United States Patent

Yamamoto

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[54] **FUEL FEED DEVICE FOR AN INTERNAL COMBUSTION ENGINE**

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[51] **Int. Cl.**....**F02m 39/00,** F02b 33/04, F02b 33/12

[58] **Field of Search**.....123/139 AJ, 73 R, 73 A, 139 BG, 123/74 R

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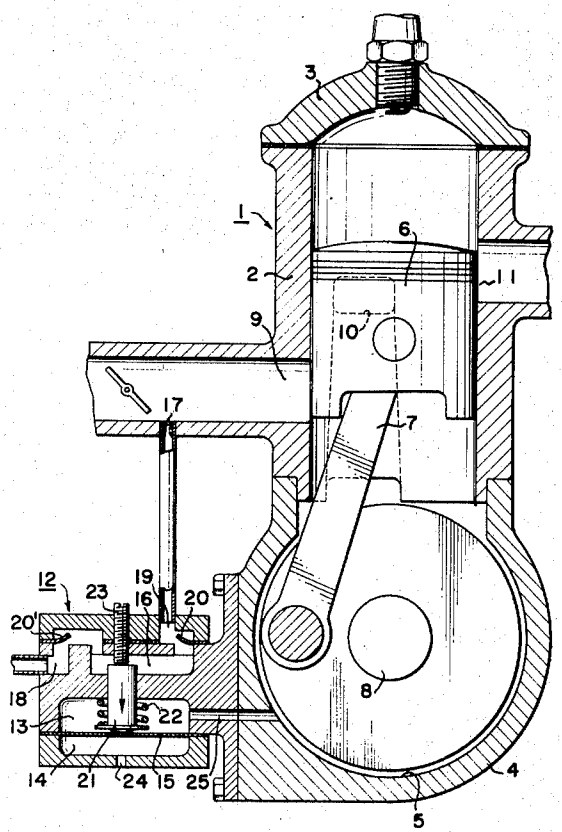
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[57] **ABSTRACT**

A fuel feed device for use in crank chamber compression-type two-cycle engines, comprising a first chamber and a second chamber separated by a movable member, means for communicating said first chamber with the crank chamber of said engine, a pump member operatively connected with said movable member, a pump chamber the volume of which varies incident to movement of said pump member, and valve means operative such that fuel is sucked into said pump chamber incident to movement of said pump member when said movable member moves from said first chamber toward said second chamber and is discharged therefrom incident to reverse movement of said pump member.

16 Claims, 7 Drawing Figures



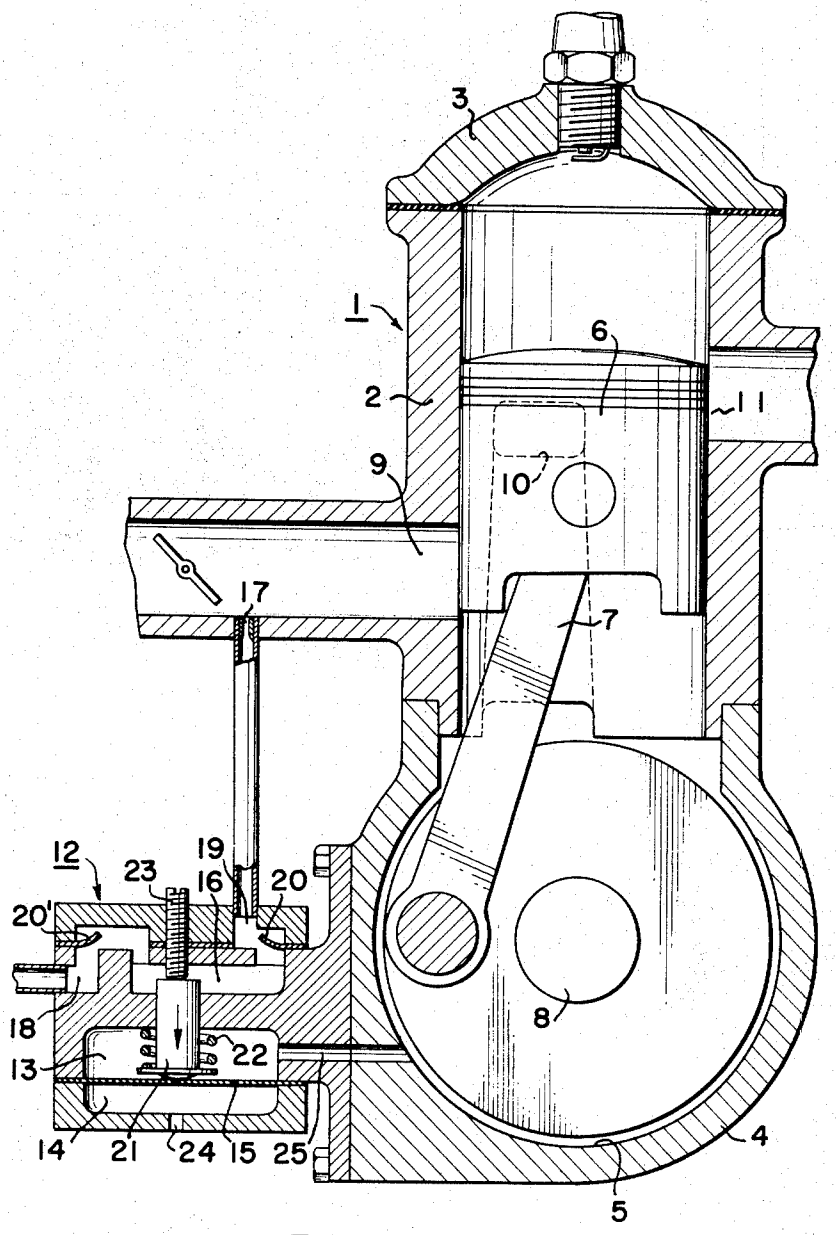


FIG. 1

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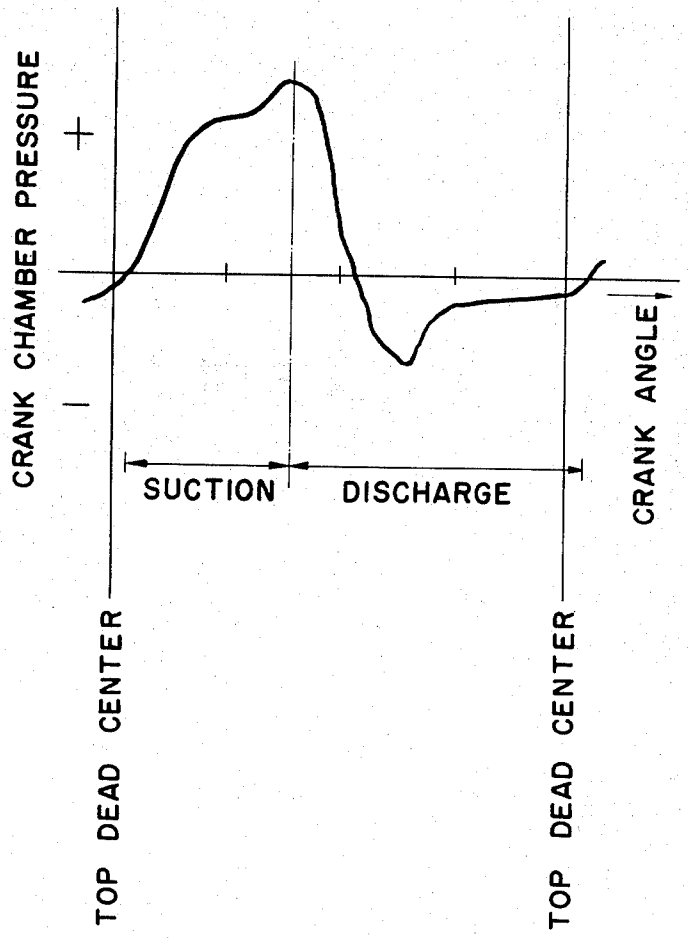


FIG.2

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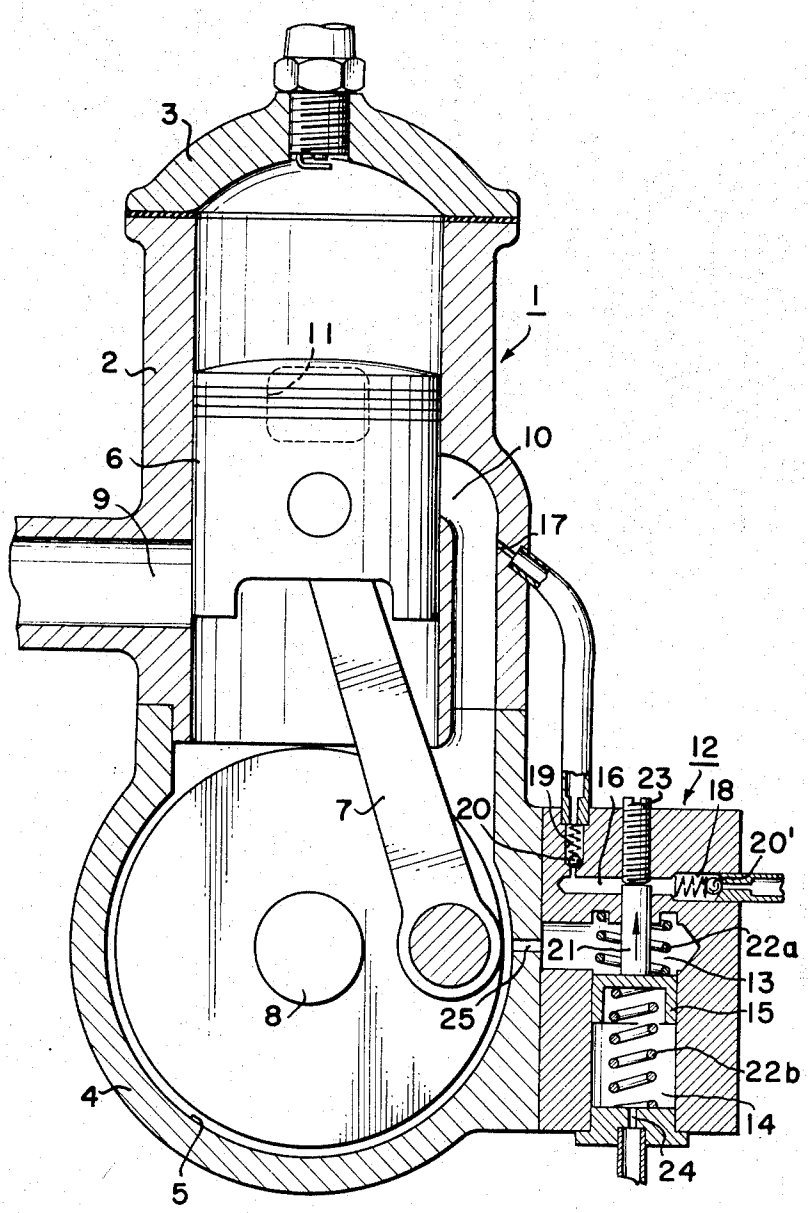


FIG. 3

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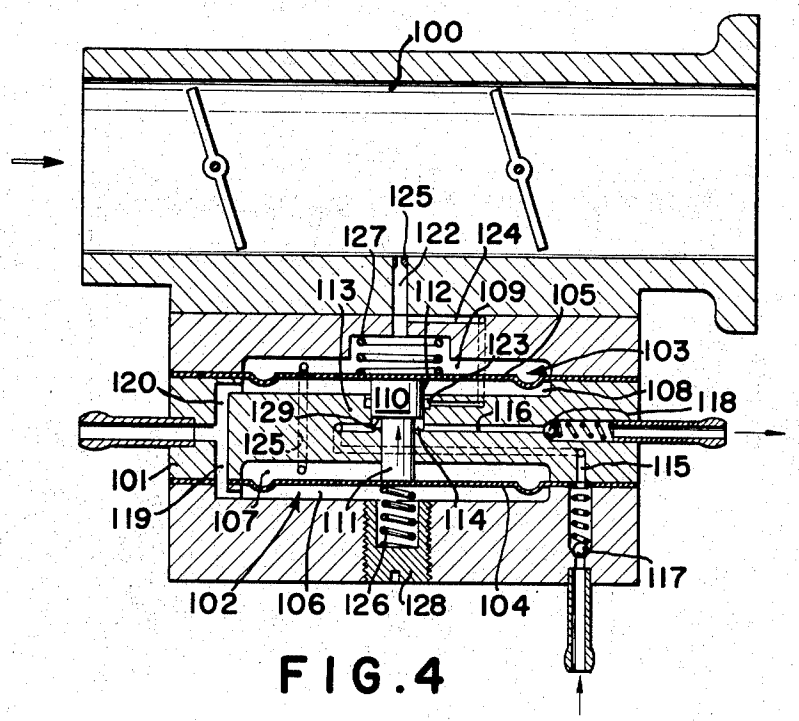


FIG. 4

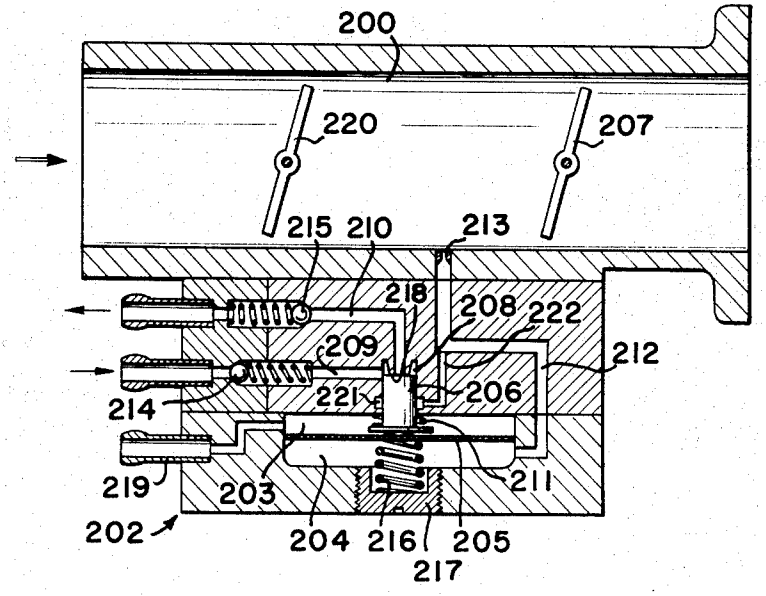


FIG. 5

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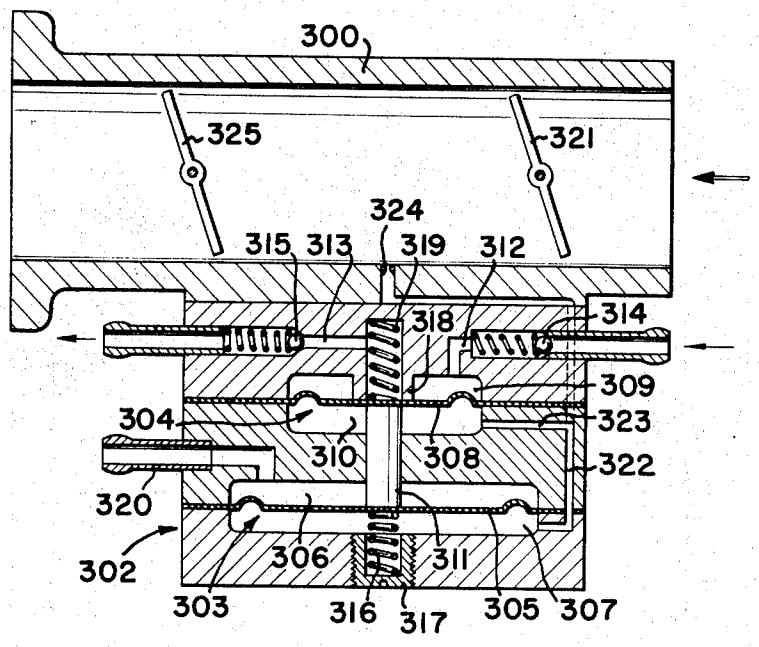


FIG. 6

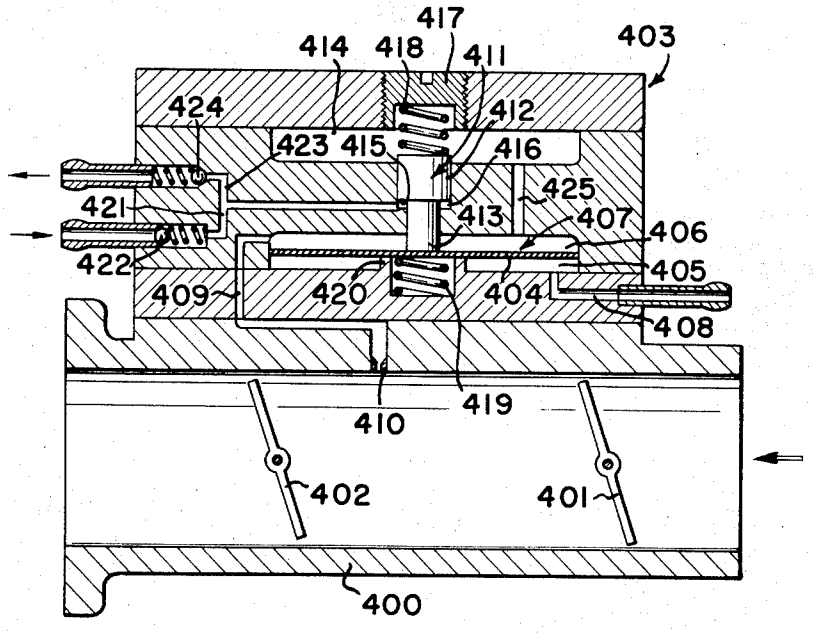


FIG. 7

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FUEL FEED DEVICE FOR AN INTERNAL COMBUSTION ENGINE

BACKGROUND OF THE INVENTION

This invention relates to a fuel feed device for feeding a suitable quantity of fuel to a two-cycle engine, and more specifically to a fuel feed device of the type which feeds fuel by making use of the varying pressure in a crank chamber.

In crank chamber compression-type two-cycle engines, fuel pumps utilizing the pressure in the crank chamber as its driving source have widely been used in floatless carburetors, and some of them have been used as a fuel injection pump, with metering function afforded thereto. However, since the conventional devices of the type described are unexceptionally designed to suck fuel when a negative pressure appears in the crank chamber and discharge the fuel when a positive pressure appears in said chamber, the pressure difference between the injection pressure and the pressure in the crank chamber at the time of fuel injection is small, rendering the fuel injection into the crank chamber difficult. Furthermore, in crank chamber compression-type two-cycle engines, when fuel is injected utilizing, as a metering signal, the maximum value of the positive pressure in the crank chamber which is believed to be proportional to the quantity of air sucked into the engine during the suction stroke, a quantity of fuel corresponding to the metering signal cannot entirely be injected due to the short period of injection and the resistance of the injection nozzle, and thus inaccurate metering results.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to eliminate the above-described defects in the fuel feed devices for crank chamber compression-type two-cycle engines, of the type which feeds fuel by making use of the varying pressure in the crank chamber.

Another object of the invention is to provide a fuel feed device for two-cycle engines, which is simple in construction and capable of accurate metering.

The fuel feed device according to the present invention comprises a first chamber and a second chamber separated by a movable member, means for communicating said first chamber with the crank chamber of a two-cycle engine, a pump member operatively connected with said movable member, a pump chamber the volume of which varies incident to movement of said pump member, and valve means operative such that fuel is sucked into said pump chamber incident to movement of said pump member when said movable member moves from said first chamber toward said second chamber and is discharged therefrom incident to reverse movement of said pump member.

According to the invention, the fuel is sucked into the pump chamber during the period wherein the positive pressure in the crank chamber increases, and is discharged therefrom during the period wherein the positive pressure in the crank chamber decreases and the crank chamber is maintained in negative pressure. Therefore, the discharge period becomes long and no error will occur in the discharge quantity even if the movable member responds with time lag.

According to the invention, the occurrence of time lag in the movement of the movable member is rare and

the fuel sucked into the pump chamber is discharged therefrom entirely positively. Further, according to the invention, the fuel can be discharged efficiently since the discharge of fuel takes place over the period from the scavenging stroke to the suction stroke of the engine during which period a sufficiently large pressure difference between the first and second chamber is available.

The movable member is preferably a diaphragm but may be a piston. Similarly, the pump member may be of either a diaphragm type or a plunger type. By limiting the amount of movement of the pump member during its discharge stroke so that suction and discharge may be effected substantially when the pressure in the crank chamber is positive, the amount of movement of the movable member can be made proportional to the maximum value of the positive pressure in the crank chamber and a quantity of fuel proportional to the amount of suction air can be fed.

These and other objects, features and advantages of the invention will become apparent from the following description with reference to preferred embodiments of the invention illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical cross section of a two-cycle engine, showing one embodiment of the invention;

FIG. 2 is a diagram graphically showing the varying pressure in the crank chamber of the crank chamber compression-type two-cycle engine;

FIG. 3 is a vertical cross sectional view showing another embodiment of the invention;

FIG. 4 is a cross section of an embodiment in which a pump operating mechanism is of a dual diaphragm structure;

FIG. 5 is a cross section of an embodiment in which the crank chamber pressure and the suction pressure act on both sides of a pump operating piston;

FIG. 6 is a cross section of an embodiment provided with a diaphragm type pump; and

FIG. 7 is a cross sectional view showing still another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings and particularly to FIG. 1, the crank chamber compression-type two-cycle engine generally indicated by numeral 1 has a cylinder 2, a cylinder head 3 and a crank case 4, and a crank chamber 5 is formed in the crank case 4. A piston 6 is disposed in the cylinder 2 for sliding movement therein, and connected with a crank shaft 8 by a connecting rod 7. The side wall of the cylinder 2 is provided with a suction port 9, a scavenging port 10 and an exhaust port 11. Reference numeral 12 generally designates a fuel feed system which includes a first chamber 13 communicating with the crank chamber 5, an air chamber or a second chamber 14 separated from said first chamber 13 by a diaphragm 15 and communicating with the atmosphere, and a pump chamber 16 communicating with a fuel tank through an intake passage 18 having a check valve 20' provided therein and also communicating with a fuel injection nozzle 17 through a discharge passage 19 having a check valve 20 provided therein. In

the embodiment illustrated, the nozzle **17** is provided in the suction passage but it may be provided in the crank chamber **5** or the scavenging port **10**. Slidably extending through a partition wall by which the pump chamber **16** and the chamber **13** are separated, is a plunger **21** which has one end in contact with the diaphragm **15**, with the other end projecting into the chamber **16**. Reference numeral **22** designates a compression spring by which the plunger **21** is urged against the diaphragm **15**. The upward stroke of the plunger **21** and therefore the diaphragm **15**, is limited by an adjustable stopper **23**. Reference numeral **24** designates a vent hole communicating the air chamber **14** with the atmosphere therethrough, and **25** designates a passage communicating the pump chamber **13** with the crank chamber **5**. The adjustable stopper **23** is substantially so adjusted that it highly contacts with said other end of the plunger **21**, when the two-cycle engine **1** is stopped.

The fuel feed device of the construction described above operates in the following manner.

Namely, when the two-cycle engine **1** is set in motion, fresh gas is pre-compressed in the crank chamber **5**, so that the pressure in the crank chamber **5** varies synchronously (FIG. **2**) and the varying pressure is transmitted to the pump chamber **13** through the passage **25**. Consequently, the diaphragm **15** makes a reciprocal motion to move the plunger **21** and therefore, the volume in the oil chamber **16** is repeatedly increased and decreased, whereby a pumping action is set up. In this case, the diaphragm **15** during the combustion and exhaust strokes of the engine or during the compression stroke of the crank chamber is deflected in the direction of the arrow up to the point corresponding to the maximum value of the positive pressure in the crank chamber, to suck fuel into the chamber **16**. During the scavenging and compression suction strokes of the engine or during when the pressure in the crank chamber **5** decreases from the positive pressure to a negative pressure, the diaphragm **15** is deflected in the opposite direction and the plunger **21** is elevated until it is stopped by the stopper **23**. Thus, the fuel sucked into the chamber **16** is accurately discharged into the injection nozzle **17**.

FIG. **3** shows another embodiment of the invention. This embodiment is exactly the same as the preceding embodiment, except that a piston **15'** is used instead of the diaphragm **15**, that ball type valves are used for all check valves and that the nozzle is open, not into the suction passage but into the scavenging passage, and parts corresponding to those in the preceding embodiment are indicated by same reference numerals. In this embodiment, the pump piston **15'** undergoes the actions of a pair of balance springs **22***a*, **22***b* but its function is exactly the same as that of the diaphragm in the preceding embodiment.

Referring now to FIG. **4**, a pump casing **101** has two diaphragm chambers **102**, **103**. The chamber **102** is divided into a first chamber **106** and a second or air chamber **107** by a suction diaphragm **104**, while the chamber **103** is similarly divided into a chamber **108** and a chamber **109** by a discharge diaphragm **105**.

Interposed between the suction diaphragm **104** and the discharge diaphragm **105** is a plunger **110** which has one end face in contact with the suction diaphragm **104** and the other end face with the discharge diaphragm **105**, and also has a smaller diameter portion **111** on the side closer to the suction diaphragm **104** and a larger diameter portion **112** on the side closer to the discharge diaphragm **105**. This plunger **110** is disposed in a sleeve **113** integral with the case **101** and, together with said sleeve **113**, defines a pump chamber **114** the volume of which is repeatedly increased and decreased. Reference numeral **115** designates an intake passage formed in one end portion of the case **101**, with one end thereof communicating with the pump chamber **114** and the other end with a fuel tank (not shown). Reference numeral **116** designates a discharge passage through which the pump chamber **114** communicates with the discharge end.

At the inlet end of the intake passage **115** is provided a check valve **117** which is openable only in a direction to permit fuel to flow into the chamber **114**, and at the discharge end of the discharge passage **115** is provided a check valve **118** which is openable only in the fuel discharging direction. Reference numerals **119** and **120** designate passages communicating the chambers **106** and **108** with the crank chamber of the engine respectively, **121** a passage communicating the chambers **107** and **109** with each other, and **122** a passage communicating the chamber **109** with a suction passage **100**. In the wall of the sleeve **113** surrounding the large diameter portion **112** of the plunger **110** is formed an annular groove **123** which communicates with the passage **122** through the passage **124**. Reference numeral **125** designates a orifice, **126**, **127** designate balance springs and **128** designates an adjust screw to retain the balance spring **126**. The adjust screw **128** is substantially so adjusted that the shoulder **129** of the plunger **110** slightly contacts with the bottom of the pump chamber **114**, when the two-cycle engine is stopped.

The diaphragm type pump constructed as described above operates as follows: Namely, when the engine is set in motion, the pressure in the crank chamber varies periodically and the varying pressure is transmitted to the chambers **106**, **108** through the passages **119**, **120** respectively. When a positive pressure appears in the crank chamber, the suction diaphragm **104** and the discharge diaphragm **105** are moved in the direction of the arrow, so that the plunger **110** is moved by the suction diaphragm **104** and the volume of the pump chamber **114** is increased. Thus, the fuel corresponding in amount to the sucked air is introduced into the pump chamber **114** through the intake passage **115**, upon opening the check valve **117**. When the pressure in the crank chamber starts to decrease from the maximum value of the positive pressure, the suction diaphragm **104** and the discharge diaphragm **105** are moved in the opposite direction and the plunger is moved by the discharge diaphragm **105**. Thus, the volume of the pump chamber **114** is decreased and the fuel previously sucked thereinto is discharged therefrom. According to this embodiment, the response characteristic is drastically improved since the two diaphragm operate in cooperation with each other. Further, according to this embodiment the air in the chamber **108** will not be allowed to leak into the pump chamber **114** and a complete sealing effect can be obtained since the negative pressure in the suction passage **100** is led into the groove **123** encircling the larger diameter portion of the plunger **110**.

With reference to FIG. 5, a suction pipe 200 having a throttle valve 207 and a choke valve 220 has a fuel feed system or pump 202 attached thereto. The fuel pump 202 is formed therein with a first chamber 203 communicating with the crank chamber of a two-cycle engine and a second chamber 204 opposite to said first chamber 203. The chambers 203 and 204 are separated from each other by a diaphragm 205, and a plunger 206 is arranged so as to be reciprocated by the diaphragm 205. The plunger 206 projects at one end into a pump chamber 208. The pump chamber 208 and a fuel tank are communicated with each other by an intake passage 209 and further the pump chamber 208 is communicated with a fuel injection nozzle (not shown) by a discharge passage 210. The plunger 206 is held in pressure contact with the piston 205 by a spring 211. In this embodiment, the second chamber 204 is communicated with the suction pipe 200 by a passage 212, at a location intermediary of the throttle valve 207 and the choke valve 220, and a nozzle 213 is provided in the passage 212 to control the negative pressure from the suction pipe 200. Reference numeral 214 designates a check valve provided in the intake passage 209, 215 a check valve provided in the discharge passage 210, 216 an adjust spring to adjust the amplitude of the diaphragm 205, and 217 an adjust screw to retain the adjust spring 216. In the pump chamber 208 is provided an annular stopper 218 to limit the stroke of the plunger 206 by engagement therewith. The chamber 203 is communicated with the crank chamber (not shown) by a pipe 219. Further, the casing is formed with an annular groove 221 encircling the plunger 206. The annular groove 221 is communicated with the passage 212 through a passage 222 and constitutes a seal similar to that in the preceding embodiment. According to this embodiment, the fuel passage is closed when the plunger 206 abuts against the stopper 218.

FIG. 6 shows still another embodiment of the invention. As shown, a fuel feed device or fuel pump 302 is attached to a suction pipe 300 having a throttle valve 321 and a choke valve 325 provided therein. In the fuel pump 302 are formed an operating chamber 303 and a metering chamber 304 smaller than said operating chamber. The operating chamber 303 is divided by a main diaphragm 305 into a first chamber 306 and a second or air chamber 307. The chamber 306 is communicated with the crank chamber (not shown) of a two-cycle engine by a pipe 320. Further, the metering chamber 304 is divided by an auxiliary diaphragm 308 into a pump chamber 309 and an air chamber 310. A connecting rod 311 is provided extending through the partition wall between the operating chamber 303 and the metering chamber 304, with the opposite end faces thereof in engagement with the main diaphragm 305 and the auxiliary diaphragm 308 respectively. The pump chamber 309 is communicated with a fuel tank (not shown) by an intake passage 312 having a check valve 314 provided therein, and the pump chamber 309 is communicated with a fuel injection nozzle (not shown) by a discharge passage 313 also having a check valve 315 provided therein. The main diaphragm 305 is held in pressure engagement with the connecting rod 311 by an adjust spring 316 which is retained by an adjust screw 317. The movement of the auxiliary diaphragm 308 is restricted by an annular stopper 318. The auxiliary diaphragm 308 is held in pressure engagement with the connecting rod 317 by a spring 319. The spring 319 in co-operation with the adjust spring 317 maintains the auxiliary diaphragm 308 substantially in contact with the stopper 318, when the two-cycle engine is stopped. In this embodiment, the chamber 307 is communicated with the suction pipe 300 by a passage 322, at a location intermediary of the throttle valve 312 and the choke valve 325. Similarly, the chamber 310 is communicated with the suction pipe 300 by a passage 323 which is in communication with the passage 322. In the passage 322 is provided a nozzle 324 to control the negative pressure from the suction pipe 300. The embodiment described above operates in the same manner as the preceding embodiment, except that the pump is a diaphragm pump, and since the negative pressure in the suction pipe acts on the driving diaphragm, a fuel-air mixture of high concentration can be secured during the start when the choke valve 325 is closed as well as a high-load high speed operation of the engine.

FIG. 7 shows still another embodiment of the invention. As shown, a fuel feed device or pump 403 is attached to a suction pipe 400 having a throttle valve 401 and a chock valve 402 provided therein. The pump 403 has a cavity 407 therein which is divided by a piston 404 into a first chamber 405 and a second chamber 406. The first chamber 405 is communicated with the crank chamber (not shown) of a two-cycle engine by a passage 408, while the second chamber 406 is communicated with the suction pipe 400 by a passage 409 having an orifice 410 provided therein. In the casing of the pump 403 is disposed a plunger 411 having a larger diameter portion 412 and a smaller diameter portion 413, the end face of said smaller diameter portion 413 being in abutting engagement with the piston 404. The casing also has a chamber 414 formed therein adjacent the end of the larger diameter portion of the plunger 411. The plunger 411 forms between its shoulder 415 and the casing an annular pump chamber 416. Further, the plunger 411 is urged against the diaphragm 404 by a spring 418 which is bearing against the end of the larger diameter portion of the plunger 411 at one end and supported by an adjust screw 417 at the other end. The piston 404 is urged against the plunger 411 by a spring 419. Reference numeral 420 designates an annular stopper to limit the stroke of the diaphragm 404. The pump chamber 416 is communicated with a fuel tank (not shown) by a passage 421 having a check valve 422 provided therein and also communicated with a fuel injection nozzle (not shown) by a passage 423 having a check valve 424 provided therein. The chamber 414 is communicated with the chamber 406 by a passage 425.

In this embodiment, since the air chambers 406, 414 adjacent the pump chamber 416 are both communicated with the suction pipe 400, there is no fear of air leaking into the pump chamber 416.

Although the present invention has been described and illustrated herein in terms of preferred embodiments thereof, it should be understood that many changes and modifications can be made to the details of the embodiments without deviating from the scope of the invention.

I claim:

1. A fuel feed device for use in crank chamber compression-type two-cycle engines, comprising a first chamber and a second chamber separated by a movable member, means for communicating said first chamber with the crank chamber of said engine, a pump member operatively connected with said movable member, a pump chamber the volume of which varies incident to movement of said pump member, and valve means operative such that fuel is sucked into said pump chamber incident to movement of said pump member when said movable member moves from said first chamber toward said second chamber and is discharged therefrom incident to reverse movement of said pump member.

2. A fuel feed device according to claim 1, wherein said movable member is a diaphragm.

3. A fuel feed device according to claim 1, wherein said movable member is a piston.

4. A fuel feed device according to claim 1, wherein said pump member is a plunger.

5. A fuel feed device according to claim 1, wherein said pump member is a diaphragm.

6. A fuel feed device according to claim 1, wherein a stopper is provided to limit the movement of said pump member in the fuel discharging direction such that the amount of movement of said pump member is proportional to the maximum value of the positive pressure in the crank chamber.

7. A fuel feed device according to claim 6, wherein a fuel passage leading from the pump chamber is formed through said stopper and said fuel passage is closed when the pump member abuts against said stopper.

8. A fuel feed device according to claim 1, wherein means is provided to communicate said second chamber with the intake passage of the engine.

9. A fuel feed device according to claim 8, wherein said means to communicate said second chamber with the intake passage of the engine includes a passage opening at a location downstream of a choke valve provided in the engine intake passage.

10. A fuel feed device for use in crank chamber compression-type two-cycle engines, comprising a casing having a cavity therein, a movable member dividing said cavity into a first chamber and a second chamber, means for communicating said first chamber with the crank chamber of the engine, a pump chamber formed in said casing in adjacent relation to said first chamber, a plunger slidably received in a bore communicating said first chamber and said pump chamber with each other, means for urging said plunger into abutting engagement at one end with said movable member, valve means operative such that fuel is discharged from said pump chamber incident to movement of said plunger toward said pump chamber and is sucked into said pump chamber incident to reverse movement of said plunger, an annular groove formed in the wall of said bore in a manner to encircle said plunger, and means for communicating said annular groove with the suction passage of the engine.

11. A fuel feed device for use in crank chamber compression-type two-cycle engines, comprising a casing having first and second cavities therein, a first diaphragm dividing said first cavity into a first pressure chamber and a first air chamber, a second diaphragm dividing said second cavity into a second pressure chamber and a second air chamber, said first and second pressure chamber being on the same side with respect to the respective diaphragms, means for communicating said first and second pressure chambers with the crank chamber of the engine, a plunger slidably disposed in said casing with the opposite end thereof in abutting engagement with said first and second diaphragms respectively, a pump chamber defined by said plunger and said casing and the volume of which increases incident to movement of said plunger when the pressure in the crank chamber increases, and valve means operative such that fuel is sucked into the pump chamber when the volume of said pump chamber increases and discharged therefrom when said volume decreases.

12. A fuel feed device according to claim 11, wherein the casing is formed with an annular groove encircling said plunger and means is provided to communicate said annular groove with the suction passage of the engine.

13. A fuel feed device according to claim 11, wherein said first and second air chambers are communicated with the suction passage of the engine.

14. A fuel feed device for use in crank chamber compression-type two-cycle engines, comprising a casing having a first cavity and a second cavity therein, a first diaphragm dividing said first cavity into a pressure chamber and a first air chamber, a second diaphragm dividing said second cavity into a pump chamber and a second air chamber, said first and second air chambers being on the same side with respect to the respective diaphragms, means for communicating said pressure chamber with the crank chamber of the engine, a slidable connecting rod operatively connecting said first and second diaphragms with each other, and valve means operative such that it permits fuel to flow into said pump chamber incident to movement of the second diaphragm in a direction to increase the volume of said pump chamber and to be discharged therefrom incident to reverse movement of said diaphragm.

15. A fuel feed device according to claim 14, wherein said first and second air chambers are communicated with the suction passage of the engine.

16. A fuel feed device for use in crank chamber compression-type two-cycle engines, comprising a casing having first and second cavities, a piston dividing said first cavity into a first chamber remote from said second cavity and a second chamber close to said second cavity, means for communicating said first chamber with the crank chamber of the engine, means for communicating said second chamber and second cavity with the suction passage of the engine, a bore formed in the casing and opening into said second chamber at one end and into said second cavity at the other end, a plunger slidably disposed in said bore, elastic means for urging said plunger against said diaphragm, a pump chamber formed between said plunger and said casing and the volume of which increases incident to movement of said plunger toward said second cavity, and valve means operative such that fuel is sucked into said pump chamber when the volume of said pump chamber increases and discharged therefrom when said volume decreases.

* * * * *