May 24, 1966 E. A. JOHNSON ET AL 3,252,424

FUEL SYSTEMS

Filed Jan. 15, 1960 4 Sheets-Sheet 1

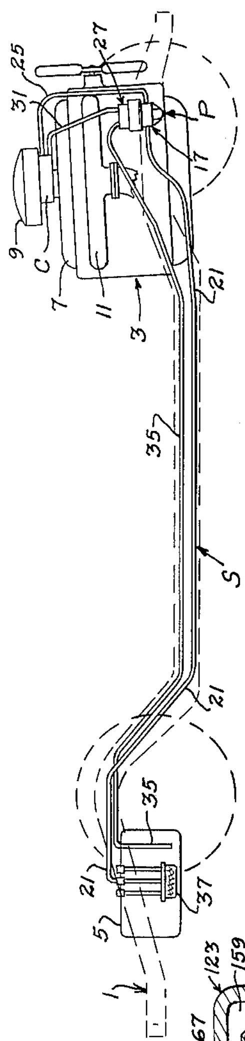

FIG. 1.

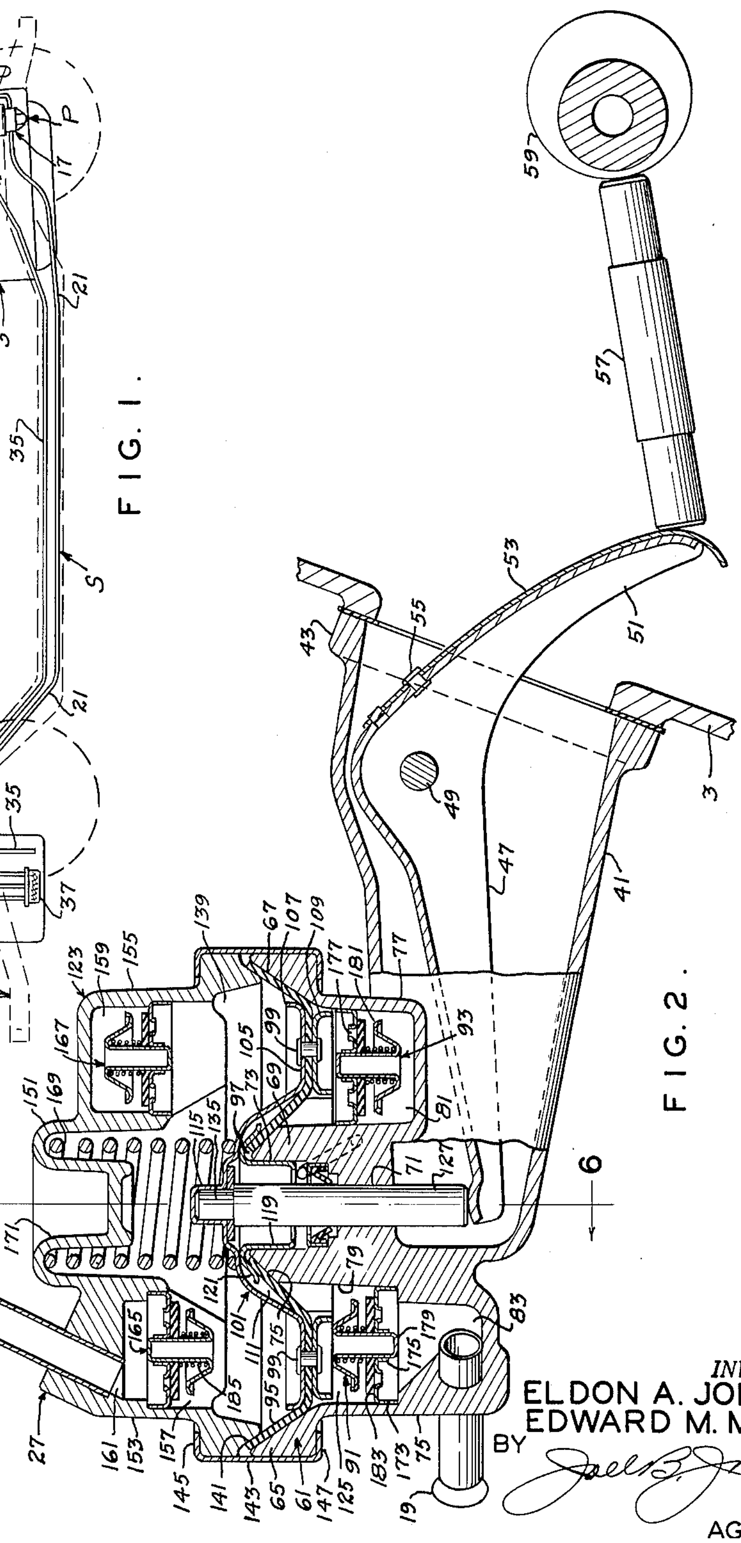

FIG. 2.

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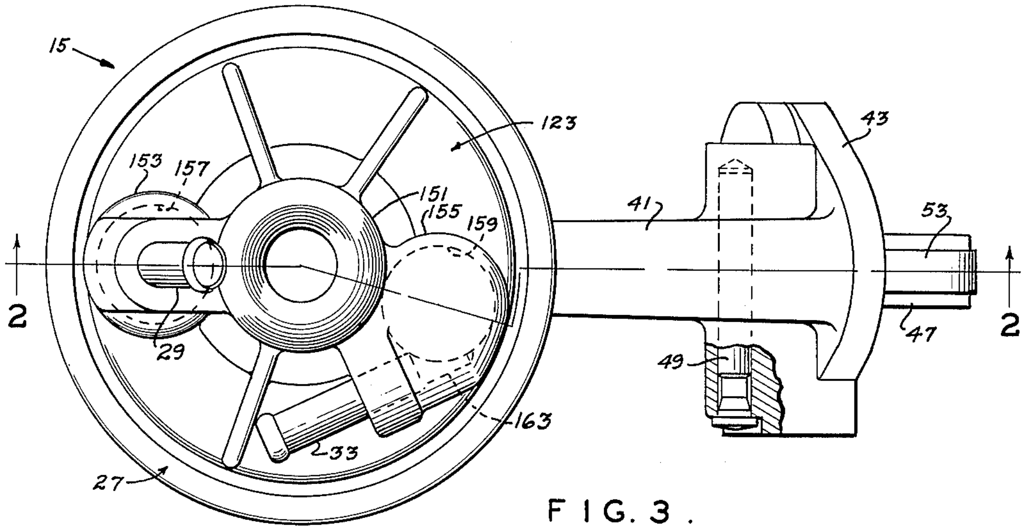

FIG. 3.

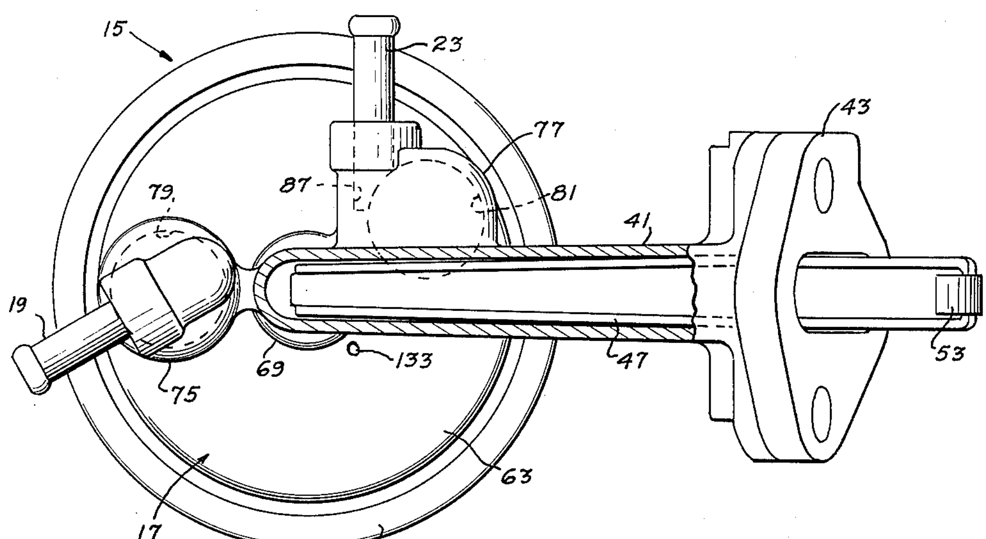

FIG. 4.

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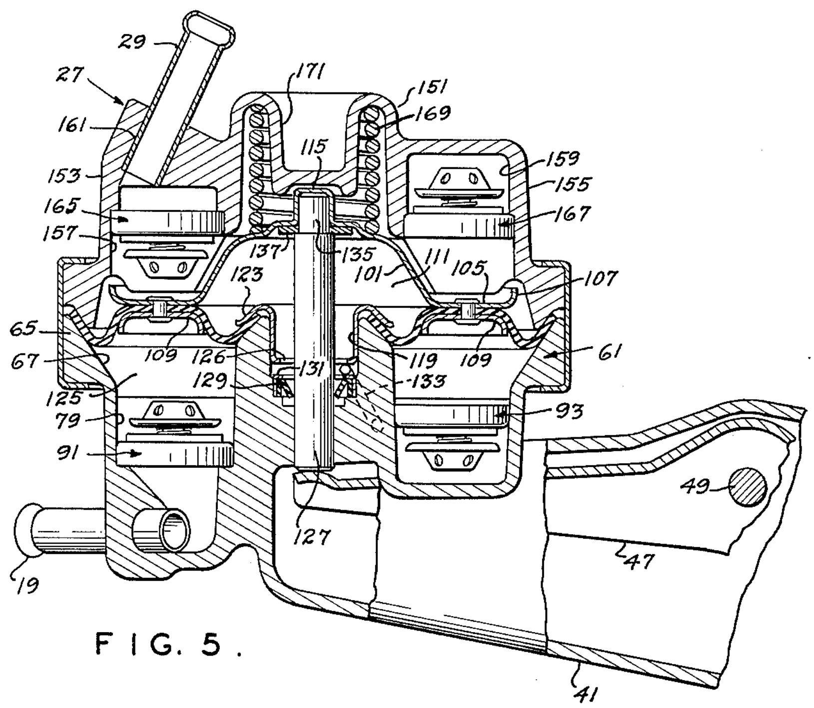

FIG. 5.

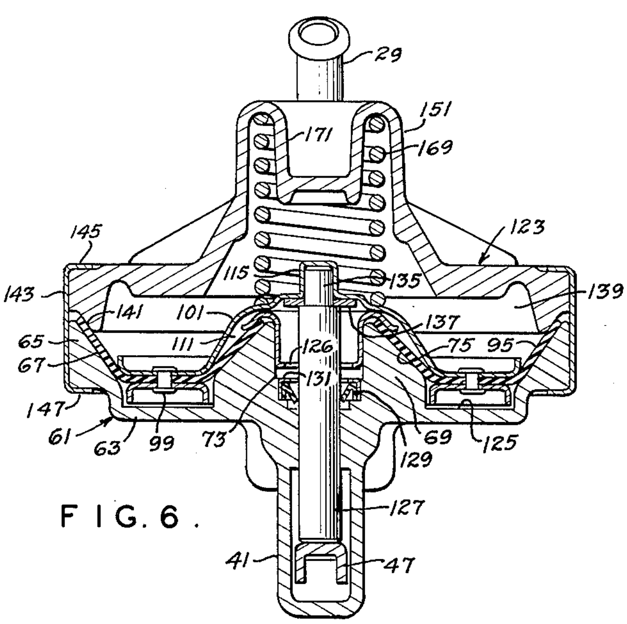

FIG. 6.

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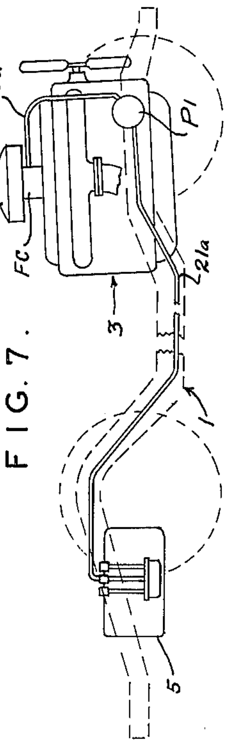

FIG. 7.

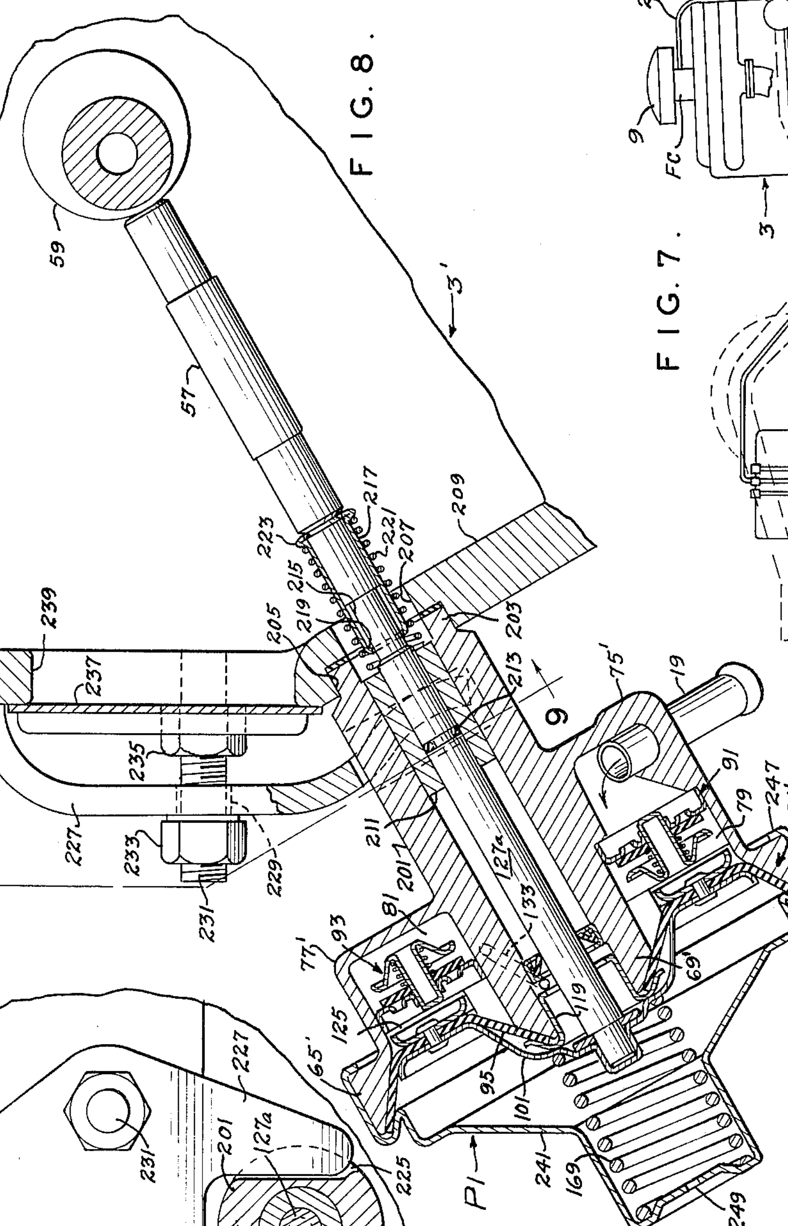

FIG. 8.

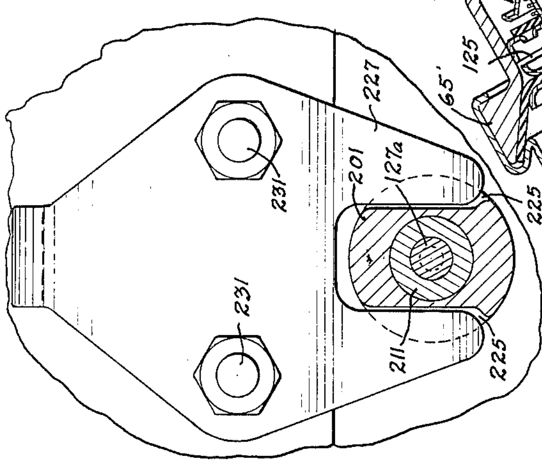

FIG. 9.

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FUEL SYSTEMS

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Filed Jan. 15, 1960, Ser. No. 2,656
4 Claims. (Cl. 103—150)

This invention relates to fuel systems for internal combustion engines, more particularly to fuel systems for automotive engines, and to fuel pumps used in such systems.

The invention pertains to a fuel system of the type wherein fuel is supplied from the fuel tank of the automotive vehicle to a carburetor having a fuel bowl from which fuel overflows above a predetermined level, overflow fuel being returned to the tank, there being a constant circulation of fuel from the tank to the carburetor and back to the tank when the engine is in operation. This type of fuel system may be referred to as a "recirculating" system, since fuel is constantly being recirculated through the system when the engine is in operation. In such a system, fuel needs to be pumped from the tank to the fuel bowl at a rate in excess of the engine fuel demand in order to maintain the predetermined level or head of fuel in the bowl for accurate metering of fuel from the bowl to the engine, and overflow fuel needs to be pumped back to the tank to avoid flooding. The pumping of overflow fuel back to the tank is referred to as "scavenging."

A more conventional fuel system for the engine of an automatic vehicle comprises a float-type carburetor and an engine-driven pump for pumping fuel from the fuel tank of the vehicle to the fuel bowl of the carburetor, admission of fuel to the bowl being controlled by a float valve. Such a pump conventionally comprises a diaphragm, a compression spring tending to move the diaphragm in one direction through a discharge stroke, a diaphragm-actuating rod for moving the diaphragm in the opposite direction, a rocker arm for moving the diaphragm-actuating rod, and a push rod actuated by an engine-driven cam for operating the rocker arm. The rocker arm is provided to avoid any necessity for using packing to make a fuel-tight seal on the diaphragm-actuating rod. In this respect, it will be understood that rod packing exposed to fuel is apt to cause trouble, due, for example to swelling of the packing and binding on the rod.

The invention comprehends the provision of an improved packless diaphragm pump construction, i.e., a pump construction devoid of such packing for the diaphragm-actuating rod as might fail under the attack of fuel, which enables the provision of a practical, economical dual diaphragm pump for a recirculating system by means of which the pumping of fuel to the fuel bowl of the carburetor and the scavagening of fuel from the carburetor is accomplished by means of a single diaphragm, with the diaphragm spring-loaded for movement in one direction through a primary discharge stroke and a scavenger intake stroke, and adapted to be moved in the opposite direction through a primary intake stroke and a scavenger discharge stroke by driving the diaphragm-actuating rod from the engine, and which also enables the provision of a practical, economical packless diaphragm pump for a conventional float carburetor system wherein the diaphragm-actuating rod may be directly driven by a cam-operated push rod in line with the diaphragm-actuating rod without the interposition of a rocker arm.

The pump construction of this invention which is applicable to both the dual diaphragm pump and the pump for a conventional float carburetor system essentially comprises a pump body having an opening, a diaphragm having a hole therein registering with the opening in the body, the diaphragm having its inner margin around the hole therein and its outer margin sealed to the body with an intermediate annular portion of the diaphragm free for flexure, thereby providing a pump chamber on one side of the diaphragm. A head is secured in sealed relation to the intermediate annular portion of the diaphragm on the other side of the diaphragm, there being an air space between the head and the diaphragm which is vented to the outside of the body. A diaphragm-actuating rod extends through the opening in the body and the hole in the diaphragm and engages the head. With this arrangement, a spring may be used biasing the head in the direction toward the rod and thereby tending to contract the pump chamber. With the inner margin of the diaphragm around the hole therein sealed to the body, no packing is required on the rod to seal the pump chamber. In the case of the dual pump of this invention, there is an additional pump chamber on the other side of the diaphragm.

As regards the dual diaphragm pump and the recirculating system including the pump, this invention involves an improvement over the pump and system disclosed and claimed in the copending coassigned application of Eldon A. Johnson, Serial No. 2,660, filed January 15, 1960, entitled Fuel Systems.

In this respect, it will be observed that where in the stated copending application, the primary and scavenger pump chambers are simultaneously spring-discharged, in the present invention only the primary pump chamber is spring-discharged, the discharge of the scavenger pump chamber being accomplished by the engine-driven cam. Thus, the load on the spring may be less in the present case than in the prior case.

Other objects and features will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the constructions hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated,

FIG. 1 is a view in elevation illustrating a dual diaphragm pump of this invention in use on the engine of an automotive vehicle in a recirculating fuel system of this invention;

FIG. 2 is a vertical section of the dual diaphragm pump taken essentially on line 2—2 of FIG. 3;

FIG. 3 is a top plan view of the dual diaphragm pump, with parts broken away and shown in section;

FIG. 4 is a bottom plan view of the dual diaphragm pump, with parts broken away and shown in section;

FIG. 5 is a fragment of FIG. 2 showing a moved position of parts;

FIG. 6 is a vertical transverse section taken on line 6—6 of FIG. 2;

FIG. 7 is a view in elevation illustrating a single-acting pump of this invention in use on the engine of an automotive vehicle in a float carburetor fuel system;

FIG. 8 is a vertical section of the single-acting pump; and

FIG. 9 is a section taken on line 9—9 of FIG. 8.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring to FIG. 1 of the drawings, there is indicated at 1 the frame of an automotive vehicle having engine 3 at the front. The engine is adapted to be supplied with fuel from fuel tank 5 at the rear of the vehicle by a recirculating fuel system S of this invention which includes pump P of this invention and carburetor C mounted on the engine. Pump P is mounted on the side of the engine. Carburetor C is mounted on intake manifold **7** on top of the engine. An air filter for carburetor C is indicated at **9**. The exhaust manifold of the engine is indicated at **11**.

Carburetor C is a floatless carburetor having a fuel bowl and an overflow chamber, fuel spilling over into the overflow chamber from the bowl on exceeding a predetermined level in the bowl. Reference may be made to the above-noted copending coassigned Johnson application for details of a flatless carburetor which may be used.

Pump P is a dual diaphragm pump having a lower pump section **17** (which in recirculating system S is the primary pump section) having an inlet nipple at **19** (see FIGS. 2 and 4) to which is connected a fuel supply line **21** (see FIG. 1) from fuel tank **5** and an outlet nipple at **23** (see FIG. 4) to which is connected a fuel delivery line **25** (see FIG. 1) leading to the fuel bowl of carburetor C. Pump P also has an upper pump section **27** (which in recirculating system S is the scavenger pump section) having an inlet nipple at **29** (see FIGS. 2 and 3) to which is connected a fuel line **31** (see FIG. 1) for overflow from the carburetor C and an outlet nipple at **33** (see FIG. 3) to which is connected a fuel return line **35** (see FIG. 1) leading back to the tank **5**. As shown in FIG. 1, an electric pump **37** may be provided in tank **5** for pumping fuel from the tank through line **21** to the lower pump section **17**. This is optional.

Pump P comprises a rocker arm housing **41** which is open at one end (its right end as appears in FIG. 2), this end being referred to as the inner end of the housing. The housing is of generally rectangular form in vertical cross section of decreasing height from its inner end to its outer end (which is closed). At its inner end it has a flange **43** for attaching it to the engine **3** in communication with the crankcase of the engine. A rocker arm **47** is pivoted at **49** in the housing **41** for rocking motion on a horizontal axis transverse to the housing. Arm **47** has a downwardly extending end portion **51** which projects out of the open inner end of the housing. A leaf spring **53** is secured as by a rivet at **55** to the arm extending down on the outside of end portion **51** of the arm. When the pump **15** is mounted on the engine, the free end portion of leaf spring **53** is engaged by a push rod **57** actuated by an engine-driven cam **59**. This cam is adapted to rock the arm clockwise through a cam-powered stroke away from its FIG. 2 position. The arm is adapted to be returned counter clockwise back to its FIG. 2 position by a spring to be described.

The rocker arm housing **41** is integrally formed at its outer end with an essentially cup-shaped pump body **61** having a circular bottom **63** (see FIGS. 4 and 6) and an upstanding annular wall **65** which is of cylindrical form on the outside and of conical form on the inside. The interior conical surface of wall **65** is designated **67**. It diverges (flares outward) in the direction away from the bottom of the cup, the angle of flare being about 56°, for example. At the center of the bottom of the cup-shaped pump body **61** is an upstanding cylindrical hub **69** integrally formed on the outer end of rocker arm housing. Hub **69** has a vertical bore or opening **71** as shown in FIG. 2 extending upward from the outer end of the housing **41** to a counterbore **73** in its upper end. The upper end portion of the hub **69** is exteriorly tapered, thereby providing an exterior conical surface **75** which converges in the direction away from the bottom **63** of the cup-shaped body **61**. The upper end of the hub is approximately at the same level as the rim of the cup-shaped body **61**.

Extending down from the bottom **63** of the cup-shaped primary pump body **61** at opposite sides of the hub **69** are two bosses **75** and **77** which are cored to provide cylindrical recesses **79** and **81** extending down from the interior of body **61** and open at their upper ends to the interior of body **61**. Below the recess **79** is a lower pump inlet passage **83**. This is the primary inlet passage as the pump is used in a recirculating system S. Inlet nipple **19** extends into this passage. Extending tangentially from recess **81** is a lower pump outlet passage **87**. This is the primary outlet passage as the pump is used in recirculating system S. Outlet nipple **23** extends from this passage. Recess **79** contains an inlet check valve **91**; recess **81** contains an outlet check valve **93**.

The cup-shaped pump body **61** is closed by an annular diaphragm **95** consisting of a relatively thin disk of flexible fuel-resistant material, such as a suitable synthetic rubber, which, in unstressed condition, is flat or at least substantially flat. The diaphragm has a center hole **97** the diameter of which, when the diaphragm is flat, may be slightly smaller than the diameter of the upper end of the conical tip **75** of the hub **69**. The outside diameter of the diaphragm, in its flat condition, is greater than the outside diameter of the annular wall **65** of the body **61**. The diaphragm is secured as by rivets **99** to a hat-shaped sheet metal member **101** which constitutes a head on the diaphragm. This head **101** has an outwardly extending annular flat bottom flange **105** with a turned-up peripheral lip **107**. Head **101** is large enough to fit over the upper end of hub **69**. An intermediate annular portion of the diaphragm is compressed between the flange **105** on the head **101** and a washer **109**, rivets **99** extending through rivet holes in the flange **105**, the diaphragm and the washer, so as to provide a fluid-tight seal between the diaphragm and the flange **105**. An air chamber **111** is thereby defined between the head **101** and the diaphragm. The internal diameter of the washer **109** is greater than the diameter of the hub **69**, corresponding essentially to the internal diameter of the lower part of the head **101**. The head **101** has an upwardly extending central hollow projection at the top providing a downwardly opening socket **115**.

The diaphragm is applied to the cup-shaped body **61** with the center hole **97** in the diaphragm registering with the counterbored openings **73** the hub **69** of body **61**, and with the central portion or inner margin of the diaphragm around the center hole **97** therein distorted to conical form and engaging the conical surface **75** at the upper end of the hub **69** and the outer peripheral marginal portion of the diaphragm distorted to conical form and engaging the interior conical surface **67** of the wall **65** of the cup-shaped body **61**, with head **101** on the outside and washer **109** on the inside as regards body **61**. The inner margin of the diaphragm is clamped against conical surface **75** in fluid-tight sealing engagement therewith by a tubular clamp element or thimble **119** extending through the center hole **97** in the diaphragm and pressed into the counterbored opening **73** in the hub **69** and having an external annular conical head **121** at its upper end engaging the inner margin of the diaphragm. The outer margin of the diaphragm is clamped against the conical surface **67** in fluid-tight sealing engagement therewith by a casting **123** which constitutes the body of the pump section **27** and which serves as an enclosure on body **61** for the hat-shaped or cup-shaped head **101** and the diaphragm.

The diaphragm **95**, initially assembled as above described between the lower pump body **61** and the upper pump body **123**, assumes the form of an annular downwardly directed loop with a flat bottom portion and conical inner and outer side portions which diverge from the flat bottom portion in upward direction (see FIGS. 2 and 6). The upper margin of the inner side portion of the annular loop is clamped against the conical upper end of the hub **69** by thimble **119** and the upper margin of the outer side portion of the annular loop is clamped against conical surface **67** by the upper pump body **123**. The inner side portion of the annular loop lies on the conical upper end of the hub; the outer side portion lies on conical surface **67**. The intermediate annular portion of the diaphragm attached to the flange **105** of head **101** is slack and free for flexure. The top of the head **101** engages the upper end of the thimble **119** and washer **109** is contiguous to the bottom of the cup-shaped body **61**. The diaphragm, being sealed to the cup-shaped primary pump body **61** at the inner margin of the diaphragm around the center hole **97** in the diaphragm and at the outer margin of the diaphragm, closes off an annular space in body **61** around the hub **69**, this space constituting an annular lower pump chamber **125**. This is the primary pump chamber as the pump is used in recirculating fuel system S.

The bottom of the thimble **119** has a central hole **126** accommodating a diaphragm-actuating rod **127**. This rod is vertically slidable in the hub **69**, having a sliding fit in the bore **71** in the hub. A wiper for wiping crankcase oil from the rod is indicated at **129** in the lower end of the counterbore **73** in the boss. Wiper **129** comprises a ring of flexible fuel-resistant material such as a suitable synthetic rubber having an inturned conical lip which hugs the rod. It is held in the lower end of the counterbore **73** by a sheet metal ring **131** press-fitted in the counterbore prior to pressing thimble **119** therein. The bottom of thimble **119** is spaced above the ring **131**, and hub **69** is provided with a breather passage or vent **133** open at its inner end to the space between the bottom of thimble **119** and the ring **131** and open at its outer end to the atmosphere outside of the cup-shaped body **61**. The lower end of the rod **127** engages the inner end of the rocker arm **47**. The rod **127** has a reduced-diameter upper end extension **135** received in socket **115** at the top of the head **101**. A collar **137** is applied to the annular shoulder on rod **127** at the lower end of extension **135** engaging the inside of the top of the head **101**.

The body **123** of the upper pump section **27** is of circular form in plan, having a downwardly opening circular cavity which constitutes an upper pump chamber **139**. This is the scavenger pump chamber as the pump is used in recirculating fuel system S. Body **123** has an external conical surface portion **141** at the bottom which engages the outer margin of the diaphragm **95** to clamp it against the conical diaphragm-seating surface **67** of the lower pump body **61**. Body **123** is held in assembly on the lower pump body **61** by a sheet metal ring **143** surrounding the annular wall **65** of the lower pump body **61** and the rim of body **123**, this ring **141** having an upper portion **145** spun over on body **123** and a lower portion **147** spun under the body **61** to hold the parts together with sufficient compression of the outer margin of the diaphragm for sealing thereof against surfaces **67** and **141**. Thus, bodies **61** and **123** constitute a pump casing providing the two pump chambers **125** and **139** separated by the diaphragm **95**.

The upper pump body **123** has an upwardly extending hollow central boss **151** and two bosses **153** and **155** at opposite sides of the central boss **151**. Bosses **153** and **155** are cored to provide cylindrical recesses **157** and **159** extending up from pump chamber **139** and open at their lower ends to this chamber. Above recess **157** is an upper pump inlet passage **161** (the scavenger inlet passage as the pump is used in recirculating system S) in which is fitted the inlet nipple **29**. Extending tangentially from the upper part of recess **159** is a pump outlet passage **163** (the scavenger outlet passage as the pump is used in recirculating system S) in which is fitted the outlet nipple **33**. Recess **157** contains an inlet check valve **165**; recess **159** contains an outlet check valve **167**. A coil compression spring **169** reacts from the upper end of hollow boss **151** downward against the top of head **101** to bias the latter downward. This is the spring previously referred to which acts to return the rocker arm **47** in counterclockwise direction. Boss **151** has a central projection **171** extending downward from its top for centering the spring **169** and filling the space within

the spring for increasing the volumetric efficiency of the upper pump section **27**.

The check valves **91, 93, 165** and **167**, as shown, are all identical. Each comprises a circular valve seat **173** having a central hole **175** and a series of ports **177**, such as arcuate slots, around the hole **175**. Press-fitted in the hole **175** is a hollow stem **179** closed at its end in the hole, and having at its other end a mushroom head constituting a spring seat **181**. A ring-shaped disk valve member **183**, which may be made of a suitable fuel-resistant synthetic rubber for cushioned sealing, is slidable on the stem **179**, and is biased toward engagement with the valve seat by a coil compression spring **185** surrounding the stem reacting from the spring seat **181**. As to each of the four check valves, the valve seat **173** is press-fitted and positioned horizontally in the respective recess **79, 81, 157, 159**, with the disk valve member **183** and stem **179** on the appropriate side for inward or outward opening of the valve member, as the case may be. Thus, the stems **179** of the valve **91** for inlet passage recess **79** and the valve **167** for outlet passage recess **159** extend upward and the stems **179** of the valve **93** for outlet passage recess **81** and the valve **165** for inlet passage recess **157** extend downward.

In the operation of the dual diaphragm pump P, and upon each revolution of the cam **59**, starting with the cam in the FIG. 2 position wherein its low point engages the push rod **57**, the rocker arm **47** swings clockwise from its FIG. 2 position to its FIG. 5 position and then swings back from its FIG. 5 position toward its FIG. 2 position. The rocker arm is driven clockwise by the cam **59**, counterclockwise by the spring **169** acting through the rod **127**. With the rocker arm in the FIG. 2 position, its end which engages rod **127** is at the lower limit of its movement. Accordingly, rod **127** is at the lower limit of its vertical sliding movement, the head **101** is at the lower limit of its range of vertical movement, and the slack loop of the diaphragm **95** is at the limit of its downward flexure. Under these circumstances, the lower pump chamber **125** (the primary chamber) is fully contracted and the upper pump chamber **139** (the scavenger pump chamber) is fully expanded. The air chamber **111** is fully contracted.

As the end of the rocker arm **47** in engagement with rod **127** moves upward, it pushes rod **127** and head **101** upward against the downward bias of spring **169**. Head **101** pulls the flat bottom portion of the looped free intermediate annular portion of the diaphragm upward. This expands the lower (primary) pump chamber **125** and effect a suction stroke as regards the lower (primary) pump section **17** (inlet valve **91** opening up as the diaphragm is flexed upward and outlet valve **93** being held closed), and simultaneously contracts the upper (scavenger) pump chamber **139** and effects a discharge stroke as regards the upper (scavenger) pump section **27** (outlet valve **167** opening up as the diaphragm is flexed upward and inlet valve **165** being held closed). Accordingly, fuel is drawn from the tank **5** via line **21** into the primary chamber **125**, and fuel is discharged from the scavenger chamber **139** via line **35** to the tank. As the head **101** is pushed upward by the rod **127**, air chamber **111** expands. Air enters chamber **111** as it expands through the breather passage **133** to avoid development of a vacuum in chamber **111**. In this respect, it will be observed that if a vacuum were developed in chamber **111**, the force required to drive the diaphragm upward might be excessive, and oil might be sucked in from the crankcase. At the upper end of the stroke of rod **127**, spring **169** is fully loaded.

As the end of the rocker arm in engagement with rod **127** completes its upward movement, the rod **127** and the head **101** reach the position shown in FIG. 5, the slack loop of the diaphragm then being bulged upward as appears in FIG. 5. This occurs when the high point of the cam engages the push rod (180° from the cam position shown in FIG. 2). Then, as the cam completes a revolution, spring 169 becomes effective to drive the head 101 and the rod 127 downward. The head 101 thereupon pushes the slack loop of the diaphragm downward to contract the lower (primary) pump chamber 125 and effects a discharge stroke as regards the lower (primary) pump section 17 (outlet valve 93 opening up as the diaphragm flexes downward and inlet valve 91 being held closed) and simultaneously expands the upper (scavenger) pump chamber 139 to effect a suction stroke as regards the upper (scavenger) pump section (inlet valve 165 opening up as the diaphragm flexed downward and outlet valve 167 being held closed). Accordingly, fuel is discharged from the primary chamber 125 to the curburetor C via line 25, overflow fuel is drawn from the carburetor via line 31 into the scavenger chamber 139. As the head 101 is pushed downward, air chamber 111 contracts. Air in chamber 111 is then exhausted via breather passage 133. In this respect, it will be observed that if chamber 111 were closed, the spring force required to drive the diaphragm downward might be excessive, since it would have to be sufficient to compress air in chamber 111.

The extent to which head 101 and the slack loop of diaphragm 95 are driven downward by the spring 169 depends primarily upon the back pressure in the primary chamber 125. If the back pressure is high (i.e., if flow of fuel through line 25 to the carburetor is relatively restricted), the downward movement of head 101 and the slack loop of the diaphragm and consequently the output of the pump will be restricted. Conversely, if the back pressure is low, the downward movement of head 101 and the slack loop will be greater and, if sufficiently low, the head 101 will move downward to its lower limit in which it appears in FIGS. 2 and 6. The back pressure is controlled at the carburetor, as may be ascertained by reference to the stated copending Johnson application. On strokes of the diaphragm less than full stroke, the rocker arm 47 idles as regards rod 127 for part of the rocker arm stroke, slapping being prevented by the leaf spring 53.

Referring to FIG. 7 of the drawings, there is again shown the frame 1 of an automotive vehicle having engine 3 at the front, but with a conventional float-type carburetor FC on the intake manifold 7 of the engine. Carburetor FC is supplied with fuel from tank 5 by a system including a single-acting pump P1 of this invention which is supplied through a line 21*a* and delivers through a line 25*a*. There is no return to the tank in this type of system.

FIG. 8 discloses in detail the single acting pump P1 of FIG. 7 which incorporates a modification of the invention. Prime numbers indicate parts of the structure of FIG. 8, which correspond with similar parts of the structure of FIG. 2, while the same numbers are used for identical parts. As shown in FIG. 8, pump P1 has a cup-shaped pump body 61′ corresponding to body 61 of pump P, but this body, instead of being on the outer end of a rocker arm housing, is integrally formed on one end of a tubular rod housing 201 with hub 69′ of body 61′ coaxial with the tubular housing 201. This end of housing 201 is referred to as its outer end. At its inner end, tubular housing 201 is reduced as indicated at 203 to fit in a counterbore 205 at the outer end of a hole 207 specially drilled in the wall 209 of the crankcase of engine 3′. The diaphragm-actuating rod of pump P1 differs from the rod 127 of pump P and is specially designated 127*a* because of its differences. It is considerably longer than rod 127, and extends through tubular housing 201 and out of the inner end of housing 201, being slidable in a bushing 211 in the housing. Packing as indicated at 213 may be provided on the rod 127*a* in the bushing. This is not subject to attack by fuel. Adjacent its outer end, rod 127*a* has a wide annular groove 215. A cap 217 is telescoped over the outer end of the rod 127*a*, having an inturned lip 219 received in the groove 215 to hold the cap on the rod while allowing it to slide relative to the rod. A spring 221 reacts from bushing 211 against a flange 223 on the cap to bias the cap in the direction away from the rod.

The housing 201 has shoulders 225 for engagement by a clamping fork 227 (see FIGS. 8 and 9) to hold the pump P1 on the wall 209. Fork 227 has holes such as indicated at 229 receiving screws 231 projecting from the wall 209 and is clamped in place by nuts 233 threaded on the screws. Screws 231 also accept nuts 235 for clamping a closure plate 237 over the customary rocker arm hole 239 in the crankcase wall, this hole 239 not being used when pump P1 is used. With the pump P1 so mounted on the engine, rod 127*a* is aligned with the push rod 57 which is actuated by the engine-driven cam 59, the outer end of the push rod 57 engaging the end of the spring cap 217.

In pump P1, a sheet metal cap 241 replaces the body 123 of pump P, and hence pump P1 has only the one pump chamber 125 and does not have the upper valves 165 and 167 of pump P. Cap 241, as shown in FIG. 8, has a V-shaped annular portion 243 for clamping the outer margin of the diaphragm 95 against the conical diaphragm-seating surface 67′ of body 61′, and is held in assembly with body 61′ by having a skirt 245 surrounding the annular wall 65′ of body 61′, this skirt having a rim portion 247 spun over on the body 61′. Cap 241 also has a vent hole 249. Cap 241 constitutes an enclosure for the hat-shaped or cup-shaped head 101.

In other respects, pump P1 is the same as pump P. Nipple 19 thereof has fuel supply line 21*a* connected thereto, and nipple 23 has fuel delivery line 25*a* connected thereto. In the operation of pump P1, and upon each revolution of cam 59, starting with the cam in the FIG. 8 position wherein its low point engages the push rod 57, the diaphragm-actuating rod 127*a* is driven outward away from its FIG. 8 position and returned toward its FIG. 8 position by spring 169. In the FIG. 8 position, the pump chamber 125 is fully contracted. Upon outward movement of the rod 127*a*, head 101 pulls the slack loop of diaphragm 95 outward to draw fuel into chamber 125. The rod 127*a* completes its outward movement when the high point of the cam engages the push rod (180° from the cam position shown in FIG. 8). Then spring 169 becomes effective to drive the head 101 and the slack loop of the diaphragm inward to effect a pumping stroke. The extent to which the head and slack loop of the diaphragm are driven inward depends upon the back pressure in chamber 125, which is determined by the position of the float of the float valve in the carburetor FC. If the float valve is closed, the head and slack loop of the diaphragm will remain in outward position against the inward bias of spring 169 until the float valve opens. Under such circumstances, and under conditions where the head and slack loop are actuated through less than a full stroke, spring cap 217 prevents slapping.

It will be observed that the construction shown in FIG. 8 enables the diaphragm-actuating rod 127*a* to be arranged directly in line with push rod 57, eliminating any necessity for a rocker arm, while still allowing compression spring 169 to be located on the outside of the diaphragm to provide for spring-powered pump discharge, and without any packing being required on rod 127*a* to seal the pump chamber 125. Also, with the in-line arrangement, pump P1 can be located off to one side and downward from the engine so as to be less subject to engine heat such as tends to cause vapor difficulties.

It is contemplated that the dual pump P may be utilized as a double-acting pump in a float carburetor fuel system. This may be accomplished by supplying fuel from the tank to the two pump inlets 19 and 29 and connecting the two pump outlets for delivering fuel to the carburetor, with a suitable by-pass arrangement to by-pass excessive delivery from chamber 139 of the pump around to chamber 125 of the pump on upward movement of rod 127 by the cam 59.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

We claim:

1. A fuel pump for use on an internal combustion engine for pumping fuel to a carburetor for the engine, said engine having a push rod actuated thereby, said pump comprising a housing adapted for mounting at one end thereof on the engine in line with the push rod, a pump body on the other end of the housing, said housing having an opening therethorugh extending from its said one end to the body, a diaphragm having a hole therein secured to the body with the hole registering with said opening, the diaphragm being marginally sealed to the body and also sealed to the body around said opening by a tubular clamp element extending through the center hole in the diaphragm and secured in the opening in the body with a flange thereon engaging the diaphragm around its center hole, with an intermediate annular portion of the diaphragm free for flexure, thereby providing an annular pump chamber on one side of the diaphragm adapted to be expanded and contracted by the diaphragm, a head secured in sealed relation to said intermediate annular portion of the diaphragm on the other side of the diaphragm, and a pump rod slidable in said opening and extending through the hole in the diaphragm into engagement with the head, said pump rod extending through and being spaced from said tubular element to permit free reciprocatory motion of said rod without being interfered with by said tubular clamp element, said pump rod adapted to be aligned with and actuable by said push rod when the pump is mounted on the engine.

2. A fuel pump as defined in claim 1 including passage means formed in said housing, said passage means being communicated with an intermediate space formed between said head and said housing and atmosphere, thereby providing a breather passage for entry of air to, and escape of air from said intermediate space as said diaphragm is reciprocated.

3. A fuel pump for use in an internal combustion engine for pumping fuel to a carburetor for the engine, said engine having a push rod actuated thereby, said pump comprising a housing adapted for mounting at one end thereof on the engine in line with the push rod, a cup-shaped pump body having a central hub on the other end of and aligned with the housing, said housing having an opening therethrough extending from its said one end through the hub, a diaphragm having a center hole registering with the opening in the hub, the diaphragm having its inner margin around its center hole sealed to the hub around the opening in the hub and having its outer margin sealed to the wall of the cup-shaped body with an intermediate annular portion of the diaphragm between said hub and wall constituting an annular slack loop free for flexure, thereby providing an annular pump chamber on the side of the diaphragm toward the body adapted to be expanded and contracted by said loop, said body having a valved inlet and a valved outlet for said chamber, a cup-shaped head having a rim portion secured in sealed relation to the loop on the other side of the diaphragm, and a rod extending slidably through the opening in the hub and the center hole in the diaphragm and engaging said head, said rod being adapted for reciprocation by said push rod to actuate the head thereby to actuate the diaphragm, and an enclosure on said cup-shaped body for the head and diaphragm, said enclosure clamping the outer margin of the diaphragm against the wall of the body, the inner margin of the diaphragm around the center hole therein being clamped against the end of the hub by a tubular clamp element being spaced from the said rod and secured in the opening in the hub, and a compression spring reacting from said enclosure against the head for driving the head and the intermediate annular portion of the diaphragm in the direction for contracting said annular pump chamber, said rod being adapted to move said head and the intermediate annular portion of the diaphragm in the opposite direction to expand said chamber and load said spring.

4. A fuel pump as defined in claim 3 including passage means formed in said body and terminating in said hub, said passage means being communicated with a source of air from atmosphere to provide a breather passage for entry of air to, and escape of air from an intermediate space formed between said head and said diaphragm as the latter is reciprocated.

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