United States Patent [19]

Knapp

[11] **3,727,598**

[45] **Apr. 17, 1973**

[54] **TEMPERATURE-RESPONSIVE SYSTEM FOR REGULATING THE FUEL MIXTURE IN AIR-COOLED INTERNAL COMBUSTION ENGINES**

[76] Inventor: **Heinrich Knapp,** Hummelbergweg 24, Leonberg-Silberberg, Germany

[22] Filed: **Sept. 28, 1970**

[21] Appl. No.: **76,036**

[30] **Foreign Application Priority Data**

Jan. 29, 1970 Germany ..... P 20 03 927.4

[52] **U.S. Cl.** ....**123/140 MC,** 123/140 R, 123/179 L, 123/179 G, 123/119 F

[51] **Int. Cl.** **F02d 1/04,** F02n 17/00

[58] **Field of Search** ..... 123/140 MC, 140 R, 123/140 EC, 179 L, 179 G, 119 F; 73/363.5, 363.1, 364, 362.6

[56] **References Cited**

UNITED STATES PATENTS

2,011,899	8/1935	Jorgensen	73/362.6
2,100,709	11/1937	Crone	73/362.6
1,703,235	2/1929	Heath	73/362.6
3,177,720	4/1965	Metheny	73/362.6
3,401,666	9/1968	Munroe	73/362.6
1,243,112	10/1917	Sandvoss	73/362.6
2,852,011	9/1958	Pringham	123/140 MC
2,881,748	4/1959	Foddy	123/140 MC
2,465,090	12/1960	Claire	123/179 L
3,004,123	10/1961	Cannon	73/363.1
3,107,532	10/1963	Lingnau	73/363.5
3,344,672	10/1967	Lingnau	73/363.5
3,577,978	5/1971	Gargea	123/140 MC

FOREIGN PATENTS OR APPLICATIONS

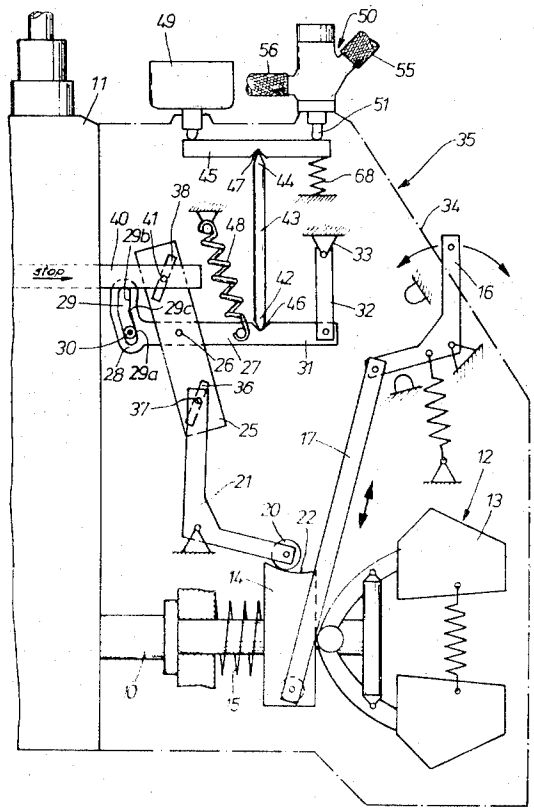
1,171,201	5/1964	Germany	123/140 MC

Primary Examiner—Laurence M. Goodridge
Assistant Examiner—Ronald B. Cox
Attorney—Edwin E. Greigg

[57] **ABSTRACT**

In the cooling circuit of an air-cooled internal combustion engine there is disposed a temperature responsive member which moves a lever connected to a fuel quantity control member of a fuel injection pump. The transmission of motion from said lever to said control member is affected by a contoured control edge or cam track provided in the former.

3 Claims, 3 Drawing Figures

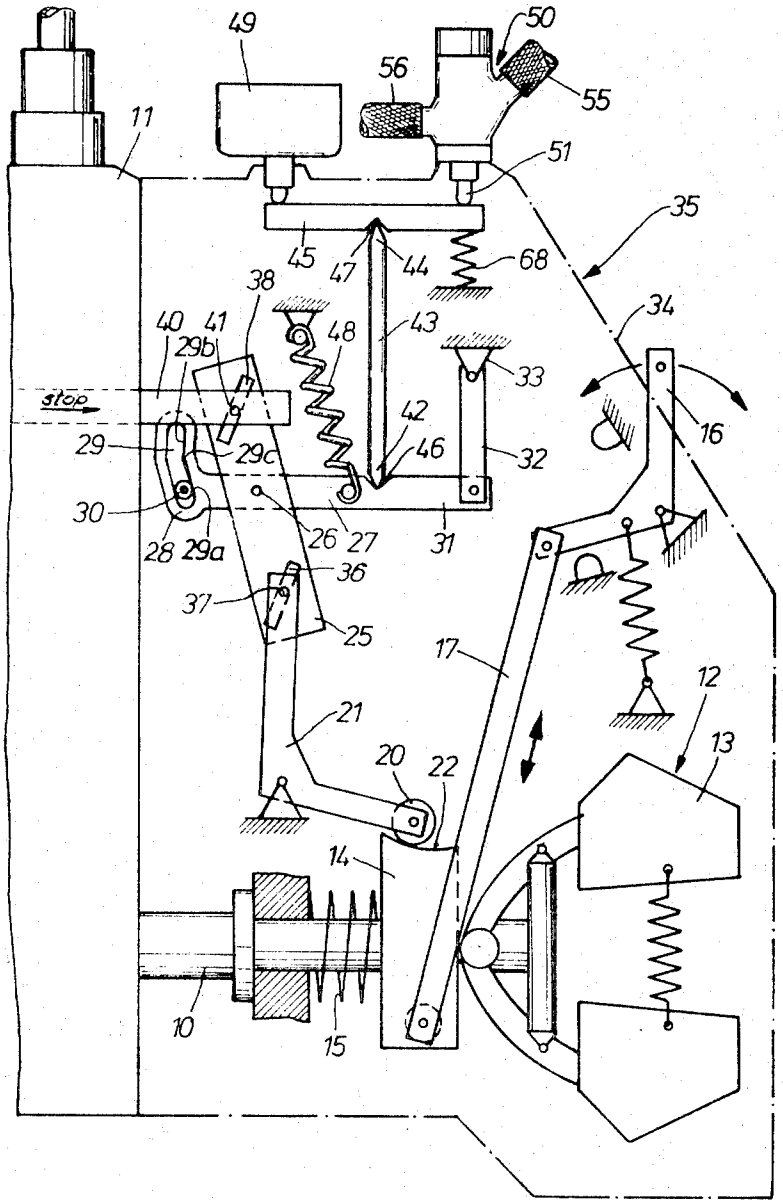


PATENTED APR 17 1973

3,727,598

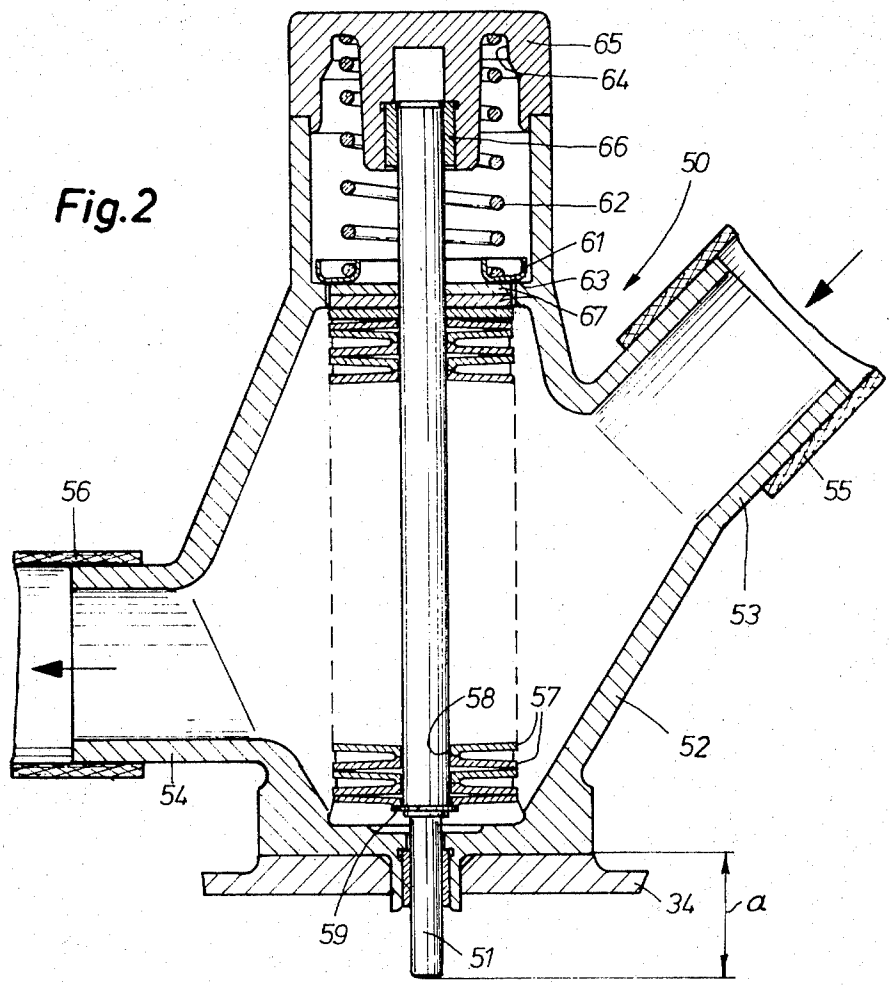
SHEET 1 OF 2

Fig. 1



INVENTOR.
Heinrich Knapp
BY
Edwin E. Greigg

Fig.2



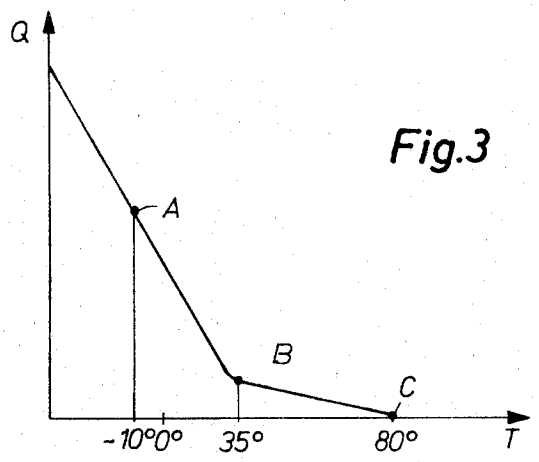


Fig.3

TEMPERATURE-RESPONSIVE SYSTEM FOR REGULATING THE FUEL MIXTURE IN AIR-COOLED INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The invention relates to a regulating system for controlling the air-fuel mixture in externally ignited internal combustion engines. The system is of the type that includes a preferably rpm-dependent setting member, the setting motions of which may be transmitted by means of a first and a second intermediate lever to a fuel quantity control member. The pivotal point of the second intermediate lever is disposed on a correcting lever which is provided with a contoured edge and which is engaged by setting members movable dependent upon operational magnitudes of the engine. One of the last-named setting members is a temperature sensor responsive to the temperature of the engine coolant.

In regulating systems of the afore-outlined type it is required that, in addition to other operational magnitudes, the intake air temperature and the cylinder head temperature of the engine also be taken into account for the formation of fuel mixture and it is further required to vary the quantities delivered by the fuel injection system of the engine as a function of the aforenoted temperatures.

In a known regulating system of the aforenoted type (as described, for example, in German Pat. No. 1,171,201), the temperature-dependent change of the delivered fuel quantities is controlled by a temperature sensitive member exposed to the circulating water coolant in a water-cooled engine. Such variations in the fuel quantity, however, serve only for correcting an engine operation in a hot condition, wherein the supplementary fuel quantities required for a satisfactory operation of a cold engine are continuously decreased up to a coolant temperature of approximately 35° C. Above this temperature, the delivered fuel quantities are no longer affected by the temperature sensitive member.

Since water-cooled engines are so-called temperature-stabilized engines, that is, the circulation of the water coolant is adjusted to the operational condition of the engine by control elements, the temperature of the cylinder head is substantially constant and the limit values regarding the harmful components of the exhaust gases (the so-called California test) may be maintained by an appropriate setting of the correcting members. The temperatures of the inlet channel and the cylinder head determining the formation of the fuel mixture, are thus well represented by the temperature of the water coolant.

In air-cooled engines which are not temperature-stabilized and in which the flow rate of cooling air is rpm-dependent, but not controlled, the temperature of the cylinder head depends very closely from the operational condition of the engine and from the temperature of the air. Thus, an exhaust gas composition which does not exceed maximum permissible values is difficult to obtain, particularly in city driving.

It has already been proposed to install in the wall of the cylinder head of the engine and in the suction tube, electric temperature sensors which generate control signals for the setting members. In fuel injection systems that have a mechanical regulating system, such a solution, however, is complex and expensive.

It has further been proposed to utilize the temperature of the engine oil for control purposes in a manner similar to the temperature of the water coolant. This, however, cannot be materialized in a satisfactory manner, since the oil reacts very sluggishly to temperature changes.

OBJECT AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved regulating system of the aforenoted type which in air-cooled, not temperature-stabilized engines adjusts the fuel quantities delivered by the fuel injection system during hot engine operation and adjoining operational ranges in such a manner to the temperatures of intake air and cylinder head that a very satisfactory engine operation is achieved and the limit values for the proportions of harmful components in the exhaust gas are not exceeded.

Briefly stated, according to the invention, there is provided a temperature sensing member which is formed preferably of a great number of heat expandable elements of large surface and which is exposed to at least one part of the cooling air heated by the engine cylinders of an air-cooled, not temperature-stabilized engine. Further, the contoured control edge of the correcting lever has a first, very steep portion for effecting correction of the injected fuel quantities during hot engine operation and a second, substantially flatter portion for the correction of the injected fuel quantities dependent from the operational temperature of the engine. It is particularly advantageous to use a single temperature sensing member.

The invention will be better understood as well as further objects and advantages of the invention will become more apparent from the ensuring detailed specification of a preferred, although exemplary embodiment taken in conjunction with the drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic view of a regulating system incorporating the invention;

FIG. 2 is an enlarged, axial sectional view of a part of FIG. 1, and

FIG. 3 is a diagram illustrating the values of the delivered fuel quantities v. temperature, as controlled by a regulating system according to FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Turning now to FIG. 1, to the drive shaft **10** of an only schematically indicated fuel injection pump **11** associated with an air-cooled not temperature-stabilized Otto-engine, there is mounted a centrifugal governor **12**, the weights **13** of which displace, in case of a change in the rpm, a three-dimensional cam **14** which is movable as an rpm-dependent setting member against the force of a spring **15**. The three-dimensional cam **14** may be rotated by an actuating arm **16** through linkage **17** in such a manner that, dependent upon the position of the actuating arm **16**, a different cam track of the cam face is aligned with a follower roller **20** carried by a bell crank-type first intermediate lever **21**. The actuating arm **16** is connected in a known manner (not shown) with the accelerator pedal and with the butterfly throttle of the engine.

Rpm-dependent linear displacements, as well as rotational motions (caused by actuating arm **16**) executed by the three-dimensional cam **14** result in a pivotal motion of the first intermediate lever **21** as a function of the shape of the momentary cam track **22** aligned with the follower roller **20**. The motion of lever **21** is transmitted to a second intermediate lever **25** which has a pivot pin **26** supported on a correcting lever **27**. The latter carries at one end **28** a contoured control edge **29**. The latter slides, during motions of the correcting lever **27**, along a pin **30** fixedly attached to a schematically indicated housing **34** of the regulating system **35**. The other end **31** of the correcting lever **27** is articulatedly connected by means of a shackle **32** to a bracket **33** rigidly secured to housing **34**.

The second intermediate lever **25** has, at one end, a slot **36** into which extends a pin **37** of the first intermediate lever **21**. At its other end, the lever **21** has a second slot **38** in which there is guided a pin **41** fixedly secured to a fuel quantity control member **40** of the fuel injection pump **11**. Thus, motions of the bell crank lever **21** or the pin **26** of the second intermediate lever **25** are transmitted to the fuel quantity control member **40**.

A pressure bar **43** engages the one end **42** the correcting lever **27** between the pivot **26** and the shackle **32**, while the other end **44** of the pressure bar **43** is in contact with a lever **45**. The sharp ends **42** and **44** of the bar **43** are received in notches **46** and **47** provided, respectively, in the correcting lever **27** and in the lever **45**. The pressure bar **43** is maintained in its position by means of a tension spring **48** which, by virtue of its oblique position, simultaneously presses the contoured control edge **29** of the correcting lever **27** to the stationary pin **30** so that all play is eliminated. The lever **45** transmits the setting motion of two setting members **49** and **50** (responsive to operational magnitudes of the engine) to the pressure bar **43**, which, in turn, displaces the correcting lever **27** against the force of the spring **48** as soon as at least one of said operational magnitude varies.

The setting member **49** is a height correcting device and responds to the ambient air pressure surrounding the engine. The setting member **50** is a temperature sensing member which is affected by the temperature of the cooling air and the setting motions of which are transmitted by a rod **51** through the lever **45** and the pressure bar **43** to the correcting lever **27**.

Turning now to FIG. **2**, the temperature sensing member **50** comprises a housing **52** which is affixed to the housing **34** of the regulating system **35** and which has two coupling nipples **53** and **54**, constituting, respectively, an inlet and an outlet for the cooling air. One part of the cooling air that is heated by the engine cylinder and used for heating the passenger compartment of the vehicle, is branched off in a manner not shown and is directed, through a hose **55** and the coupling nipple **53**, to the temperature sensing member **50** and is taken out therefrom through the coupling nipple **54** and an adjoining hose **56**. Due to the fact that the engine is not temperature-stabilized, i.e., the flow rate of air is not regulated, but varies in an rpm-dependent manner according to the delivery characteristics of the fan, the temperature of the cooling air is a measure of the temperature of the engine cylinders. In order to sense the temperature variations of the cooling air in a sufficiently rapid manner even at low rpms and thus at low air flow rates, the temperature sensing member **50** has, as heat expandable elements, a series of disc-like bimetallic plates **57** arranged in pairs, the outer surface of which is exposed to the flow of the cooling air. The bimetallic plate pairs **57** have a central bore **58** by means of which they are inserted and thus stacked on the actuating rod **51**.

The actuating rod **51** is held in the housing **52** and has, at one end, a collar **59** formed by a snap ring on which the stack of plates **57** rests. As a second support for the plates **57**, there is provided a spring seat disc **61** which is pressed against a shoulder **63** of housing **52** by a take-up spring **62** forming a resilient abutment for the stack of plates **57**. The spring **62** is received in a cavity **64** of a cap **65** closing the housing **52**. The cap **65** further carries a bearing member **66** in which one end of the actuator rod **51** is received. Between the bimetal plate **57** that is disposed closest to the spring seat disc **61** and the latter there are inserted compensating discs **67** with the aid of which a basic position of the temperature sensing member **50** may be set. This position is characterized by the distance *a* which, in turn, represents the extent of protrusion of the actuating rod **51**. There is further provided a compression spring **68** (FIG. **1**) engaging the housing **34** and urging the lever **45** continuously against the temperature sensing member **50**.

Turning once again to FIG. **1**, the contoured control edge **29** is kinked and has a steep portion **29***a* and a flat portion **29***b*. Edge portion **29***a* controls the fuel quantities delivered to the engine in a cold condition of the engine up to a cooling air temperature of approximately 35° C. The edge portion **29***b* controls the operational range between temperatures of 35° and 80° C. The edge portion **29***b* terminates in a rigid stop (formed here as the end of a slot) for reasons to become clear as the specification progresses. During idling operation, the contoured control edge **29** effects a course of delivered fuel quantities as indicated in the diagram according to FIG. **3**. In this figure, the abscissa indicates the temperature T of the cooling air, whereas the ordinate is the fuel quantity Q expressed in mm^3/stroke. At −10° C, the fuel quantity delivered is A, whereas the kink point of the curve (at 35° C) is indicated at B, and the terminus of the control curve at 80° C is indicated at C. If the cooling air temperatures are over 80° C, the delivered fuel quantities are no longer affected by the temperature sensing member **50**.

OPERATION OF THE EMBODIMENT

The operation of the individual structural groups of the regulating system has already been described hereinabove and in the description that follows, emphasis is placed on the mode of operation of the temperature sensing member **50**. In the example described, the engine starts at low temperature. In order to simplify the operational description, it is further assumed that the actuating arm **16** is in an idling position.

In case of a cooling air (i.e., ambient air) temperature under 35° C, the correcting lever **27** is in a position as shown in FIG. **1**. This position corresponds, for example, in case of an air temperature T of −10° C to a fuel quantity A in FIG. **3**.

After starting the engine, the temperature of the cylinder head increases, and the cooling air is warmed accordingly. One part of the circulating cooling air is, through the flexible conduit **55**, directed to the inside of the housing **52** of the temperature sensing member **50**. By virtue of their large surface, the bimetallic plates **57** very rapidly assume themselves these higher temperatures; they expand, and pressing on the collar **59** of the actuating bar **51**, displace the same against the force of the spring **68**. The actuating rod **51** transmits its displacement to the lever **45** which, in turn, through the pressure bar **43**, exerts a force on the correcting lever **27**. As a result, the latter moves downward, whereby the contoured control edge **29** slides along the stationary camming pin **30**. At the same time, the pin **26** of the second intermediate lever **25** is displaced downwardly and to the right causing, through the pin **41**, the fuel quantity control rod **40** of the fuel injection pump **11** to be displaced in the direction of a smaller fuel quantity delivery. By virtue of the slots **36** and **38**, provided in the second intermediate lever **25**, the downward motion of the latter causes no change in the position of the fuel quantity control member **40**. Solely the slope of the control edge **29** is a measure for the change of the fuel quantity control member and thus the delivered fuel quantities.

Up to approximately 35° C, the correcting lever **27** follows the portion **29*a*** of the contoured control edge **29**. As the kink point **29*c*** reaches the pin **30**, the fuel quantity control rod **40** has been displaced to such an extent that the delivered fuel quantity Q corresponds to the magnitude B in FIG. **3**.

As the temperature of the cooling air further increases, the bimetallic plates **57** continue their approximately linear expansion, but, by virtue of the relatively flat portion **29*b*** of the contoured control edge **29**, the decrease of the delivered fuel quantities occurs at a smaller rate. Up to 80° C, the delivered fuel quantities Q follow the curve portion B – C of FIG. **3**. At 80° C, the contoured control edge **29** terminates and the pin **30** is stopped at the end of the portion **29*b***. The delivered fuel quantities at that point correspond to the magnitude C in FIG. **3**. Further temperature increases do not result in any further control motions since the bimetallic plates **57** now displace the spring seat disc **61** against the force of the take-up spring **62**. By virtue of its compression it is prevented that unpermissibly high forces are introduced into the regulating system.

It is thus seen that by means of the portion **29*a*** of the contoured control edge the hot engine run is controlled, while portion **29*b*** provides that at different temperatures of the cylinder head in the load range, the delivered fuel quantities are so adjusted that no unpermissibly high proportions of harmful pollutants will appear in the exhaust gases.

What is claimed is:

1. In a regulating system for controlling the fuel mixture delivered by a fuel injection system to an externally ignited, air-cooled internal combustion engine, said regulating system is of the type that includes (a) an rpm-responsive setting member, (b) a first intermediate lever to which the motions of said rpm-responsive setting member are transmitted, (c) a second intermediate lever connected to said first intermediate lever and to a fuel quantity control member to transmit thereto displacements of said rpm-responsive setting member and (d) a correcting lever to which said second intermediate lever is pivotally secured, the improvement comprising,

A. an expandable temperature sensing member constituting an additional setting member and disposed within the cooling circuit of said air-cooled engine to respond to the temperatures of the cooling air, said temperature sensing member having a first end and a second end,

B. rod means attached to said first end of said temperature sensing member, said rod means being displaced in a first direction by said temperature sensing member by virtue of its expansion caused by an increase in the temperature of said cooling air,

C. first spring means constituting a resilient abutment for said temperature sensing member and being in engagement with said second end thereof, said first spring means opposing the expansion of said temperature sensing member,

D. second spring means operatively connected to said rod means for urging the latter in a second direction opposite to said first direction; said second spring means being weaker than said first spring means for allowing said rod means to move in said first direction in response to the expansion of said temperature sensing member,

E. a contoured control edge provided on said correcting lever and having

1. a first, steep portion,
2. a second, relatively substantially flatter portion and
3. rigid stop means at the end of said second portion and

F. camming means cooperating with said contoured control edge for causing a relatively fast rate of motion of said correcting member and thus a relatively large rate of displacement of said fuel quantity control member while said camming means is in contact with said steep portion and for causing a relatively slow rate of motion of said correcting member and thus a relatively small rate of displacement of said fuel quantity control member while said camming means is in contact with said flatter portion, said camming means arriving into engagement with said rigid stop means when a certain state of expansion of said temperature sensing member is reached in response to a predetermined temperature; the engagement between said rigid stop means and said camming means preventing further movement of said rod means in said first direction in response to temperatures beyond said predetermined temperature, said first spring means undergoing compression beyond said predetermined temperature for taking up the forces generated by the expansion of said temperature sensing member subsequent to the engagement between said camming means and said rigid stop means.

2. An improvement as defined in claim **1**, wherein the transition of said camming means from said first portion of said contoured control edge to said second portion thereof occurs at a temperature of approximately 35° C of the cooling air.

3. An improvement as defined in claim 1, wherein said predetermined temperature is approximately 80° C.

* * * * *