Sept. 2, 1958 C. F. HIGH 2,849,998

FUEL INJECTION METERING CONTROL APPARATUS

Filed Sept. 7, 1954 2 Sheets-Sheet 1

FIG. 2

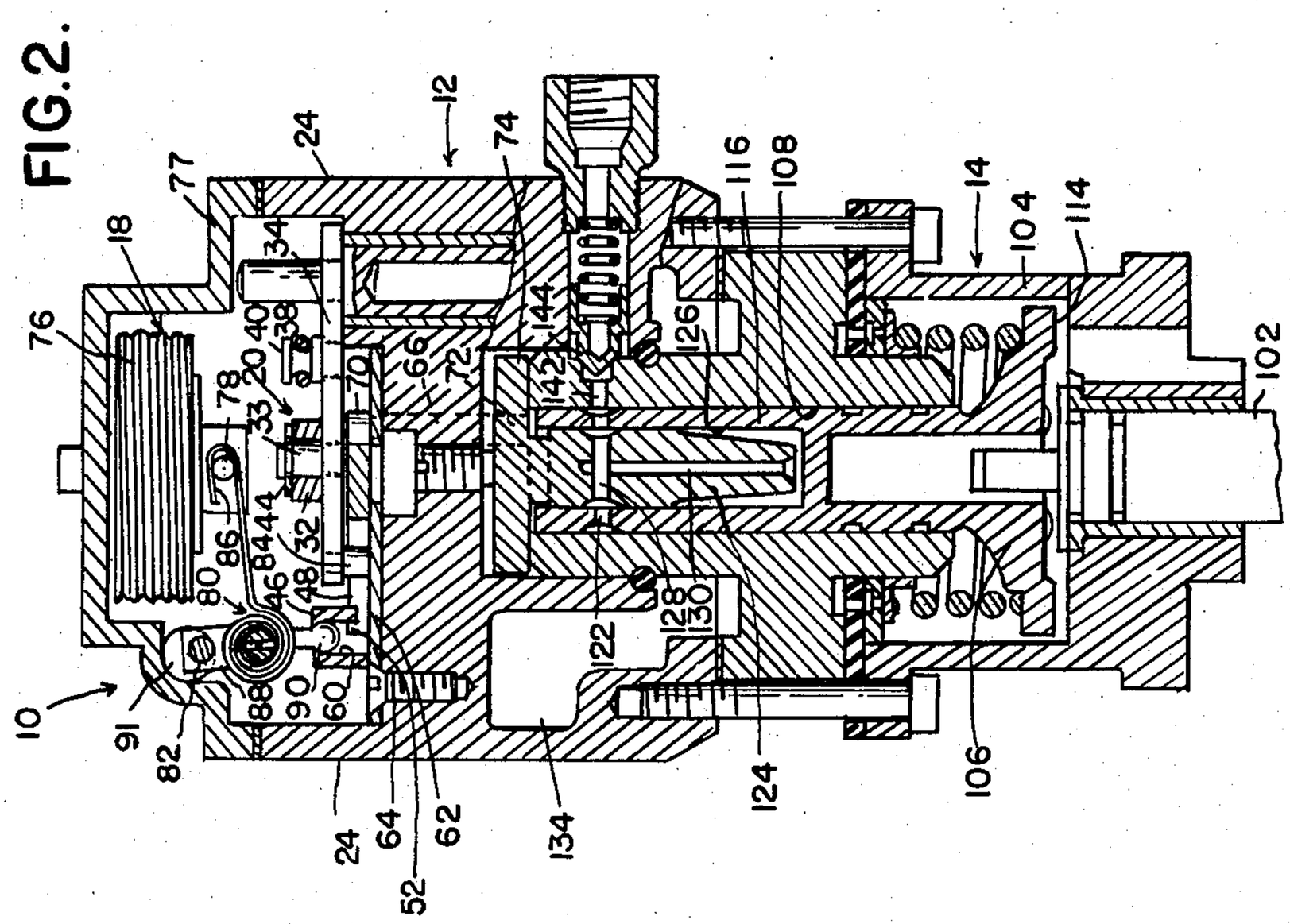


FIG. 1.

INVENTOR.

CARL F. HIGH

BY Parker & Handley

ATTORNEYS

Sept. 2, 1958 C. F. HIGH 2,849,998

FUEL INJECTION METERING CONTROL APPARATUS

Filed Sept. 7, 1954 2 Sheets-Sheet 2

FIG.3.

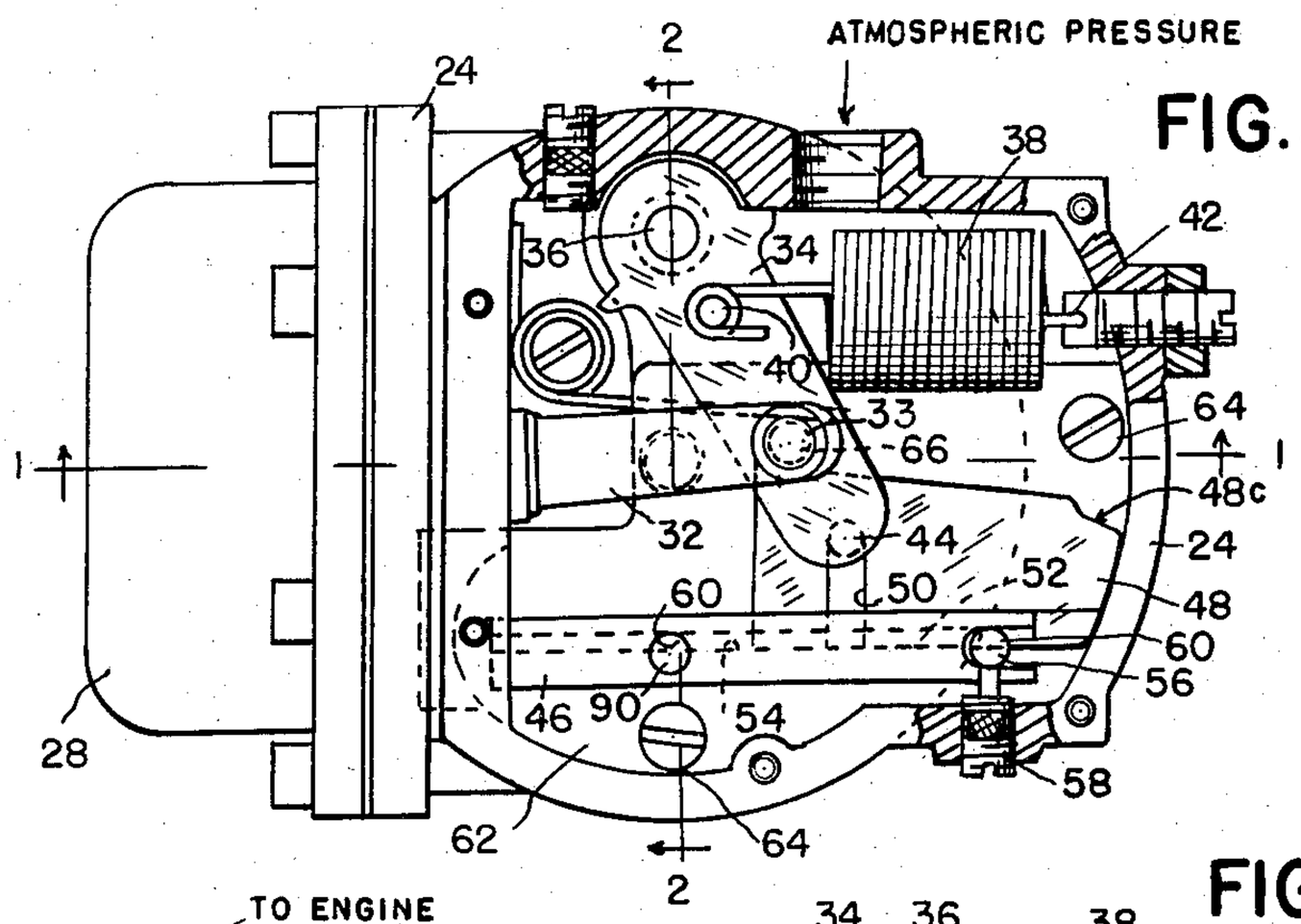


FIG.4.

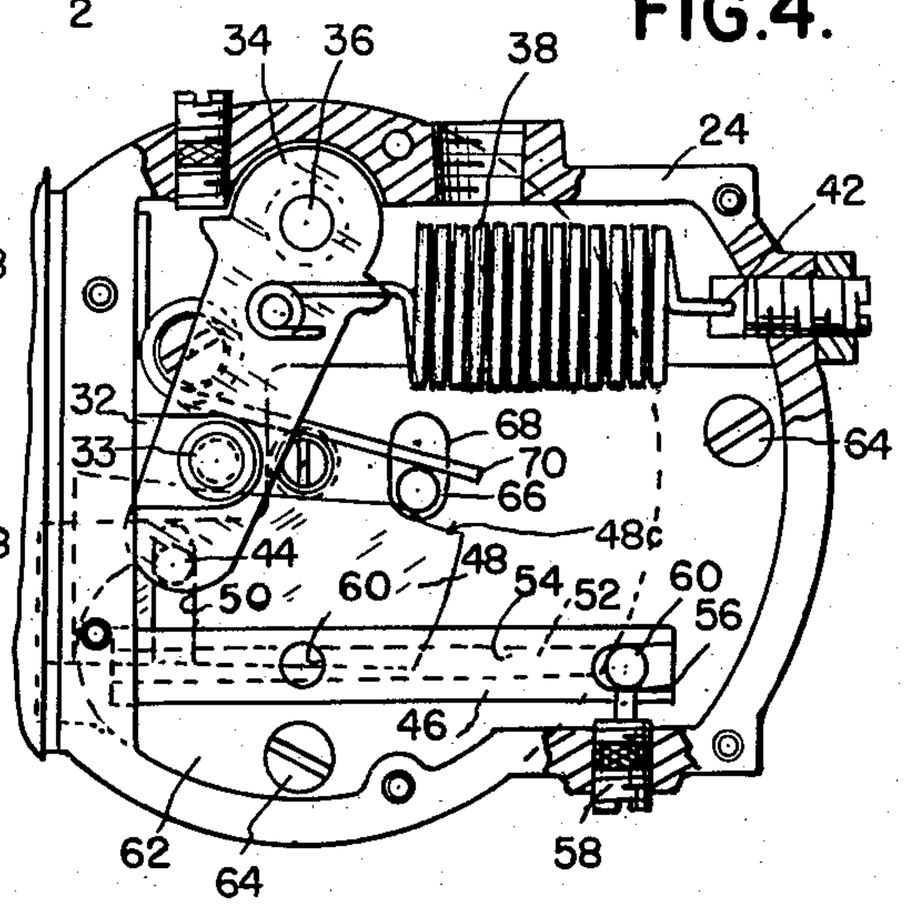


FIG.6.

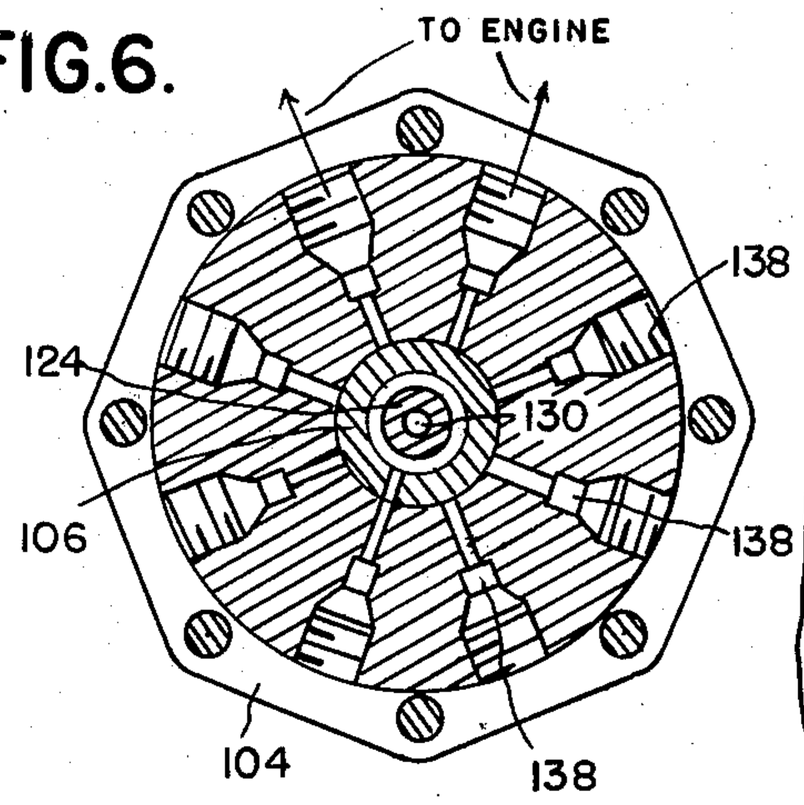


FIG.5.

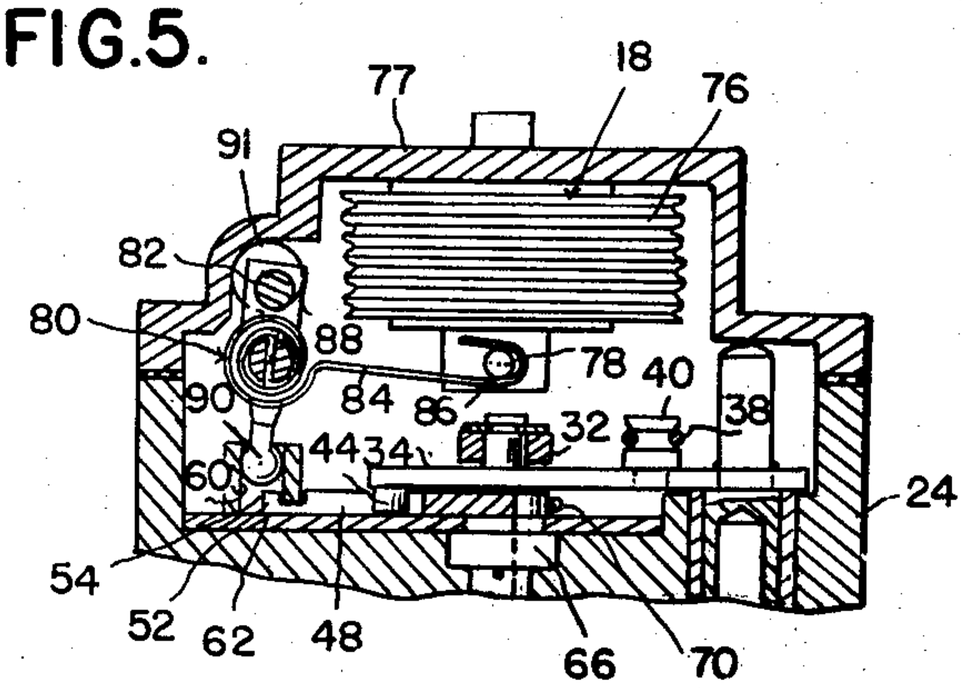
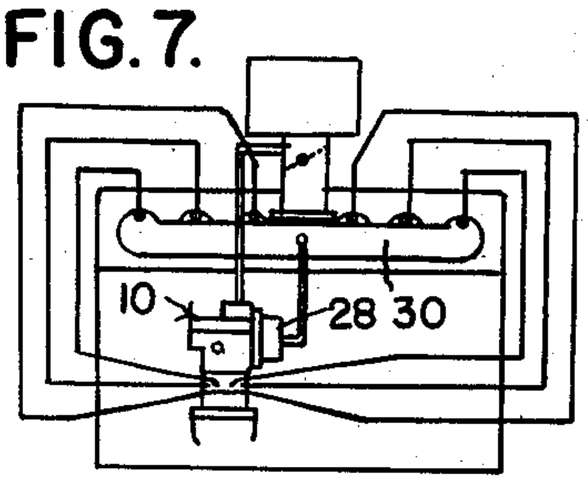


FIG.7.



INVENTOR.

CARL F. HIGH

BY

Hauke & Hardesty.

ATTORNEYS

United States Patent Office

2,849,998

Patented Sept. 2, 1958

2,849,998

FUEL INJECTION METERING CONTROL APPARATUS

Carl F. High, Detroit, Mich.

Application September 7, 1954, Serial No. 454,274

18 Claims. (Cl. 123—140)

This invention relates to a liquid fuel injection device for multiple cylinder internal combustion engines, and more particularly to a novel and inventive control mechanism in such device constituting a simplified compact means to control the fuel metering pump mechanism of the device.

The improved control mechanism here disclosed is related to my fuel injection apparatus invention patented on February 2, 1954, under Patent No. 2,667,840, and entitled "Fuel Injection Apparatus and Control Mechanism Therefor."

The present invention involves certain improved features of construction and functional advantages over the above referred to structure. In the "instant" invention, the manual and automatic adjustments of the control mechanism are achieved by a motion multiplying means whereby movement ratios of other than 1:1 are employed between a pressure sensitive diaphragm assembly and a slide cam, the latter device operating a metering valve of the injection pump portion of the mechanism. In this way, the diaphragm assembly being responsive to air density and pressure in a manifold serving the engine, the fuel pump will be controlled to deliver a predetermined precise amount of fuel to enter with and ignite the quantity of air then being drawn into the cylinder. Instead of a straight line movement as conceived and employed in the above referred to patent, a multiplied movement obtained by relocating relative points of rotation in leverage and linkage accomplishes the very desirable result of simplifying and compacting the entire control mechanism with a consequent substantial reduction in costs.

Another structural feature of the invention is the direct mounting of the fuel-air cam to the metering valve. By virtue of this construction, direct control of the fuel metering, namely; its spill and discharge, is obtained.

In addition to the factor of air density in the manifold, which serves the diaphragm assembly of the control device, and the factor of atmospheric pressure which enters the control mechanism by way of the control housing, the factor of speed sensitivity is also involved in the functioning of the control mechanism. Speed sensitivity is provided by a spring actuated valve arranged in the body of the control mechanism whereby fuel which is spilled out by the fuel metering valve passes to the preloaded restricting valve. The relative position of the fuel metering valve as operated by the fuel-air cam and the pressure developed ahead of the spill valve, before it opens, contribute most to give exceptional performance by the control mechanism in an internal combustion engine. This system may be called the speed-density system, in accordance with the factors involved in its efficient operation. The simplified speed-density system as here described expands the application of the fuel injection apparatus to a substantially larger group of internal combustion engines.

Another feature of construction having an improved functional result is the provision of a heat dam at the fuel body portion of the apparatus. The damaging effect of heat in the fuel control and pump areas, which the heat dam reduces, is further controlled by bleeding the unused fuel through the spill valve, together with all vapor and fuel through the bleed orifice, which fuel is all returned to the fuel tank to prevent a dangerous heat build-up in the pump. A flexible boot or seal is provided at the metering valve, between it and the control mechanism, that prevents any leakage of fuel into the control compartment of the apparatus. There is practically no fuel pressure on this seal or boot as bleed and leakage fuel which it seals from the control chamber is conducted through a drilled hole back to the spill-valve mounting and from there through tubing back to the fuel tank. To overcome any resistance of the metering valve or the boot is a coiled spring applying its effort to the stem of the metering valve and through it to the fuel-air cam. The spring applies its effort on the stem of the metering valve on the side opposite the cam's contoured effective surface.

Certain additional manual and automatic features of construction are embodied in the apparatus which are essential to more efficient engine performance. As a base for all adjustments is the cam guide, which may be adjusted manually or automatically. Automatic full-throttle adjustment is under the control of an aneroid mechanism, which aneroid expands upon the reduction in atmospheric pressure. Elongation of the aneroid device moves the cam-guide bar and with it the fuel-air cam that effects a "leaning out" or reduction of the fuel delivered to the engine. The fulcrum of the bell-crank or link between the aneroid and cam-guide, which moves the cam side-wise, serves for manual adjustment. A feature of the cam-guide adjusting mechanism is the provision of a temperature sensitive and responsive element that supplies a measure of adjustment throughout the temperature range.

Another feature of the construction is the provision of a chamber between the fuel pump mechanism chamber and the control mechanism chamber. The function and purpose of this third chamber is to prevent the transfer of any fuel vapors, pressures or interference by the operating fuel pump mechanism with the proper functioning of the control mechanism. Thus, the third chamber, which might be called the "by-pass chamber," provides a means for tapping off any excessive pressure which is generated by the fuel pump mechanism before it can adversely affect the control mechanism.

Additional structural features, objects and advantages of the invention will become more apparent from the description given below. For a visual understanding of the invention, reference is made to the accompanying drawing in which like parts are referred to by like reference numerals throughout the several views illustrating a preferred embodiment of the invention, and in which

Fig. 1 is a vertical sectional view of the fuel injection apparatus embodying the invention.

Fig. 2 is a vertical sectional view of the apparatus of Fig. 1 at substantially 90° to the plane of Fig. 1.

Fig. 3 is a top plan view of the apparatus of Fig. 1, partially in section.

Fig. 4 is a view similar to Fig. 3, showing the adjusted fuel-air cam position just at the point of fuel cut-off.

Fig. 5 is a vertical sectional view of the aneroid control portion of the inventive structure in adjusted position.

Fig. 6 is a horizontal sectional view on the line **6—6** of Fig. 1.

Fig. 7 is a diagrammatic view of the fuel injection apparatus as applied to an internal combustion engine.

Refering now to the several views of the drawings, and at this time more particularly to Figs. 1 and 2, the fuel injection apparatus **10** comprises a fuel pump control

mechanism **12** and a fuel pump and metering mechanism **14** responsively coupled to the control mechanism **12**.

The control mechanism **12** comprises a diaphragm assembly **16**, an aneroid assembly **18**, and a metering control cam mechanism **20** contained within the fuel control body **24**.

Diaphragm assembly **16** comprises a pressure sensitive and responsive diaphragm **26** suspended between the fuel control body **24** and a pressure chamber cover **28**. Cover **28** has an orifice leading from chamber **29** and communicating with the intake manifold **30**.

Affixed to the diaphragm **26** is a lever **32** that is connected at its opposite end by a pin **33** to a lever **34**. Lever **34** is fulcrumed at the pin **36**, and its movement about fulcrum **36** is resisted by spring **38** connected at **40** on lever **34** and at **42** on body **24**.

Lever **34** is provided with a cam pin **44** at the end opposite its fulcrum end. Thus, upon movement of diaphragm **26** as pressure within the chamber **29** is reduced by reason of vacuum in the manifold **30**, movement of the lever **34** in the direction of the diaphragm moves the lever cam pin **44**.

Slidingly mounted in cam guide **46** is the fuel-air cam **48**. Cam **48** is provided with a pin slot **50** into which lever cam pin **44** projects and operates. As shown in Figs. 3 and 4, when diaphragm **26** draws lever **34** toward it against resistance of spring **38**, the cam **48** is also moved in the same direction.

The guide edge of cam **48** is provided with a key portion **52** that slides in cam guide slot **54**. Cam guide **46** is fulcrumed at **56** by a manually adjustable pin **58** and is provided with a ball socket **60** for swinging movement about the fulcrum **56**. Both cam **48** and cam guide **46** are arranged to rest and move upon plate member **62** which is supported and anchored on control body **24** by screws **64**.

A cam follower **66** is mounted in control body **24** and is movable within a slot **68**, being urged constantly against the cam **48** by spring **70** supported on the control body. The end **72** of cam follower **66** is integrally formed with disc **74**, which is the head of the fuel metering valve (to be described below) and which is radially adjusted in the intermediate chamber **75**. A flexible boot or seal **76** is arranged about the cam follower **66** closing it off from the chamber **75** and separating the fuel control mechanism **12** from the fuel pump and metering mechanism **14** of which disc **74** is a component element.

The cam follower end **72**, metering valve head **74**, and flexible seal **76** are contained within the intermediate chamber **75**, which is disposed below control body plate number **62** in the control chamber of the control body **24**. Intermediate chamber **75** is further disposed over the fuel pump chamber in fuel pump body **104**, and is in direct communication via passage **79** with the fuel chamber **134**. The top opening part **81** of chamber **75** is sealingly closed off by flexible seal or boot **76** which is arranged, as shown in Fig. 1, over the mouth of chamber part **81**.

The aneroid assembly **18** comprises principally a pressure sensitive and responsive bellows **76** supporting a bellcrank mounting pin **78** at its lower end. The upper end of bellows **76** is mounted to the control body **24** by means of cap **77**. Bellcrank **80** is fulcrumed at **82** on the control body cap **77** and has a thermal sensitive lever arm structure **84** connected to pin **78** by a yoke **86** and has a lever arm **88** terminating in a ball **90** which seats in cam guide ball socket **60**. Fulcrum **82** is in the form of a pin eccentrically mounted on a shaft or screw **91** that is threadedly mounted in control body cap **77**. Thus, when shaft **91** is radially adjusted, the eccentricity developed in fulcrum pin **82** carries over to bell crank **80** so as to adjust the position of cam guide **46**. Thus, when the aneroid bellows **76** responds to variations in atmospheric pressure, the bellows expands or contracts moving the cam guide **46** about its fulcrum **56**. Such adjustment or movement of the cam guide affects the relative position of the cam follower **66** as it bears upon the cam **48** which is automatically adjusted by the movement of the cam guide **46**. This adjustment of the cam guide **46** is modified by the action of the lever arm **84**, which tends to unwind with an increase in temperature within the injector, and to wind up with a decrease in temperature, respectively shifting the cam guide **46** to the lean and to the rich position.

The fuel pump and metering mechanism **14** comprises principally a drive shaft **102** rotatably mounted in the fuel pump body **104**. A fuel pumping plunger **106** is arranged to rotate in pump body bore **108** and to reciprocatingly move in the bore. Reciprocating movement is achieved by means of cam roller **110** mounted on pin **112** fixed in fuel pump body **104**, and the configuration of the bottom portion **114**, of plunger **106**, which is undulating in contour, as described in the above referred to patent, and thus provides a reciprocating motion as it rides over roller **110**, being rotated by shaft **102**.

Plunger **106** is provided with a barrel **116** having fuel discharge ports **118**, fuel intake ports **120** and fuel spill ports **122** arranged therein.

A fuel metering valve **124** is fixedly mounted to disc **74** and this assembly is rotative or angularly positioned within plunger cylinder **126** upon movement of cam follower **66**. A fuel spill passage **128** communicating with the vertical passage **130**, is provided in valve **124**.

Fuel intake ports **132** are arranged in pump body **104** which communicate with the fuel chambers **134** for drawing fuel into the pump cylinder **126**. Fuel discharge ports **138** are disposed radially at the bottom of the cylinder **126** according to the view in Fig. 6.

As shown in Fig. 2, the fuel spill passage **128** in the metering valve **124**, upon rotation, communicates with the passages **122** in the plunger **106** leading to the pump body passage **142** where the spill fuel will be emitted against the spring actuated resistance of valve **144**.

A slight modification of structure, but not of function, is the disposition of the diaphragm resistance spring **38** directly against the diaphragm **26** in the pressure chamber **29** of the diaphragm assembly **16**. This alternative arrangement may be more desirable in certain applications. The function of the control mechanism **12**, however, remains the same.

The operation of the control mechanism for the fuel injection apparatus is as follows:

Upon a decrease of pressure in the chamber **29** of the diaphragm assembly **16**, occasioned by a decrease in air density in the manifold **30**, diaphragm **26** moves in the direction of the diaphragm chamber cover **28**. This movement brings lever **34** into action against cam slot **50**, resisting the tension of spring **38**, and causing the cam **48** to move in cam guide slot **54**.

Upon a change in atmospheric pressure, the aneroid bellows **76** expands or contracts to swing bellcrank arm **88** through an arc which moves cam guide **46** about its fulcrum **56** on pin **58**.

Any shift in position of the cam **48** or cam guide **46** is immediately reflected in the position of cam follower **66** which is in constant engagement with the cam **48** by virtue of spring **70**. As the cam and/or cam guide move, the cam follower **66** adjusts to its new position on the edge of cam **48** causing the disc **74** and the fuel metering valve **124** to rotate and shift the position of its fuel spill groove passage **128** with respect to plunger spill ports **122**, so that in one position of cam follower **66**, the spill ports **122** are in full communication with spill groove passage **128**.

This would occur when the cam surface **48***c* dropped below the cam follower. So long as the cam follower rides on the cam surface **48***b*, the spill ports **122** are in part communication with passage **128** with amount spilled depending on the cam contour, which determines the positioning of the metering valve and the point where the spill

ports, due to the rotation of the pumping plunger which carries the matching ports, go out of registry. The end of cam surface 48*c* is cut away to permit metering valve **124** to reach the limit of its radial positioning so that spill ports are open throughout the up or pumping stroke and thus all fuel is spilled throughout the stroke and no fuel is delivered to the engine, which is equivalent to "no fuel" or pump completely shut off. By "shut-off," it is meant that no fuel is delivered and this is the "shut-off" position referred to when the vacuum in the engine manifold exceeds the vacuum of ordinary slow idle as when the engine, with closed throttle, is driven at high speed by a coasting vehicle.

Plunger fuel discharge ports **118** communicate with the plunger cylinder **126** and with pump body discharge ports **138** at a time when fuel intake ports **120** are out of communication with fuel chamber **134**. During the discharge stroke, dependent upon the position of the cam follower **66** against cam **48**, the relative position of pump spill passage **128** with respect to the plunger spill port **122** will determine the amount of fuel spilled out which determines the amount of fuel delivered to the engine. All of the pump's full-displacement of fuel is either spilled or delivered to the engine and when all of the full-displacement of fuel is spilled, none is delivered and the pump is said to be "shut-off."

Fuel will be discharged from the pump cylinder **126** upon an upward stroke of the plunger **106**, as the undulating bottom portion **114** rides upward upon roller **110**. On the down stroke of plunger **106**, the plunger will rotate and close off its discharge ports **118** and at the same time bring its intake ports **120** into communication with pump cylinder **126** and the fuel chamber **134**, causing fuel to flow into cylinder **126**.

The constant rotation and reciprocating movement of plunger **106** provides the full pumping action that passes fuel to the body discharge ports **138**, in such amount as the control mechanism, through cam **48**, cam follower **66**, and full metering valve **124**, will permit. In all positions of the plunger **106**, the fuel metering valve **124** does not move longitudinally, though it does rotate to the extent that it is angularly adjusted by the control mechanism.

The intermediate chamber **75** functions as a fuel close-off chamber to prevent interference by fuel vapors or liquid from registering an effect upon the control mechanism **12** within the control chamber of the device. This feature of the invention, it will be apparent, provides for trouble-free operation of the control mechanism, which in turn exercises more accurate control of the fuel pump mechanism whereby the functioning of the entire device is rendered more precise and efficient. The admission of fuel vapors or liquid into the control chamber, it is obvious, would have a material effect upon the operation of the control mechanism. Therefore, the embodiment of an intermediate chamber and the use of a flexible seal over the radially movable cam follower **66**, which operates in both the control chamber and the intermediate chamber, provides novel and inventive structure that substantially and materially increases the efficiency of the device.

I claim:

1. In a fuel injection apparatus for an internal combustion engine and operable to supply fuel to said engine, a casing, a fuel injection pump driven by said engine, an adjustable metering valve operable to vary the fuel supplied by said pump to said engine, said casing provided with a fuel inlet chamber, a control chamber and an intermediate valve chamber disposed between said control and fuel inlet chambers, control mechanism generally housed in said control chamber and associated with said fuel injection apparatus and comprising a movable control member, a cam actuated by said movable control member, and a cam follower actuated by said cam and connected with said adjustable metering valve, said casing fuel inlet chamber having an outlet opening through which fuel is

fed to said pump and discharged therefrom in accordance with the setting of said adjustable metering valve, said metering valve being housed in said intermediate valve chamber, means connecting said intermediate chamber with said fuel inlet chamber, said cam follower comprising connecting means between said cam and metering valve extending from said control chamber into said intermediate valve chamber, and a flexible closure means sealingly affixed about said cam follower and to said casing whereby to seal off said control chamber from said intermediate valve chamber.

2. In a fuel injection apparatus for an internal combustion engine and operable to supply fuel to said engine, a casing, a fuel injection pump driven by said engine, an adjustable metering valve operable to vary the fuel supplied by said pump to said engine, said casing provided with a fuel inlet chamber, a control chamber and an intermediate valve chamber disposed intermediate said control and fuel inlet chambers, control mechanism generally housed in said control chamber and associated with said fuel injection apparatus and comprising a movable control member, a cam actuated by said movable control member, and a cam follower actuated by said cam and connected with said adjustable metering valve, said casing fuel inlet chamber having an outlet opening through which fuel is fed to said pump and discharged therefrom in accordance with the setting of said adjustable metering valve, said metering valve being housed in said intermediate valve chamber, means connecting said intermediate chamber with said fuel inlet chamber, said casing having an opening between said control and intermediate chamber through which said cam follower extends and having a dimension permitting lateral displacement of the cam follower in said casing as said cam follower is moved by the cam to adjust said metering valve, and a flexible closure means supported by said casing and sealingly affixed to said cam follower to seal off the control chamber from said intermediate chamber.

3. In a fuel injection apparatus for an internal combustion engine and operable to supply fuel to said engine, a casing, a fuel injection pump driven by said engine, an adjustable metering valve operable to vary the fuel supplied by said pump to said engine, said casing provided with a control chamber, a fuel inlet chamber and an intermediate valve chamber disposed intermediate said control and fuel inlet chambers, control mechanism generally housed in said control chamber and associated with said fuel injection apparatus and comprising a movable control member, a cam actuated by said movable control member, a cam follower actuated by said cam and connected with said adjustable metering valve, said casing having a fuel inlet chamber having an outlet opening through which fuel is fed to said pump and discharged therefrom in accordance with the setting of said adjustable metering valve, said metering valve being housed in said intermediate valve chamber, means connecting said intermediate chamber with said fuel inlet chamber to vent vapor accumulations from said fuel inlet chamber to said intermediate valve chamber, and means venting said drained intermediate fuel chamber to atmosphere.

4. In a fuel injection apparatus for an internal combustion engine and operable to supply fuel to said engine, a casing, a fuel injection pump driven by said engine, an adjustable metering valve operable to vary the fuel supplied by said pump to said engine, said casing provided with a control chamber, a fuel inlet chamber and an intermediate valve chamber disposed intermediate the control and fuel inlet chamber, control mechanism generally housed in said control chambers and associated with said fuel injection apparatus and comprising a movable control member, a cam actuated by said movable control member, a cam follower actuated by said cam and connected with said adjustable metering valve, said casing fuel inlet chamber having an outlet opening through which fuel is

fed to said pump and discharged therefrom in accordance with the setting of said adjustable metering valve, said metering valve being housed in said intermediate valve chamber, means connecting said intermediate chamber with said fuel inlet chamber at a point remote from said outlet opening, said casing having an opening between said control and intermediate chamber through which said cam follower extends and having a dimension permitting lateral displacement of the cam follower in said casing as said cam follower is moved by the cam to adjust said metering valve, and a flexible closure means supported by said casing and sealingly affixed to said cam follower to seal off the control chamber from said intermediate chamber, said flexible closure means comprising a flexible boot anchored to said casing and attached to said cam follower and serving as a seal to prevent leakage of fuel and vapor from said intermediate chamber to said control chamber.

5. In a fuel injection apparatus for an internal combustion engine and operable to supply fuel to said engine, a casing, a fuel injection pump driven by said engine, an adjustable metering valve operable to vary the fuel supplied by said pump to said engine, said casing provided with a control chamber, a fuel inlet chamber and an intermediate valve chamber disposed between said control and fuel inlet chambers, said fuel inlet chamber having an outlet opening through which fuel is fed to the pump control mechanism generally housed in said control chamber and associated with said fuel injection apparatus and comprising a movable control member, a cam actuated by said movable control member, a cam follower actuated by said cam and connected with said adjustable metering valve, said casing having a fuel inlet chamber from which fuel is fed to said pump and discharged therefrom in accordance with the setting of said adjustable metering valve, said metering valve being housed in said intermediate valve chamber, means connecting said intermediate chamber with said fuel inlet chamber at a point above and remote from said outlet opening, said means arranged to vent vapor accumulations from said fuel inlet chamber, said intermediate chamber disposed directly underneath the control chamber.

6. In a fuel injection apparatus for an internal combustion engine and operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a cam plate having a contoured cam edge and movably supported by said casing, guide means for said cam plate, a cam actuating lever pivotally supported by said casing and connected with said control member and actuated thereby, a cam follower actuated by the contoured edge of said cam plate and connected with said adjustable metering valve means whereby to relatively adjust said metering valve on movement of said cam plate, said cam actuating lever comprising a motion multiplying lever, said guide means confining the travel of said cam plate along a longitudinal path in a horizontal plane of said camplate, said cam guide means comprising a susbtantially straight elongated guide member constructed and arranged to be manually laterally adjusted at one end, and means automatically laterally adjusting said guide members at the other end in response to changes in atmospheric pressure, said guide means thereby constraining the longitudinal movement of said cam plate to a substantially straight path of travel, said guide means being thereby adjustably positioned to angularly and laterally adjust the path of travel of said cam plate in said horizontal plane aforesaid.

7. In a fuel injection apparatus for an internal combustion engine and operable to supply fuel to said engine, a fuel injection pump associated with and driven

by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, said casing having a supporting plane surface, a cam plate having a contoured cam edge and movably supported on said plane surface, guide means for said cam plate, a cam actuating lever pivotally supported by said casing and connected with said control member and actuated thereby, a cam follower actuated by the contoured edge of said cam plate and connected with said adjustable metering valve means whereby to relatively adjust said metering valve on movement of said cam plate, said guide means confining the travel of said camplate along a longitudinal path in a horizontal plane of the camplate and being laterally and angularly adjustable in said plane, said cam plate thereby constrained to be longitudinally moved in a substantially straight path of travel, said guide means being thereby adjustably positioned to angularly and laterally adjust the path of travel of said cam plates in said horizontal plane aforesaid.

8. A fuel injection apparatus for an internal combustion engine operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a substantially flat cam plate movably supported by said casing and having a contoured cam edge, a guide means constructed and arranged to confine movement of said cam plate along a longitudinal substantially straight path in a plane containing said cam edge, a cam actuating lever pivotally supported by said cam plate, said actuating lever comprising a motion multiplying lever operable to effect said movement of said cam plate upon movement of said control member, the ratio of movement of said cam plate with respect to said control member being respectively greater than one-to-one, a cam follower contacting the contoured edge of said cam plate and actuated by movement of said cam plate, said cam follower connected with said metering valve whereby to relatively adjust same on movement of said cam plate, and means adjusting said guide means susbtantially laterally relative to the longitudinal path of said cam plate, whereby to laterally adjust the path of travel of said cam plate in a common plane containing said cam edge.

9. A fuel injection apparatus for an internal combustion engine operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a substantially flat cam plate having a contoured cam edge and movably supported by said casing, a guide means constructed and arranged to confine movement of said cam plate along a substantially straight longitudinal path in a plane containing said cam edge, a cam actuating lever pivotally supported by said casing and operably connecting said control member and said cam plate, a cam follower contacting the contoured edge of said cam plate and actuated by movement of said cam plate, said cam follower connected with said metering valve whereby to relatively adjust same on movement of said cam plate, a first adjusting means for said guide means operable to laterally angularly adjust same relative to the longitudinal path of travel of said cam plate, and a second adjusting means for said guide means comprising a second control member movable in response to variations of atmospheric pressure and means connecting said second control member to said guide means to further laterally adjust the position of same, the aforesaid cam guide adjusting means operable to laterally angularly adjust the longitudinal line of travel of said cam plate as moved by said

first control member, whereby to adjust the fuel supply to said engine throughout the range and atmospheric conditions of engine operation.

10. A fuel injection apparatus for an internal combustion engine operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a substantially flat cam plate having a contoured cam edge and movably supported by said casing, a guide means constructed and arranged to confine movement of said cam plate along a substantially straight longitudinal path in a plane containing said cam edge, a cam actuating lever pivotally supported by said casing and operably connecting said control member and said cam plate to effect said movement of said cam plate upon movement of said control member, a cam follower connecting the contoured edge of said cam plate and actuated by movement of said cam plate, said cam follower connected with said metering valve whereby to relatively adjust same on movement of said cam plate, a first means adjusting said guide means laterally relatively to the longitudinal path of travel of said cam plate, whereby to laterally shift the path of travel of said cam plate in a common plane containing said cam edge, and a second adjusting means for said guide means comprising a second control member movable in response to variations of atmospheric pressure and means connecting said second control member to said guide means to further laterally adjust the position of same, the aforesaid cam guide adjusting means being operable to laterally angularly adjust the longitudinal line of travel of said cam plate as moved by said first control member, whereby to adjust the fuel supply to said engine throughout the range and atmospheric conditions of engine operation, said connecting means being said second control member and said guide means comprising a bell crank lever fulcrumed to the casing and actuable on movement of said second control member.

11. A fuel injection apparatus for an internal combustion engine operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a substantially flat cam plate having a contoured cam edge and movably supported by said casing, a guide means constructed and arranged to confine movement of said cam plate along a substantially straight longitudinal path in a plane containing said cam edge, a cam actuating lever pivotally supported by said casing and operably connecting said control member and said cam plate, said actuating lever comprising a motion multiplying lever operable to effect said movement of said cam plate upon movement of said control member, the ratio of movement of said cam plate with respect to said control member respectively being greater than one-to-one, a cam follower connecting the contoured edge of said cam plate and actuated by movement of said cam plate, said cam follower connected with said metering valve whereby to relatively adjust same on movement of said cam plate, a first means for adjusting said guide means laterally relatively to the longitudinal path of travel of said cam plate to laterally shift the path of travel of said cam plate in a common plane containing said cam edge, and a second adjusting means for said guide means comprising a second control member movable in response to variations of atmospheric pressure, and means connecting said second control member to said guide means to further laterally adjust the position of same, the aforesaid cam guide adjusting means being operable to laterally angularly adjust the longitudinal line of travel of said cam

plate as moved by said first control member, whereby to adjust the fuel supply to said engine throughout the range and atmospheric conditions of engine operation, said connecting means between said second control member and said guide means comprising a bell crank lever fulcrumed to the casing and actuable on movement of said second control member to laterally adjust the position of said guide means, said bell-crank lever comprising an arm connected to said second control member and an arm connected to said guide means, at least one arm aforesaid constructed of thermal sensitive material and operable to modify lateral adjustment of said guide means in response to temperature changes in said casing.

12. A fuel injection apparatus for an internal combustion engine operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a substantially flat cam plate having a contoured cam edge and movably supported by said casing, a guide means constructed and arranged to confine movement of said cam plate along a substantially straight longitudinal path in a plane containing said cam edge, means connecting said control member and said cam plate to effect said movement of said cam plate upon movement of said control member, a cam follower connecting the contoured edge of said cam plate and actuated by movement of said cam plate, said cam follower connected with said metering valve whereby to relatively adjust same on movement of said cam plate, a first means for adjusting said guide means laterally relatively to the longitudinal path of travel of said cam plate, a second adjusting means for said guide means comprising a second control member movable in response to variations of atmospheric pressure, and means connecting said second control member to said guide means to laterally adjust the position of same, the aforesaid cam guide adjusting means being operable to laterally angularly adjust the longitudinal line of travel of said cam plate as moved by said first control member, whereby to adjust the fuel supply to said engine throughout the range and atmospheric conditions of engine operation, said connecting means between said second control member and said guide means comprising a bell crank lever fulcrumed to the casing and actuable on movement of said second control member, said bell-crank fulcrum comprising an adjustable pivot element eccentrically mounted in said casing.

13. A fuel injection apparatus for an internal combustion engine operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a substantially flat cam plate having a contoured cam edge and movably supported by said casing, a guide means constructed and arranged to confine movement of said cam plate along a longitudinal substantially straight path in a plane containing said cam edge, means operably connecting said control member and said cam plate to effect movement of said cam plate in a longitudinal direction upon movement of said control member, a cam follower contacting the contoured edge of said cam plate and actuated by movement of said cam plate, said cam follower connected with said metering valve whereby to relatively adjust same on movement of said cam plate, and means adjusting said guide means laterally relative to the longitudinal path of travel of said cam plate whereby to adjust the path of travel of said cam plate in a common plane containing said cam edge, said guide means comprising a substantially straight guide member adjustably pivotally supported at one end to the casing, said cam plate having a guide edge slidably contacting said guide member, and said cam plate longitu-

dinally guided by said guide member along a straight line path.

14. A fuel injection apparatus for an internal combustion engine operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a substantially flat cam plate having a contoured cam edge and movably supported by said casing, a guide means constructed and arranged to confine movement of said cam plate along a longitudinal path in a plane containing said cam edge, means operably connecting said control member and said cam plate to effect movement of said cam plate in a longitudinal direction upon movement of said control member, a cam follower contacting the contoured edge of said cam plate and actuated by movement of said cam plate, said cam follower connected with said metering valve whereby to relatively adjust same on movement of said cam plate, and means adjusting said guide means laterally relative to the longitudinal path of travel of said cam plate, whereby to adjust the path of travel of said cam plate in a common plane containing said cam edge, said guide means comprising a substantially straight guide member adjustably pivotally supported at one end to the casing, said cam plate having a guide edge slidably contacting said guide member, and said cam plate longitudinally guided by said guide member along a straight line path, and a second guide adjusting means comprising a second control member movable in response to variations of atmospheric pressure and means connecting said second control member to said guide member to laterally angularly adjust same about its adjustable pivot axis upon movement of said second control member and thereby laterally angularly adjust the longitudinal path of travel of said cam plate as same is moved by said first control member.

15. A fuel injection apparatus for an internal combustion engine and operable to supply fuel to said engine, a fuel injection pump associated with and driven by said engine and comprising a casing, an adjustable metering valve means supported by said casing and operable to vary the fuel supplied by said pump to said engine, a movably supported control member, a substantially flat cam plate having a contoured cam edge and movably supported by said casing, a guide means constructed and arranged to confine movement of said cam plate along a longitudinal path in a plane containing said cam edge, a cam actuating lever pivotally supported by said casing and operably connecting said control member and same cam plate to effect movement of said cam plate in a longitudinal direction upon movement of said control member, a cam follower contacting the contoured edge of said cam plate and actuated by movement of said cam plate, said cam follower connected with said metering valve whereby to relatively adjust same on movement of said cam plate, and means adjusting said guide means laterally relative to the longitudinal path of travel of said cam plate, whereby to adjust the path of travel of said cam plate in a common plane containing said cam edge, said metering valve means being rotatably supported by said casing, and said cam follower operable to angularly adjust said metering valve means upon movement of said cam plate.

16. In an apparatus for supplying fuel to an internal combustion engine, a fuel injection pump connected to and driven by said engine and comprising an injector casing, an angularly adjustable metering valve structure rotatably supported by the casing and operable to vary the fuel supplied to the engine, an eccentricaly mounted pin carried by said metering valve structure, a cam supporting means comprising a plane surface extending normal to the axis of said metering valve structure and substantially overlying said metering valve structure and provided with an opening through which said pin projects, a movable control member, a cam movably mounted on said cam supporting plane surface and connected with the aforesaid control member, said cam constructed and arranged to actuate said pin and to thereby angularly adjust the metering valve member, and means for adjustably shifting the relative position of said cam with respect to the eccentrically mounted pin carried by said metering valve structure, whereby to selectively adjust the fuel and air ratio of the fuel and air mixture being supplied to said engine throughout the operating range of engine operation, said adjustable cam shifting means comprising a cam guide provided with a substantially straight track constructed and arranged to constrain movement of said cam to a substantially straight linear travel, and at least two independently actuated cam guide adjusting means respectively connected with longitudinally spaced portions of said cam guide track and operable to laterally shift said cam guide in a plane parallel to said cam supporting plane surface.

17. In an apparatus for supplying fuel to an internal combustion engine, a fuel injection pump connected to and driven by said engine and comprising an injector casing, a movable control member, an adjustable metering valve structure supported by said casing and operable to vary the fuel supplied to the engine, a substantially flat cam plate operatively connected with said control member and having a contoured cam edge and movably supported by said casing, said casing provided with a cam plate support comprising a plane surface, means coacting with the contoured cam edge and operatively connected with said metering valve structure to effect an adjustment of said metering valve on movement of said cam plate in response to movement of said control member, and means for adjustably laterally shifting the relative position of said cam plate whereby to adjust the fuel and air ratio of the fuel and air mixture being supplied to the said engine throughout the operating range of engine operation, said adjustable cam shifting means comprising a cam plate guide provided with a substantially straight track constructed and arranged to constrain movement of said cam plate to a substantially straight linear travel, and at least two independently actuated guide adjusting means respectively operatively connected with longitudinally spaced portions of said cam guide and operable to laterally shift said cam guide in a plane parallel to said cam plate supporting plane surface.

18. In an apparatus for supplying fuel to an internal combustion engine, a fuel injection pump connected to and driven by said engine and comprising an injector casing, a movable control member, an adjustable metering valve structure supported by said casing and operable to vary the fuel supplied to the engine, a substantially flat cam plate operatively connected with said control member and having a contoured cam edge and movably supported by said casing, said casing provided with a cam plate support comprising a plane surface, means coacting with the contoured cam edge and operatively connected with said metering valve structure to effect an adjustment of said metering valve on movement of said cam plate in response to movement of said control member, and means for adjustably laterally shifting the relative position of said cam plate whereby to adjust the fuel and air ratio of the fuel an air mixture being supplied to said engine throughout the operating range of engine operation, said adjustable cam shifting means comprising a cam plate guide provided with a substantially straight track constructed and arranged to constrain movement of said cam plate to a substantially straight linear travel, and at least two independently actuated guide adjusting means respectively operatively connected with longitudinally spaced portions of said cam guide and operable to laterally shift said cam guide in a plane parallel to said cam plate supporting plane surface, one of said guide adjust-

ing means comprising a manually adjusted pivotal guide support located at one end portion of said guide.

References Cited in the file of this patent

UNITED STATES PATENTS

2,156,933	Alden	May 2, 1939
2,213,683	Banning	Sept. 3, 1940
2,378,037	Reggio	June 12, 1945
2,435,902	Reggio	Feb. 10, 1948
2,667,840	High	Feb. 2, 1954
2,670,724	Reggio	Mar. 2, 1954

FOREIGN PATENTS

666,491	Germany	Oct. 21, 1938
504,592	Great Britain	Apr. 27, 1939