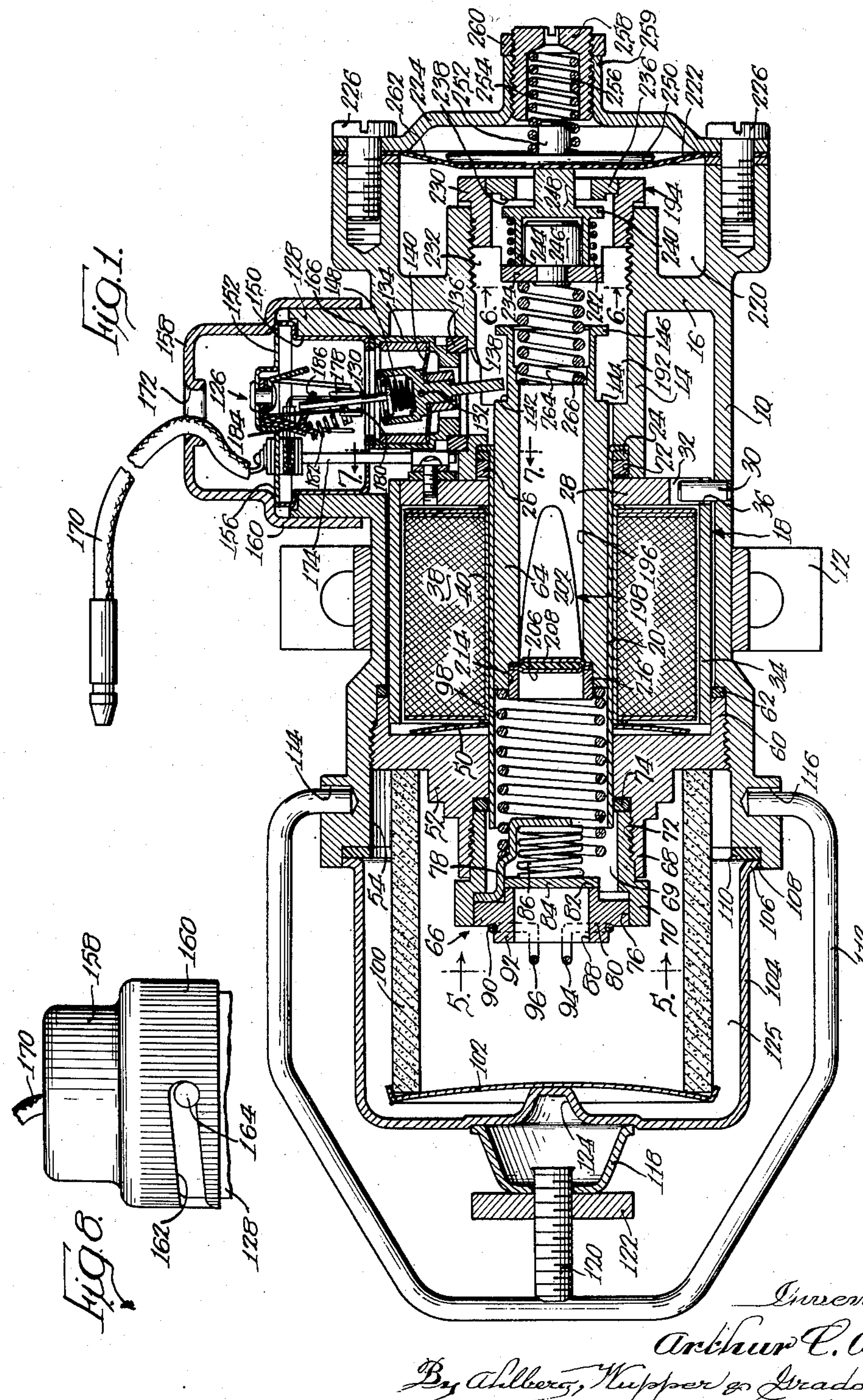
Feb. 10, 1959 A. C. ALLEN 2,872,871

HIGH CAPACITY FUEL PUMP

Filed May 10, 1956 2 Sheets-Sheet 1

Fig. 1

Fig. 8



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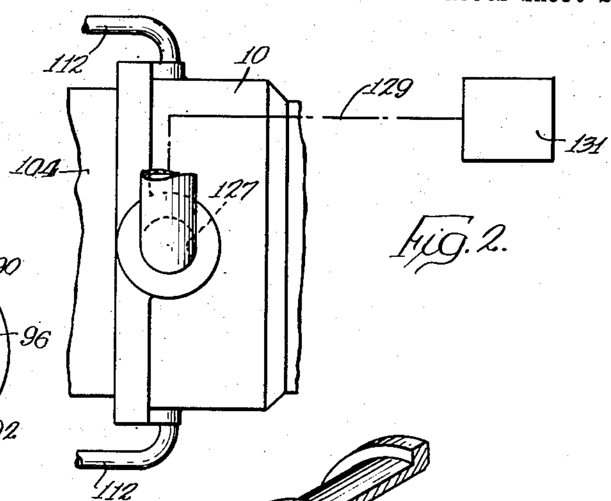


Fig. 2.

Fig. 5.

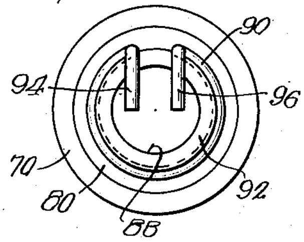


Fig. 4.

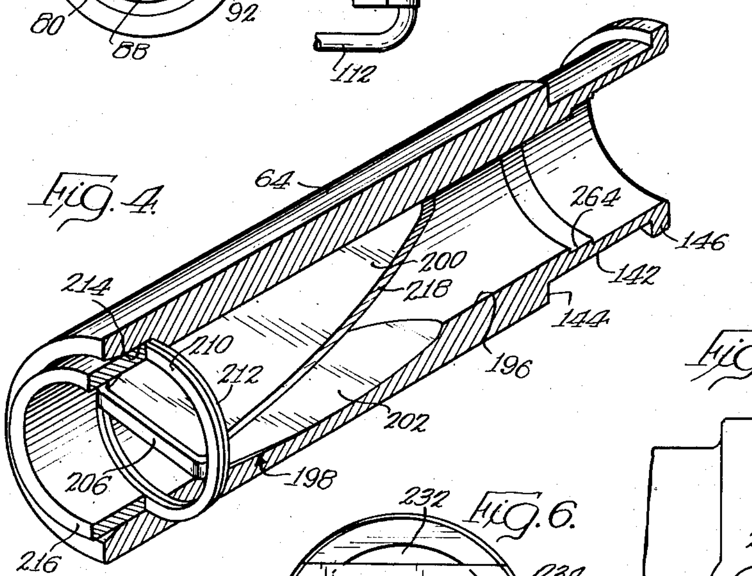


Fig. 3.

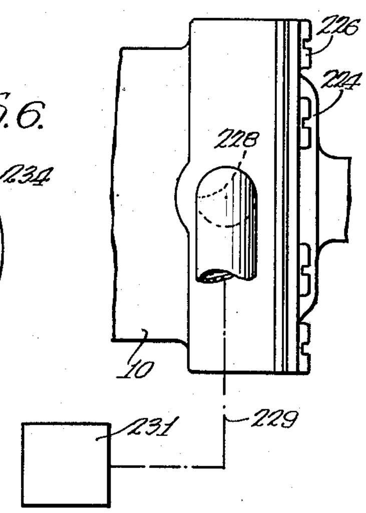


Fig. 6.

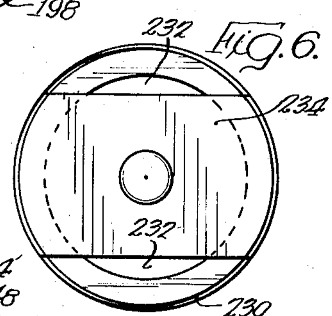
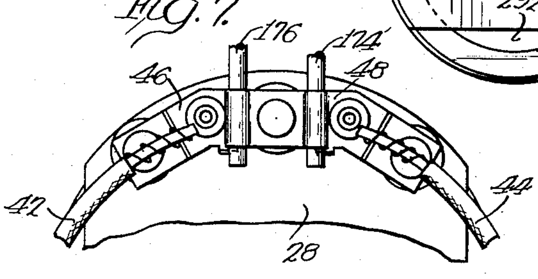


Fig. 7.



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United States Patent Office

2,872,871
Patented Feb. 10, 1959

2,872,871

HIGH CAPACITY FUEL PUMP

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Application May 10, 1956, Serial No. 584,093

13 Claims. (Cl. 103—37)

The present invention relates to fuel pumps for carburetor type internal combustion engines and more particularly to electric pumps for supplying fuel to the carburetors of automotive vehicle engines.

One object of the invention is to provide for maintaining a continuously adequate supply of liquid fuel to the carburetor of a high powered automotive vehicle engine, for example, an improved electric fuel pump, self-controlled to operate only as necessary to maintain a limited back pressure on the pump and having exceptional operating efficiency that provides at once for very significant minimization of the size and weight of the pump and for strikingly sharp responsiveness of the pump to only a slight diminution in normal back pressure to pump fuel at a high rate sufficient to meet the requirements of even the most powerful engines used in automotive vehicles.

Another object is to provide an improved pump of the above character which has at once the pumping efficiency recited in the previous object and the capacity to efficiently strain foreign particles from the fuel flow through the pump in a manner which maintains the pumping efficiency unimpaired by even substantial accumulations of material strained from the fuel.

Another object is to provide for the utmost convenience in servicing the improved pump recited in the preceding objects.

A more specific object is to provide an improved pump of the character recited which has an even output pressure that can be readily adjusted to meet the fluid pressure requirements of different carburetors.

A further object is to provide a high capacity, solenoid operated fuel pump which is exceptionally quite in operation.

Other objects and advantages will become apparent from the following description of the exemplary form of the invention illustrated in the drawings, in which:

Figure 1 is a longitudinal sectional view of a pump embodying the invention;

Fig. 2 is a fragmentary plan view showing the fuel inlet portion of the pump body and illustrating diagrammatically the connection of the pump inlet to a fuel tank;

Fig. 3 is a fragmentary plan view showing the fuel outlet portion of the pump body and illustrating diagrammatically the connection of pump outlet to a carburetor;

Fig. 4 is a perspective view showing the pump plunger rotated 90° with respect to its position shown in Fig. 1 and partially sectioned to reveal internal valve structure;

Fig. 5 is an internal end view taken from the line 5—5 of Fig. 1;

Fig. 6 is a fragmentary detail view taken along the line 6—6 of Fig 1;

Fig. 7 is a fragmentary sectional view taken along the line 7—7 of Fig. 1; and

Fig. 8 is a fragmentary plan view showing the control switch cover.

As will presently appear, the structure of the pump embodying the present invention is integrated together in a unique manner which facilitates servicing of the pump by providing quick access to any structural component.

In the preferred form shown, the improved pump comprises a hollow elongated body 10 molded integrally as a unitary aluminum casting and having an outer generally cylindrical shell (also denoted by the numeral **10**). Convenient support for the pump is provided by a suitable mounting bracket 12 embracing the medial portion of the body 10 and adapted for attachment to any suitable vehicle structure (not shown).

The body 10 includes a hollow cylindrical barrel element 14 concentric with the outer shell of the body and extending to the right, Fig. 1, of the longitudinal center of the body. Radially spaced inwardly from the outer shell of the body 10, the barrel element 14 is supported by an annular web 16 extending radially inward from the outer body shell and merging with a medial segment of the barrel element.

The pump is energized magnetically by a solenoid assembly 18 removably mounted within the central portion of the body 10. The solenoid assembly 18 encircles a cylindrical plunger guide tube 20 which projects from the inner end of the barrel element 14 nearly to the opposite end of the body 10. The tube 20 is formed from brass or other suitable nonmagnetic material. The barrel element end of the guide tube 20 is flanged radially outward, as shown, and held firmly in a shallow counterbore 22 in the inner end of the barrel element 14 by an annular seal 24. The seal 24 is backed up by a circular gland 26 pressed into the counterbore 22 behind the seal.

The solenoid assembly 18 comprises a centrally bored flat disc 28 closely encircling the guide tube 20 and abuttingly engaging the inner end of the barrel element 14. Proper orientation of the disc 28 around the tube 20 is assured by a short locating pin 30 supported in the outer shell of the body 10 to extend inwardly into a radial slot 32 in the periphery of the disc. The disc 28 is formed of magnetic material to become one element of a magnetic circuit around the assembly 18.

The outer periphery of the disc 28 fits within one end of a cylindrical insert 34 lining the outer shell of the body 10 from the disc 28 for a substantial distance toward the end of the body opposite the barrel element 14. Formed of magnetic material, the insert 34 provides an outer longitudinal continuation of the magnetic circuit from the disc 28.

Proper location of the magnetic insert 34 in the body 10 is facilitated by the locating pin 30 which extends through a short longitudinal slot 36 in the adjacent end of the insert.

The space between the insert 34 and the tube 20 forms an annular pocket which receives a solenoid 38 prewound on a spool 40, dimensioned to have a close sliding fit around the tube 20. Two lead wires 42, 44, Fig. 7, extend from the solenoid 38 past the disc 28 to connect with two terminal sockets 46, 48 attached to the side of the disc 28 opposite the solenoid.

The solenoid spool 40 is held firmly against the disc 28 by a spring washer 50, Fig. 1, encircling the tube 20 at the end of the solenoid opposite the disc 28. From an inner peripheral edge which engages the solenoid spool 40, the spring washer 50 is dished away from the solenoid 38 to engage the adjacent surface of a centrally bored retaining nut 52 which fits closely around the outer end of the tube 20. The outer periphery of the retainer 52 is threaded into a counterbore 54 formed in the body 10 and extending from the adjacent end of the body somewhat beyond the adjacent end of the insert 34.

A cylindrical gland skirt 60 integral with the outer marginal edge of the retainer **52** telescopes around the adjacent end of the insert **34** to abut against an annular seal **62** at the bottom of the counterbore **54**.

The retainer **52** is formed from magnetic material to provide a continuation of the magnetic solenoid circuit extending radially inward from the adjacent end of the insert **34** to the tube **20**.

The guide tube **20** provides support to a cylindrical pumping plunger **64** dimensioned to have a close sliding fit within the tube. Formed of magnetic material, the plunger **64** serves as a solenoid core which, upon energization of the solenoid **38**, tends to seek a position along the axis of the solenoid which minimizes the reluctance of the magnetic circuit around the solenoid. This magnetic circuit extends through the retainer **52**, the insert **34**, the disc **28**, and the portion of the plunger **64** between the disc **28** and the retainer. Thus, upon energization of the solenoid **38**, the plunger is magnetically urged longitudinally to telescope into the retainer **52**, as well as into the disc **28**, to minimize the overall space and hence the magnetic reluctance between the plunger and the two magnetic elements formed by the disc **28** and the retainer **52**.

The end of the tube **20** remote from the barrel element **14** is covered by an intake valve assembly **66** threaded into an annular boss **68** formed on the side of the retainer **52** opposite the solenoid **38**. The boss **68** encircles and extends somewhat beyond the adjacent end of the tube **20**. As will presently appear, the intake valve assembly **66** together with the portion of the tube **20** between the valve assembly and the adjacent end of the plunger **64** define a pumping chamber **69** into which fuel is admitted through the valve assembly.

Structurally, the intake valve assembly **66** comprises a centrally bored gland nut **70** threaded into a counterbore **72** in the boss **68**. The inner end of the nut **70** telescopes around the adjacent end of the tube **20** and compresses an annular seal **74** against the bottom of the counterbore **72**, causing the seal to firmly engage the tube.

A counterbore **76** in the outer end of the gland nut **70** receives the radially outward extremities of a spring retaining spider **78**. The central portion of the spider **78** is offset, as shown, along the axis of the tube **20** toward the plunger **64**. The outer ends of the spider **78** are anchored in the counterbore **76** by a centrally bored annulus **80** pressed into the counterbore behind the spider.

The radially inward marginal edge of the annulus **80** facing the plunger **64** provides a seat **82** for a circular check valve disc **84** biased against the valve seat by a compression spring **86** inserted between the valve disc and the adjacent central portion of the spring retaining spider **78**.

Collection of magnetic particles from fuel entering the central bore **88** in the annulus **80** is provided for in an extremely simple manner. For this purpose a magnetic wire **90**, Figs. 1 and 5, is shaped to embrace a boss **92** formed on the annulus **80** to encircle the outer end of the bore **88**. Opposite ends **94**, **96** of the wire **90** are turned into parallel spaced relation to each other to extend part across the bore **88**. The wire **90** is permanently magnetized so that its opposite ends **94**, **96** form pole pieces of opposite polarity which attract magnetic particles from the stream of fuel entering the bore **88**.

The intake valve assembly **66**, including the magnetized wire **90**, can be demounted simply by unscrewing the nut **70** from the retainer boss **68**. Removal of the intake valve assembly opens up the adjacent end of the tube **20** for convenient withdrawal of the plunger **64**, which contains an internal valve of improved construction that will be described presently.

Normally, the plunger **64** is biased away from the intake valve assembly **66** to create a substantial gap along the axis of the tube **20** between the inner periphery of the magnetic circuit member **52** and the adjacent end of the plunger. This biasing action is produced by a helical compression spring **98** seated at opposite ends against the spider **78** and the plunger **64**. As will presently appear, the strength of the spring **98** is coordinated with the control structure used in the improved pump to provide exceptional operating efficiency.

Foreign particles are filtered from the fuel flow through the pump in an extremely efficient manner which avoids interference with the output efficiency of the pump even after the accumulation of matter filtered from the fuel has become substantial.

For this purpose a hollow cylindrical filter **100**, Fig. 1, having a diameter approximately equal to that of the solenoid assembly **18**, is disposed in surrounding spaced relation to the intake valve assembly **66**. One end of the filter **100** abuttingly engages the peripheral edge of the retainer **52**. The other end of the filter **100** extends a substantial distance beyond both the body **10** and the intake valve assembly **66**. A pressure disc **102** closes the projecting end of the filter **100**.

The portion of the filter **100** projecting beyond the body **10** is encased with a filter bonnet or bowl **104**. A radial flange **106** on the body end of the bonnet **104** fits within a shallow counterbore **108** in the adjacent end of the body **10** containing a sealing gasket **110**.

The bonnet **104** is releasably held firmly against the gasket **110** by means of a swingable bail **112** extending across the outer end of the bonnet and having opposite ends pivotally supported in diametrically opposed bores **114** and **116** formed in the adjacent marginal edge of the body **10**. Pressure is applied from the center of the bail **112** to the center of the bonnet **104** by a screw assembly comprising an outwardly convex pressure cup **118** adapted to seat against the center of the bonnet **104**, a threaded stem **120** projecting through the cup **118** to engage the bail, and a knurled pressure nut **122** threadedly receiving the stem **120** and abutting against the cup.

It will be noted that a protuberance **124** swaged inwardly from the center of the bonnet **104** engages the pressure disc **102** to apply sufficient longitudinal pressure to the filter **100** to form an effective seal around opposite ends of the filter.

To gain access to the filter **100** it is necessary merely to turn the nut **122** to release pressure on the bonnet **104**, swing the bail **112** to one side, and remove the bonnet **104**. The filter **100** can then be lifted off for replacement or to provide unobstructed access to the previously described internal components of the pump.

The filter **100** is completely surrounded by a fuel supply chamber **125** formed by cylindrical space between the filter and radially outward structure of the body **10** and the bonnet **104** and by space between the pressure disc **102** and the bonnet. Fuel is supplied to the chamber **125** through an inlet bore **127**, Fig. 2, extending radially through the marginal edge of the body **10** which surrounds the body end of the filter **100**. As illustrated diagrammatically in Fig. 2, the inlet bore **127** is connected to a suction line **129** extending to a fuel tank **131**.

The very large cylindrical area of the porous filter **100** provides, in effect, for a free flow of fuel through the filter from the supply chamber **125** to the space around the inlet valve **66**. The differential pressure required to strain fuel through the filter at a high rate is not sufficient to produce any significant impairment of the operating efficiency of the pump even though the overall accumulation on the filter of foreign material screened from the fuel has become substantial.

Energization of the solenoid **38** is controlled by a readily demountable snap switch assembly **126** supported on a cylindhical boss **128** integrally formed on and extending laterally from the outer shell of the body **10**. As shown in Fig. 1, the boss **128** is aligned along the longitudinal axis of the body **10** with the portion of the barrel element **14** extending inwardly from the web **16**.

The snap switch **126** is controlled in response to reverse movements of the pistons **64** by means of a generally vertical lever assembly **130.**

The lever assembly **130** is centrally supported by a horizontal pivot pin **132** extending across the medial portion of a cartridge **134.** The cartridge **134** is inserted through the centrally open boss **128** and seated against a gasket **136** encircling a radial bore **138** in the adjacent side of the barrel element **14.** The cartridge **134** has an open outer end separated from an inwardly open inner end by a transverse annular diaphragm **140** substantially alined with the pivot pin **132.** The diaphragm **140** has an inner marginal edge sealed around the medial portion of the lever assembly **30** and an outer marginal edge firmly held and sealed against the outer shell of the cartridge **134.**

The sealing diaphragm **140** is formed from a tough plastic material which is substantially unaffected by contact with automotive vehicle fuels and highly resistant to fatigue by flexure. A preferred material used for this purpose is tetrafluoroethylene available under the trade name "Teflon" from E. I. du Pont de Nemours & Co., Inc., Arlington, New Jersey.

The inner end of the lever assembly **130** extends into an annular groove **142** recessed into the outer cylindrical surface of the adjacent end of the plunger **64.** As shown, the groove **142** extends a substantial distance along the axis of the plunger **64** between an annular shoulder **144** and an annular abutment **146** on the extreme adjacent end of the plunger.

To soften the action of the abutments **144, 146** on the lever assembly **130,** as this action is transmitted to the outer end of the lever assembly, the lever assembly is centrally connected together by a resilient coupling **148** which yieldably holds opposite ends of the lever assembly in a predetermined fixed relationship to each other while at th same time providing for limited bending of the lever assembly at the coupling.

From the coupling **148,** the lever assembly **130** projects outwardly through the bottom of a cup-shaped switch casing element **150** nested in the boss **128.** Covered by a circular switch support plate **152,** the outer end of the switch cup **150** is flanged radially outward. Axial pressure is applied to the outer periphery of the switch cup **150** through the annular marginal edge of the plate **152,** which is engaged by an annular shoulder **156** on a quick disconnect cap **158** forming a domelike cover for the plate **152.** The cap **158** is retained on the boss **128** by quick thread means. As shown in Fig. 8, a skirt **160** on the cap **150** telescopes around the boss **128** and defines two open ended helical slots **162** which receive two anchoring pins **164** projecting from opposite sides of the boss. It will be understood that the construction shown in Fig. 8 is duplicated on the other side of the boss **128** and cap **158.**

It is noteworthy that the switch actuating cartridge **134** is inserted through the boss **128** ahead of the covered cup **150** and held firmly against the seal **136** by pressure applied, as shown, through an annular washer **166** inserted between the outer end of the cartridge and the adjacent inner end of the cup.

Electric power for energizing the solenoid **38** is supplied through an insulated lead wire **170** adapted to interconnect with the positive terminal of a vehicle battery (hot shown). The wire **170** extends through a central opening **172** in the cap **164** to connect with a positive terminal post **174** supported at its outer end on the plate **152.** As shown in Fig. 7, the terminal post **174** extends inwardly into the terminal clip **48,** which is connected through the wire **44** to one end of the solenoid **38.**

The other terminal clip **46,** Fig. 7, connected to the opposite end of the solenoid **38,** receives the inner end of a second terminal post **176** parallel to the post **174** and supported at its outer end on the plate **152.**

The terminal post **176** and hence the solenoid **38** is controllably grounded through the previously mentioned snap switch assembly **126.** Since the specific construction of the switch assembly **126** can be varied by those skilled in the art, it need not be specifically described here. It is sufficient to point out that the terminal post **176,** Fig. 7, is connected to a pair of yieldably supported stationary contacts **178,** Fig. 1. The contacts **178** oppose a coacting pair of yieldably supported, movable contacts **180** grounded through the plate **152.**

The contacts **180** are moved into and out of engagement with the contacts **178** by an over-center compression spring **182** acting between the contacts **180** and a swingable spring support element **184** extending downwardly from the plate **152.** An apertured lug **186** on the spring support **184** receives the upper end of the lever assembly **130.** The support element **184** is formed from an insulating material.

The lever assembly **130** moves the spring support element **184** through a dead center position between one extreme position in which the spring **182** biases the contacts **180** into engagement with the contacts **178** and another extreme position in which the spring **182** biases the contacts **180** out of engagement with the contacts **178** to break the circuit through the solenoid **38.**

The positional relationship of the parts is such that upon opening of the switch **126** to deenergize the solenoid **38** the spring **98** moves the plunger **64** to the right, Fig. 1, to produce a substantial gap between the inner periphery of the circuit member **52** and the adjacent end of the plunger before the plunger shoulder **144** operates through the switch assembly **130** to close the switch. The solenoid assembly **18** then operates as described to magnetically move the plunger **64** in the opposite direction until the plunger shoulder **146** engage the lever **130** to effect opening of the switch **126** with a snap action. This deenergizes the solenoid **38** to continue reciprocation of the plunger.

Electrically energized reciprocation of the plunger **64** thus provided for is utilized to pump fuel from the pumping chamber **69** to a plenum chamber **192** formed at the right hand end of the plunger.

The plenum chamber **192** is defined within the intermediate portion of the barrel element **14.** The lateral bore **138** opening through the barrel element **14** is closed by the previously mentioned switch control cartridge **134.** The end of the barrel element **14** opposite the plunger **64** is plugged by a fluid flow control assembly **194** to be described presently.

Reciprocation of the plunger **64** pumps fluid from the chamber **69** into the plenum chamber **192** through a cylindrical bore **196,** Figs. 1 and 4, extending longitudinally through the plunger. The bore **196** contains a highly efficient check valve **198** which is practically silent in operation even when the plunger is reciprocating at a rapid rate to effect self priming of the pump.

Actually the cylindrical, plunger bore surface (also denoted by the numeral **196**) forms a part of the valve **198** which seals the bore against reverse flow of fluid. As shown in Figs. 1 and 4, sealing of the bore **196** against the reverse flow of fluid is effected by engagement with the bore surface of the semi-elliptical edges of a pair of flexible valve blades **200, 202.** The base of each blade is just sufficiently wide to extend transversely across the bore **196.** As shown, each blade **200, 202** extends from its base toward the plenum chamber end of the bore **196** and has a length approximately twice the diameter of the bore.

The bases of the two blades **200** and **202** are integrally joined together and clamped between two narrow, opposing supports **206** and **208** extending transversely across the bore **196.** The two supports **206** and **208** join respectively at opposite ends with two clamping rings **210** and **212** inserted into a counterbore **214** in the intake valve end of the plunger **64.** A cylindrical retaining ring

216 pressed into the counterbore 214 holds the rings firmly in place against the bottom of the counterbore.

Both blades 200, 202 are formed from a single flat section of a firm yet flexible plastic material, preferably tetrafluoroethylene, which will be referred to by the previously mentioned trade name "Teflon."

Integrally formed from the same piece of material, the blades 200 and 202 tend to straighten out with respect to each other to engage the marginal edge of each blade with the cylindrical bore surface 196. The semi-elliptical shaping of each blade permits the blade to remain substantially flat while effecting an engagement between the marginal edge of the blade and the bore surface 196 which is continuous around the blade as it projects from its supported base. Moreover, the marginal edge of each blade—see, for example, the edge 218 of the blade 200, Fig. 4—is shaped to make surface rather than line contact with the bore surface 196.

In operation, only slight differential fluid pressure tending to produce fluid flow through the bore 196 toward the plenum chamber causes the two valve blades 200, 202 to swing together. This allows substantially unrestricted laminar flow of fluid through the bore. Resistance to the flow of fluid through the valve 198 is minimized not only by the large unobstructed flow areas around the supports 206, 208 and along the blades but also by the fact that the fluid passes by the valve and through the bore 196 in a laminar flow pattern without changing direction.

Reverse flow of fluid through the bore 196 is prevented by the blades 200, 202 swinging outwardly to seal against the bore surface 196 in the manner described. Differential pressure tending to produce a reverse flow of fluid past the valve serves to increase the pressure with which the edges of the blades 200, 202 are sealed against the bore surface.

Constructed in the manner described, the valve 198 is virtually soundless in operation.

This noiseless operation of the valve 198 is particularly significant in quieting operation of the pump even when the plunger 64 is reciprocated at the exceptionally high rates prevailing when the pump is pumping air and fuel vapor in a self-priming phase of its operation.

The free flow characteristics of the unidirectional valve 198 facilitates quick movement of the plunger 64 toward the intake valve assembly 66 to successively recock the power spring 98. The ability of the plunger 64 to move quickly toward the intake valve is highly advantageous. It minimizes the period during which the actuating solenoid 38 must be energized, with consequent reductions in the power consumption of the pump. Also, it minimizes interruption in the maintenance of normal pumping pressure in the plenum chamber 192.

The effective volumetric output of the pump from the pumping chamber 192 is controlled in accordance with the back pressure on the pump by means of a regulator, including the previously mentioned assembly 194, which serves the additional function of assuring an even pump output pressure that can be adjusted to different pressure levels to fulfill the fluid pressure requirements of different internal combustion engine carburetors.

The regulator valve assembly 194 operates to throttle fluid under pressure from the plenum chamber 192 into a discharge chamber 220 formed in the adjacent end of the body 10 around and extending beyond the outer end of the barrel element 14. The outer end of the discharge chamber 220 is closed by a flexible diaphragm 222 also formed from tetrafluoroethylene. The peripheral edge of the diaphragm 222 is secured to the adjacent marginal edge of the body 10 by the peripheral edge of a header disc 224 detachably secured to the body by screws 226. An outlet from the discharge chamber 220 is provided by a radial bore 228, Fig. 3, extending through the adjacent marginal edge of the body shell 10. As shown diagrammatically in Fig. 3, the bore 228 connects with a fuel line 229 extending to an internal combustion engine carburetor 231.

Structurally, the regulator valve assembly 194 comprises an outwardly open cup 230, Figs. 1 and 6, threaded into the outer end of the barrel element 14. Two openings 232 in the bottom 234, Fig. 6, of the cup 230 provide communication between the pumping chamber 192 and the interior of the cup.

A centrally bored annulus 236 pressed into the outer end of the cup 230 defines an annular valve seat 238 opposing a circular valve member 240 urged toward the seat by a compression spring 242 supported by the cup bottom 234. A cylindrical skirt 244 on the valve member 240 encircles a cylindrical guide 246 staked to the cup bottom 234.

The inner diameter of the valve member skirt 244 is dimensioned to provide radial clearance around the cylindrical guide 246 just sufficient to provide an effective dashpot action which steadies movement of the valve member 240 toward and away from the seat 238.

The valve member 240 is moved away from the seat 238 against the spring 242 by means of a stem 248 extending from the valve member through the annulus 236 to engage the center of the diaphragm 222.

The central portion of the diaphragm 222 is backed up on the side opposite the valve assembly 194 by a circular support or pressure distribution head 250. A stem 252 fixed to the side of the pressure head 250 opposite the diaphragm 222 extends into a helical compression spring 254 seated within an inwardly open bore 256 in a pressure regulating screw 258. The screw 258 is threaded into a central spud 259 on the header plate 224 and held in adjusted position by a locknut 260.

The pressure control spring 254 acts through the head 250 and diaphragm 222 to hold the valve member 240 in open position until the back pressure on the pump, i. e., the pressure within the discharge chamber 220, has reached a predetermined value sufficient to meet the fuel pressure requirements of the carburetor 231. When this back pressure, which is practically synonymous with the effective output pressure of the pump, reaches the predetermined value the pressure of fuel on the diaphragm 222 overcomes the force of the spring 254 allowing the spring 242 to move the valve member 240 toward the seat 238.

The back pressure required to effect closing of the regulating valve in this manner can be readily adjusted to meet the fuel pressure requirements of different carburetors by adjusting the threaded screw 258 to vary the residual stress in the spring 254.

It is significant that in addition to its function in serving as a control for the throttling valve member 240 the diaphragm 222 provides effective assurance of an even output pressure from the discharge chamber 220. Thus, as shown, the pressure head 250 terminates a substantial distance radially inward of the adjacent marginal edge of the body 10, thus leaving an annular portion 262 of the diaphragm unsupported by the pressure head. Due to the flexibility of the material forming the diaphragm 222, the unsupported annular portion 262 pulsates to effectively suppress rapid pressure fluctuations which might otherwise occur in the discharge chamber 220. As a result, the output pressure from the chamber 220 is maintained at a substantially even level.

It may be observed that the plunger 64 could have a tendency to over-travel when it is cycling at an accelerated rate during a pump priming phase of its operation. This is effectively controlled by means of a buffer spring 264, Fig. 1, supported in a counterbore 266 in the plenum chamber end of the plunger 64 and projecting outwardly beyond the plunger to engage the bottom of the valve cup 230.

The improved pump thus formed has extraordinary efficiency in operation which provides not only for highly significant minimization of the size and weight of the pump structure but also for strikingly sharp responsiveness of the pump to only a slight diminution in the normal back pressure in the pump discharge chamber **220** to pump fuel at a high rate sufficient to meet the requirements of even the most powerful engines used in automotive vehicles. The automatically controlled throttling action of the regulator valve assembly **194** limits the pressure in the discharge chamber **220** to a predetermined value which can be tolerated by the carburetor **231**, while at the same time providing for the use of a powerful plunger operating spring **98** that enables the pump to meet extremely high volumetric output requirements by means of pumping structure of reduced overall size and weight. The extraordinary responsiveness of the pumping action to even a slight diminution in the normal back pressure in the discharge chamber **220** is such that the discharge of fuel from the pump at a rate sufficient to supply a carburetor of even the most powerful automotive vehicle engine does not result in an undesirable drop in pressure at the pump outlet **228**, Fig. 3.

To briefly review the extraordinary serviceability of the pump thus provided, it will be appreciated that every major component of the pump is readily accessible for inspection or repair in the event this becomes desirable. The switch **126** can be quickly removed simply by turning the cap **158** to release the latter from the boss **128**. After lifting the switch **126** and cup **150** out of the boss **128**, the service man can lift out the lever **130** and cartridge **134**.

Removal of the screw attached header **224** provides free access not only to the diaphragm **222** and its spring support structure but, also, to the throttling valve assembly **194**, which can be quickly unthreaded from the barrel element **14**.

Turning of the nut **122** at the opposite end of the pump releases the bail **112** in the manner described, thus affording convenient access to the filter **100** and intake valve assembly **66**. The assembly **66** can be screwed out of the boss **68** to permit withdrawal of the spring **98** and plunger **64** if desired. Further, the retainer **52** can be screwed out of the counterbore **54** to permit the remaining components of the solenoid assembly **18** to be slid off the tube **20** and out of the body **10**.

The readiness with which access may be had to the component structure of the pump adds much in the way of the overall utility to the operational capabilities afforded by the invention.

I claim:

1. For supplying fuel to an internal combustion engine carburetor, a high capacity fuel pump comprising, in combination, a reciprocable magnetic plunger, means including one end of said plunger defining a plenum chamber, means including the opposite end of said plunger defining a pumping chamber, means including a fuel intake check valve connected to supply fuel to said pumping chamber, a solenoid operating assembly including two spaced circuit members disposed in adjacent relation to said plunger to urge the latter magnetically toward an overlapping position with respect to both circuit members, a powerful operating spring connected to said plunger to urge the latter away from said position in a direction for expanding said pumping chamber, said plunger defining a passageway extending therethrough between said pumping chamber and said plenum chamber, a check valve mounted on said plunger to prevent reverse flow of fluid through said passageway toward the pumping chamber end thereof, electric power supply means connected to said solenoid assembly and mounted in association with said plunger to energize the solenoid assembly as an incident to predetermined spring produced movement of the plunger toward said plenum chamber and to deenergize the solenoid assembly as an incident to predetermined magnetically produced movement of the plunger toward said pumping chamber, means defining a fuel discharge chamber and including yieldable means preconditioned to move reversibly in response to changing fluid pressure within the discharge chamber, a control valve connecting said plenum chamber to said discharge chamber, and means coacting with said control valve and with said yieldable discharge chamber defining means to effect closing of the control valve as an incident to movement of said yieldable means by an increase in pressure within said discharge chamber to a predetermined value and to quickly open the control valve as an incident to movement of said yieldable means in response to a slight decrease in the discharge chamber pressure below said predetermined value.

2. For maintaining a continuously adequate supply of fuel to a high powered internal combustion engine carburetor, a compact high capacity electric fuel pump comprising, in combination, a body including an elongated outer shell and a hollow barrel element generally concentric with the outer shell, a nonmagnetic guide tube projecting from one end of said barrel element generally along the axis of elongation of said body shell and disposed substantially within said shell, a solenoid slidably encircling said tube, magnetic circuit means for said solenoid including two annular discs detachably encircling said tube at opposite ends of the solenoid, the disc remote from said barrel element forming a retainer detachably secured to said body shell, a fuel intake valve assembly threadedly secured in said retainer disc in covering relation to the adjacent end of said tube, a magnetic plunger slidably disposed within said tube for reciprocation therein, a strong power spring inserted between said intake valve assembly and the adjacent end of said plunger to urge the latter away from said retainer disc, said plunger defining a bore extending longitudinally therethrough, a check valve mounted on said plunger to prevent reverse flow of fluid through said plunger bore toward said intake valve assembly end thereof, said barrel element defining an opening in the side thereof, a switch actuating cartridge removably disposed in sealing relation to said opening and containing a transverse sealing diaphragm in the cartridge, a switch actuating lever assembly pivotally supported on said cartridge and extending into coacting relation with the adjacent end of said plunger for actuation by movement of the latter in opposite directions, said body shell defining a hollow boss thereon aligned with said actuator cartridge to permit ready insertion and removal of the latter through the boss, a control switch assembly shaped to fit removably into said boss for coaction with said switch actuator, said switch assembly including terminal posts extending inwardly, terminal sockets connected with said solenoid and supported on said annular solenoid circuit disc adjacent said barrel element in position to receive said terminal posts, a quick disconnect cap disposed in covering relation to said boss and shaped to apply retaining force to said switch assembly, a control valve assembly detachably secured in the end of said barrel element opposite said solenoid whereby said barrel element is closed off to form a plenum chamber therein, means on said body adjacent said control valve cooperating with the body to define therewith a discharge chamber communicating with the downstream side of said control valve, said discharge chamber defining means including pressure responsive means positioned to operate in response to changes in fluid pressure within said discharge chamber, means coacting with said pressure responsive means and with said control valve to close the latter automatically in response to a buildup in pressure within said discharge chamber to a predetermined carburetor supplying level and to open said control valve automatically in response to a receding in the discharge chamber pressure below said level, and means defining an outlet from said discharge chamber.

3. For providing a high powered internal combustion engine carburetor with a continuously adequate supply

of fuel under proper pressure, a compact high capacity fuel pump comprising, in combination, a reciprocable magnetic pump plunger, means supporting said plunger for reciprocation and forming an effective fluid seal therearound, means including one end of said plunger defining a plenum chamber, and means including the other end of said plunger defining a pumping chamber, means including a fuel intake check valve connected to supply fuel to said pumping chamber, said plunger defining a bore extending therethrough between said pumping chamber and said plenum chamber, a check valve mounted on said plunger in position to automatically block fluid flow through said bore toward the pumping chamber end thereof, a strong power spring interconnected with said plunger to urge the latter in a direction to contract said plenum chamber, said power spring having great effective strength relative to the effective pressure area of the plenum chamber end of said plunger to produce an excessive fluid pressure within said plenum chamber, a solenoid assembly positioned in relation to said plunger to operate upon energization of the solenoid assembly to magnetically force the plunger against the action of said power spring a substantial distance in a direction to contract said pumping chamber, means for controlling energization of said solenoid assembly in response to movement of said plunger in opposite directions, means defining a discharge chamber adjacent said plenum chamber, a control valve connecting said plenum chamber with said discharge chamber, said discharge chamber defining means including a movable element exposed to fluid pressure within the discharge chamber, resilient means coacting with said movable element to urge the latter in a direction for contracting said discharge chamber, said resilient means having an effective strength such that the fluid pressure within said discharge chamber required to move said movable element through a predetermined positional range closely approaches a predetermined carburetor pressure, and means interconnecting said control valve with said movable element to effect opening and closing of said valve as an incident to reverse movements of said element through said predetermined range thereof.

4. For maintaining a continuously adequate supply of fuel to a high powered internal combustion engine carburetor, a compact highly efficient electric fuel pump capable of producing an even output pressure readily adjustable to different values, said pump comprising, in combination, a hollow body, an elongated plunger formed of magnetic material, means on said body supporting said plunger for reciprocation and forming an effective fluid seal therearound, means including one end of said plunger defining a plenum chamber within said body, means including the other end of said plunger defining a pumping chamber, fluid supply means including an inlet check valve connected to supply fuel to said pumping chamber, said plunger defining a bore extending therethrough between said chambers at opposite ends thereof, a check valve mounted on said plunger to automatically prevent flow of fluid through said bore toward the pumping chamber end thereof, a strong power spring coacting with said plunger to urge the latter in a direction for contracting said plenum chamber, a solenoid assembly positioned in relation to said plunger to operate upon energization the solenoid assembly to magnetically move said plunger against said spring in a direction for contracting said pumping chamber, a removable switch mounted on said body and connected to energize said solenoid assembly, removable actuating means for said switch coacting with said plunger to close said switch as an incident to movement of the plunger by said spring to a predetermined position and to open said switch as an incident to predetermined movement of the plunger by the solenoid assembly to a second predetermined position, means on said body coacting therewith to define a discharge adjacent said plenum chamber, a control valve connecting said plenum chamber with said discharge chamber, said discharge chamber defining means including a flexible diaphragm supported at the peripheral edge thereof, a support head engaging the central portion of said diaphragm on the side thereof opposite from said discharge chamber, the outer periphery of said support head terminating a substantial distance radially short of the supported peripheral edge of said diaphragm thus leaving an annular portion of said diaphragm around said head free to pulsate to absorb pressure fluctuations within said discharge chamber, spring means operating on said head to urge said diaphragm in a direction to contract said discharge chamber, adjusting means coacting with said head spring means to regulate the residual force thereof thereby controlling the carburetor supplying fluid pressure with said discharge chamber required to move said diaphragm through a predetermined positional range, means connected between said diaphragm and said control valve to effect opening and closing of said valve as an incident to movement of the diaphragm in opposite directions through said predetermined positional range, and said plunger power spring having a strength related to the effective pressure area of the plenum chamber end of the plunger such that the maximum spring pressure exerted on fluid within said plenum chamber is greatly in excess of the discharge chamber fluid pressure required to move said diaphragm to effect closing of said control valve.

5. A compact high capacity electric fuel pump comprising, in combination, a body including a hollow shell, an elongated magnetic plunger, means supporting said plunger within said body shell for reciprocation and forming an effective fluid seal around the plunger, means including one end of said plunger defining a plenum chamber, means including the opposite end of said plunger and a fuel intake check valve defining a pumping chamber, a strong power spring interconnected with said plunger to urge the latter in a direction for contacting said plenum chamber, a solenoid assembly positioned in relation to said plunger supporting means to operate upon energization of the solenoid assembly to magnetically force the plunger against said power spring therefor in a direction for contracting said pumping chamber, switch means connected to controllably energize said solenoid assembly, switch control means coacting with said switch means and with said plunger to energize and deenergize said solenoid in response to movement of said plunger respectively toward and away from said plenum chamber, said plunger defining a cylindrical bore extending therethrough between said pumping chamber and said plenum chamber, narrow valve support means mounted on said plunger and extending diametrically across said bore therein, a pair of flexible check valve blades disposed within said plunger bore and supported at the base of each blade by said valve support means, each blade having a maximum length perpendicular to said valve support means substantially greater than the radius of said plunger bore and extending from said valve support means toward the plenum chamber end of said bore, the marginal edge of each blade away from said valve support means having a generally semi-elliptical shape to seal against the adjacent cylindrical surface of said plunger bore in response to differential fluid pressure across said blades tending to produce fluid flow toward the pumping chamber end of said bore, said plenum chamber defining means including a control valve for releasing fluid therefrom, means including a fluid pressure responsive actuator mounted on said body to define therewith a discharge chamber adjacent said plenum chamber and communicating directly with the discharge side of said control valve, means interconnecting said fluid pressure responsive actuator with said control valve to effect closing of the latter automatically in response to a build-up in pressure in said discharge chamber to a predetermined carburetor supplying pressure, said power spring for said plunger

having a predetermined strength in relation to the effective pressure area of the plenum chamber end of the plunger to produce within said plenum chamber a maximum fluid pressure greatly in excess of the fluid pressure required in said discharge chamber to effect closing of said control valve by means of said pressure responsive actuator therefor, and means defining an outlet from said discharge chamber.

6. For maintaining a continuously adequate supply of fuel to a high powered internal combustion engine carburetor, a readily serviceable electric fuel pump comprising, in combination, a body including an elongated outer shell and a hollow barrel element having an inner end disposed within the medial portion of the shell, a nonmetallic guide tube extending from said inner end of said barrel element along the axis of said shell, a solenoid slidably encircling said tube, magnetic circuit means for said solenoid including a magnetic disc encircling said tube at the inner end of said barrel element and an annular magnetic retainer detachably secured to said body shell and encircling the end of said tube remote from said barrel element, a magnetic plunger slidably disposed within said tube, an intake check valve assembly detachably mounted on said retainer in covering relation to the adjacent end of said tube whereby a pumping chamber is defined between said intake valve assembly and the adjacent end of said plunger, a strong power spring interposed between said intake valve assembly and the adjacent end of said plunger to urge the latter away from said magnetic retainer, a hollow cylindrical strainer removably seated in encircling relation to said intake valve assembly, said strainer being substantially coaxial to said tube and having a diameter approximately equal to that of said solenoid, a strainer bonnet covering the end of said strainer remote from said retainer, quick release means detachably holding said bonnet in sealed relation to said body shell, means for supplying fuel into surrounding relation to said strainer, a control valve removably secured in the end of said barrel element opposite said solenoid, the intermediate portion of said barrel element defining a plenum chamber, removable switch actuating means extending into the plenum chamber portion of said barrel element and forming a seal therewith, said switch actuating means coacting with said plunger for actuation by movement of the latter in opposite directions, said body shell defining a hollow boss substantially alined with said switch actuating means, a quickly removable switch seated in said boss and coacting with said actuating means for operation thereby, separable means connecting said switch with said solenoid, a quick disconnect cap mounted in covering relation to said boss to hold said switch in seated position therein, said plunger defining a bore extending therethrough between said pumping chamber and said plenum chamber, a check valve mounted on said plunger to prevent reverse flow of fluid through said bore toward said pumping chamber end thereof, movable pressure responsive means attached to the end of said body opposite said strainer end thereof to define with the body a discharge chamber communicating with the outlet of said control valve, means for closing said control valve in response to movement of said pressure responsive means by predetermined carburetor supplying fluid pressure within said discharge chamber, said plunger power spring having an effective strength related to the pressure area of the plenum chamber end of said plunger to produce fluid pressure within said plenum chamber greatly in excess of the fluid pressure required in said discharge chamber for actuating said pressure responsive means to close said control valve, and means forming a fluid outlet from said discharge chamber.

7. In an electric fuel pump, the combination of an elongated magnetic plunger, means supporting said plunger for reciprocation and forming an effective fluid seal therearound, means defining a plenum chamber at one end of said plunger, means including a fuel intake valve defining a pumping chamber at the other end of said plunger, said plunger defining a bore extending longitudinally therethrough between said pumping chamber and said plenum chamber, narrow check valve support means mounted on said plunger and extending diametrically across said bore therein a substantial distance from the plenum chamber end of the bore, two flexible valve blades each having a base thereof anchored to said valve support means, said blades being formed of a plastic material highly resistant to petroleum fuels, each of said blades extending from said support means therefor toward the plenum chamber end of said bore and having a peripheral edge shaped to separably seal against the adjacent surface of the bore, a strong power spring coacting with said plunger to urge the latter in a direction to expand said pumping chamber, solenoid means positioned in relation to said plunger to magnetically move the latter against the force of said spring in a direction for contracting said pumping chamber, and control means connected with said solenoid means and coacting with said plunger to control said solenoid means in response to reverse movements of said plunger.

8. For maintaining to a high powered internal combustion engine carburetor an adequate supply of fuel at an even adjustable pressure, a compact high capacity electric fuel pump comprising, in combination, a magnetic plunger, means supporting said plunger for reciprocation and defining an effective fuel seal therearound, means including a fuel intake valve defining a pumping chamber at one end of said plunger, said plunger defining a bore extending therethrough from said pumping chamber, a check valve mounted on said plunger to prevent reverse flow of fluid through said bore toward said pumping chamber end thereof, a strong power spring coacting with said plunger to urge the latter in a direction to expand said pumping chamber, solenoid means positioned in relation to said plunger to magnetically urge the latter against said spring therefor in a direction for contracting said pumping chamber, switch means coacting with said plunger and connected with said solenoid to control energization of the latter in response to reverse movements of the plunger, means including a control valve assembly defining a plenum chamber at the end of said plunger opposite said pumping chamber, said control valve assembly including a valve seat, a movable valve member disposed in opposing relation to said seat, a cylindrical guide skirt on said movable valve member, a guide stem extending into said skirt to guide and hydraulically check movement of the valve member toward and away from said valve seat, means including a flexible diaphragm defining a discharge chamber communicating with the downstream side of said control valve assembly, stationary means supporting the marginal edge of said diaphragm, a movable support head engaging the central portion of said diaphragm on the side thereof opposite said discharge chamber, the peripheral edge of said support head terminating radially short of the supported marginal edge of said diaphragm to leave an annular portion of said diaphragm unsupported to pulsate to absorb incipient pressure fluctuations within said discharge chamber, pressure control spring means coacting with said support head to urge the latter in a direction for contracting said discharge chamber, adjustable means positioned to regulate the residual stress in said pressure control spring means, means positioned to transmit reverse movements of the head supported portion of said diaphragm to said movable control valve member to effect movement of the latter toward and away from the coacting valve seat in response to reverse movements of the head supported portion of the diaphragm, and means defining a fluid outlet from said discharge chamber.

9. For providing to a high powered internal combustion engine carburetor a clean continuously adequate supply of

fuel under proper pressure, a compact highly efficient electric fuel pump comprising, in combination, an elongated body shell, an elongated magnetic plunger, means supporting said plunger for reciprocation within said shell and forming an effective fluid seal around the plunger, means including a detachable intake valve assembly defining a pumping chamber at one end of said plunger, said intake valve assembly including a fuel inlet bore therein, a permanently magnetized wire shaped to clamp on said valve assembly and having opposite ends shaped to extend across said intake valve bore and magnetized to collect magnetic particles from fuel flowing through the bore, a strong power spring interposed between said intake valve assembly and said plunger to urge the latter in a direction to expand said pumping chamber, a solenoid assembly detachably mounted within said shell in position to urge said plunger against said spring in a direction for contracting said pumping chamber, a hollow cylindrical filter removably seated in surrounding relation to said intake valve assembly, a covering bonnet for said filter, quick disconnect means supporting said bonnet on said shell in housing relation to said filter, means defining a fuel inlet communicating with the outer surface of said filter, said plunger defining a bore extending therethrough from said pumping chamber, a check valve supported on said plunger to prevent reverse flow of fluid through said plunger bore toward the intake valve assembly end thereof, means defining a plenum chamber at the end of said plunger opposite said pumping chamber, and solenoid control means connected with said solenoid assembly and coacting with said plunger to control energization of the solenoid assembly in response to movement of the plunger in opposite directions.

10. For supplying the large and sharply varying fuel requirements of a high powered internal combustion engine carburetor, a self-contained fuel pump having an output pressure highly stabilized continuously at a limited pressure level and comprising, in combination, means defining a pumping chamber and including as a component thereof a reciprocable pumping element movable in opposite directions to expand and contract the pumping chamber, a fuel inlet check valve communicating at the downstream side thereof with said pumping chamber, means including a component portion of said pumping chamber means and defining a plenum chamber immediately adjacent said pumping chamber, a check valve mounted between said pumping and plenum chambers on said component portion of said pumping chamber means and having an upstream side communicating directly with said pumping chamber and a downstream side communicating directly with said plenum chamber, means including a component portion of said plenum chamber means and defining a fuel discharge chamber immediately adjacent said plenum chamber, a control valve mounted between said plenum and discharge chambers on said component portion of said plenum chamber means and having an upstream end communicating directly with said plenum chamber and a downstream end communicating directly with said discharge chamber, said discharge chamber defining means including as a component thereof a movable chamber expanding and contracting element spring biased with a yieldable force which moves the expanding and contracting element in a discharge chamber contracting direction against internal discharge chamber pressures less than a predetermined limited value and which allows discharge chamber pressures greater than said predetermined valve to move the expanding and contracting element in a discharge chamber expanding direction, means coacting with said expanding and contracting element and with said control valve to effect opening and closing of the latter by movement of said expanding and contracting element in chamber contracting and expanding directions respectively, a damper connected to said control valve to steady opening and closing movements thereof, reciprocating means coacting with said reciprocable pumping element and including a powerful spring connected with said pumping element to urge the latter in one direction and including externally energized power means coacting with the pumping element to intermittently move the latter in the opposite direction against said spring, and said reciprocating means having sufficient strength to pump into the plenum chamber a maximum pressure greatly in excess of said predetermined limited value and being yieldable against a plenum chamber pressure in excess of said maximum pressure.

11. In a fuel pump of the type in which a piston is reciprocated in a cylinder by an electro-magnet and by a return spring engaging the piston to pump fuel from a pumping chamber to a second chamber to which an outlet is connected and in which inlet and check valves are provided for preventing reverse flow of fuel through the pump, wherein the pump is characterized by: the piston return spring being oversized; a third chamber integral with the pump, disposed immediately adjacent the second chamber, and interposed between the second chamber and the outlet; a relatively unrestricted passageway interconnecting the second chamber with the third chamber to provide substantially no line pressure drop between the chambers; a third valve disposed in the passageway; ing element in first and second opposite directions to and an elastic element in the third chamber operatively connected to the third valve for reducing and regulating the pressure of the fuel flowing from the second chamber into the third chamber, thereby to provide a high capacity, fast response pump characteristic.

12. For supplying fuel to an internal combustion engine, a high capacity constant pressure fuel pump comprising a reciprocable pumping element; means including one surface of said pumping element defining a pumping chamber; a first and second power means for urging said pumping element in first and second opposite directions to respectively draw fuel into said pumping chamber under vacuum and to force fuel from said pumping chamber under pressure; one of said power means operated by an external source of power, the other comprising an oversized power spring in operative engagement with the pumping element and capable of producing a force substantially in excess of that required for desired fuel pump discharge pressures; the power means causing discharge of fuel from the pumping chamber being elastic and capable of producing a fuel discharge pressure substantially greater than desired fuel pump output pressures; inlet and outlet check valve means for said pumping chamber; means integral with the pump immediately adjacent said pumping chamber and directly connected therewith defining a plenum chamber; said outlet check valve interposed between said plenum chamber and said pumping chamber; means integral with the pump immediately adjacent said plenum chamber and directly connected therewith defining a fuel discharge chamber including a yieldable element preconditioned to move reversibly in response to changing fluid pressure within the discharge chamber; a control valve interposed between said plenum chamber and said discharge chamber; and linkage connecting the control valve and the yieldable element for urging the control valve toward closed position incident to movement of the yieldable element by an increasing pressure within said discharge chamber to a predetermined value and urging the control valve toward open position incident to movement of said yieldable element by a slight decrease in the discharge chamber pressure below said predetermined value.

13. A fuel pump for supplying the large and sharply varying fuel requirements of a high pressure internal combustion engine carburetor comprising; a pumping chamber; a plenum chamber communicating with one side of the pumping chamber; a fuel inlet communicating with the other side of the pumping chamber; a reciprocable element in the pumping chamber and inlet and outlet

valves for pumping fuel from the inlet, through the pumping chamber, and into the plenum chamber; a first power means for urging the pumping element in one direction at a pressure substantially in excess of that required by the carburetor; an oversized biasing spring engaging the element to urge it in the opposite direction at a pressure substantially in excess of that required by the carburetor; a third chamber integral with the pump and immediately adjacent the plenum chamber; a fuel outlet communicating with the third chamber; a substantially unrestricted passageway interposed between the third chamber and the plenum chamber to permit substantially no line pressure drop between the chambers; a third valve disposed in the passageway; and an elastic element in the third chamber connected to the third valve for reducing and regulating the pressure of the fuel flowing from the plenum chamber into the third chamber.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,872,871 February 10, 1959

Arthur C. Allen

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 5, line 65, for "(hot shown)" read -- (not shown) --; column 16, line 26, strike out "ing element in first and second opposite directions to".

Signed and sealed this 11th day of August 1959.

(SEAL)
Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents