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May

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[54] **MEMBRANE-TYPE FUEL INJECTION PUMP OPERATED AND CONTROLLED BY FLUID PRESSURE**

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[51] **Int. Cl.** **F02m 39/00,** F02b 3/00

[58] **Field of Search** ..... 123/187.5, 139 A, 139 AW, 123/139 AJ; 417/380

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Primary Examiner—Laurence M. Goodridge
Assistant Examiner—Ronald B. Cox
Attorney, Agent, or Firm—Edwin E. Greigg

[57] **ABSTRACT**

In a fuel injection pump of the type having a pump membrane which, by virtue of its oscillation caused by the pulsating pressure in the crank case of the associated internal combustion engine, delivers fuel under pressure to a fuel injection nozzle for injection into the air intake tube of the engine, there is provided a manually operable primer pump for driving an initial fuel quantity to the injection nozzle and a manually adjustable bias control means for arbitrarily changing the closing force exerted on the outlet valve of the pump. The said bias control means is a unitary structure so designed that, first, a permanent fine adjustment may be effected in a stepless manner to set the exact metered fuel quantities for normal engine operation and, second, a temporary decrease in the bias force map be brought about to effect an increased fuel delivery (enriched air-fuel mixture) during the cold starting of the engine.

2 Claims, 6 Drawing Figures

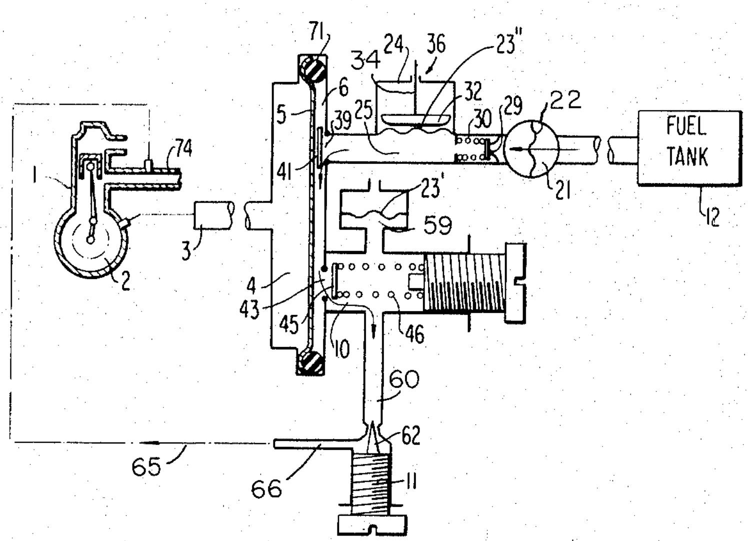


FIG.1

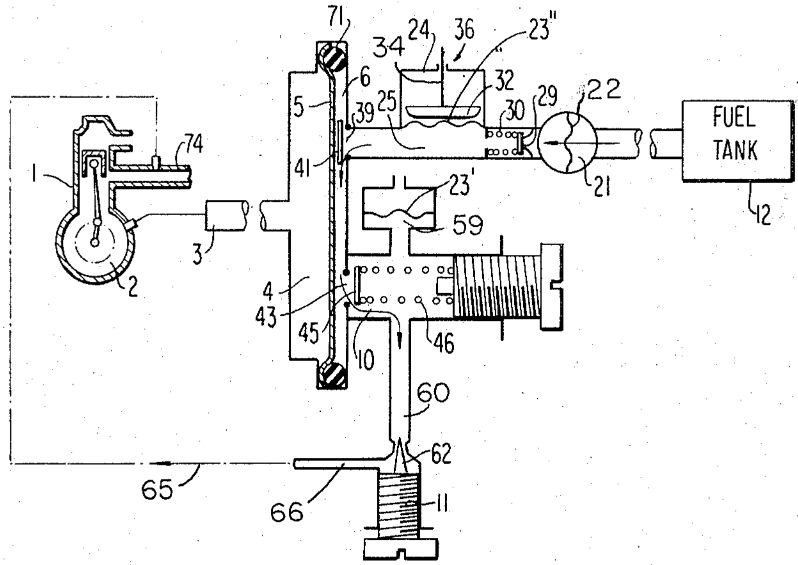


FIG.2

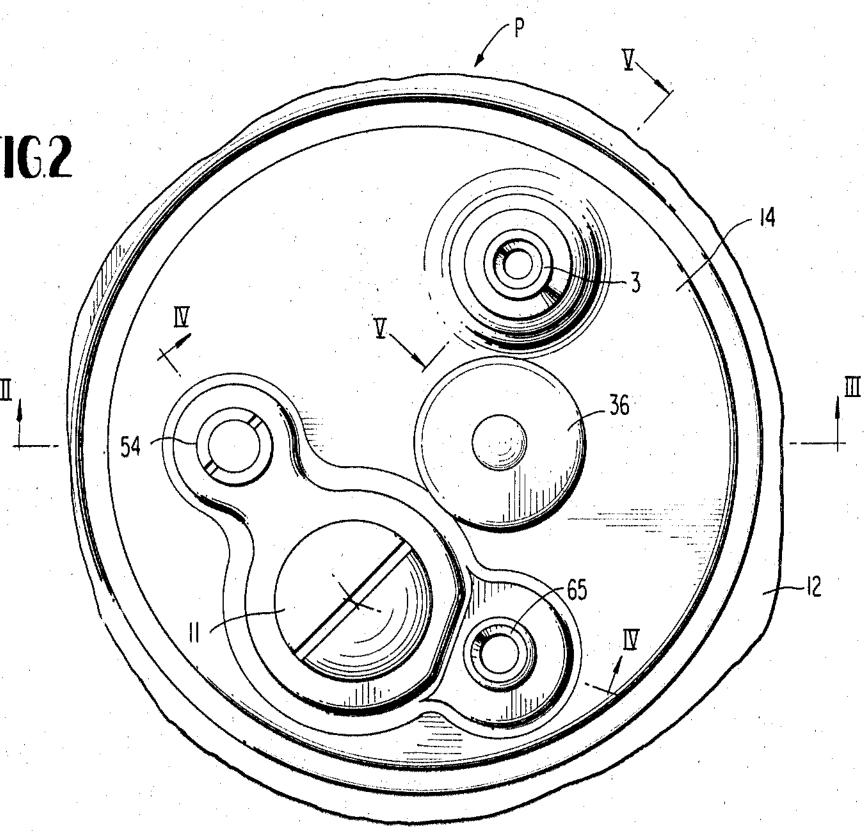
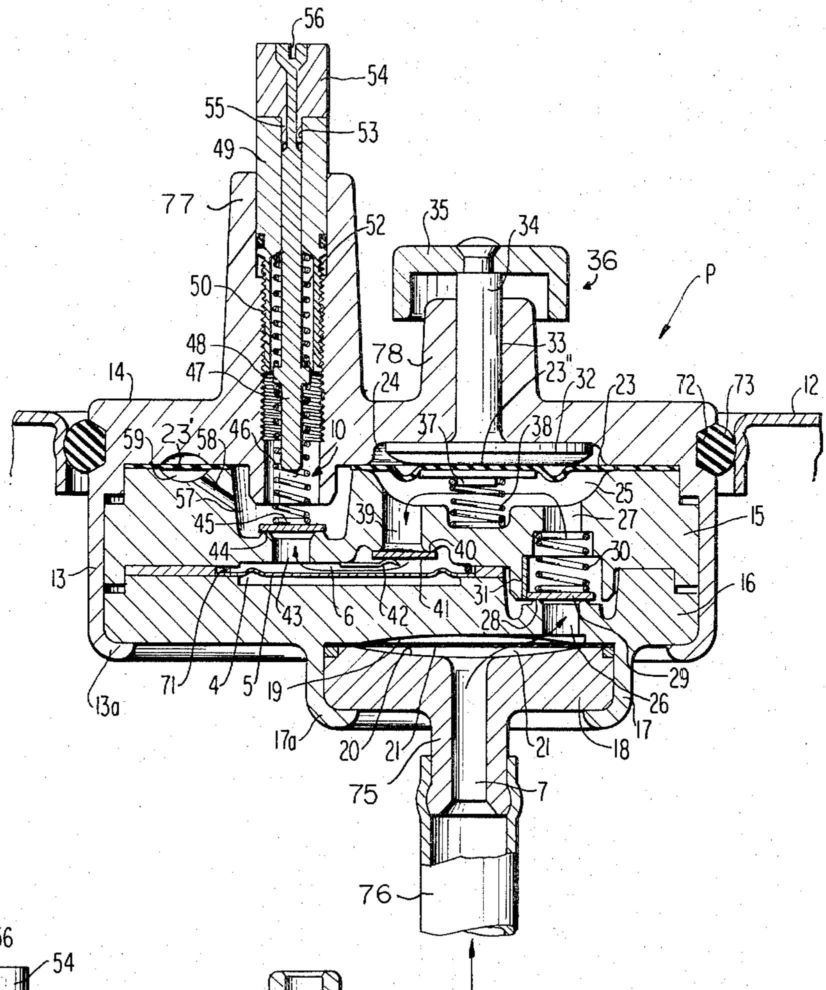


FIG.3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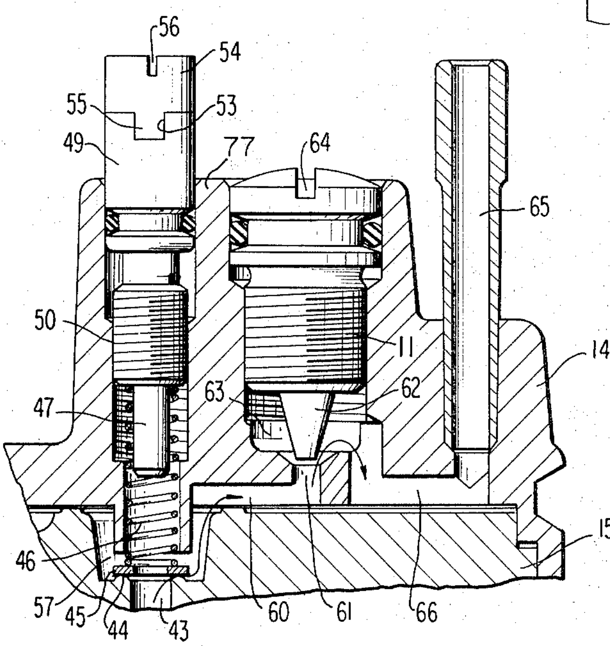
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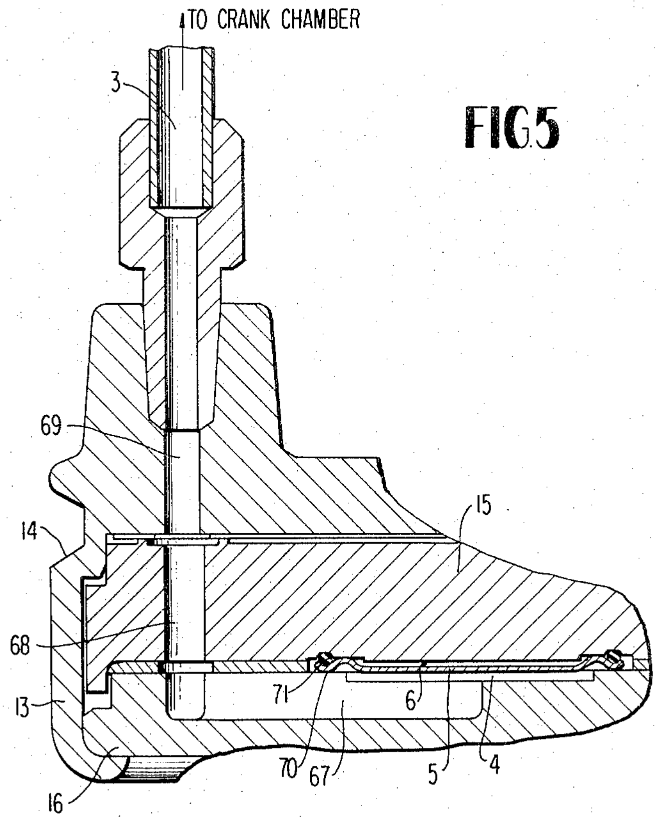
FIG.4


TO CRANK CHAMBER
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71
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67
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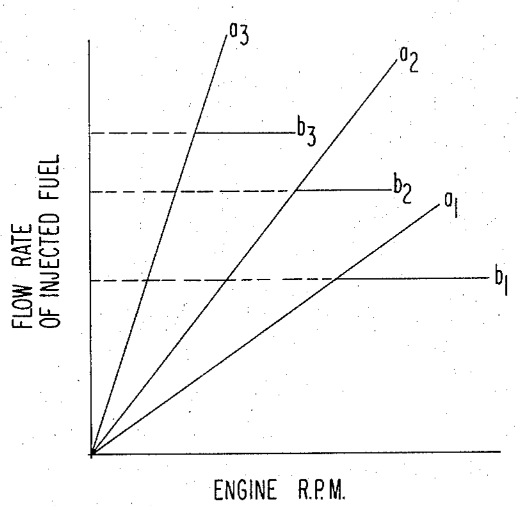
4

FIG.5


a3
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b3
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a1
b1
FLOW RATE
OF INJECTED FUEL
ENGINE R.P.M.

FIG.6

MEMBRANE-TYPE FUEL INJECTION PUMP OPERATED AND CONTROLLED BY FLUID PRESSURE

BACKGROUND OF THE INVENTION

This invention relates to a fuel injection pump which may find application in externally ignited internal combustion engines particularly of the one-cylinder, two-cycle type such as used, for example, in power saws, motorboats, motorcycles and snowmobiles.

The fuel injection pump with which the present invention is concerned is further of the type that is driven by the pressure which prevails in the engine cylinder or in the crank case and which pulsates synchronously with the reciprocation of the engine piston. This pulsating pressure is transmitted to the fuel injection pump by a fluid pressure medium to cause oscillation of a membrane which forms part of the fuel injection pump. This membrane, which is the pumping element proper of the fuel injection pump draws fuel from a fuel tank and drives the same under pressure through a fuel line to a fuel injection nozzle. The latter injects the fuel directly into the air intake tube (suction duct) of the internal combustion engine.

The amplitude of the pressure pulsations and thus the amplitude of the oscillation executed by the membrane are a function of the engine rpm which, in turn, depends upon the flow rate of the intake air. Consequently, since the output of the fuel injection pump depends upon the amplitude of the membrane oscillation, the fuel injection pump of the afore-outlined type provides automatically for a fuel metering as a function of the intake air without additional fuel regulating mechanisms.

A fuel injection pump of the afore-outlined type is disclosed in U.S. Pat. No. 3,425,403, issued to Michael G. May on Feb. 4, 1969.

It has been found that in fuel injection pumps built in accordance with the aforenoted patent, difficulties arise in obtaining a satisfactory control input, so that the accuracy of fuel metering over the wide range of operating conditions tends to be below the desired requirements due, for example, to the mass effect or inertia of the fuel, the phenomenon of natural oscillation and the pulsations in the fuel intake conduit. Also, fuel injection pumps of the afore-noted type lack simple means for adjusting the pump characteristics.

OBJECTS AND SUMMARY OF THE INVENTION

It is an object of the invention to provide an improved fuel injection pump of the type described in U.S. Pat. No. 3,425,403 in which the pump characteristics are accurately adjustable in an arbitrary manner with simple means and its behaviour during starting is ameliorated.

Briefly stated, according to the invention, in a fuel injection pump of the afore-identified known type there is provided a manual primer pump means in the fuel path of the pump to introduce an initial fuel quantity through the injection nozzle into the air intake tube of the engine prior to starting and means for manually adjusting the bias of the pressure valve at the output side of the fuel injection pump to vary the output thereof for a large rpm range. The last-named means is so designed, that first said bias is steplessly adjustable over a wide operational range and, second, independently from the stepless setting, said bias may be de-

creased to a predetermined extent to effect an enrichment of the air-fuel mixture for a cold starting of the engine.

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

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a schematic illustration of the basic structure of the fuel injection pump according to the preferred embodiment and its connection to the internal combustion engine;

FIG. **2** is a top plan view of the fuel injection pump according to the preferred embodiment;

FIG. **3** is a sectional view taken along line III—III in FIG. **2**;

FIG. **4** is a fragmentary sectional view taken along line IV—IV of FIG. **2**;

FIG. **5** is a fragmentary sectional view taken along line V—V in FIG. **2** and

FIG. **6** is a schematic diagram illustrating the relationship between the engine rpm and the flow rate of fuel delivered by the fuel injection pump according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the description that follows an actual structure of the preferred embodiment will be described with reference to FIGS. **2**, **3**, **4** and **5**.

The body of the entire fuel injection pump generally indicated at P is essentially formed of a base block **14**, an intermediate block **15** and a frontal block **16**. These three components are rigidly held together by an inwardly crimped terminus **13***a* of a cylindrical skirt portion **13** forming an integral part of the base block **14**. The fuel injection pump P is inserted into an opening of a fuel tank **12** and is held therein in a sealed manner by means of an O-ring **73** which is seated in a circumferential groove **72** provided at the outer periphery of the base block **14** and which is in engagement with the aforenoted opening of the fuel tank **12**.

An inwardly turned terminal edge **17***a* of an outwardly extending skirt portion **17** which is an integral part of the frontal block **16**, fixedly holds a nipple body **18** provided with a fuel inlet port **7**. An outwardly projecting nipple neck portion **75** of the nipple body **18** carries the terminus of a fuel hose **76** which extends preferably to the lowest point in the fuel tank **12**. An inner concave face **20** of the nipple body **18**, together with a registering concave face **19** provided in the frontal block **16** forms a filter chamber **21** across which there extends a fuel filter **22** clamped along its edge portions between the nipple body **18** and the frontal block **16**.

Downstream of the fuel filter **22** the filter chamber **21** is in communication with a port **26**, the downstream end of which is formed as a valve seat **28** which cooperates with a check valve **29** biased closed in an upstream direction by a spring **30**. Preferably, the check valve **29** has a polygonal (for example, hexagonal) configuration. In this embodiment three sides of the hexagonal check valve **29** are associated with a stationary guide means **31** which, in the first place, prevents a lateral displacement of the check valve and, in the second place, aids in decreasing the flow resistance of the fuel.

Between registering recesses formed in adjacent faces of intermediate block **15** and frontal block **16** there extends a pump membrane **5** which may be made, for example, of a copper-beryllium alloy. The membrane **5** divides the cavity formed by the aforenoted two recesses into a fuel pump chamber **6** and a control chamber **4**. The membrane **5** is securely clamped at its edges between a shoulder **70** of the frontal block **16** and the intermediate block **15** with the interposition, according to the invention, of an O-ring **71** to provide a secure seal between the control chamber **4** and the pump chamber **6**.

According to the invention, the pump chamber **6** has a relatively small height and is preferably between 0.2 and 0.5 mm and is advantageously 0.3 mm. In this manner it is practically ensured that in the pump chamber **6** no air bubbles may dwell or may be generated

As it may be observed in FIGS. **1** and **5**, the control chamber **4** communicates with the crank case **2** of the internal combustion engine **1** by means of a conduit **3**, ports **69, 68** and space **67** to transmit the pulsating pressure in the crank case **2** to the control chamber **4** for driving the membrane **5** as outlined earlier.

Turning once again to FIG. **3**, the pump chamber **6** is in communication with the space immediately downstream of the check valve **29** through a port **27**, a primer pump chamber **25** and a port **39**. All components **27, 25** and **39** are provided in the intermediate block **15**. In the fuel pump chamber **6**, at the downstream end of the port **39**, there is disposed a suction or pump inlet valve **41** which is pressed against a valve seat **40** by means of a leaf spring **42**.

From the fuel pump chamber **6** there extends an outlet port **43**, the downstream end of which is provided with a valve seat **44** with which there cooperates an outlet or pressure valve **45**. The latter is urged into a closed position in an upstream direction towards the valve seat **44** by means of a manually adjustable biasing device generally indicated at **10**. This device constitutes one feature of the invention and will be described in detail as the specification progresses.

Immediately downstream of the pressure valve **45** there is provided an outlet chamber **57** which, through a channel **58**, communicates with a chamber **59**, the purpose of which will be discussed later.

As it may be observed in FIG. **4**, the outlet chamber **57** communicates with a channel **60**, the downstream end of which is formed of a passage **61**. The latter is throttled by a valve needle **62** in a variable manner for a purpose discussed during the course of the operational description of the fuel injection pump. The valve needle **62** is an integral part of an adjusting screw **11** which has a head accessible from the outside and provided with a slot **64** for engagement with a screwdriver. The adjusting screw **11** engages a threaded internal wall of a projection **77** which is an outwardly extending, integral part of the base block **14**. The aforenoted internal wall of the projection **77** defines a chamber **63** into which the passage **61** merges and which receives the valve needle **62**. It is seen that by adjusting the screw **11**, the flow passage section of the passage **61** is varied. From the chamber **63** there extends a port **66** joined by a pressure line **65**. The latter leads to the fuel injection nozzle disposed in the suction duct **74** of the internal combustion engine as ilustrated in the schematic FIG. **1.**

The device **10** for manually controlling the bias of the pressure valve **45** is best illustrated in FIGS. **3** and **4** and will now be described.

The projection **77** of the base block **14** has a throughgoing bore, the wall of which is provided with a thread **50**. The latter is engaged by an external thread provided on a setting screw **49** extending out of the projection **77**. The setting screw **49** has a central bore which receives a stem **47** provided with an integral collar **48** and, at its outer terminal end, with a slot **56** for a screwdriver.

Between the upper shoulder of the collar **48** and the base of a downwardly open enlarged axial bore in setting screw **49** there is disposed a spring **52** which urges the stem **47** downwardly. To the upper terminal portion of the stem **47** there is affixed a surrounding head **54**. Thus, the spring **52** urges, through the stem **47**, the head **54** into contact with the upper portion of the setting screw **49**. The latter is provided with a slot **53** into which there fits an integral, downwardly projecting lug **55** of the head **54**. For a purpose to be set forth later, the head and stem assembly **47, 54** may be displaced axially by manually engaging the head **54** and lifting its upwards. In this manner, the stem **47** executes a linear shift with respect to the setting screw **49**. When in its elevated position, the head **54** may be turned approximately 90° whereupon the lug **55** thereof is brought out of alignment with the slot **53**. If in this position the assembly **47, 54** is released, the lug **55** will come to rest on the uppermost free surface of the setting screw **49**. In this manner, the assembly **47, 54** may be immobilized temporarily in its outwardly extended position, whereby the spring **52** is compressed.

Between the lower shoulder of the collar **48** provided on the stem **47** and the upper face of the pressure valve **45** there is disposed a bias spring **46**, the force of which exerted on the valve **45** determines the opening pressure thereof.

It is thus apparent that a permanent, wide-range fine adjustment of the bias of spring **46** may be obtained by turning the assembly **47, 54, 49** as a unit in the thread **50**, for example, by means of a screwdriver inserted in slot **56**. It is also seen that by means of the aforedescribed axial lifting of the assembly **47, 54**(and thus moving it with respect to the setting screw **49**), the force of spring **46** may be temporarily decreased. The purpose of both types of adjustment will be discussed in the operational description of the fuel injection pump.

Turning once again to FIG. **3**, between the intermediate block **15** and the base block **14** there is clamped a diaphragm **23** preferably made of rubber.

One portion **23'** of the diaphragm **23** bounds the already mentioned chamber **59** which serves as an expansible outlet surge tank to render the flow of fuel through the fuel injection pump more uniform and to reduce inaccuracies in the metered fuel quantities due to the mass or inertia effect of the fuel.

Another portion **23''** of the diaphragm **23** extends through a cavity formed of complemental recesses in base block **14** and intermediate block **15** and divides this cavity into an already mentioned primer pump chamber **25** and an actuator chamber **24**. In a projection **78** extending outwardly and being integral with the base block **14**, there is held a primer actuator comprising a rod 34 slidable in the bore 33 of the projection 78, a shoe 32 accommodated in the actuator chamber 24 and contacting the upper face of membrane portion 23'' and a manually engageable button 35 secured to the outer free terminus of the rod 34. In the primer pump chamber 25 there is disposed a spring 38 which, with one end, engages the lower face of membrane portion 23'' and surrounds thereon a centering lug 37 and, with the other end, contacts the base of the primer pump chamber 25. Thus, the spring 38 continuously urges the slidable primer actuator 32, 34, 35 outwardly into an inoperative position. The primer actuator 32, 34, 35 is thus the operator member of a primer actuator pump which is generally indicated at 36 and which includes the membrane portion 23'', serving as the primer pump membrane, and the spring 38. It is to be understood that the membrane portion 23'' may be actuated by mechanisms other than the linearly shifting assembly 32, 34, 35. The purpose of the primer actuator pump which constitutes a feature of the invention, will be described in connection with the operation of the fuel injection pump.

It may be observed particularly well in FIGS. 2 and 3 that all the manually engageable operator members for controlling the fuel injection pump are mounted on the base block 14 and are oriented outwardly. The outer planar face of the base block 14 is approximately flush with the fuel tank 12 and thus the bulk of the fuel injection pump takes up no additional external space, since it extends into the fuel tank 12.

OPERATION OF THE PREFERRED EMBODIMENT

For placing the fuel injection pump P in readiness, prior to the starting of the engine, the primer actuator pump 36 is operated to draw fuel from tank 12 and drive the same into the pump chamber 6 and inject an initial fuel quantity into the air intake pipe 74 and also, at the same time to expel the air from th fuel path of the pump. For this purpose, the button 35 of the primer actuator 32, 34, 35 is depressed several times against the force of spring 38, as a result of which the membrane portion 23'' performs a pumping action.

When the internal combustion engine 1 is started, a pressure builds up in the crank case 2 which pulsates synchronously with the engine rpm. This pulsating pressure is transmitted by a fluid medium through the conduit 3 to the control chamber 4. As a result, the pump membrane 5 starts to oscillate and thus the fuel injection pump is in operation.

By virtue of the oscillating motion of the pump membrane 5, fuel is drawn from the fuel tank 12 through the fuel hose 76.

The fuel path in the fuel injection pump P as it may be best observed from FIGS. 1 and 3, is as follows: the fuel enters the fuel injection pump P from the fuel hose 76 through the fuel inlet port 7 and is drawn through the filter 22 into the port 26 and past the check valve 29. Therefrom the fuel flows through the port 27, the primer actuator pump chamber 25, and the port 39 to the inlet or suction valve 41. Therefrom the fuel is drawn into the pump chamber 6 during the suction stroke of the membrane 5 and it is expelled therefrom during the pressure strokes thereof. The fuel thus leaves the pump chamber 6 through the pressure or outlet valve 45. The latter is opened by the output pressure of the fuel against the bias of the spring 46. Once downstream of the pressure valve 45, the fuel flows through the outlet chamber 57, the adjoining outlet port 60, and the adjustable throttle 61, 62. Therefrom the fuel flows through the outlet port 66 into the pressure conduit 65 which introduces the fuel into the air suction pipe 74 through an injection nozzle. The fuel is metered as a function of the amplitudes of the membrane oscillation which, in turn, is dependent upon the air flow rate in the air intake tube 74 as discussed in more detail in the aforenoted U.S. Pat. No. 3,425,403.

During the starting run of the cold internal combustion engine, it is desired to supply a relatively rich air-fuel mixture. For this purpose, under the given conditions of operation, the metered fuel quantities should be increased. This is achieved, according to the invention, by manually pulling the knob 54 outwardly, thus causing a simultaneous outward axial movement of the stem 47 fixed thereto. Such an outward movement of the stem 47 and the collar 48 fixed thereto causes an expansion of the spring 46 and thus its force exerted in a closing direction on pressure valve 45 is decreased. Therefore, less force on the part of the pressurized fuel in pump chamber 6 is needed to open the pressure valve 45. Or, stated differently, with the same fuel pressure in port 43, the outlet valve 45 will open more widely and the result is thus an increased fuel output. As described before, the assembly 54, 47 may be temporarily immobilized in its operative position by rotating it approximately 90°, whereby the lug portion 55 integral with the head 54 is brought out of alignment with respect to the slot 53 provided in the upper portion of the set screw 49. Upon release of the knob 54, the lug 55 will come to rest on the uppermost face of the set screw 49. It is apparent that at the end of the period in which an enriched air-fuel mixture is desired, the assembly 54, 47 may be placed into its usual, inoperative position by rotating the head 54 until the lug 55 is in alignment with the slot 53. Upon releasing the head 54, the spring 52 will urge the assembly 54, 47 into its inoperative position, as illustrated in FIGS. 3 and 4.

A fine and wide range adjustment of the metered fuel quantities for normal engine operation can be effected according to the invention in a stepless manner by means of the set screw 49 controlling the bias of spring 46.

For a clear illustration of the effect of adjustment performed with the set screw 49 and 11, reference is had to FIG. 6 in which the output flow rate of the fuel injection pump P is shown in a diagram as a function of the engine rpm. In this diagram the characteristic curve with its branches *a*, *b* is shown in several positions, dependent upon the setting of the adjusting screws 49 and 11.

The setting of the screw 49, that is, the adjustment of the bias spring 46 determines the position of branch *a* of the pump curve. Thus, for 118 of assuming an initial position of the set screw 49 wherein the curve branch *a* is in the position a_1, the set screw 49 is screwed outwardly, the bias on spring 46 will decrease and in a certain position of the set screw 49, the curve branch *a* will assume the position a_2. It may be observed from FIG. 6 that, in such a case, for the same engine rpm, the output fuel rate is now increased.

The horizontal branches b_1, b_2 and b_3 illustrate the maximum fuel delivery as adjusted by the set screw 11 which varies the flow passage section of the throttle **61, 62.** Thus, as it may again be observed from FIG. **6,** the branch *b* of each characteristic curve may be shifted parallel to the ordinate by adjusting the set screw **64.**

What is claimed is:

1. In a fuel injection pump associated with an externally ignited internal combustion engine for injecting fuel into the suction duct thereof through a fuel injection nozzle, said fuel injection pump being of the known type that has (a) a control chamber, (b) conduit means maintaining communication between the crank case of said engine and said control chamber for transmitting the pressure pulsating in said crank case in synchronism with the engine rpm to said control chamber, (c) a pump chamber situated in the fuel path of said fuel injection pump, (d) a pump membrane separating said control chamber from said pump chamber, said pulsating pressure in said control chamber causing oscillation of said pump membrane for alternately drawing fuel from a fuel tank into and forcing it out of said pump chamber, (e) an intake check valve disposed in said fuel path at the input side of said pump chamber and (f) a pressure valve disposed in said fuel path at the output side of said pump chamber, the improvement in said height dimension being taken in the direction of approximately 0.2 to 0.5 mm for preventing a dwelling and a generation of air bubbles in said pump chamber, said height diemension being taken in the direction of oscillation of said pump membrane.

2. An improvement as defined in claim **1,** wherein said dimension is approximately 0.3 mm.

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