Nov. 10, 1936. C. F. HIGH 2,060,076

FUEL PUMP

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Fig. 1

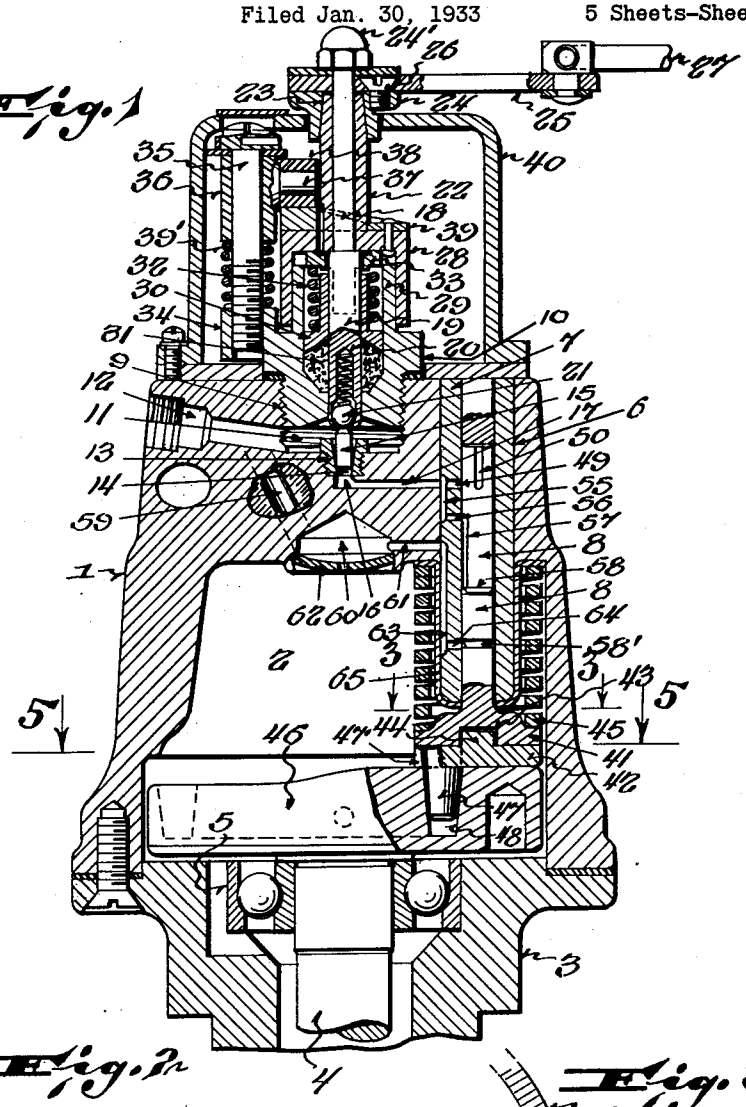

Fig. 2

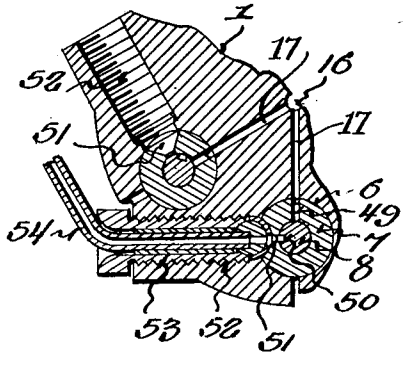

Fig. 3

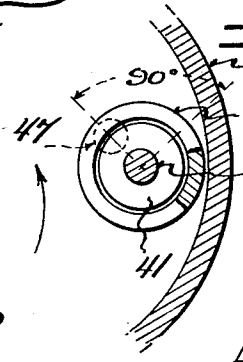

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Fig. 4

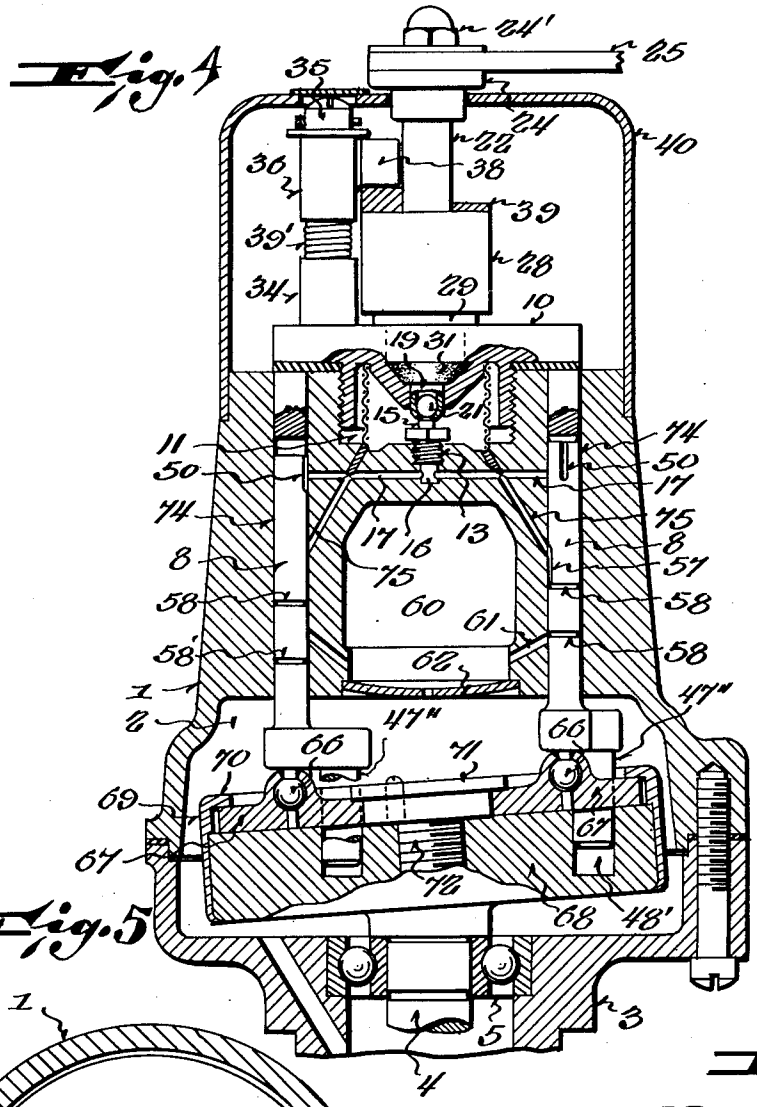

Fig. 5

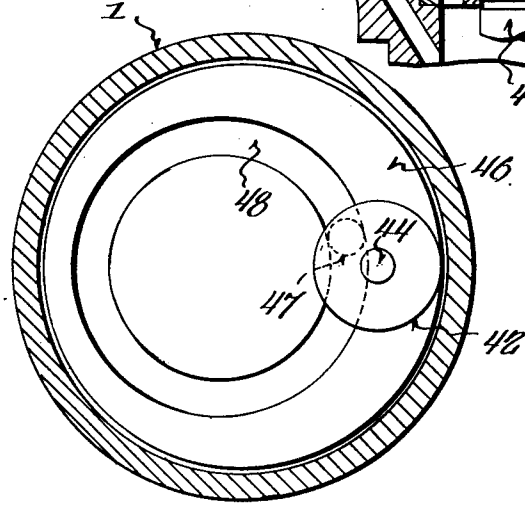

Fig. 6

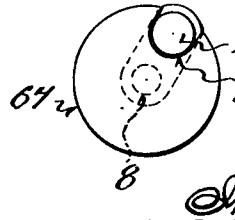

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Fig. 7

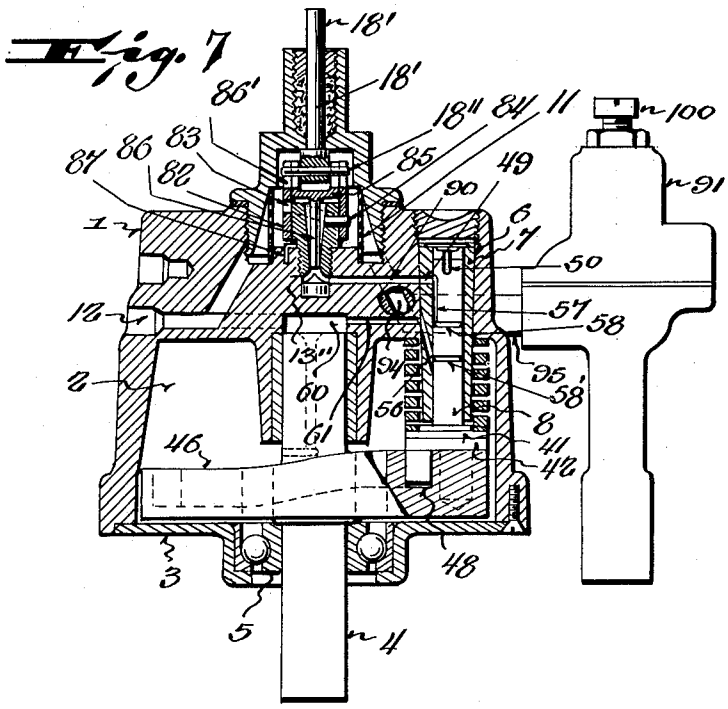

Fig. 8

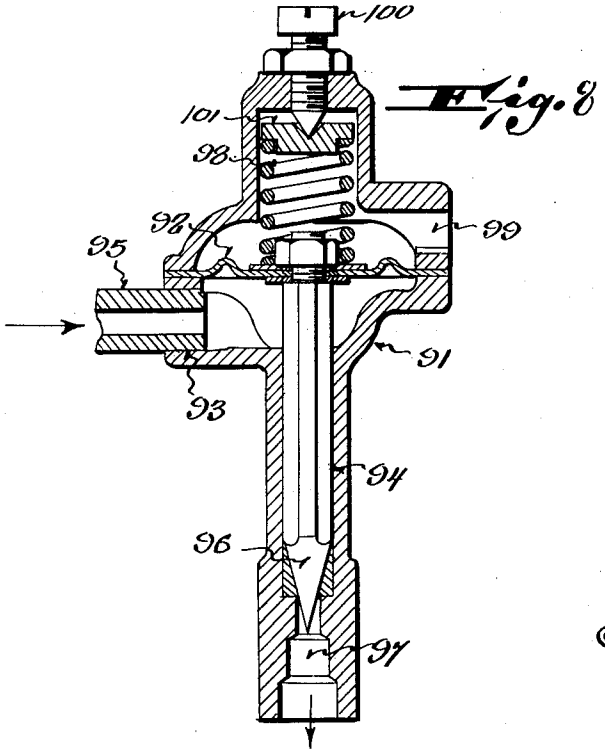

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Fig. 9

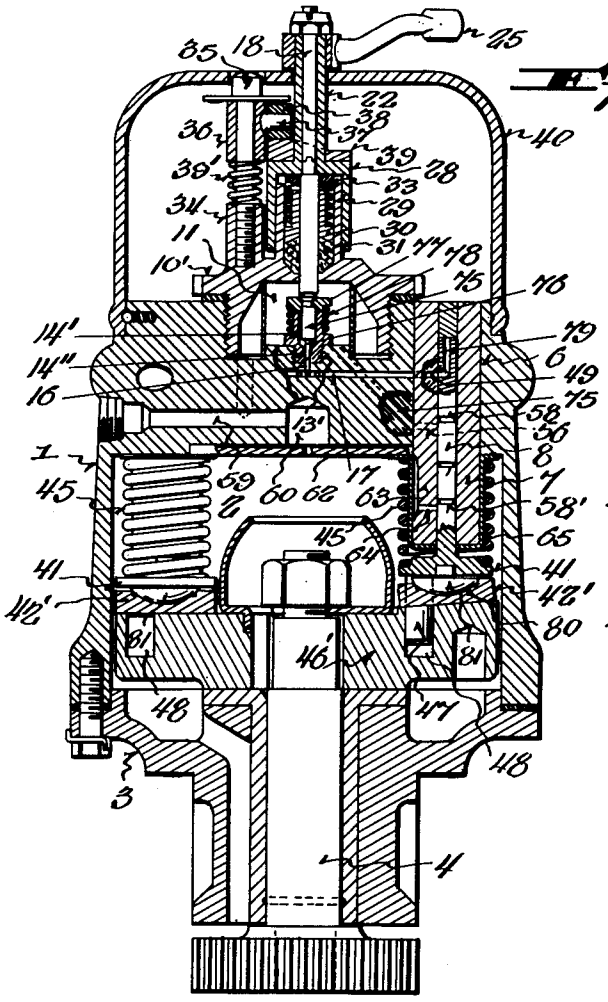

Fig. 10

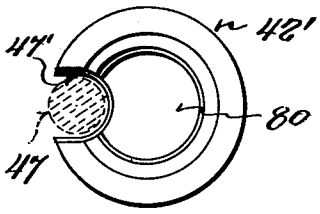

Fig. 11

Fig. 12

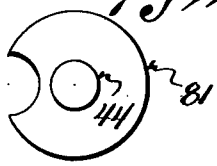

Fig. 13

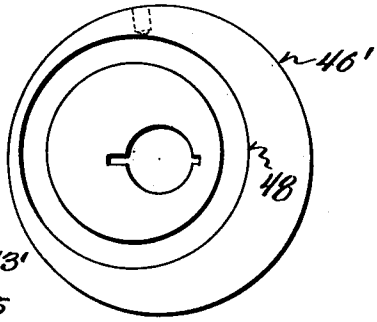

Fig. 14

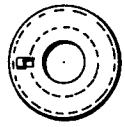

Fig. 15

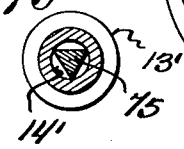

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Fig. 16.

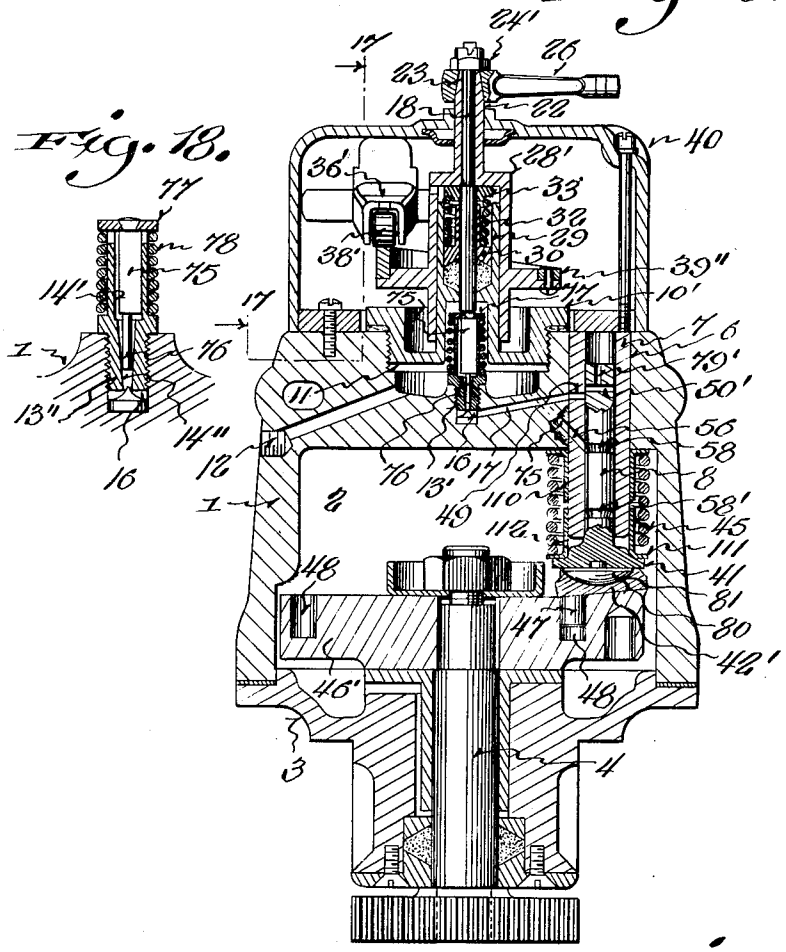
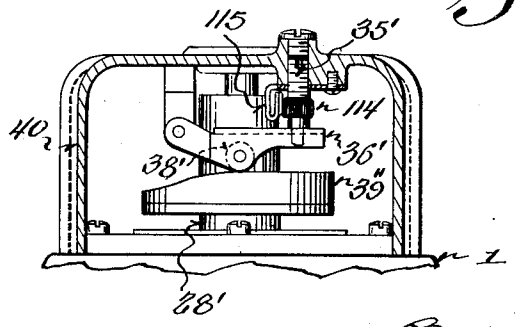


Fig. 18.

Fig. 17.



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Patented Nov. 10, 1936 2,060,076

UNITED STATES PATENT OFFICE

2,060,076

FUEL PUMP

Carl F. High, Flint, Mich.

Application January 30, 1933, Serial No. 654,275

8 Claims. (Cl. 103—173)

The present invention relates to fuel pumps for use in connection with internal combustion engines, and more particularly to a fuel mechanism of the type comprising a plurality of pumps, concentrically arranged about a common fuel orifice, and in which the pump plungers both control and effect discharge of the metered fuel.

The invention has primarily for its object to improve the construction and efficiency of devices of the foregoing type to the extent of overcoming numerous inherent objections resulting in operation, and difficult manufacturing problems encountered in high speed, heavy load pumps, in which timing and metering must essentially be controlled to a high degree of accuracy.

Incidental to the foregoing, a more specific object of the invention resides in the provision of improved means for metering the fuel supplied to a common distributing orifice on the suction side of the pumps.

A further object is to provide means for arresting fuel that may pass the heads of the pump plungers, and returning the same to the intake passages, or to the common source of supply.

Another object resides in providing an improved type of cam and cam follower, which permits the pump plungers to be both reciprocated and oscillated directly off of the face of the cam, thus eliminating intermediate mechanism heretofore employed.

Incidental to the foregoing, a further object resides in the provision of a face cam having high and low faces positioned in different planes, the high face of the cam being inclined downwardly toward its axis.

A still further object is to provide an automatic altitude control for fuel injection pumps, in which the pressure in the engine intake manifold controls the return of excess fuel, which in turn regulates the pressure of fuel at the metering orifice, thus correlating the amount of fuel metered through said orifice with the volume of air entering the engine manifold.

Another object of the invention resides in the provision of means for effecting self-oiling of the pump plungers from a contained supply of lubricant in the pump casing, thus eliminating the necessity of a forced supply of lubricant from a heated crank case, heretofore the practise, with resulting over-heating of the pump, and boiling of the fuel, which naturally affects the uniform fuel flow.

Another object is to reduce wear at the tip of the plunger resulting from side thrust, due to the pressure developed, by so constructing the plunger tip as to equalize the pressure around the same and eliminate side thrust.

While the main objects have been generally stated, the invention contemplates numerous specific objects, it being understood that such changes in the precise embodiment of the invention may be made, as come within the scope of the appended claims.

The accompanying drawings illustrate several examples of the physical embodiment of the present invention constructed according to the best modes so far devised for the practical application of the principles thereof.

In the drawings:—

Figure 1 is a vertical section through a fuel pump constructed in accordance with one form of the present invention.

Figure 2 is a fragmentary transverse section through two of the pump units, showing the intake and discharge ports.

Figure 3 is a transverse section taken on the line 3—3 of Figure 1.

Figure 4 is a vertical section of a modified form of the invention.

Figure 5 is a transverse section taken on the line 5—5 of Figure 1.

Figure 6 is a bottom plan detail of one of the cam followers illustrated in Figure 4, in connection with one of the pump plunger cranks.

Figure 7 is a vertical section through a pump constructed in accordance with the present invention, and designed particularly for use on aircraft engines in which an automatic altitude control is employed.

Figure 8 is a vertical section through the valve controlling the return of excess fuel.

Figure 9 is a vertical section through a multiple pump fueling mechanism, embodying certain modifications of the present invention.

Figure 10 is a plan view of one of the cam followers illustrated in Figure 9.

Figure 11 is a transverse section of the follower.

Figure 12 is a plan view of the semi-spherical button used in connection with the follower illustrated in Figures 9 and 10.

Figure 13 is a detail plan view of the cam illustrated in Figure 9.

Figure 14 is a bottom plan view of the retainer illustrated in Figure 9.

Figure 15 is a transverse section through the metering valve and guide illustrated in Figure 9.

Figure 16 is a vertical section through still another form of the invention.

Figure 17 is a fragmentary detail section taken on the line 17—17 of Figure 16, and

Figure 18 is a detailed section through the metering valve and orifice.

Referring now more particularly to the accompanying drawings, and especially to that form of the invention illustrated in Figures 1 to 3 and 5, inclusive, the numeral 1 designates a cylindrical housing provided with a recess 2 in its lower end, and a bearing cap 3 secured thereto in any suitable manner to form a closure for the recess, and also a bearing for the cam shaft 4, the latter being journaled in an anti-frictional bearing 5 mounted in the cap 3.

The housing 1 is provided with a plurality of spaced vertical bores 6, concentrically arranged about the axis of the housing, each of said bores receiving a cylindrical sleeve 7 for reception of a reciprocating and oscillating pump plunger 8.

The head of the housing 1 is provided with a central recess 9, into which a cap 10 is threaded. The cap 10 terminates short of the bottom of the recess 9, and forms a closure therefor, thus providing a central distributing chamber 11 with which the inlet or supply port 12 communicates, the fuel being supplied to the chamber 11 through either gravity or pressure. Threaded in the bottom of the distributing chamber 11 is a plug 13 provided with a tapered orifice 14 controlled by a valve shank 15. Obviously, as the valve shank 15 is raised and lowered, the discharge of fuel from the distributing chamber, through the plug 13, is regulated to a high degree of accuracy.

Communicating with the orifice 14, and formed in the head of the housing 1, is a central opening 16, which in turn communicates with a plurality of radial ducts 17 that extend laterally through the head of the housing to the vertical bores 6. Thus the fuel discharged from the distributing chamber 11, through the tapered orifice 14, is delivered in metered quantities through the radial ducts to the concentrically arranged vertical bores 6.

In order to meter the fuel to the orifice 16, provision is made for raising and lowering the valve shank 15, comprising a shaft 18, the head 19 of which is slidably and rotatably guided in the cap 10, and, as best shown in Figure 1, its lower end is provided with a recess 20 for reception of the spherical head 21 carried by the valve shank 15. A spring disposed in the recess 20 serves to frictionally hold the head 21 in the spherical seat formed therein, thus permitting universal movement between the valve shank 15 and the actuating head 19, which insures proper seating of the valve shank within the tapered orifice 14.

For vertically reciprocating the shaft 18, to effect metering of the fuel through raising and lowering of the valve 15, the shaft 18 has a sleeve 22 mounted thereon, which abuts the shoulder formed by the enlarged head 19. The upper end of the sleeve 22 is tapered at 23 for reception of a flanged hub 24, to which an actuating arm 25 is locked by means of a screw 26. A washer, and cap nut 24', threaded on the outer end of the shaft 18, serves to lock the actuating lever 25 and hub 24 on the shaft 18. The usual connecting rod 27 is pivotally attached to the outer end of the actuating arm 25 for remotely effecting operation of the same.

The lower end of the sleeve 22 is provided with an enlarged head 28, which is recessed for reception of the sleeve extension 29 of the cap 10, that serves to slidably and rotatably guide the sleeve 28, and consequently the shaft 18. Disposed within the sleeve extension 29, and surrounding the head 19, is a conventional packing gland 30 which is held against the packing 31 by means of a spring 32 disposed between the gland and a washer 33 abutting the top of the recess formed in the head 19, thus securely sealing the opening through the cap 10, and at the same time permitting vertical and rotary movement of the head 19.

The spring 32 serves the further function of aiding in the vertical reciprocation of the shaft 18, as the actuating arm 25 is rotated. It will be noted that the cap 10 is provided with an offset boss 34, which receives the threaded stud 35. Mounted on the stud 35, and abutted against its head, is a sleeve 36 provided with a laterally projecting stud 37, upon which the roller 38 is journaled. A spring 39' surrounding the stud 35 serves to hold the sleeve against the head of the stud, and therefore as the stud 35 is run in and out of the boss 34, the sleeve 36, and consequently the roller 38, are raised and lowered. Inasmuch as the roller 38 engages an annular face cam 39, secured on the top of the head 19, the reciprocative movement of the sleeve 22 and the shaft 18 is controlled and limited by the position of the roller, rotation of the sleeve 22, together with the cam 39, serving to vertically reciprocate the shaft 18, which actuates the metering valve 15. Obviously the spring 32 serves to hold the cam 39 against the roller 38.

The entire mechanism for actuating the metering valve is preferably enclosed by a cover 40, secured to the top of the housing 1, thus retaining lubricant and preventing accumulation of dirt and dust in the working parts.

Considering the pump-actuating mechanism, it will be noted that the lower ends of the pistons 8 are provided with flanged heads 41, which are supported upon shoes or followers 42, the heads 41 being provided with recesses 43 for reception of the studs 44 carried by the shoes, thus retaining alinement between the plungers and followers. Coil springs 45, engaging the heads 44, serve to return the plungers on the suction stroke and at the same time hold the followers into engagement with the face of the cam 46. In order to provide for oscillatory movement of the plungers, the flanged heads 41 are provided with cranks 47 which ride in an eccentric or cam groove 48 formed in the face of the cam 46, it being understood that the cranks 47 pass through radial slots 47' formed in the followers 42. Obviously, as the cam 46 is rotated, its high face will raise the plungers, which are simultaneously oscillated by means of the cranks and eccentric groove to cut off the respective intakes on the working stroke, and open the discharge ports. As the plungers return on their suction stroke, they are again rotated in the opposite direction to open the respective inlet ports for the admission of fuel.

As best shown in Figure 1, the sleeves 7 are provided with inlet ports 49, alined with the ducts 17, while the heads of the plungers 8 are provided with vertical grooves 50, which are rotated into and out of alinement with the inlet ports 49, the distance of rotation of the plungers being approximately ninety degrees.

Referring to Figure 2, it will be noted that the sleeves 7 are provided with discharge ports 51, positioned at approximately 90° to the intake ports and alined with threaded openings 52 which

receive the coupling members 53, that carry the nozzle supply tubes 54, it being understood that injection of fuel can be made either into the engine manifold, or directly into the cylinder ports, this forming no part of the present invention.

Attention is here directed to the fact that one of the important features of the present invention resides in the provision of means for arresting fuel as it passes the heads of the pump plungers, and returning the same to the intake passages, or to the source of supply. In that form of the invention illustrated in Figure 1, this is accomplished by means of vertical grooves 55 formed in the sides of the sleeves 7, which grooves form communications between the intake ports 49 and the openings 56, also formed in the sleeve 7 below the intake ports. In order to force the fuel that passes the head of the plungers through the openings 56, and return the same to the intake ports 49, or the ducts 17, the plungers are provided with vertical grooves 57, alined with the openings 56 when the plungers reach the end of their discharge stroke.

The lower ends of the grooves 57 communicate with annular grooves 58 formed in the plungers and designed to collect and feed oil upwardly within the sleeves 7, thus lubricating the plungers and at the same time sealing the same. Obviously, as the plungers travel upwardly on their discharge stroke, any fuel which may have leaked past the head will be picked up by the groove 58, and when the vertical grooves 57 register with the openings 56, such pressure as has been developed will force the creeping fuel back through the return to the intake port or duct.

Lubrication of the various working parts is accomplished in a simple manner, the oil being supplied by gravity or under pressure to a duct 59 formed in the housing. This duct communicates with a central chamber 60 formed in the housing and provided with a plurality of radial ducts 61 communicating with the bores 6 to distribute oil thereto. The bottom of the chamber 60 is closed by a perforate washer 62, which permits a predetermined quantity of lubricant to drain into the lower compartment 2 for lubricating the cam 46, and the cam followers 42.

In order to lubricate the pump plungers 8, the sleeves 7 are provided with vertical peripheral grooves 63, which form communications between the ducts 61 and openings 64 provided in the lower portions of the sleeves 7. The openings 64 communicate with the interior of the sleeves 7, and as lubricant is fed to the plungers, the same is picked up by the annular grooves 58', which serve to progressively feed oil upwardly within the cylinders to a point where the same is picked up by the annular groove 58, it being appreciated that oil accumulating in the grooves 58' and 58 serves to not only lubricate the plungers, but also seal the same to prevent leakage of fuel into the lubricant.

In connection with the foregoing, it will be noted that the vertical grooves 63 formed in the sleeves 7 are closed by means of the flanged cylindrical shells 65, the flanges of which receive the upper ends of the coil springs 45, and therefore permit the same to rotate freely with the oscillating of the plungers.

That form of the invention illustrated in Figures 4 and 6, inclusive, differs from the structure heretofore described, primarily with respect to the cam and plunger actuating mechanism. In this form of the invention, the plungers 8 are provided with spherical heads 66, which carry sliding cam followers 67, thus providing a universal movement between the plungers and cam followers. As best shown in Figure 4, the cam employed for imparting reciprocative movement to the plungers comprises what is ordinarily termed a swash plate 68, the axis of which is offset at an angle with relation to the axis of the cam shaft 4. Obviously, as the swash plate 68 is rotated, the high part of the face will progressively raise the plungers 8, while the same are positively returned on their suction stroke by means of a retaining ring 69 secured to the plate 68 and provided with an internal flange 70 adapted to engage the followers 67. Functioning in cooperation with the retaining ring 69 is a flanged head 71 threaded or otherwise secured on the offset end 72 of the cam shaft 4. Thus the followers 67 are engaged by both the retainer ring 69 and the flanged head 71, whereby they are under positive control upon both strokes, instead of depending upon springs, as in the structure heretofore described.

The advantage of this structure resides in the fact that positive return of the cam followers and plungers enables the pump to be operated at crank shaft speed, thus making it possible to utilize a four cylinder pump for serving an eight-cylinder engine, in which instance each nozzle serves a Siamese port connected with two cylinders to alternately inject fuel into the cylinders. This constitutes what is termed "out-of-phase fueling," and results in the obvious advantage of materially simplifying and reducing the cost of manufacture of the fuel pump.

Oscillation of the plungers 8, like in the previous form of the invention, is accomplished through the cranks 47'' which project through slots 73 formed in the followers, and depending into the eccentric or cam groove 48' formed in the face of the cam plate 68.

It will also be noted that in the present form of the invention, the sleeves 7 are eliminated, and the plunger cylinders 74 formed directly in the housing 6. Therefore, in this form of the invention the vertical grooves 57 formed in the plungers 8 register with the diagonal ducts 75, which form communications between the ducts 17 and the inner walls of the plunger cylinders, for the return of fuel that leaks past the head of the piston, in the identical manner heretofore described.

Otherwise, valving or control of the fuel is accomplished in the same manner as previously explained, and the method of lubrication remains the same.

Considering now that form of the invention illustrated in Figures 9 to 15, inclusive, the essential difference resides in the metering valve and the specific structure of cam and cam follower employed for actuating the pistons. Also, in this form of the invention, fuel creeping past the head of the pump plungers is returned to the fuel supply chamber 11, instead of to the radial ducts 17, or the inlet ports 49.

While the structural features of the cap 10' differ slightly from the cap 10, as illustrated in Figure 1, the same functions to produce the identical results, and therefore it is considered unnecessary to describe the same in further detail.

In connection with metering, in that form of the invention illustrated in Figure 9, the plug 13', threaded into the bottom of the supply chamber 11, is provided with a cylindrical recess 14', terminated in a restricted tapered opening 14'' controlled by a valve stem or needle point 76,

which in turn is carried by a shank 75 slidably guided within the recess 14' and provided with flat sides, as best shown in Figure 15, to permit the fuel to pass the same. Riveted or otherwise secured to the head of the shank 75 is a washer 77 opposed by the spring 78 to raise the metering valve when the same is released by actuation of the shaft 18. In this form of the invention the lower end of the shaft 18 merely abuts the head of the shank 76, as illustrated in Figure 9, the spherical universal connection heretofore described being eliminated.

Instead of vertical grooves 50 being formed in the sides of the plungers, as illustrated in Figures 1 and 4, the plungers, as shown in Figure 9, are provided with internal ducts 79, which form communications between the sides and heads of the plungers, said ducts being alternately alined with the intake ports and discharge ports, similar to peripheral grooves 50, whereby valving of the fuel is accomplished upon reciprocation of the plunger.

Aside from the foregoing, the plunger actuating mechanism, disclosed in Figure 9, differs slightly from that illustrated in Figure 1, in that the follower 42' is provided with a semi-spherical seat 80 for reception of a corresponding button 81 carried by the flanged head 41 of the plunger 8. The cam 46' is similar to the cam 46, in that its top face is provided with high and lower surfaces for effecting reciprocation of the pump plungers. However, as will be noted in Figure 9, the high face of the cam is inclined downwardly and inwardly toward the axis of the cam, and the angle at which it approaches the axis, and the distance from the axis at which it cuts the lower surface, determines the period of lift of the plunger. It will be further understood that two or more lifts may be employed without affecting the fundamental principle.

From the foregoing it will be quite apparent that the plunger actuating mechanism just described has obvious advantages over the preceding structures, in that the same is inexpensive to manufacture and produces a free universal movement, which reduces bind and friction between the followers and cam to a minimum, thus insuring accurate operation of the pump plungers, and reducing wear upon the followers. Oscillation of the plungers is accomplished by means of cranks working in a cam groove, as heretofore described.

In Figures 7 and 8 is illustrated a fueling mechanism embodying the features of the present invention, in combination with an automatic altitude control for correlating the amount of metered fuel with atmospheric conditions. For illustrative purposes, a simple form of the present fuel injector is illustrated, although it is to be understood that the altitude control is equally applicable to other forms of the invention heretofore described. Also, in this form of the invention, a slight modification has been made in the metering mechanism, in that the orifice plug 13'' has slidably and rotatably mounted thereon a sleeve 82 provided with a cam slot 83 for reception of a pin 84 carried by the orifice plug 13''. The sleeve 82 has a ferrule 85 secured therein, which carries a valve stem 86 that controls the flared orifice in the plug 13''. To effect rotation and reciprocation of the cam sleeve 82, to raise and lower the valve stem 86, the lower end of the shaft 18' carries a transverse pin 18'', which projects into vertical slots 86' formed in the upper end of the cam sleeve 82 and the ferrule 85. Obviously, when the shaft 18' and the sleeve 82 are rotated, the pin 84, riding in the cam slot 83, causes the same to be raised and lowered, which in turn raises and lowers the metering valve 86. In order to prevent rotation of the orifice plug 13, which is screwed into the casing 1, a pin 87 is turned into a groove formed in the side of the plug.

Fuel metered through the plug 13'' passes through the radial ducts 89 to the pump plungers, as heretofore described, and with slight variation in the plunger follower construction, the same are actuated in the manner described in connection with that form of the invention disclosed in Figures 1 and 9, springs being utilized to return the plungers on the suction stroke.

In connection with aircraft engines, it is essential to provide automatic altitude control for the metered fuel, which can not be practically accomplished through the usual actuation of the metering valve, due to the fact that it is customary to employ a supercharger for supplying auxiliary air to the engine manifold, thus necessitating a wider range of control. It is therefore proposed to accomplish automatic control of the fuel, in addition to manual control, by means of a valve actuated by the pressure in the intake manifold of the engine, to regulate the pressure created upon the fuel in proportion to the volume of air entering the manifold.

As best illustrated in Figure 8, the automatic control valve comprises a split casing 91 having a diaphragm 92 secured between its upper and lower sections. The lower section is provided with an inlet 93 connected with a duct 94, formed in the housing 1 and communicating with the fuel distributing chamber 11, by means of the pipe or tubing 95, thus providing for the delivery of excessive fuel to the valve casing below the diaphragm 92, and inasmuch as fuel is supplied to the distributing chamber by means of a pump, naturally a pressure is built up against the lower side of the diaphragm 92. Carried by the diaphragm 92 is a valve 96, which controls the outlet 97 formed in the lower end of the casing 91, and connected by a return line, not shown, with the fuel tank. A spring 98, positioned within the casing 91 above the diaphragm, serves to normally seat the valve 96 and close the fuel return outlet 97. However, it will be appreciated that the fuel pressure built up within the casing below the diaphragm, when the valve is closed, opposes the spring 98 to the extent that the diaphragm is nearly balanced. Above the diaphragm 92 the casing 91 is provided with an outlet 99 connected with the engine manifold (not shown), and inasmuch as the diaphragm is normally nearly balanced, it will be quite apparent that slightly reduced pressure, normally created within the manifold, will raise the diaphragm and permit excess fuel to pass the valve and return to the tank. The usual adjusting screw 100, working on the disc 101, serves to regulate the tension upon the spring 98 to effect the desired actuation of the valve 96.

From the foregoing explanation, it is believed that the operation of the valve 96 will be quite apparent in that when the pressure within the manifold is increased as a result of auxiliary air supplied by a supercharger, the spring 98 is allowed to overcome the fuel pressure created upon the bottom of the diaphragm 92, thus seating the valve and permitting the fuel pump, which supplies the distributing chamber 11, to build up a pressure at the metering orifice in the plug 13'', thus automatically supplying an in-

creased volume of fuel in predetermined relation to the volume of air supplied to the engine manifold.

This automatic altitude-responsive control means is described in greater detail and is claimed in my copending application Serial No. 90,056, filed July 11, 1936.

Considering now that form of the invention illustrated in Figures 16 to 18, inclusive, the same differs from the modification shown in Figure 9 in two major respects, namely in the provision of self-feeding means for supplying oil to the pump plungers, and means for equalizing the hydraulic pressure at the tip of the plungers to eliminate side thrusts with resultant wear. Other structural features differ slightly, but do not affect the principle of operation.

Referring now to lubrication of the pump plungers, as embodied in the foregoing structure of the invention, it has been found in practice that where oil is supplied to the pump from the heated crank case of an engine, the pump has a tendency to over-heat above the boiling point of the fuel, which naturally is detrimental to maintaining a uniform fuel flow. The present form of the invention endeavors to overcome the foregoing objections by forcing a lubricant supply contained in the recess 2 to the pump plungers, through the action of the plungers. This is accomplished by splitting the sleeve surrounding the lower end of the cylindrical bushing 7 into upper and lower sections 110 and 111, respectively, the lower section being carried by the flanged head 41 of the plunger 8, and thus being reciprocated therewith. It will also be noted that the lower section of the sleeve is provided with a port 112 which admits lubricant from the recess or compartment 2 to the interior of the sleeve.

Obviously, on the down-stroke of the plunger, lubricant will be drawn through the port 112 to the interior of the sleeve, and upon the up-stroke of the plunger, due to the restricted dimension of the port 112, a portion of the lubricant will be forced upwardly around the plunger 8 by the plunger head 41, thus serving to supply lubricant to the piston which is progressively carried up along the walls of the bushing 7, as heretofore explained.

In order to eliminate side thrust on the pistons, with resultant wear at the tip, it is proposed in the present form of the invention to eliminate the vertical side grooves 50, and instead provide the tip of the piston with a transverse port 50' extending entirely through the plunger and communicating with a vertical central port 79' for the discharge of fuel taken in by the plungers. It will be quite apparent that any hydraulic pressure created at the tip of the plunger will be distributed to opposite sides of the plunger through the transverse port 50', thus eliminating side thrust and reducing wear to a minimum.

A structural difference in the present modification of the invention, over those heretofore described, resides in the means for controlling the metering valve 76. In the present instance the cam track 39'', carried by the enlarged head 28', engages a roller 38', which, instead of being mounted upon a spring-urged sleeve, is carried by a pivotally mounted arm 36', the same being held in adjusted position by a threaded stud 35' provided with an annular serrated surface 114 engaged by a spring detent 115, which frictionally holds the same in adjusted position.

A cap, screw-threaded into the boss of the cover 40, which carries the stud 35, serves as a seal for the opening. The metering valve structure remains the same as that disclosed in Figure 9.

From the foregoing, it will be readily seen that the present invention comprises numerous marked improvements in fuel injection pumps, not only from the standpoint of increasing efficiency in operation, but materially reducing the cost of manufacture, a problem heretofore presenting serious difficulties because of the extremely fine workmanship and accuracy required in machining and fitting the various parts.

In addition to the foregoing, the present invention provides exceedingly simple and efficient means for arresting fuel that may pass the pump plungers, and returning the same to the suction side of the pump. Also, marked improvement has been made in the plunger-actuating mechanism, inasmuch as the plungers are oscillated and reciprocated directly off of a face cam, which eliminates intermediate mechanism, such as sliding heads actuated in guideways, and at the same time reduces friction and wear on the parts to a minimum.

I claim:—

1. In a fuel injection pump comprising a casing provided with a fuel metering orifice, a valve controlling said orifice, a plurality of cylinders, plungers therein, said casing being provided with ducts forming communications between said orifice and said cylinders at a point below the orifice, means for reciprocating said plungers to pump a fluid and for oscillating said plungers to control the inlet and outlet of fluid to and from the cylinders, said plungers being provided with annular grooves and vertical grooves communicating therewith and adapted to register with said communications between said cylinders and said supply communications when said plungers reach the limit of their working strokes, whereby fuel passing the heads of the plungers is arrested and returned to said supply communications.

2. In a fuel injection pump comprising a casing provided with a fuel metering orifice, a plurality of cylinders uniformly arranged with relation to said orifice and having inlet communications therewith and outlets, oscillating and reciprocating pump plungers operable in said cylinders, and having means for controlling said inlet communications and outlets, a movably mounted cam for actuating said plungers, said cam being provided with a cam groove, and means for oscillating said plungers to control the inlet and outlet of fluid to and from said cylinders comprising cranks carried by said pistons for engagement in said groove, and followers connected with said pistons for sliding engagement with the face of said cam, said followers being provided with radial slots to permit said cranks to project therethrough.

3. In a fuel injection pump comprising a casing provided with a fuel metering orifice, a plurality of pump cylinders uniformly arranged with relation to said orifice, and having inlet communications therewith and outlets, oscillating and reciprocating pump plungers operable in said cylinders and having means for controlling said inlet communications and outlets, a movably mounted double cam for actuating said plungers, the face of said cam being formed in upper and lower planes, the face in the upper plane being inclined downwardly and inwardly toward the axis of said cam, means for oscillating said plungers to control the inlet and outlet of fluid to and from said cylinders comprising a cam groove in the face

of said cam, cranks carried by said plungers for engagement in said groove, and followers carried by said plungers for sliding engagement with the face of said cam.

4. In a fuel injection pump comprising a casing provided with a fuel metering orifice, a plurality of cylinders uniformly arranged with relation to said orifice and having communication therewith, oscillating and reciprocating pump plungers operable in said cylinders, a cam having a face for reciprocating and a slot for oscillating said plungers, followers carried by said pistons for sliding engagement with the face of said cam and said slot, and a retaining ring carried by said cam for retaining said followers in engagement with said cams.

5. In a fuel injection pump comprising a casing provided with a fuel distributing chamber, and a pump cylinder in communication therewith and having its lower end projecting into a lubricant chamber, a pump plunger operable in said cylinder and provided with an enlarged head adjacent its lower end for forcing lubricant into said cylinder around said plunger, and a sleeve surrounding said head and said cylinder to form a lubricant cylinder, said sleeve having a restricted opening permitting lubricant to pass from the chamber into the lubricant cylinder.

6. A fuel injection pump comprising, in combination, a casing having a plurality of cylinders arranged in a circle, plungers in said cylinders, means for reciprocating said plungers comprising a rotatably mounted face cam the face of which is formed in upper and lower planes with relatively short connecting inclined portions, followers connected to said plungers for sliding engagement with the face of said cam, and means for oscillating said plungers for controlling the inlet and outlet of fuel to and from said cylinders comprising a cam groove in the face of said cam, and cranks carried by said plungers engaging in said groove.

7. In a fuel injection pump comprising a casing provided with a fuel metering orifice, a plurality of cylinders uniformly arranged with relation to said orifice and having communication therewith, oscillating and reciprocating pump plungers operable in said cylinders, means for reciprocating said plungers comprising a rotary cam and followers connected with said plungers for sliding engagement with said cam, and means for oscillating said plungers to control the inlet and outlet of fuel to and from said cylinders comprising a cam groove formed in said cam, and cranks carried by said plungers engaging in said groove, said followers having openings therein through which said cranks project.

8. In a fuel injection pump comprising a casing provided with a fuel metering orifice, a plurality of cylinders uniformly arranged with relation to said orifices and having communication therewith, oscillating and reciprocating pump plungers operable in said cylinders, means for reciprocating said plungers comprising a rotary face cam for actuating said plungers through their pressure strokes, followers carried by said plungers and slidably engaging the face of said cam, a plurality of coiled springs for returning said plungers, and means for oscillating said plungers to control the inlet and outlet of fuel to and from said cylinders comprising a cam groove formed in the face of said rotary cam, and cranks carried by said plungers engaging in said groove.

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