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(19)

(11) Publication number: **0 397 897 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 89108690.2

(51) Int. Cl.5: F02M 69/00

(22) Date of filing: 13.05.89

(43) Date of publication of application: 22.11.90 Bulletin 90/47

(84) Designated Contracting States: DE FR GB IT

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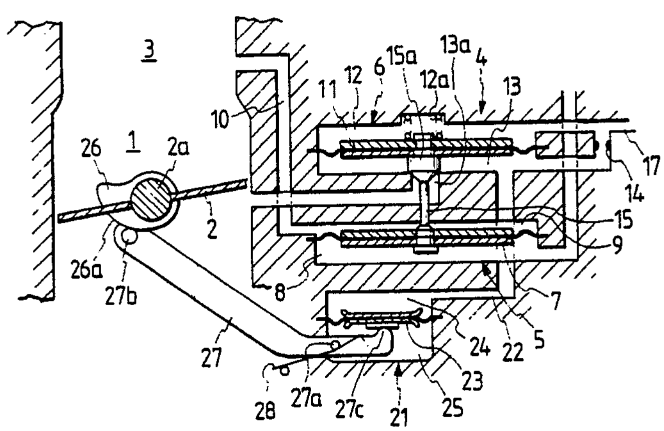
(54) Fuel injection system for injection carburetors.

(57) The fuel injection system for injection carburetors comprises an air section of regulator (5) including a depression chamber (9) and an atmosphere chamber (8) separated from each other by a first diaphragm (7), a fuel section of regulator (6) including a fuel pressure chamber (12) and a fuel injection chamber (13) separated from each other by a second diaphragm (11), a fuel jet (14) communicating the fuel pressure chamber (12) and the fuel injection chamber (13) with each other, a connecting member (15) connected between the first (7) and second diaphragms (11) and equipped with a fuel injection valve (15a) capable of opening and closing a fuel injection port (13a), an acceleration chamber (21) including an auxiliary fuel chamber (24) and an atmosphere chamber (25) separated from each other by a third diaphragm (23), said auxiliary fuel chamber (24) being communicated with said fuel injection chamber (13), and a link (27) or an electromagnetic plunger (31) for increasing and decreasing the volume of the auxiliary fuel chamber (24) in accordance with increase or decrease of opening degree of a throttle valve (2). This fuel injection system is capable of adequately preventing air-fuel ratio of the mixture from being varied in the transient conditions at abrupt acceleration time and abrupt deceleration time by eliminating the mixture lean phenomenon at the acceleration time and mixture rich phenomenon at the deceleration time.

FIG. 3



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Fuel Injection System for Injection Carburetors

The present invention relates to a fuel injection system for injection carburetors adapted to control fuel injection rate on the basis of negative pressure produced depending on flow rate of air to be sucked into the suction tube.

A fuel injection system of this type has already been proposed by the inventor et al. of the present invention. This fuel injection system will be described below with reference to Fig. 1. The reference numeral 1 represents a suction tube and the reference numeral 2 designates a throttle valve arranged downstream a venturi 3 in the suction tube 1. The reference numeral 4 represents a fuel control unit consisting of an air section of regulator 5 and a fuel section of regulator 6. The reference numeral 7 represents a first diaphragm for dividing the air section of regulator into an atmosphere chamber 8 and a depression chamber 9, the reference numeral 10 designates a negative pressure passage designed as air flow rate metering means having an end communicated with the depression chamber 9 and the other end opened to the venturi 3 in the suction tube 1, the reference numeral 11 denotes a second diaphragm for dividing the fuel section of regulator 6 into a fuel pressure chamber 12 and a fuel injection chamber 13, the reference numeral 12a represents a spring arranged in the fuel pressure chamber 12 so as to urge the first diaphragm 11 toward the fuel injection chamber 13, the reference numeral 13a designates a fuel injection port arranged in the fuel injection chamber 13 so as to be opposed to the second diaphragm 11, the reference numeral 14 denotes a fuel jet arranged in parallel to the second diaphragm 11 and designed as fuel metering means communicating the fuel pressure chamber 12 with the fuel injection chamber 13, the reference numeral 15 represents a connecting member for connecting the first diaphragm 7 to the second diaphragm 11, and the reference numeral 15a represents a fuel injection valve which is formed integrally with the connecting member 15 and used for controlling fuel injection rate in cooperation with the fuel injection port 13a, said fuel injection valve 15a serving to close the fuel injection port 13a in the rest condition of engine where pressure in the atmosphere chamber 8 is balanced with that in the depression chamber 9 in the air section of regulator 5. The reference numeral 16 represents a fuel injection passage having an end communicated with the fuel injection port 13a and the other end opened to the suction tube 1 at a location downstream the throttle valve 2. When a negative pressure is introduced into the depression chamber 9 in the fuel control unit 4 having the structure described above, the first diaphragm 7 is displaced upward (toward the depression chamber 9), and the connecting member 15 and the second diaphragm 11 are also displaced upward. The reference numeral 17 represents a fuel passage for communicating a fuel tank 18 with the fuel pressure chamber 12, the reference symbol P represents a fuel pump arranged in the course of the fuel passage 17 for pressurizing and feeding fuel into the fuel pressure chamber 12, and the reference numeral 19 designates a regulator communicated with a fuel passage 17a branched at a location downstream the fuel pump P, said regulator 19 serving to adjust fuel pressure in the fuel passage 17 for controlling flow rate of the fuel flowing into the fuel pressure chamber 12 and return excessive fuel to the fuel tank 18 through a return passage 20.

When the throttle valve 2 is opened after starting the engine, an air flow is produced in the suction tube 1, a negative pressure produced in the venturi 3 is introduced into the depression chamber 9 of the fuel control unit 4 through the negative pressure passage 10, and the first diaphragm 7 is displaced upward. Then, the connecting member 15 is shifted upward to make the fuel injection valve 15a apart from the fuel injection port 13a, the fuel is ejected from the fuel injection chamber 13 into the suction tube 1 through the fuel injection passage 16 and the second diaphragm 11 is also displaced upward. Owing to this upward displacement of the connecting member 15 and since the pressurized fuel is fed into the fuel pressure chamber 12, the fuel is supplied, while being metered, from the fuel pressure chamber 12 into the fuel injection chamber 13 through the fuel jet 14. Since difference in the fuel pressure is minimized between the fuel pressure chamber 12 and the fuel injection chamber 13 by the supply of the fuel described above, a force is applied in the direction to close the fuel injection port 13a and the fuel injection valve 15 is stopped at a position where the pressure applied to the first diaphragm 7 is balanced with that applied to the second diaphragm 11. Opening degree of the fuel injection port 13a varies in accordance with increase or decrease of the negative pressure and fuel injection rate is increased or decreased accordingly. When the throttle valve 2 is opened rapidly for acceleration as illustrated in Fig. 2A in such a fuel injection system, the second diaphragm 11 is also diaplaced remarkably upward to abruptly increase the volume of the fuel injection chamber 13 (Fig. 2B), but a certain time is required until the fuel of the quantity corresponding to the increment of the volume of the fuel injection chamber 13 completes flowing into the fuel injection chamber 13 since the fuel introduced from the fuel pressure chamber 12 into the fuel injection chamber 13 passes through the fuel jet 14. For this reason, the increase of the fuel injection rate is retarded (Fig. 2D) as compared with the increase of the air flow rate (Fig. 2C), whereby the fuel to be ejected is temporarily insufficient in the quantity corresponding to the volume increased by the displacement of the second diaphragm 11 until the first and second diaphragms 7 and 11 are balanced with each other, and as a result, a mixture lean phenomenon takes place (Fig. 2E). Further, when the engine is abruptly decelerated, a mixture rich phenomenon takes place inversely to the acceleration time.

In view of the problem described above, it is a primary object of the present invention to provide a fuel injection system for injection carburetors adapted to be free form the mixture lean phenomenon at the acceleration time and the mixture rich phenomenon at the deceleration time, and capable of preventing air-fuel ratio of the mixture from being varied in the transient condition during abrupt acceleration or deceleration.

According to the present invention, this object is attained by equipping a fuel injection system with an air section of regulator comprising a depression chamber and an atmosphere chamber separated from each other by a first diaphragm, a fuel section of regulator comprising a fuel pressure chamber and a fuel injection chamber separated from each other by a second diaphragm and comprising a fuel jet communicating the fuel pressure chamber and fuel injection chamber with each other, a connecting member connected between the first diaphragm and the second diaphragm and having a fuel injection valve capable of opening and closing a fuel injection port, an acceleration fuel supply unit comprising an auxiliary fuel chamber and an atmosphere chamber separated from each other by a third diaphragm, said auxiliary fuel chamber being communicated with the fuel injection chamber, and interlock means for increasing or decreasing the volume of the auxiliary fuel chamber in accordance with increase or decrease of opening degree of a throttle valve.

In the fuel injection system according to the present invention, a fuel is fed from the auxiliary fuel chamber into the fuel injection chamber the moment the volume of the fuel injection chamber is increased due to increase of a negative pressure at the acceleration time, and the fuel is sucked from the fuel injection chamber into the auxiliary fuel chamber the moment the volume of the fuel injection chamber is decreased due to decrease of a negative pressure at the deceleration time. Accordingly, variation of air-fuel ratio of the mixture is prevented in the transient condition during acceleration or deceleration.

In a preferred formation of the present invention, the interlock means consist of a cam attached fixedly to the throttle shaft, and a lever having one end engaged with said cam and the other end engaged said third diaphragm.

In another preferred formation of the present invention, the interlock means consist of a potentiometer outputting an electrical signal of a level corresponding to opening degree of the throttle valve, an electromagnetic plunger or stepping motor capable of displacing the third diaphragm, and a control circuit capable of controlling duty ratio of the electromagnetic plunger or rotating angle of the stepping motor in accordance with the output from the potentiometer.

This and other objects as well as the features and advantages of the present invention will become apparent from the following detailed description of the preferred embodiments when taken in conjunction with the accompanying drawings.

Fig. 1 is a schematic sectional view illustrating the conventional fuel injection system for injection carburators;

Fig. 2A through Fig. 2E are curves illustrating the variations of the control variables during accelaration in the fuel injection system shown in Fig. 1;

Fig. 3 is a schematic sectional view illustrating Embodiment 1 of the fuel injection system for injection carburetors according to the present invention; and

Fig. 4 is a schamatic sectional view illustrating Embodiment 2 of the present invention.

Now, the Embodiment 1 of the present invention will be described below with reference to Fig. 3 wherein the members used in the conventional fuel injection system shown in Fig. 1 are representd by the same reference numerals, but detailed descriptions are omitted on these members.

In Fig. 3, the reference numeral 21 represents an acceleration chamber communicated with the fuel injection chamber 13 through a fuel feeding passage 22, the reference numeral 23 designates a diaphragm for dividing the interior of the acceleration chamber 21 into a fuel chamber 24 and an atomosphere chamber 25, the reference numeral 26 denotes a cam attached fixedly to a throttle valve shaft 2a, and the reference numeral 27 represents a link capable of swinging round a shaft 27a and equipped at one end with a pin 27b engaged with a cam surface 26a of the cam 26 and at the other end with a protrusion 27c engaged with the diaphragm 23 in the acceleration chamber 21. When the throttle valve 2 is opened, the pin 27b is pushed by the cam 26 to turn the link 27 counterclockwise and the protrusion 27c pushes the diaphragm 23 to decrease the volume of the fuel chamber 24. When the throttle valve 2 is closed, the link 27 turns clockwise to move downward the protrusion 27c which is pushing the diaphragm 23, whereby the diaphragm 23 diaplaces toward the atmosphere chamber 25 to increase the volume of the fuel chamber 24. Further, the link 27 is biased by a spring 28 so that the pin 27b is engaged with the cam surface 26a of the cam 26.

Now, functions of the above-described fuel injection system will be explained below.

When the throttle valve 2 is opened abruptly for acceleration, flow rate of the air passing through the venturi 3 increases rapidly and the negative pressure introduced into the depression chamber 9 through the nagative pressure passage 10 is enhanced, thereby displacing the first diaphragm 7 remarkable upward (toward the depression chamber 9). Then, the fuel injection valve 15a of the connecting member 15 separates rapidly from the fuel injection port 13a and the second diaphragm 11 displaces remarkably upward (toward the fuel pressure chamber 12), whereby the fuel to be injected becomes temporarily insufficient in the quantity corresponding to the volume increased by the displacement of the second diaphragm 11 and the pressure is lowered in the fuel injection chamber 13, but on the other hand, the cam surface 26a of the cam 26 pushes the pin 27b downward in accordance with the rotation of the throttle valve 2, the link 27 is rotated counterclockwise round the shaft 27a and the protrusion 27c displaces the diaphragm 23 in the acceleration chamber 21 upward (toward the fuel chamber 24), thereby decreasing the volume of the fuel chamber 24. Accordingly, the fuel in the fuel chamber 24 is fed into the fuel injection chamber 13 kept at a low pressure through the fuel passage 22. In this case, it is possible to eject the fuel through the fuel injection port 13a in the quantity corresponding to the air flow rate and balance the downward urging force applied to the second diaphragm with the upward urging force applied to the first diaphragm in a short time by preliminarily selecting such a shape of the cam 26 and such a lever ratio of the link 27 as to feed the fuel into the fuel injection chamber 13 in the volume corresponding to the increment of the volume caused by the displacement of the second diaphragm 11 for enhancing the pressure in the fuel injection chamber 13. Since the fuel injection rate is enhanced in the substantially same phase as that of the increase curve of the flow rate of the air flowing through the venturi 3 at the accleration time, the Embodiment 1 of the present invention can prevent the temporary variation of the air- fuel ratio of the mixture, i.e., the mixture lean phenomenon in the transient condition during acceleration. Further, when the throttle valve 2 is closed abruptly for deceleration, flow rate of the air flowing through the venturi 3 is rapidly decreased and the negative pressure in the depression chamber 9 is abruptly lowered, whereby the first diaphragm 7 displaces toward the atmosphere chamber 8, the fuel injection valve 15a moves in the direction to close the fuel injection port 13a and the second diaphragm 11 is displaced toward the fuel injection chamber 13 to enhance the pressure in the fuel injection chamber 13, but on the other hand, the pin 27b follows the variation of the cam surface 26a of the cam 26, under the urging force applied by the spring 28, in accordance with the rotation of the throttle valve 2 to turn the link 27 clockwise, and the protrusion 27c stops urging the diaphragm 23 in the acceleration chamber 26 to allow the diaphragm 23 to displace toward the atmosphere chamber 25, thereby increasing the volume of the fuel chamber 24. Then, from the fuel injection chamber 13 in which the pressure is enchanced, the fuel is fed into the fuel chamber 24 of the acceleration chamber 26, the fuel injection rate through the fuel injection port 13a is lowered in accordance with the decrease of the air flow rate in the suction tube 1, and the upward urging force applied to the second diaphragm 11 is balanced in a short time with the downward urging force applied to the first diaphragm 7. The Embodiment 1 of the present invention can prevent the temporary variation of air-fuel ratio of the mixture, i.e., the mixture rich phenomenon in the transient condition during deceleration as described above.

Though the interlock means for varying the volume of the fuel chamber 24 of the acceleration chamber 21 in conjunction with the opening or closing of the throttle valve 2 is composed mechanically of the cam 26 and the link 27 in the Embodiment 1 described above, it is possible to compose the interlock means of electrical means, for example, so as to vary the volume of the fuel chamber 24 by detecting motion of the throttle valve 2 and electrically controlling an electromagnetic plunger or a stepping motor. Fig. 4 illustrates the Embodiment 2 of the present invention wherein the volume of the fuel chamber 24 is varied by utilizing an electromagnetic plunger. In this drawing, the reference numeral 29 represents a potentiometer for detecting opening degree of the throttle valve 2 and the reference numeral 30 designates a control circuit for controlling operation of the electromagnetic plunger 31 with input from the potentiometer 29. When the throttle valve 2 is fully opened, a plunger 31a is raised for the maximum stroke by the electromagnetic plunger 31 which is energized by means of the potentiometer 29 and the control circuit 30, thereby displacing the diaphragm 23 fully upward. When the throttle valve 2 is closed completely, the plunger 31a is returned to the position shown in Fig. 4. In addition, in a case where a stepping motor is employed, it will be adequate to control operation of the stepping motor with output from the control circuit 30 by fixedly attaching a cam (like the cam 26 shown in Fig. 3) to be engaged with the diaphragm 23 to its rotor shaft.

Claims

1. A fuel injection system for injection carburetors comprising an air section of regulator including a depression chamber and an atmosphere chamber separated from each other by a first diaphragm, a fuel section of regulator including a fuel pressure chamber and a fuel injection chamber separated from each other by a second diaphragm and including a fuel jet communicating said fuel pressure chamber and said fuel injection chamber with each other, a connecting member connected between said first and second diaphragms and equipped with a fuel injection valve capable of opening and colsing a fuel injection port formed in said fuel injection chamber, an acceleration fuel supply unit including an auxiliary fuel chamber and an atmosphere chamber separated from each other by a third diaphragm, said auxiliary fuel chamber being communicated with said fuel injection chamber, and interlock means for increasing and decreasing volume of said auxiliary fuel chamber in accordance with increase and decrease of opening degree of a throttle valve.

2. A fule injection system for injection carburetors according to Claim 1 wherein said interlock means consist of a cam fixedly attached to a throttle valve shaft, and a lever member having an end engaged with said cam and the other end engaged with said third diaphragm.

3. A fuel injection system for injection carburetors according to Claim 1 wherein said interlock means consist of electrical means capable of outputting electrical signal of a magnitude in accordance with opening degree of the throttle valve, electomagnetic driving means capable of displacing said third diaphragm and a control circuit capable of controlling operation of said electromagnetic driving means in accordance with the output from said electrical means.

FIG. 1
PRIOR ART

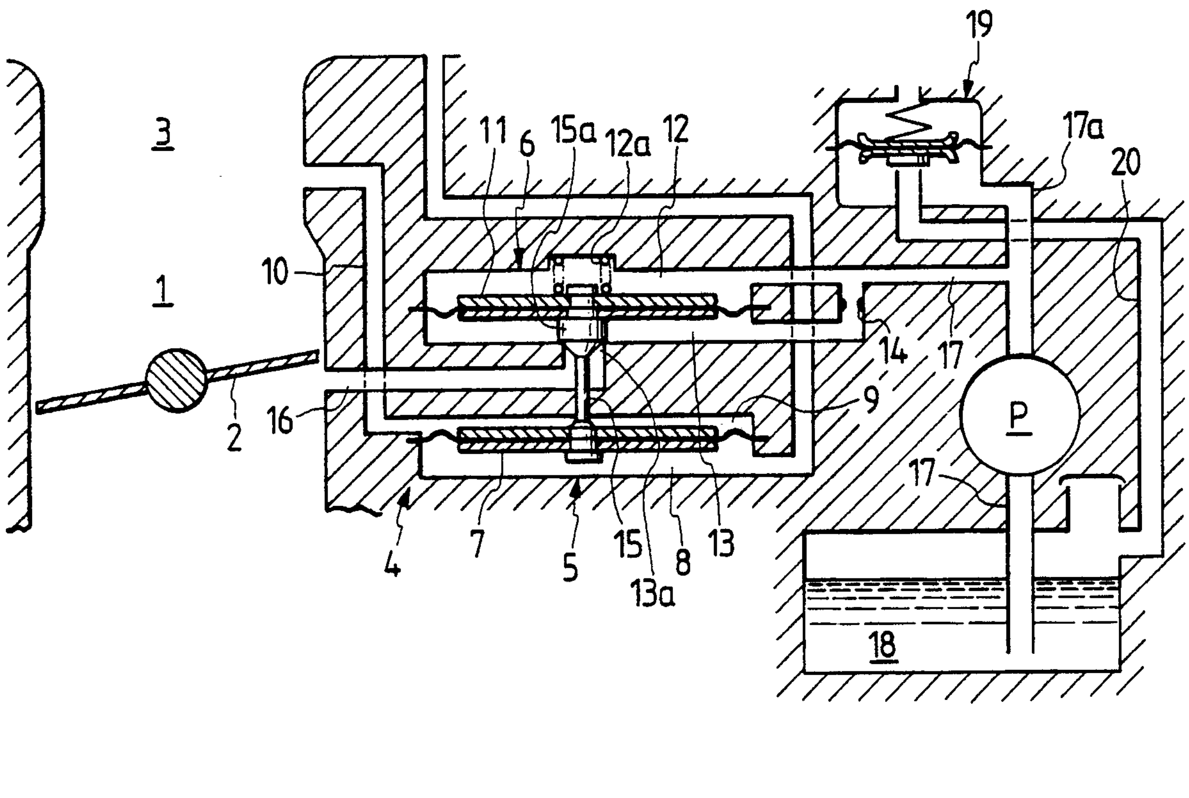

FIG. 2A

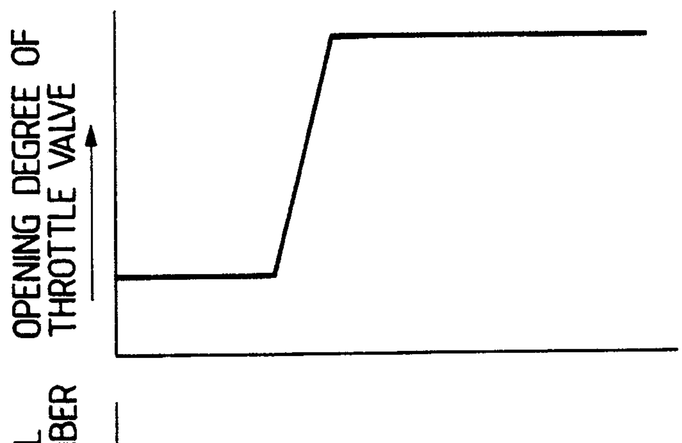

FIG. 2B

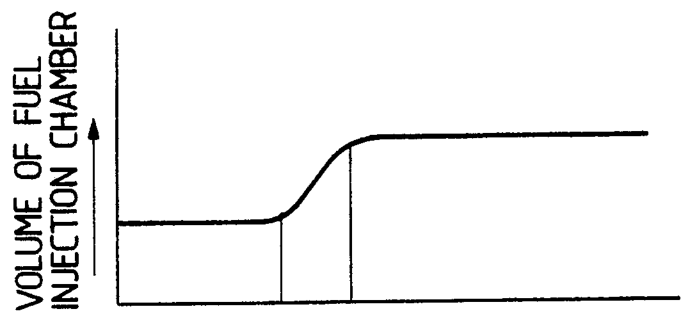

FIG. 2C

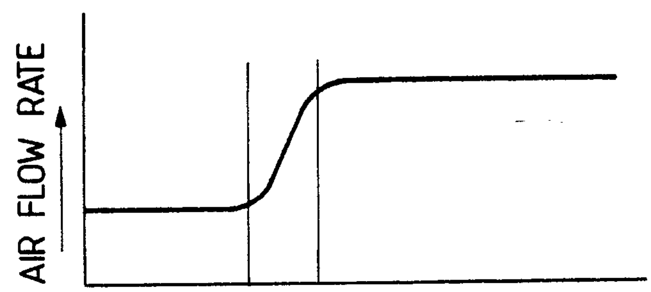

FIG. 2D

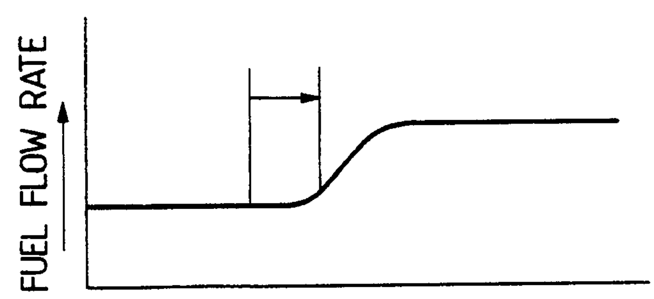

FIG. 2E

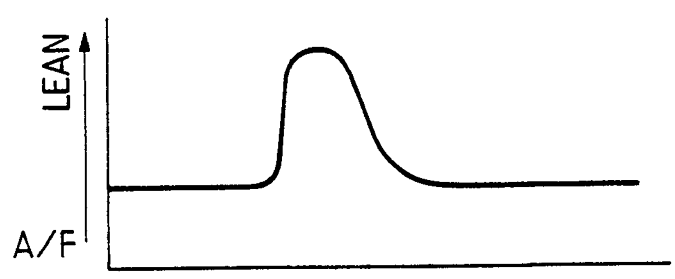

FIG. 3

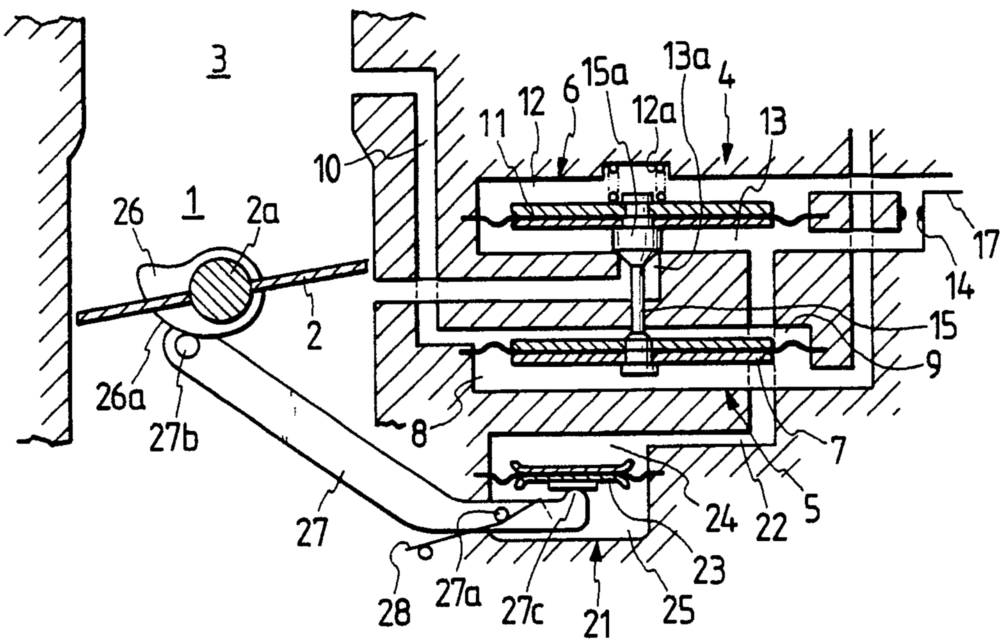
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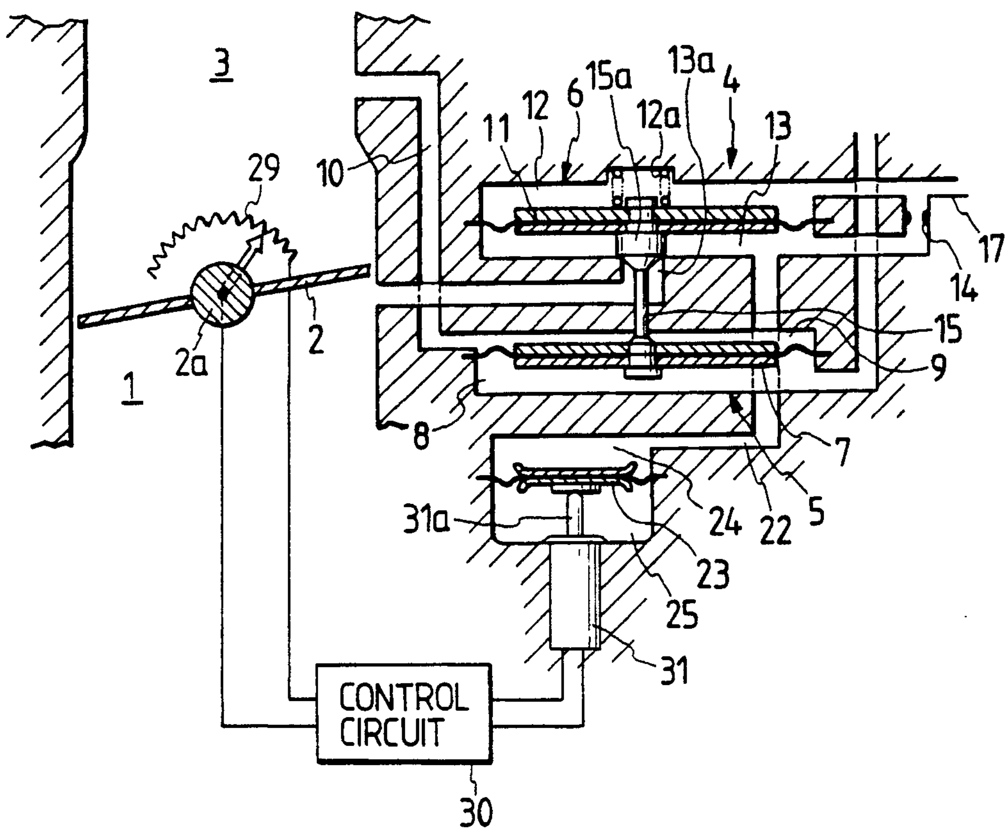
FIG. 4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CONTROL
CIRCUIT
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EUROPEAN SEARCH REPORT

Application Number

EP 89 10 8690

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	DE-A-1476227 (LOHNER) * page 7, lines 8 - 11; figure 1 *	1, 2	F02M69/00
A	US-A-2540735 (HUNT) * column 6, line 44 - column 7, line 18; figure 1 *	1, 2	
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 281 (M-520)(2337) 25 September 1986, & JP-A-61 101662 (NIPPON CARBURETER) 20 May 1986, * the whole document *	1, 2	
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 112 (M-215)(1257) 17 May 1983, & JP-A-58 32964 (MITSUBISHI DENKI) 26 February 1983, * the whole document *	1, 3	
A	US-A-3026860 (BALL) * column 8, line 57 - column 10, line 68; figures 8, 9 *	1, 2	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			F02M
A	US-A-3437081 (MENNESSON) * figures 16, 17 *	1, 2	
A	Charles H. Fischer: "Spark-Ignition Engines: Fuel Injection Systems" 1966, Chapman and Hall, London * page 128; figures 3-2 *	1	
A	US-A-2641237 (DESCHAMPS)		
A	US-A-2985160 (ARMSTRONG)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 DECEMBER 1989	ERNST J.L.

CATEGORY OF CITED DOCUMENTS

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