United States Patent

Miyaki et al.

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[45] **June 13, 1972**

[54] FUEL INJECTION APPARATUS TO COMPENSATE FOR TEMPERATURE AND PRESSURE VARIATIONS IN THE AMBIENT ATMOSPHERE

[72] Inventors: **Kiyoshi Miyaki**, Asaka; **Hiroshi Kogure**, Tokorozawa, both of Japan

[73] Assignee: **Handa Giken Kogyo Kabushiki Kaisha**, Tokyo, Japan

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[52] **U.S. Cl.**.....**123/140 MC**

[51] **Int. Cl.**.....**F02d 1/04**

[58] **Field of Search**.....123/119, 139, 140, 140 MC, 123/140 MD, 140 FG

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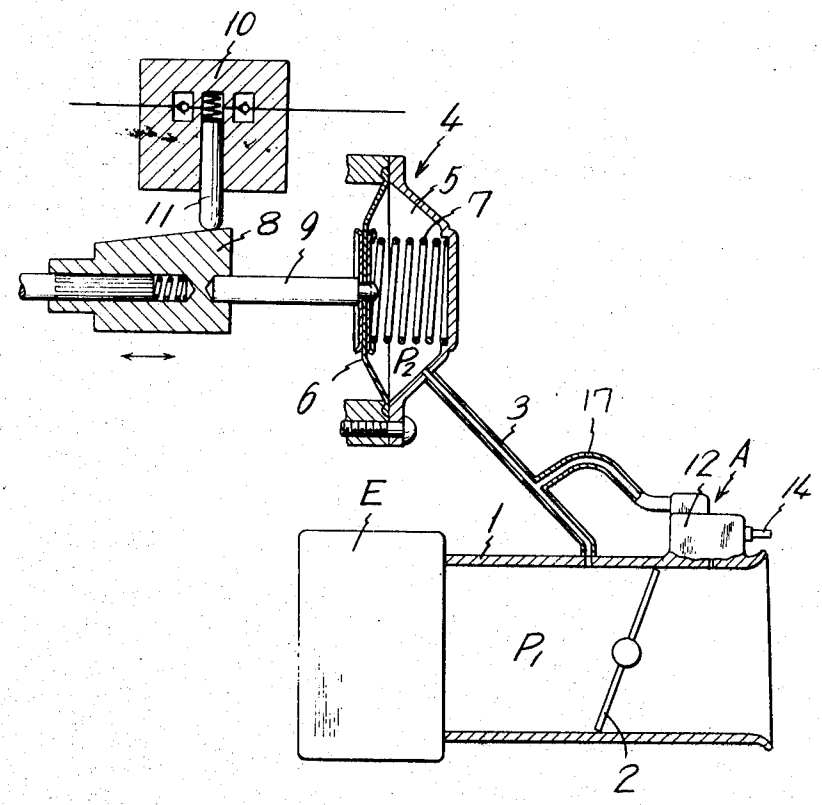
Primary Examiner—Laurence M. Goodridge

Attorney—Waters, Roditi, Schwartz & Nissen

[57] **ABSTRACT**

A fuel injection apparatus has a negative pressure chamber connected to a suction pipe behind a throttle valve for regulating the amount of fuel injected into the engine. In order to compensate for temperature and pressure variations of the ambient atmosphere and maintain the fuel-air ratio at an optimum value, a selected amount of ambient air is mixed with the suction air to control the magnitude of the negative pressure in the chamber. The amount of air is regulated by a valve controlled by a temperature sensitive member or a pressure sensitive member or both.

5 Claims, 7 Drawing Figures



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SHEET 1 OF 3

FIG. 1

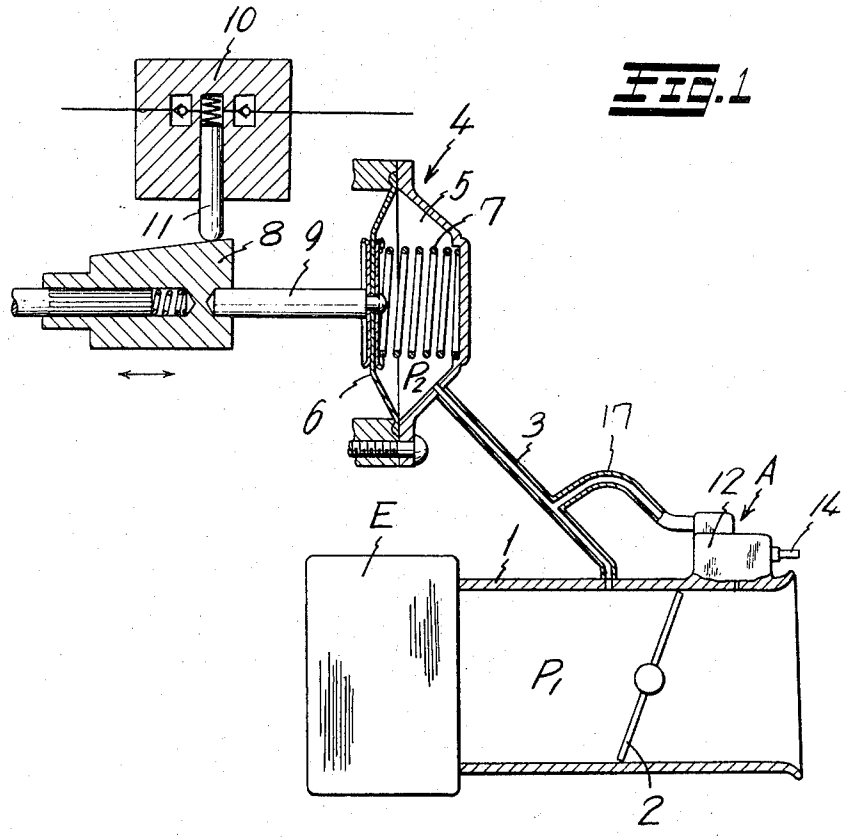
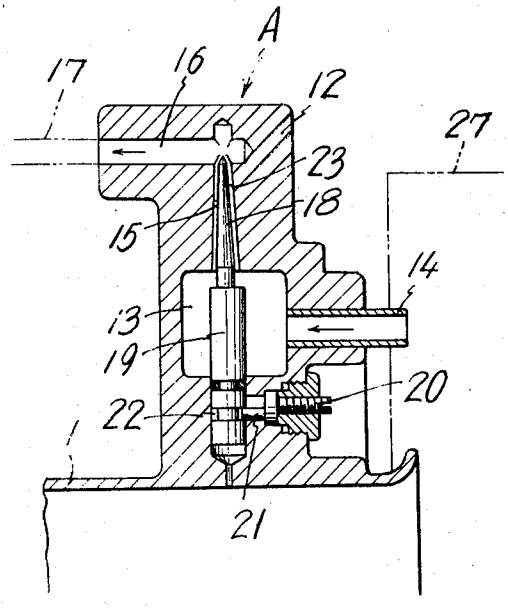


FIG. 2



INVENTOR
Kiyoshi Miyaki
BY Hiroshi Kogure

ATTORNEY

FIG. 3

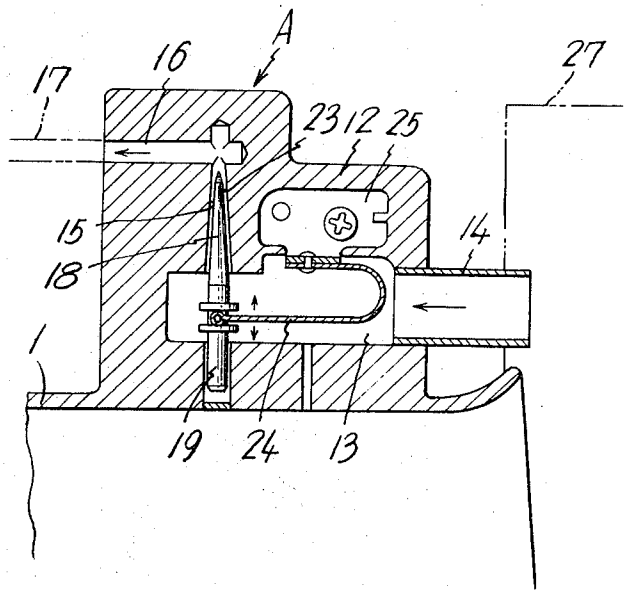
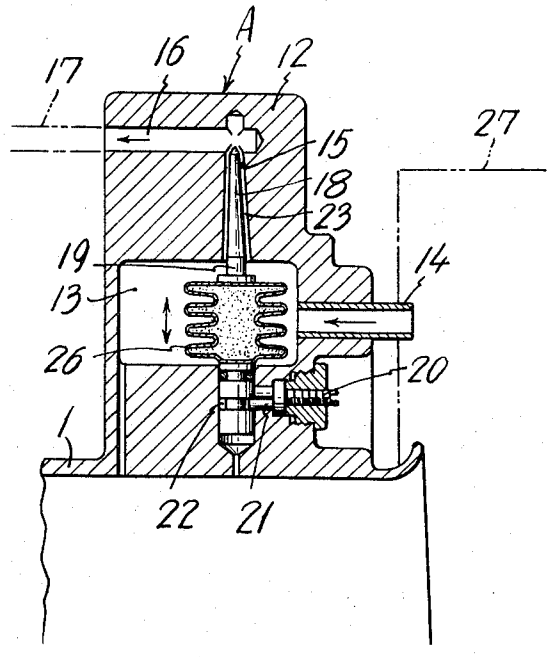


FIG. 4



INVENTOR
Kiyoshi Miyaki
BY Hiroshi Kogure

ATTORNEY

Fig. 5

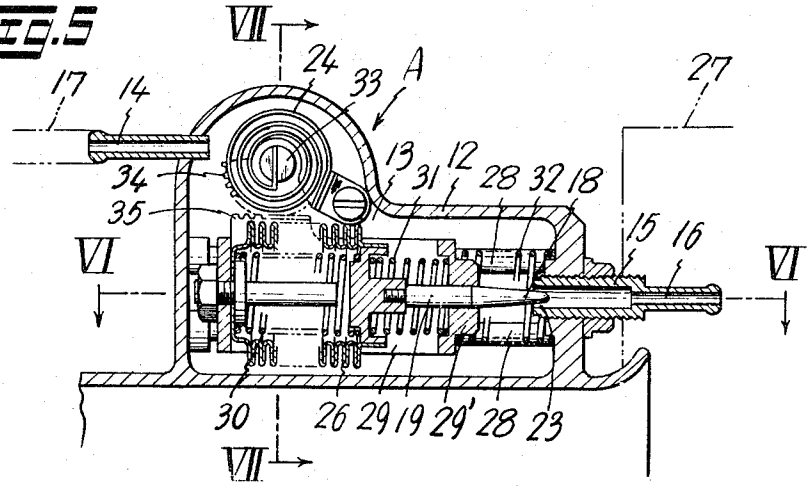


Fig. 6

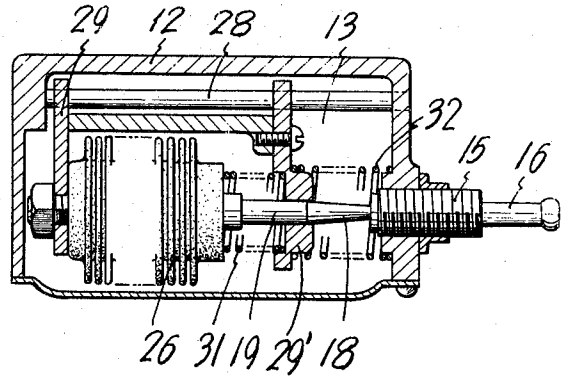
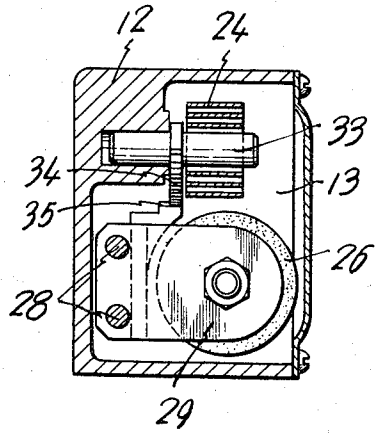


Fig. 7



INVENTOR
Kiyoshi Miyaki
BY Hiroshi Kogure

ATTORNEY

FUEL INJECTION APPARATUS TO COMPENSATE FOR TEMPERATURE AND PRESSURE VARIATIONS IN THE AMBIENT ATMOSPHERE

BRIEF SUMMARY OF THE INVENTION

This invention relates to a fuel injection compensation apparatus in a fuel injection type internal combustion engine.

The fuel injection apparatus is of the type in which the amount of fuel injected is controlled by the suction pressure produced in a suction pipe of the engine.

According to the invention the suction pressure acting on the fuel injection apparatus is compensated so that an optimum mixing ratio of air and fuel is always obtained.

It is conventional in a fuel injection type internal combustion engine to adjust the injection amount of fuel by operation of a control member of a fuel injection apparatus by a suction pressure created in the suction pipe of the engine. However, since the air varies in density with changes in temperature or pressure, the intake amount of air is increased or decreased with the change of atmospheric temperature and atmospheric pressure even if the negative pressure within the suction pipe is constant. Accordingly, it is impossible to always obtain an optimum air to fuel ratio when the control is effected merely by the negative pressure within the suction pipe.

An object of this invention is to provide fuel injection compensation apparatus in a fuel injection type internal combustion engine whereby the suction negative pressure acting on the fuel injection apparatus is compensated so that the optimum air to fuel ratio is always obtained.

Another object of this invention is to provide a compensation apparatus wherein the compensation of the foregoing negative pressure is effected by a temperature sensitive member or a pressure sensitive member or both so that the optimum ratio is automatically obtained.

According to the invention there are provided means establishing communication between ambient atmosphere and the negative pressure chamber of the fuel injection apparatus, and valve means for controlling the magnitude of ambient air which flows from the atmosphere to the negative pressure chamber.

The valve means can be controlled by a pressure sensitive member, or a temperature sensitive member or both so as to maintain an optimum air-fuel ratio irrespective of changes in ambient conditions.

BRIEF DESCRIPTION OF THE DRAWING:

FIG. 1 is a sectional view of fuel injection apparatus with the compensation apparatus according to the invention,

FIG. 2 is an enlarged sectional view of one embodiment of the compensation apparatus,

FIG. 3 is an enlarged sectional view of another embodiment thereof,

FIG. 4 is an enlarged sectional view of still another embodiment thereof,

FIG. 5 is an enlarged sectional view of a further embodiment thereof,

FIG. 6 is a sectional view taken along the line VI — VI in FIG. 5, and

FIG. 7 is a sectional view taken along the line VII — VII in FIG. 5.

DETAILED DESCRIPTION:

Referring to FIG. 1, the interior of a suction pipe I behind a throttle valve 2 communicates via a pipe 3 with a negative pressure chamber 5 of a fuel injection apparatus 4 so that the negative pressure within the suction pipe 1 acts on the interior of the negative pressure chamber 5 and, thereby, the fuel injection apparatus 4 is controlled. The construction of the fuel injection apparatus 4 will now be explained. One side wall of the negative pressure chamber 5 is formed by a diaphragm 6 and this diaphragm 6 is urged to its expanded condition by a spring 7 in compressed condition within the negative pressure chamber 5. An operation rod 9 of a control cam 8 is connected at its outer end to the center portion of the diaphragm 6 and a control rod 11 of an injection pump 10 interposed between a fuel tank and an injection nozzle is in contact with the periphery of the control cam 8, so that the amount of fuel injection of the injection pump 10 is controlled by the control cam 8 which is moved forward and backward by the operation of the diaphragm 6.

In FIG. 1, the amount of fuel injection can be increased if the control cam 8 is moved to the left but is decreased if moved to the right. Accordingly, when the engine E is operated, the change of the negative pressure within the suction pipe 1 which is a function of the operating condition of the engine acts on the interior of the negative pressure chamber 5 through the pipe 3, whereby the control cam is moved forward and backward and the amount of fuel injection of the injection pump 10 is controlled. The amount of the air taken into the suction pipe by the suction negative pressure varies with atmospheric temperature and atmospheric pressure and even if the suction negative pressure is constant, it is impossible to always obtain the proper mixing ratio by the control responsive to the suction negative pressure alone.

According to this invention, there is provided, as shown in FIG. 1, an injection fuel compensation apparatus A for compensating the above variations in temperature or pressure. FIG. 2 shows one embodiment of the injection fuel compensation apparatus A, wherein a valve chamber 13 is formed within a valve casing 12 provided on the suction pipe 1, and the valve chamber 13 is in communication with atmospheric air through a conduit 14 and is also in communication, through a valve guide 15 and a passage 16, with a leak pipe 17 branching from the pipe 3. A valve rod 19 having an integrally formed leak valve 18 is mounted in the valve guide 15 so as to be slidable up and down, and an adjusting screw 20 is in threaded engagement with one side wall of the valve casing 12 so as to be operable from the exterior, the screw 20 carrying an eccentric pin 21 at the front end thereof in engagement in a groove 22 in the valve rod 19. Accordingly, it is possible by rotating the adjusting screw 20 to move the valve rod 19 up and down and adjust the size of the space 23 between the leak valve 18 and the valve guide 15. External air can be led into the negative pressure chamber 5 through the conduit 14, the valve chamber 13, the space 23, the passage 16 and the leak pipe 17, whereby the negative pressure P_2 within the negative pressure chamber 5 becomes smaller than the negative pressure P_1 within the suction pipe 1, and the difference between the two pressure P_1 and P_2 is determined by the size of the space 23 which is a function of the up and down movement of the valve rod 19. If, accordingly, for instance, in a cold region where the fuel-air mixture may be too lean, the intake amount of the external air into the negative pressure chamber 5 is increased by lowering the valve rod 19 and, thereby, the difference between the negative pressure P_1 and P_2 within the suction pipe 1 and the negative pressure chamber 5, respectively, is increased and the diaphragm 6 in FIG. 1 is expanded to move the control cam 8 to the left and thus increase the amount of fuel injection. On the contrary, for instance, in a warm region where the fuel-air mixture may become too rich, the intake of the external air into the negative pressure chamber 5 is decreased or cut off by elevating the valve rod 19, whereby the amount of fuel injection is decreased.

In the modified arrangement as shown in FIG. 3, the amount of air supplied to the negative pressure chamber 5 is automatically adjusted by a temperature sensitive member. Namely, a temperature sensitive member such as a bimetallic element 24 is housed in the valve chamber 13, and bimetallic element 24 is fixed at one end to the valve casing 12 through a holder 25 and at its free end to a portion of the valve rod 19. The bimetallic element 24 is in communication with the external air through the conduit 14, so that the rod 19 is deflected upwards by a rise in atmospheric temperature and is deflected downwards by a fall in atmospheric temperature. If, accordingly, the atmospheric temperature rises as in a warm re-

gion, the valve rod **19** is elevated and the space **23** between the leak valve **18** and the valve guide **15** is decreased or closed and thus the intake of external air into the negative pressure chamber **5** is decreased or eliminated, whereby the amount of fuel injection is decreased. If the atmospheric temperature falls as in a cold region, the foregoing space **23** is increased and, thereby, the amount of fuel injection is increased.

A modified embodiment is shown in FIG. **4** in which the amount of atmospheric air supplied to the negative pressure chamber **5** is automatically adjusted by a pressure sensitive member. Namely, in this modification, a pressure sensitive member such as bellows **26** containing a compressible fluid, such as air, is interposed in the middle portion of the valve rod **19** and the bellows **26** is in communication with the external air through the conduit **14**. The bellows **26** is contracted by a rise in atmospheric pressure and is expanded by a reduction in atmospheric pressure. Accordingly, at a location close to sea level where the atmospheric pressure is high, the space **23** between the leak valve **18** and the valve guide **15** becomes large and the intake amount of external air into the negative pressure chamber **5** is increased to increase the amount of fuel injection. At higher elevations such in a mountainous region, where the atmospheric pressure is low, the space **23** is reduced or eliminated to decrease the amount of fuel injection. An adjusting screw **20** is provided for initial adjustment of the position of the valve rod **19**. Numeral **27** denotes an air filter.

A modified embodiment is shown in FIGS. **5** to **7** wherein the amount of atmospheric air supplied to the negative pressure chamber **5** is automatically adjusted both by a pressure sensitive member and a temperature sensitive member. In this modification, the valve chamber **13** within the valve casing **12** is in communication with the leak pipe **16** through the conduit **14** and with the external air through the valve guide **15** and the passage **16**. Horizontal guide rods **28** are provided within the valve chamber **13**, and a movable frame **29** is supported thereon so as to be slidable therealong. A pressure sensitive member such as bellows **26** is carried by the movable frame **29**. The interior of bellows **26** is under vacuum and contains a spring **30** therein, so that the bellows is contracted by a rise in atmospheric pressure and is expanded by a reduction in atmospheric pressure. The valve rod **19**, having the integrally formed leak valve **18** inserted in the valve guide **15**, is attached to one end of the bellows **26** and is supported by an end wall **29'** of the movable frame **29**, and adjusting springs **31** and **32** are interposed between the bellows **26** and the end wall **29'** and the end wall **29'** and the valve casing **12**, respectively. Thus, the valve rod **19** is moved forward and backward by the contraction and expansion of the bellows **26** and, thereby, the space **23** between the leak valve **18** and the valve guide **15** can be adjusted. A supporting shaft **33** is rotatably supported by the valve casing **12** on one side of the movable frame **29**, and a temperature sensitive member such as a bimetallic element **24** is attached at its outer end to the valve casing **12** and is attached at its base end to supporting shaft **33**. A sector gear **34** is also attached to shaft **33**. The sector gear **34** is in mesh with a rack **35** provided on the movable frame **29**. If the atmospheric temperature rises, the bimetallic element **24** is expanded to rotate the supporting shaft **33** counterclockwise in FIG. **5** and if the temperature lowers, the bimetallic element **24** is contracted to rotate the shaft **33** clockwise.

The operation of this embodiment is as follows.

Upon change of the pressure of the external air entering the valve chamber **13** through the valve guide **15**, the bellows **26** is expanded or contracted so that the valve rod **19** moves in relation to the movable frame **29** to adjust the size of the space **23**.

Upon change of the temperature of the external air, the bimetallic element **24** is expanded or contracted, so that the supporting shaft **33** is rotated and thereby the movable frame **29** is moved forward or backward along the guide rails **28** by virtue of the engagement between the sector gear **34** and the rack **27**. In view of the fact that the bellows **26** having the valve rod **19** is supported by the movable frame **29**, when the movable frame **29** is moved, the valve rod **19** moves along with the movable frame **29** and thus the size of the space **23** is adjusted. This embodiment may be modified so that bimetallic element **24** is carried by the movable frame **29** and the bellows **26** is supported by the valve casing **12** such that the movable frame **29** may be moved by this bellows **26**.

According to the invention, the suction pressure acting on the fuel injection apparatus can be freely controlled merely by adjusting the valve rod, so that any suitable air and fuel mixing ratio for any driving conditions desired by a driver can be freely selected. Additionally, according to this invention, the compensation of the suction pressure acting on the fuel injection apparatus can be automatically effected in response to atmospheric temperature, or atmospheric pressure or both thereof, so that an optimum air and fuel mixing ratio can be always obtained automatically in hot or cold regions or at sea level or at high elevations.

What is claimed is:

1. In an injection fuel compensation apparatus in a fuel injection type internal combustion engine wherein a suction pipe has an interior behind a throttle valve connected to a negative pressure chamber of a fuel injection apparatus via a pipe, an improvement comprising means providing communication between ambient atmosphere and the negative pressure chamber of the fuel injection apparatus, valve means for controlling flow of air from the ambient atmosphere to said negative pressure chamber, and means acting on said valve means in response to the pressure and temperature of the air flowing to said negative pressure chamber from the ambient atmosphere to regulate the flow of said air, the latter said means comprising a pressure sensitive member and a temperature sensitive member, said valve means comprising a displaceable valve member, and a slidable frame carrying the valve member, means connecting one of the sensitive members to the valve member for displacing the valve member with respect to the frame, means connecting the other sensitive member to the frame for displacing the frame and valve member therewith, a housing containing the valve means and the temperature and pressure sensitive members, said means which provides communication between the ambient atmosphere and the negative pressure comprising an inlet in the housing connected to ambient atmosphere, said valve member being inserted in said inlet to control flow from the ambient atmosphere into said housing, and an outlet conduit leading from the housing to the negative pressure chamber.

2. An apparatus as claimed in claim **1** wherein the temperature sensitive element comprises a bimetallic element.

3. An apparatus as claimed in claim **2** wherein said other sensitive member is the bimetallic element and the means connecting the bimetallic element and the frame comprises a rack and gear assembly.

4. An apparatus as claimed in claim **1** wherein said pressure sensitive member comprises a bellows coupled to the valve member to displace the same directly.

5. An apparatus as claimed in claim **4** wherein said one sensitive member is the bellows and the means connecting the bellows and the valve member comprises a rigid connection between said bellows and valve member.

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