further advantageous development of the invention is such that the housing of the by-pass control box is subdivided by a membrane into two chambers, the first chamber of which is connected via a first duct to the induction pipe section upstream of the throttle valve, and via a second duct to the induction pipe section downstream of the throttle valve, that the second duct can be shut off by the movable valve component of the by-pass valve supported against the membrane, that the second chamber is connected on the one hand via a throttle to the first chamber and on the other hand via the control valve to the advance control box, and houses a compression spring which acts upon the membrane in the direction of closing of the movable valve component. Preferably, the control valve comprises a rod-shaped closing member, one end of which is in the form of a truncated cone and co-operates with a fixed valve seat, and the other end of which has a spherical form, with the spherical end of the closing members cooperating with a disc on which a spring engages to bias the closing member in the direction of closing of the control valve. It is also preferred that the spring, disc and closing member of the control valve are axially enclosed by a bushing, and that the spherical end of the closing member project from the bushing in the direction towards the pressure box.

In accordance with a further advantageous development of the invention, the pressure box has on its side facing the control valve, a disc which co-operates with the spherical end of the control valve closing member; and in the event of a vacuum in the induction pipe section downstream of the throttle valve characterizing the condition when the car is overrunning the engine, the closing member of the control valve is moved, via the disc, by the pressure box in the direction of opening of the control valve, and in the event of a leakage of the pressure box the disc is pressed by the box against the bushing.

In accordance with a further advantageous development of the invention, the position of the pressure box in the advance control box can be adjusted by means of a screw.

It is also advantageous if the spring of the control valve is mounted with its axis inclined to that of the closing member so that the perforated disc is biassed against the inner wall of the bushing.

In another advantageous development of the invention, the advance control box and the second chamber of the by-pass control box are connected via a connecting tube.

In a further embodiment of the invention, the housing of the by-pass control box is subdivided by a membrane into two chambers, the first chamber of which is connected via a first duct to the induction pipe section upstream of the throttle valve, and via a second duct to the induction pipe section downstream of the throttle valve, and the second duct can be shut off by a movable valve component supported against the membrane via a pressure pin, and the first chamber is divided by a partition to form an intermediate chamber between the partition and the membrane, which intermediate chamber is connected via a throttle to the first chamber and via the control valve to the induction pipe section downstream of the throttle valve, and the second chamber houses a compression spring which together with the induction pipe pressure downstream of the throttle valve acts upon the membrane in the direction of closing of the movable valve component, and a duct from the induction pipe section downstream of the throttle valve to the chamber of the advance control box can be closed by a movable valve component of the control valve connected to the barometer box. Advantageously, the advance control box and the intermediate chamber of the by-pass control box may be connected via a connecting tube.

Two embodiments of the invention are represented in simplified form in the accompanying drawings. In the drawings:—

Fig. 1 shows, in longitudinal section a first vacuum limiter for use in a system of the invention;

Fig. 2 shows, in longitudinal section, a second vacuum limited for use in a system of the invention;

Fig. 3 shows, in diagrammatic form, a fuel supply system, being a mechanically controlled fuel injection system, according to the invention; and

Fig. 4 shows, in diagrammatic form, a further fuel supply system, being an electrical fuel injection system, according to the invention.

In Fig. 1 the vacuum limiter therein represented comprises a by-pass control box 1 and an advance control box 2. The by-pass control box 1 comprises a housing made up of two deep-drawn housing components 3 and 4 and sub-divided by a membrane 5 into a first chamber 6 and a second chamber 7. The membrane 5 is clamped into a flanged edge 8 joining the two housing components together.

The first chamber 6 of the by-pass control box 1 is connected via a first duct 9 upstream of a throttle valve to the induction pipe of an internal combustion engine and via a second duct 10 to an induction pipe section downstream of the throttle valve (see Fig. 4 and 5). In the second chamber 7, is accommodated a soft compression spring 11 which abuts with one end of the housing base of the housing component 4 and with the other end on a spring plate 12. The spring plate 12 is wedged in the centre of the membrane 5, which may consist of a rubberized fabric membrane, against a reinforcement disc 13 passing through an aperture in the membrane.

In the first chamber 6 is arranged a movable valve component 14 in plate-form the seat of which is formed on the surface-ground side face of the second duct 10 projecting into the first chamber 6. This end section of the second duct 10 is surrounded by a restoring spring 15 which abuts on the one hand on the base of the housing component 3 and on the other hand on the movable valve component 14 and which endeavours to lift the movable valve component 14 off its seat. To make possible the transmission of the membrane movement required for such a valve movement, a pressure pin 16 is arranged free of play between the reinforcement disc 13 of the membrane 5 and the movable valve component 14.

This pressure pin 16 is mounted so that it is longitudinally displaceable in a longitudinal bore 17 of a hub 18 which, made, for example, of nylon, is injection-moulded into the centre aperture 19 of a partition 20. This partition 20 consists of deep-drawn sheet steel and on its flange-like edge is clamped together with the membrane 5 in the flanged edge 8 of the housing. Its purpose is to prevent the system consisting of two springs 11 and 15 and the masses of the valve component 14, the pressure pin 16 and the reinforcement disc 13 with the spring plate 12, from being excited to oscillaitons by the influence of the pressure fluctuations caused by the induction processes of the internal combustion engine, strongly evident in particular at low speeds. To enable the pressure, prevailing in the first chamber 6 and being only slightly below atmospheric pressure, to have its full effect upon the membrane 5, a passage must exist between the first chamber 6 and the intermediate chamber 21 separated by the partition 20. To this end an equalizing bore 22 of only about 1 mm diameter is present. The intermediate chamber 21 in turn is connected via a throttle bore 23 to the second chamber 7. Advance control box 2 and by-pass control box 1 may be in fixed connection with one another, but they may also be arranged separately and be connected to one another by a tube connection 24. In the chamber 25 of the advance control box 2, a pressure-dependent controlling element in the shape of a pressure or " barometer " box 26 is arranged, the axial position of which in the chamber can be adjusted by means of a screw 27 which passes through the wall of the advance control box 2. On the side of the barometer box 26 remote from the screw 27, a disc 28 is arranged which co-operates with a rod-shaped closing member 29 of a control valve 30. The rod-shaped closing member 29 comprises a spherical end 31 facing the disc 28 and an end 32 in the form of a truncated cone which co-operates with a fixed valve seat 33. The closing member 29 is acted upon in the direction of closing by a spring 34, which applies pressure via a perforated disc 35 at the spherical end 31 of the closing member 29. Spring 34, perforated disc 35 and closing member 29 are surrounded by a bushing 36 in longitudinal direction in such a way that the spherical end 31 of the closing member 29 projects from the bushing 36 in the direction towards the barometer box 26. It is particularly advantageous if the coil end of the spring 34 of the control valve 30 remote from the perforated disc is tilted to incline the axis of the spring to that of the members 29, so that the perforated disc 35 is biassed against the inner wall of the bushing 36 and rubs against the same. In this way high-frequency, acoustically interfering, oscillations are avoided.

The chamber 25 of the advance control box 2 is connected on the one hand via a duct 37 to an induction pipe section downstream of the throttle valve and on the other hand via the control valve 30 and the tube connection 24 to the second chamber 7 of the by-pass control box 1. In order to signalize the failure of the vacuum limiter, an audible warning device, a reed pipe 38 for example, can be arranged on the advance control box 2 which responds when the induction pipe pressure downstream of the throttle valve becomes excessive. A further possibility of signalling could be, for example, the provision of electrical contacts on the side face of the bushing 36 and on the side face of the disc 28 facing the same which are connected to an indicator gauge on the instrument board which indicator gauge responds when the two contacts touch one another.

The mode of operation of the vacuum limiter represented in Figure 1 is as follows:—

The position of the barometer box 26 in the chamber 25 of the advance control box 2 in relation to the spherical end 31 of the movable closing member 29 of the control valve 30 is adjusted with the help of the screw 27 so that with vacuum arising during normal driving and at idling speeds in the induction pipe downstream of the throttle valve, the disc 28 of the barometer box remains out of touch with the spherical end 31 of the closing member 29, and so that the control valve 30 thus remains closed. However, if in the event of the car overrunning the engine, the pressure in the induction pipe downstream of the throttle valve, and hence also in the chamber 25, drops, the barometer box 26 opens, via the disc 28, the closing member 29 of the control valve 30, for example, at an absolute pressure of approx. 300 mm Hg. With the control valve 30 open, the pressure in the second chamber 7 of the by-pass control box 1 now drops, and the membrane 5 moves in the direction towards the base of the housing component 4, so that the restoring spring 15 can lift the movable valve component 14 off its seat and air can flow via the annular gap formed with the second duct 10 through the first duct 9 into the second duct 10 downstream of the throttle valve, as a result of which adequate combustion processes of the internal combustion engine are assured in spite of strong throttling. If the absolute pressure downstream of the throttle valve rises once again to a value which can be set by means of the screw 27 via the barometer box 26, the disc 28 of the barometer box 26 and the closing member 29 will disengage, and the control valve 30 closes owing to the spring force 34. Via the equalizing bore 22 and the throttle bore 23 an equalization of pressure now takes place between the chambers 6 and 7 of the by-pass control box 1, so that owing to the spring force of the soft spring 11 the movable valve component 14 is also closed. The induction pipe vacuum downstream of the throttle valve at which the movable valve component 14 of the by-pass control box 1 opens is thus not determined by the spring force 11, as in the known vacuum limiters, the spring force merely serving for maintaining the movable valve component 14 in this position when the control valve 30 is closed. In the vacuum limiter in accordance with the invention, the vacuum at which the movable valve component 14 lifts off its seat is determined by the vacuum downstream of the throttle valve at which the control valve 30 is opened by the barometer box 26, the barometer box 26 being axially adjustable by the screw 27 for the setting of this vacuum. In order to prevent, in case of a leakage of the barometer box 26, the permanent opening of the control valve 30, and consequently the movable valve component 14 likewise lifting off its seat and air being allowed constantly to flow into the induction pipe via the second duct 10, the control valve 30 is surrounded by the bushing 36 against which the disc 28 comes to rest in case of a leakage in the barometer box 30, so blocking the flow cross-section on the control valve 30.

In the second vacuum limiter according to Figure 2, the parts which are the same as in the vacuum limiter according to Fig. 1 have been given the same reference numerals. This vacuum limiter according to Fig. 2 differs essentially from that in Fig. 1 in that the equalizing bore 22 between the first chamber 6 and the intermediate chamber 21 of the by-pass control box 1, a throttle 39 is provided, and that no connection exists between the first chamber 6 and the second chamber 7. The second chamber 7 is connected via a third duct 40 to the induction pipe section downstream of the throttle valve. The tube connection between the advance control box 2 and the by-pass control box 1 opens in the second embodiment into the intermediate chamber 21 of the by-pass control box 1. The duct 37 from the induction pipe section downstream of the throttle valve to the chamber 25 of the advance control box 2 is closable by a control valve 41, which is formed by a fixed valve seat 42 and a movable valve component 43, which, as shown by way of example in Fig. 2, may be supported pivotably in a holder 44 joined to the barometer box 26.

The mode of operation of the vacuum limiter represented in Fig. 2 is as follows:

During normal driving and on idling, the control valve 41 of the advance control box 2 is opened, so that in the intermediate chamber 21 the vacuum in the induction pipe section downstream of the throttle valve prevails as also in the second chamber 7 of the by-pass control box 1. Now, if the vacuum in the induction pipe section downstream of the throttle valve attains a value characterizing the condition when the car overruns the engine, a barometer box 26 will move the movable valve component 43 in the direction towards the fixed valve seat 42 and the control valve 41 closes. Subsequently, via the equalizing bore 22 and the throttle 39, the atmospheric pressure from the first chamber 6 builds up also in the intermediate chamber 21 of the by-pass control box, so that the spring force 11 is overcome, owing to the pressure difference on the membrane 5, and the restoring spring 15 lifts the movable valve component 14 of its valve seat, so that air can flow via the second duct 10 into the induction pipe section downstream of the throttle valve. The pressure prevailing in the intermediate chamber 21 becomes effective via the tube connection 24 also in the chamber 25 of the advance control box 2, so that the control valve 41 is opened again by the barometer box 26. If a vacuum characterizing the condition when the car overruns the engine still prevails in the induction pipe section downstream of the throttle valve, the result will be that the barometer box 26 will once again shut off the control valve 41. As in the embodiment according to Figure 1, in the embodiment according to Fig. 2 the spring force 11 is once again not determining for the vacuum downstream of the throttle valve at which, when the car is overrunning the engine, air is passed via the second duct 10 to the induction pipe section downstream of the throttle valve.

A mechanically controlled fuel injection system of the invention is represented in Fig. 3. Here the combustion air flows in the direction of the arrow into an induction pipe 50 comprising a conical section 51 with a measuring element 52 arranged therein and further through a connecting tube 53 and an induction pipe section 54, comprising a controllable throttle valve 55, to one or more cylinders (not shown) of an internal combustion engine. The measuring element 52 is a plate arranged transversely to the direction of flow, which moves in the conical section 51 of the induction pipe according to an approximately linear function of the quantity of air flowing through the induction pipe, whereby for a constant restoring force impinging on the measuring element 52 and for a constant air pressure prevailing upstream of the measuring element, the pressure prevailing between the measuring element 52 and the throttle valve 55 also remains constant.

The measuring element 52 directly controls a metering and flow proportioning valve 57. For the transmission of the adjusting movement of the measuring element 52, a lever 58 connected to it is provided which is supported pivotably on a fulcrum 59 and which in its pivoting movement actuates by means of a projection 60 the movable valve component in the form of a control slide valve 61 of the metering and flow proportioning valve 57. The fuel pumped from a fuel tank 65 by a fuel pump 64 driven by an electric motor 63 passes via a duct 66 and a channel 67 into an annular groove 68 of the control slide valve 61. Depending upon the position of the control slide valve 61, the annular groove 68 covers a greater or smaller number of control slots 69 which through channels 70 each lead to a chamber 71, separated by a membrane 72 from a chamber 73, the membrane serving as a movable part of a flat-seat valve in the form of a pressure-equalizing valve 74. From the chambers 71 the fuel passes via channels 75 to the individual injection valves, not shown in the drawing, which are arranged in the vicinity of the engine cylinders in the induction pipe. From the duct 66 branches off a duct 76 comprising a relief pressure control valve 77, which allows fuel to flow back to the fuel tank 65 if the system pressure is too high.

The control slide valve 61 is acted upon on its side face facing the lever 58, by hydraulic fluid, which represents the restoring force for the measuring element 52 and which acts on the control slide valve via a duct 79 comprising a damping throttle 80.

From the duct 66, a control pressure duct 82 branches off, in which are arranged in series a coupling throttle 83, the chambers 73 of the pressure-equalizing valves 74, a throttle 84 and a solenoid valve 85. Parallel with the solenoid valve 85, a throttle 87 is arranged in a duct 86 through which the fuel can return pressureless from the control pressure duct 82 via the return duct 88 to the fuel tank 65.

To safeguard the metering of the engine combustion air at varying geodetic altitudes, a vacuum limiter, corresponding to the embodiment of Figure 1 or 2, is arranged in the by-pass about the throttle valve formed by the ducts 9, 10 as indicated in Figure 3.

The mode of operation of the fuel injection system represented in Figure 3 is as follows:—

With the internal combustion engine in operation, air is sucked in via the induction pipe 50, 53 and 54, as a result of which the measuring element 52 is subjected to a certain deflection from its rest position. According to the deflection of the measuring element 52, the control slide valve 61 of the metering and flow proportioning valve 57 which meters the fuel quantity flowing to the injection valves is also displaced via the lever 58. The direct connection between the measuring element 52 and the control slide valve 61 gives a constant ratio of air quantity and metered fuel flow.

To make it possible to obtain a richer or leaner fuel-air mixture, depending upon the section of the operating range of the internal combustion engine, a variation of the proportionality between quantity of air and metered fuel flow is required as a function of operating parameters of the internal combusion engine. The variation of the fuel-air mixture can take place on the one hand in that the restoring force on the measuring element 52 is modified, or, on the other hand, by a modification of the pressure difference at the metering valve 68, 69. An internal combustion engines with several engine cylinders it is advantages to have the valves 74 in the metering and flow proportioning valve 57 in the form of pressure-equalising valves. The differential pressure at the metering valves 68, 69 can be controlled and modified advantageously jointly by the pressure in the control pressure duct 82. In the embodiment shown, the modification of the differential pressure takes place at the decoupling throttle 83 in that the liquid flow through the decoupling throttle is variable. The modification of flow at the decoupling throttle 83 can be achieved by installing downstream of it in the control pressure circuit 82 the throttle 84 and solenoid valve 85 with the throttle 87 parallel with it. With closed solenoid valve 85 the quantity of fuel flowing through the decoupling throttle 83 is determined by the throttles 83, 84 and 87. The quantity of fuel flowing in the control pressure circuit with opened solenoid valve 85 is determined solely by the throttles 83 and 84, which results in a smaller throttling and an increased pressure difference at the decoupling throttle 83, with consequent increase also of the pressure difference at the metering valves 68, 69. The modification of the differential pressure at the decoupling throttle 83 can be achieved by the variation of the ratio of opening period to closing period of the solenoid valve 85. For a permanently closed solenoid valve, a small pressure difference and a lean fuel-air mixture are obtained, whilst for a permanently open solenoid valve 85 the pressure difference is maximum and the fuel-air mixture will be richest.

The duty cycle of the electromagnetic valve 85 can be varied according to the embodiment represented in Fig. 5 by an electronic controlling device not shown in Fig. 3 into which can be fed the output signals of an oxygen probe beside the operating parameters of the internal combustion engine picked up by transducers.

The electrically controlled fuel injection system of the invention represented in Fig. 4 is intended for the operation of a four-cylinder four-stroke internal combustion engine 90 and comprises four eletcromagnetically actuable injection valves 91, to which the injection fuel is fed from a distributor 92 via separate pipelines 93, an electrically driven fuel pump 94 which pumps fuel from a fuel tank 95, a pressure controller 96, which controls the fuel pressure to a constant value together with an electronic open and closed loop control device described in the following, which is triggered by a signal transmitter 98 coupled to the camshaft 97 of the internal combustion engine twice at each revolution of the camshaft, and which then supplies each time a square electrical opening pulse J for the injection valves 91. The duration t_i of the opening pulses indicated in the drawing determines the opening period of the injection valves and consequently the quantity of fuel which during the particular opening period issues from the inside of the injection valves 91 subject to a practically constant fuel pressure of 2 bar. The magnetic windings 99 of the injection valves are each connected in series to a decoupling resistor 100 and connected to a common amplification and power stage of an electronic control device 101 which contains at least one power transistor which is arranged with its emitter-collector junction in series with the decoupling resistors 100 and the magnet windings 99 connected to earth on one side.

In mixture-compressing internal combustion engines with mixture ignition of the type represented, the intake air quantity passing into one cylinder during a single suction stroke determines the quantity of fuel which during the subsequent working stroke can be completely burnt. For good efficiency of the internal combustion engine, it is necessary that after the working stroke no substantial excess air should be present. To achieve the desired stoichiometric ratio between intake air and fuel, an air flow meter LM is provided in the induction pipe 102 of the internal combustion engine downstream of a filter 103, but upstream of its throttle valve 105 adjustable by means of an accelerator pedal 104, which air flow meter LM consists essentially of a baffle plate 106 and a variable rheostat R, the adjustable tapping 107 of which is coupled to the baffle plate. The air flow meter LM cooperates with the electronic control device 101, which at its output supplies the injection pulses t_i.

The electronic control device 101 comprises two transistors which are in opposite operating condition to one another, and which to this end are in a crosswise feedback circuit with one another, together with an energy store which may be in the form of a capacitor, but may instead also take the form of an inductance. The duration of the discharge process of the energy store represents the opening period t_i of the injection valves. To this end the energy store has to be charged in a defined manner prior to each discharge process.

In order that the duration of discharge should contain directly the necesary information on the quantity of air required in the individual suction stroke, the charging takes place by means of a charging switch, represented in the embodiment shown in the form of a signal transmitter 98, which is actuated synchronously with the crankshaft revolutions and which causes the energy store during the charging pulses LJ, extending over a specified constant angle of rotation of the crankshaft, to be connected to a charging source, which during these charging pulses supplies a charging current. In the present case it is assumed that the signal transmitter 98, which in the practical realization may consist of a bistable multivibrator, tripped each time by the ignition pulses into the opposite operating position, is closed over a crankshaft angle of 180°, and subsequently is open over the same angle of rotation.

To safeguard the air metering, or rather the engine combustion, at different geodetic altitudes a vacuum limiter, corresponding to the embodiment of Figures 1 or 2 is arranged in the by-pass about the throttle valve 105 formed by the ducts 9, 10.

Although the present invention has been illustrated above with reference to fuel injection systems, it will be understood that the invention is applicable to fuel supply systems not using fuel injection.

WHAT WE CLAIM IS:—

1. A fuel supply system for an internal combustion engine using ignition, the system entailing supply of the metered quantity of fuel to the induction pipe, and comprising

a vacuum limiter, a selectively controllable throttle valve installed in the induction pipe and a by-pass connecting the section of the induction pipe upstream and downstream of the throttle valve, the cross-section of which by-pass can be varied by means of the vacuum limiter, the vacuum limiter comprising a control valve for controlling the variation of the by-pass cross-section and a pressure-dependent controlling element which responds to the vacuum prevailing in the induction pipe section downstream of the throttle valve when the vehicle is overrunning the engine to actuate the control valve; wherein the pressure-dependent controlling element is formed by a pressure box, namely, a hollow box having walls which are resiliently deflectable according to the pressure of differential between the inside and outside of the box, the pressure box along with the control valve is housed in the chamber of an advance control box, and the by-pass is in the form of a by-pass control box comprising a valve to vary the by-pass cross-section in response to actuation of said control valve.

2. A fuel supply system in accordance with claim 1, wherein the housing of the by-pass control box is subdivided by a membrane into two chambers, the first chamber of which is connected via a first duct to the induction pipe section upstream and via a second to the induction pipe section downstream of the throttle valve, and the second duct being closable by a movable valve component of the by-pass valve supported against the membrane, and the second chamber of which is connected on the one hand via a throttle to the first chamber and on the other hand via the control valve to the advance control box and houses a compression spring which acts upon the membrane in the direction of closing of the movable valve component.

3. A fuel-supply system in accordance with claim 2, wherein the control valve comprises a rod-shaped closing member, one end of which is in the form of a truncated cone and co-operates with a fixed valve seat and the other end of which has a spherical form, and wherein the spherical end of the closing member cooperates with a disc on which a spring engages to bias the closing member in the direction of closing of the control valve.

4. A fuel-supply system in accordance with claim 3, wherein the spring, the perforated disc and the closing member of the control valve are axially enclosed by a bushing.

5. A fuel supply system in accordance with claim 4, wherein the spherical end of the closing member projects in the direction towards the pressure box from the bushing.

6. A vacuum limiter in accordance with claim 5 wherein the pressure box has on its side facing the control valve a disc which co-operates with the spherical end of the control valve closing member.

7. A fuel supply system in accordance with claim 6, wherein in response to the event that a vacuum arises in the induction pipe section downstream of the throttle valve characterizing the condition in which the vehicle is overrunning the engine, the closing member of the control valve is movable by the pressure box in the direction of the opening of the control valve.

8. A fuel supply system in accordance with claim 7, wherein in response to a leakage of the barometer box, the disc thereof is pressed by the pressure box against the bushing.

9. A fuel supply system in accordance with any of the preceding claims, wherein the position of the pressure box in the advance control box in relation to the control valve can be adjusted by means of a screw.

10. A fuel supply system in accordance with claim 4 or any of preceding claims 5 to 9 as dependent on claim 6, wherein the spring of the control valve is mounted with its axis inclined to that of the closing member so that the perforated disc is biassed against the inner wall of the bushing.

11. A fuel supply system in accordance with any of the preceding claims, wherein the advance control box and the second chamber of the by-pass control box are connected via a connecting tube.

12. A fuel supply system in accordance with any of the preceding claims, wherein an audible-warning device is arranged in the advance control box which responds in the event of excessive vacuum in the condition when the vehicle overruns the engine.

13. A fuel supply system in accordance with claim 1, wherein the housing of the by-pass control box is subdivided by a membrane into two chambers, the first chamber of which is connected via a first duct to the induction pipe section upstream and via a second duct to the induction pipe section downstream of the throttle valve, the second duct being closable by a movable valve component supported against the membrane via a pressure pin, and the first chamber is divided by a partition to form an intermediate chamber between the partition and the membrane, which intermediate chamber is connected via a throttle to the first chamber and via the control valve to the induction pipe section downstream of the throttle valve, and the second chamber houses a compression spring which together with the induction pipe pressure downstream of the throttle valve acts upon the membrane in the direction of closing of the

movable valve component.

14. A fuel supply system in accordance with claim 13, wherein a duct from the induction pipe section downstream of the throttle valve to the chamber of the advance control box can be closed by a movable valve component of the control valve connected to the pressure box.

15. A fuel supply system in accordance with claim 14, wherein the advance control box and the intermediaite chamber of the by-pass control box are connected via a connecting tube.

16. A fuel supply system for a fuel injection system, comprising a vacuum limiter substantially as hereinbefore described with reference to Figure 1 or to Figure 2 of the accompanying drawings.

17. A fuel injection system substantially as hereinbefore described with reference to Figure 3 or to Figure 4 of the accompanying drawings.

W. P. THOMPSON & CO.,
Coopers Building,
Church Street,
Liverpool L1 3AB.

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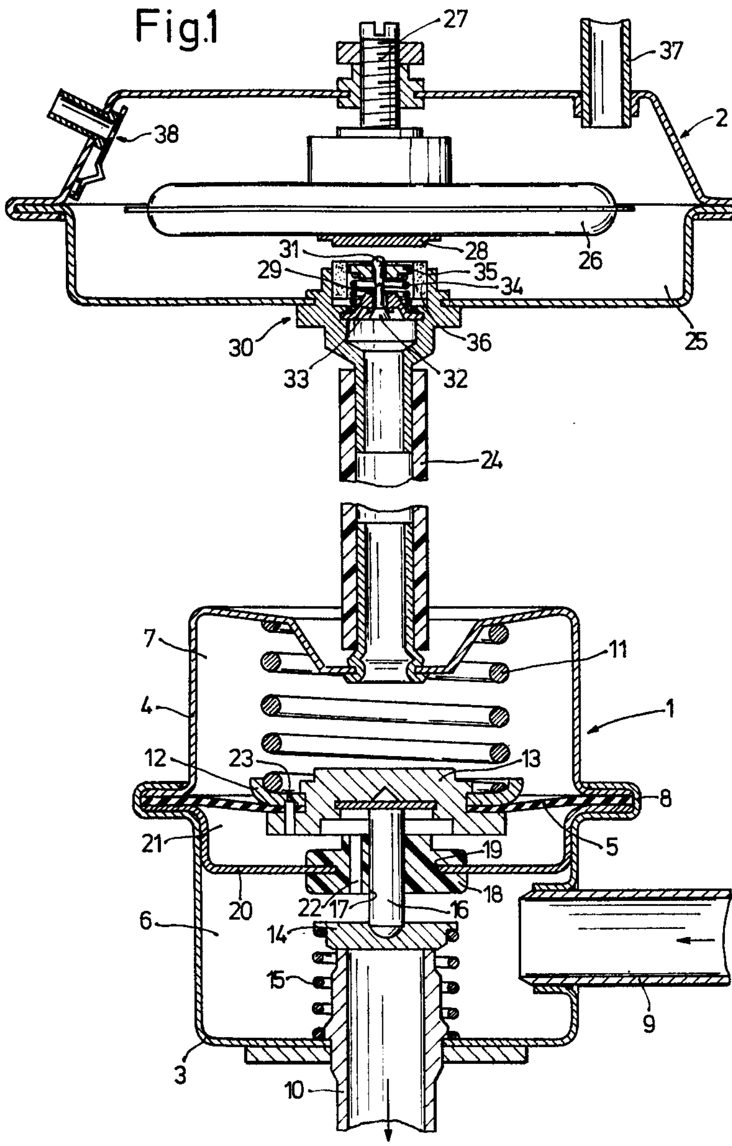
1560334 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig.1



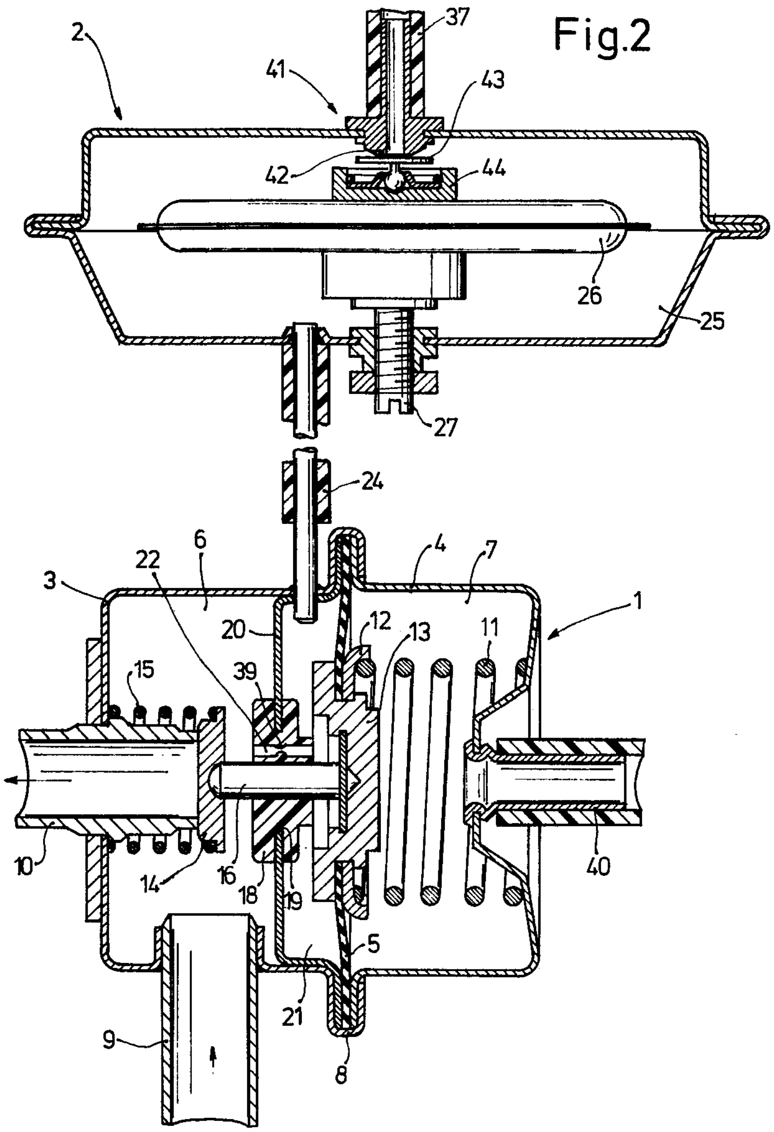

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Fig.2

Fig.4

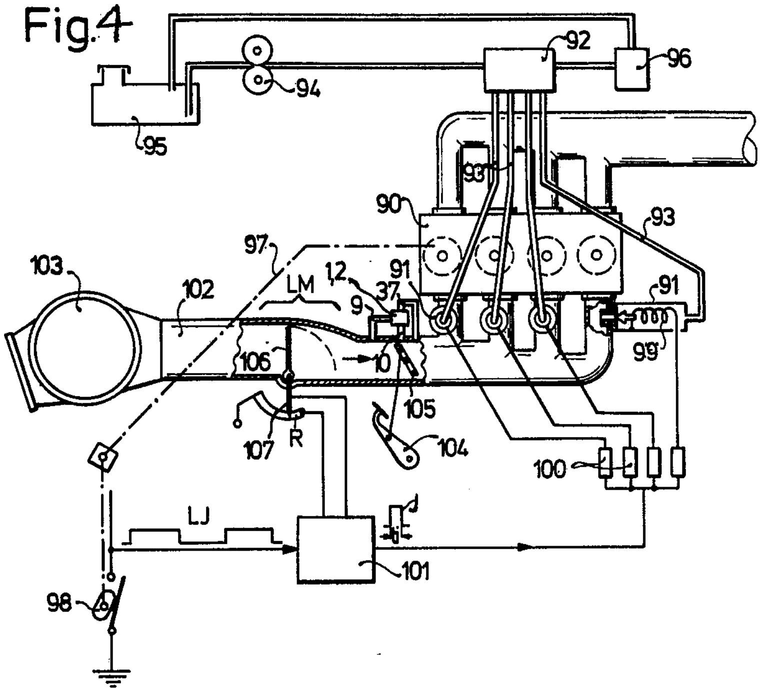
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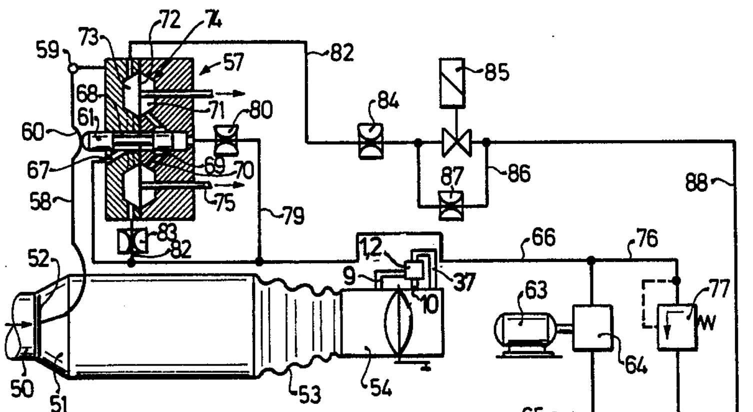
Fig.3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