Oct. 6, 1936. W. G. NOACK 2,056,204

FUEL PUMP

Filed Dec. 30, 1931 3 Sheets-Sheet 1

Fig. 1

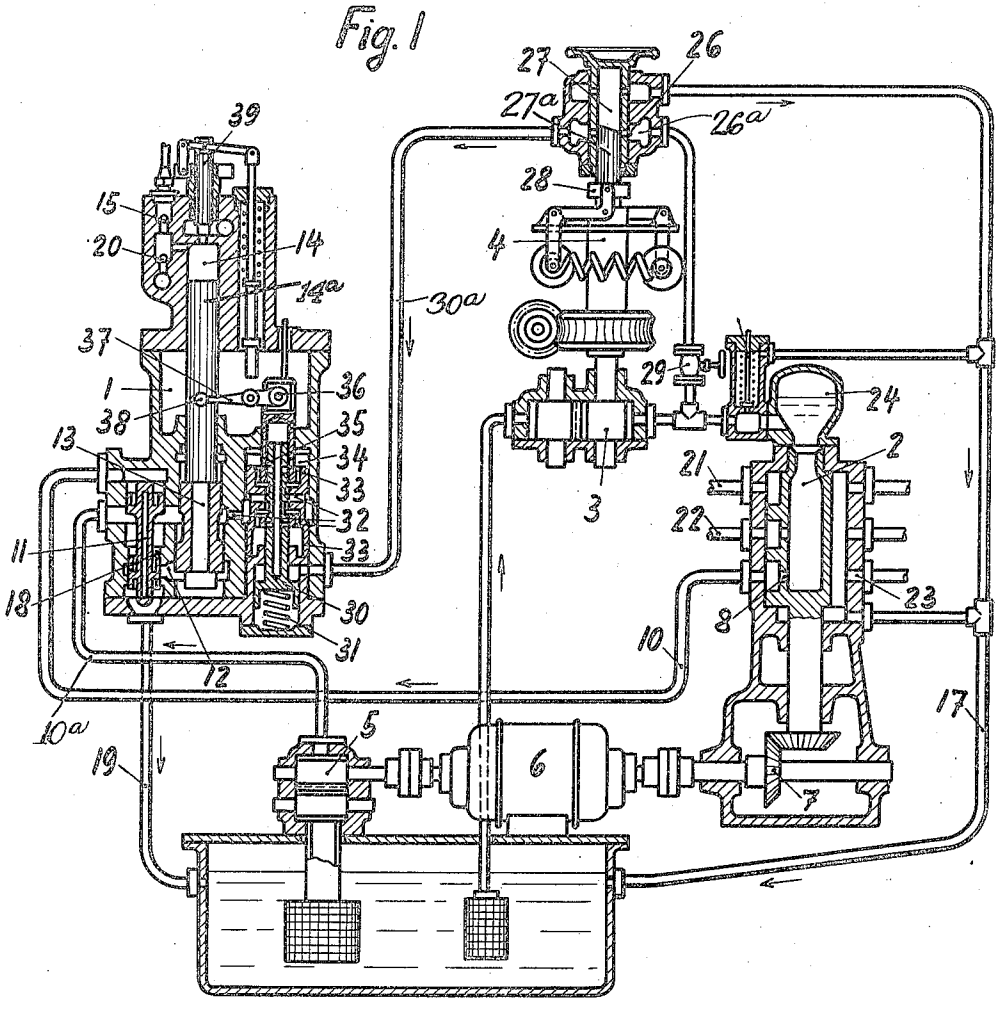
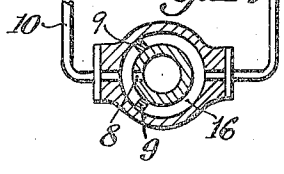


Fig. 2.



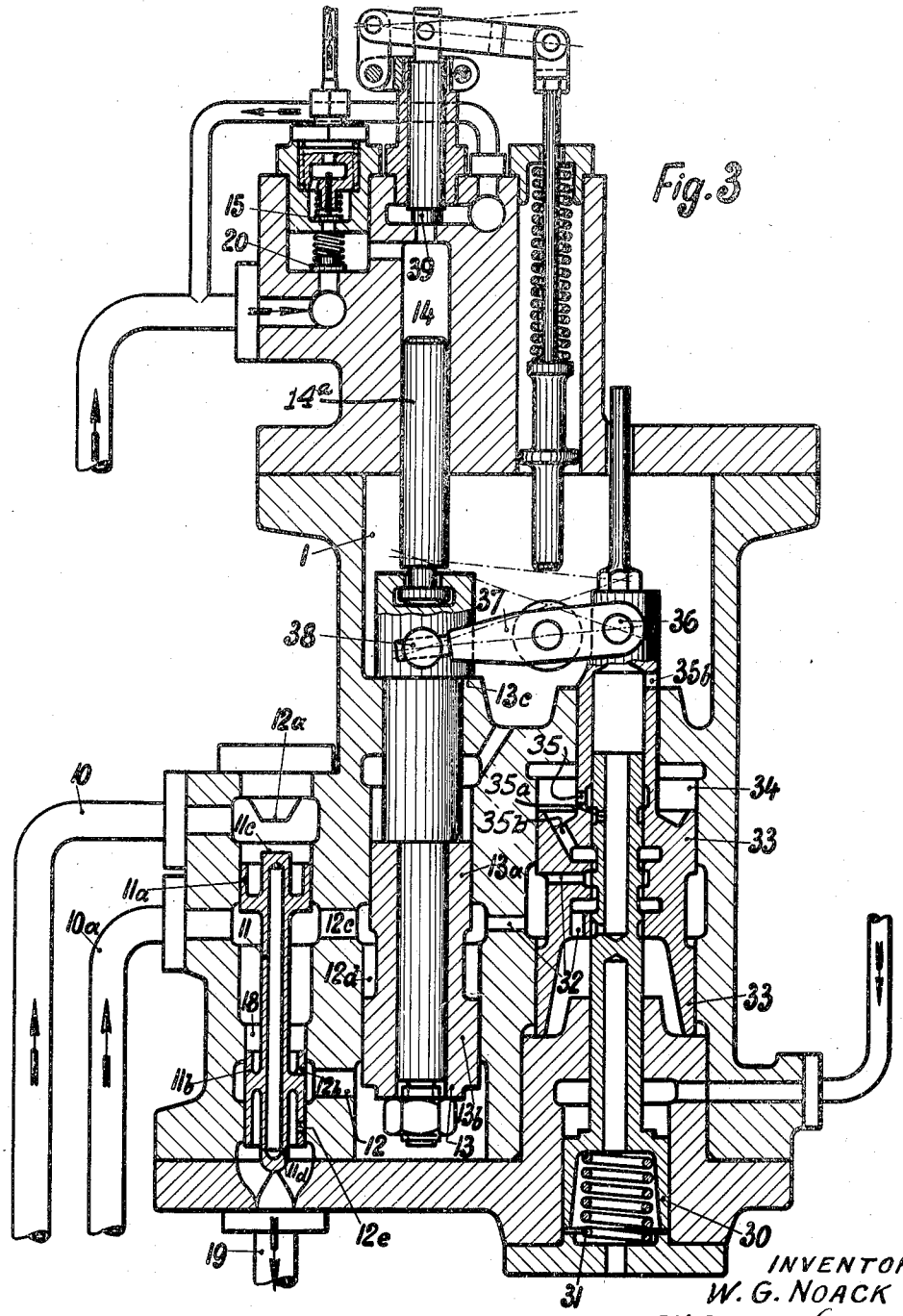
Inventor
WALTER G. NOACK
By Joseph Kuechmann
Attorney

Oct. 6, 1936. W. G. NOACK 2,056,204

FUEL PUMP

Filed Dec. 30, 1931 3 Sheets-Sheet 2

Fig. 3



INVENTOR
W. G. NOACK
BY Joseph Buchman
ATTORNEY

Oct. 6, 1936. W. G. NOACK 2,056,204

FUEL PUMP

Filed Dec. 30, 1931 3 Sheets-Sheet 3

Fig. 6

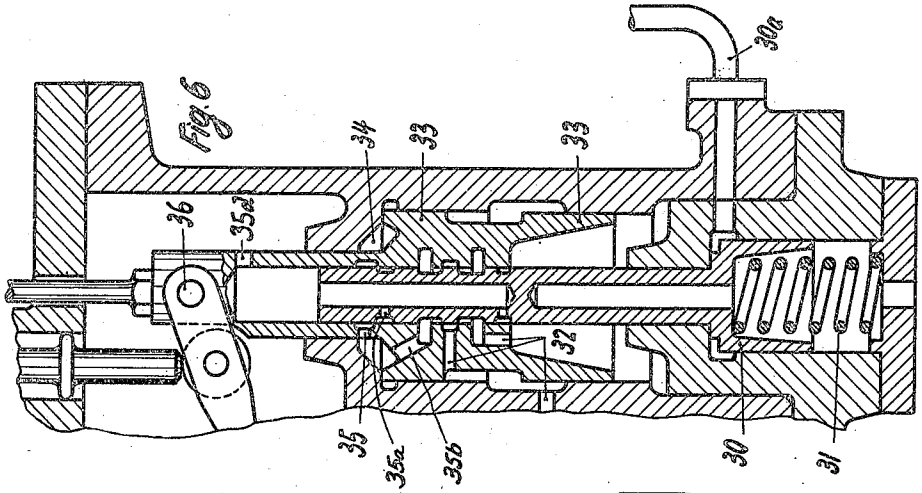


Fig. 5

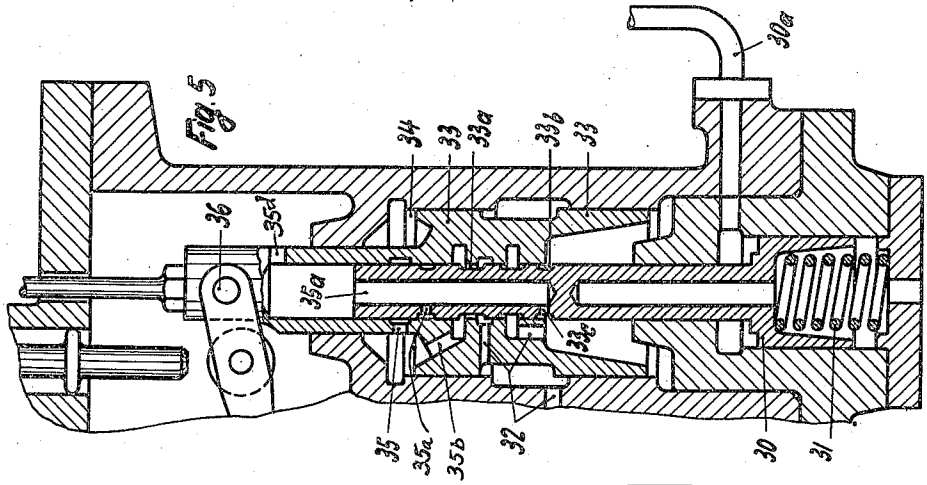
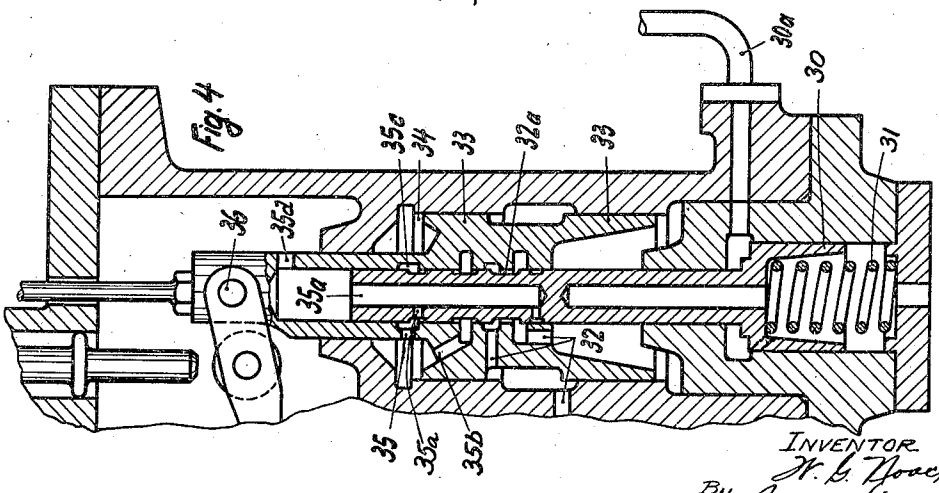


Fig. 4



INVENTOR
W. G. Noack
By Joseph Hirschman
ATTORNEY

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2,056,204

FUEL PUMP

Walter Gustav Noack, Baden, Switzerland, assignor to Holzwarth Gas Turbine Co., San Francisco, Calif., a corporation of Delaware

Application December 30, 1931, Serial No. 583,911
In Germany January 3, 1931

17 Claims. (Cl. 103—50)

My invention relates to fuel pumps and particularly to pumps suitable for use in connection with constant volume explosion chambers associated with explosion gas turbines or with steam generators.

It is already known to control the valves of explosion engines by means of a pressure medium, such as pressure oil, instead of by cams and lever mechanism, such pressure medium being made to act upon pistons associated with the movable parts of the valves, the control of the pressure medium, which is delivered by a special pump, being effected through valves or rotary distributors. It has also been already proposed to employ pressure oil for operating fuel pumps. The operating conditions in the case of fuel pumps are, however, somewhat different than in valves, as in fuel pumps comparatively large forces must be applied in very short times in order to secure rapid and powerful injections which last, however, for only a short period. In the case of explosion turbines or of steam generators wherein the heating medium comprises gases produced by explosion, not only high injection pressures but also comparatively large quantities of fuel are necessary. The power that must be temporarily applied is therefore considerable, so that the power transmitting medium, such as controlled pressure oil, must either have very high pressure or be used in very large quantities or both. It is, however, very difficult to fulfill both these requirements, both from the structural and operating standpoints, by oil control, as the necessary sensitivity (prompt responsiveness and precision) cannot be obtained with devices which must involve large masses and resist high pressures.

In order to retain the advantages of the drive and control by pressure fluid, and at the same time avoid the disadvantages thereof for the special operating conditions associated with fuel pumps, it is proposed according to the present invention to separate the drive from the control of the pump by actuating the fuel-injecting pump piston by means of a separate operating oil and to effect the control or regulation of the fuel quantities fed by the pump by means of control oil which is regulated in any suitable manner. The operating oil can then be of any desired pressure and be employed in any desired quantity, while the control oil, which serves only to regulate the rate of fuel feed, can be employed in such quantity and at such pressure as will insure reliable and accurate regulation.

In the accompanying drawings forming part of this specification, is shown by way of example a preferred arrangement embodying the present invention, Fig. 1 being a diagrammatic view in section of the fuel pump and its operating and regulating mechanism, Fig. 2 a horizontal section through the distributor, and Fig. 3 an enlarged sectional view of the fuel pump. Figs. 4 and 5 show the condition of the oil feed regulating piston at different instants during the initiation of a control movement in the upward and downward directions, respectively; while Fig. 6 illustrates the uppermost position of the piston.

The numeral 1 indicates the fuel pump, 2 the controller, in the form of a rotary distributor, for the control oil for the pump, 3 the pump for the control oil, which may for example be mounted upon the same shaft as the governor 4. The latter is driven by the engine which receives fuel from the pump. The oil pump for the operating oil is shown at 5. This pump is driven by a separate motor 6 which is coupled with the control device 2 through a reduction gearing shown conventionally at 7. The actuation of the fuel pump 1 is accomplished by causing control oil fed by the pump 3 to pass through ports or slots 8 in the rotary member of the distributor 2 into the arcuate space defined by the blocks 9 (Fig. 2) and thence to the upper side of the control piston 11 through the conduit 10. As will be seen from Fig. 3, the control piston 11 has a larger diameter at its upper part 11*a* than at its lower part 11*b*. The operating oil under pressure introduced by the conduit 10*a* leading from the pump 15 thus exerts a greater force upon the horizontal surface of the part 11*a* than upon the horizontal surface of the part 11*b*, so that there is always a differential force tending to move the piston upwardly. If the conduit 10 is not under pressure, the piston 11 will be moved upwardly until its topmost portion 11*c* engages the stop 12*a*. In this position, the port 12*b* is closed. If, however, as above-described, regulating oil is charged into the conduit 10 by the distributor 2, the total downwardly acting pressure exerted by such regulating oil upon the top surface of the part 11*a* preponderates over the just-mentioned upwardly directed differential force exerted by the pressure oil from the conduit 10*a*. The control piston 11 is consequently moved downwardly until it engages the stop 11*d*. The port or ports 12*b* located at the part 11*b* of the control piston 11 now permit the pressure oil from the conduit 10*a* to pass through the channel 12 into the space below the fuel pump piston 13. The latter is likewise provided with a part of smaller diameter 13*a* and a

part of larger diameter 13b. The pressure oil from the conduit 10a always has access through the port or ports 12c to the space 12d between the parts 13a and 13b. This pressure oil, due to the larger horizontal surface presented by the part 13b than by the part 13a, exerts a downwardly acting force upon the piston 13 (when no pressure oil enters through channel 12 into the space below the piston), the piston thus being constantly subjected to a force tending to lower the same. The piston 13 thus tends to move toward its lowest position wherein a shoulder on such piston engages the stop surface 13c. When, however, pressure oil enters through the channel 12 into the space below the piston 13, the total upward pressure exerted by such oil exceeds the downwardly directed differential pressure exerted by the oil from channel 12c. The piston is thus rapidly raised and forces the liquid fuel located in space 14 through the bore provided with the check valve 15 to the place of injection into the combustion chamber. In the meantime the blocks 9, which rotate with the rotary member 2, have brought the space 16, which is connected with an exhaust space, into communication with the conduit 10, so that the pressure upon the piston 11 is relieved, the oil flowing off through conduit 17 and the piston 11 being forced up by the action of the operating oil which occupies the space 18 and bears preponderatingly against the upper part 11a of the piston. By the movement of the piston 11 upwardly until the surface 11c strikes the stop 12a, the ports 12b in the lower part 11b of the control piston 11 are closed and the ports 12e in said part 11b are brought into communication with the channel 12. The underside of the piston 13 is now connected with the discharge pipe 19 for operating oil and such piston now moves downwardly in order to suck in a new charge of fuel through the one way valve 20 from a source of supply. This downward movement of the piston is effected, as above described, by the differential pressure of the pressure oil charged by the conduit 10a into the space 12d.

It will be seen from the above that the piston 11 operates in the manner of a slide valve to control the flow of operating oil for effecting movement of the fuel feeding piston in one or the other direction.

As can be seen from the drawings, the control member 2 is provided with further connections 21 and 22 which may serve for actuating the valves of the explosion chamber, e. g. the air inlet and the exhaust valve, as disclosed, for example, in the patents to Hans Holzwarth No. 877,194, dated Jan. 21, 1908 and No. 1,763,154, dated June 10, 1930. A second fuel pump, for a second explosion chamber, may be controlled through the opening 23 which is at the same level as the port 8. Above the housing of the distributor 2 is arranged an air chamber 24 which maintains the control oil pressure at a substantially uniform value even with varying withdrawal of pressure oil. A small relief valve 25 may be provided to limit the pressure of the control oil.

The control oil serving for the control of the operation of the fuel pump piston may also be employed satisfactorily for the regulation of the quantity of fuel itself by causing the speed governor to control the height of the control oil pressure. To this end the governor 4 is arranged to operate a slide valve 27a moving in a sleeve 27 having a port 26 leading from an oil-filled annular space 26a into the interior of the sleeve. By means of the slide valve more or less leak flow area for oil is exposed depending upon the position of the governor collar 28, the oil escaping through port 26 flowing into the exhaust conduit 17. Depending upon the magnitude of the area so exposed, the pressure of the control oil discharged into the conduit 30a by pump 3 is changed, the same being already reduced by the throttling device 29. The oil pressure controlled from the governor position operates upon a control piston 30 which is held in equilibrium by the spring 31. If the oil pressure falls because a larger area in the sleeve 27 is exposed, due to increase in the speed of the governor or to decrease in the load on the engine, the piston 30 rises under the influence of the spring, permits operating oil to pass beneath the piston 33 through the channels 32, as described more in detail below, and connects the space 34 over the piston 33 with the outer space of exhaust or atmospheric pressure through the openings 35, 35a and 35b. The piston 33 now rises until the flow of oil under the piston and the escape over the piston are checked. The piston 33 is now held in its position and with it the fulcrum 36 of the lever 37 which is moved from the fuel pump system through the follower 38 is maintained in fixed position. An overflow valve 39 is actuated in known manner by the lever 37, such valve permitting a part of the sucked-in fuel quantity to flow back again out of space 14 into the suction conduit. Upon rise of the fulcrum 36, which occurs upon increase in speed of the governor, the opening of the overflow valve occurs earlier, so that less fuel is supplied. When the fulcrum 36 falls, that is, when the control oil pressure is reduced as the speed of the governor decreases, the overflow valve opens to only a slight extent or not at all, so that all or nearly all of the sucked-in fuel is forced out by the pump and fed to the explosion chamber.

The relative movements of the pistons 30 and 33 will be clear from the following description and from Figs. 4, 5 and 6.

Fig. 4 shows the piston 33 in an intermediate position. A fall in the pressure of the oil in conduit 30a has caused the spring 31 to move the piston 30 upwardly for a certain distance. In this way, there is initiated for the piston 33 an exactly similar movement in the following manner: The upper control edge of the groove 32a on the piston 30 opens the path of flow through the bores 32 toward the lower side of the piston 33. Pressure oil from pipe 10a (see also Fig. 1) can now enter through the bores 32 and occupy the space below the piston 33. Simultaneously the upper control edge of the groove 35c on the piston 30 opens the path for the oil trapped above the piston 33 to the bore 35a through the upper bores 35. The trapped oil can now flow off through the bores 35, 35a and 35d. As pressure oil can thus flow under the piston 33 and as the oil above the piston can flow off, the piston 33 moves upwardly. By this upward movement the piston 33, however, itself again closes the path established by the upper control edges of the grooves 32a and 35c for the oil and must accordingly come to rest at the moment when the said upper control edges are again covered by the inner wall of the hollow piston 33. The relative position of the piston 33 and piston 30 which is then reached is shown clearly in Fig. 6, wherein the space below the piston 33, as well as the space above the piston, is completely closed, so that any movement of the piston 33 is made impossible. In this figure, the pistons 30 and 33 are in their uppermost positions.

In similar fashion, the piston 33 follows the piston 30 downwardly when, as indicated in Fig. 5, an impulse is exerted through the conduit 30a upon the piston 30 against the pressure of spring 31 and moves the piston 30 a definite distance downwardly. By such downward movement of piston 30 there is effected a similar movement of piston 33 and for the same distance. It being borne in mind that the piston 30 in Fig. 5 begins moving down from a position relatively to piston 33 which is similar to that shown in Fig. 6, it will be seen that the lower control edge of the groove 33a creates a connection between the upper bores 32 and the bore 35b of piston 33, so that now the pressure oil entering through the bore 32 can flow through the groove 33a and the bore 35b to the upper side of such piston. Simultaneously, the lower control edge 33b opens a discharge path for the oil trapped below the piston 33 through the bores 33c, 35a and 35d. The piston 33 accordingly moves down under the influence of the oil pressure upon its upper surface, and for so long a distance until the lower control edges of the grooves 33a and 33b are again covered by the inner wall of piston 33, that is, until the relative position of the piston 33 and piston 30 is the same as illustrated in Figs. 3 and 6. When it reaches such position, the piston 33 remains stationary.

By separation of the control oil from the operating oil it becomes possible to combine the control of the pump and the regulation of the fuel quantities with comparatively small quantities of oil and with low oil pressure, and to operate with greater precision. The use of a separate operating oil makes it also possible to apply great power for the drive of the pump, particularly when an air chamber is associated likewise with the feed conduit for the operating oil, such air chamber rendering available momentarily rather large quantities of oil without considerable fall in pressure. It will be understood that the various conduits and oil spaces do not become alternately filled with and emptied of oil; there is preferably always a body of oil in such spaces which alternately is relieved of pressure and transmits pressure impulses, so that the movement of large bodies of oil is avoided.

I claim:

1. A fuel pump system suitable for explosion chambers, comprising a cylinder, a piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, a motor cylinder and piston for operating said first piston, means for charging operating oil under relatively high pressure to said motor piston to move the same, hydraulic mechanism adapted and arranged to be operated by a separate body of control oil of relatively low pressure for controlling the flow of said operating oil, and means for charging such control oil to said mechanism.

2. A fuel pump system as set forth in claim 1, including mechanism for regulating the quantity of oil charged by the pump, means for charging to said mechanism the same control oil which controls said motor piston, and a common source of oil for said mechanism and said motor piston.

3. A fuel pump system as set forth in claim 1, including a rotary timing device in the circuit of the control oil for timing the flow of control oil to said hydraulic mechanism.

4. A fuel pump system as set forth in claim 1, including a timing device for the low pressure control oil arranged at a distance from the fuel pump, said hydraulic mechanism being located near said pump, and a conduit connecting said timing device and said mechanism.

5. A fuel pump system suitable for explosion chambers, comprising a cylinder, a fuel feeding piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, hydraulic mechanism for operating said piston comprising a source of liquid under pressure, a slide valve controlling the flow of such pressure liquid to said piston to regulate the reciprocating movement thereof, a fluid conduit associated with the slide valve and adapted to charge a liquid under pressure thereto to actuate the same, and a timing mechanism interposed in said last-mentioned conduit for periodically regulating the pressure therein to time the actuation of the slide valve and thereby of the fuel feeding piston.

6. A fuel pump system suitable for explosion chambers, comprising a cylinder, a fuel feeding piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, a motor cylinder and piston for operating the fuel feeding piston, a pressure fluid conduit, a slide valve associated with said conduit for directing fluid under pressure from said conduit to one or the other side of the motor piston, and hydraulic mechanism for operating the slide valve and comprising a conduit, a source of pressure fluid, and a timing device interposed in said last-mentioned conduit between the source of pressure fluid and the slide valve to time the operation of the slide valve and thereby of the fuel feeding piston.

7. A fuel pump system suitable for explosion chambers, comprising a cylinder, a fuel feeding piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, means for operating the piston, hydraulically operated mechanism for determining the effective feed stroke of the fuel feeding piston, a conduit for charging a liquid under pressure to said mechanism, and means for varying the pressure in said last-mentioned conduit.

8. A fuel pump system suitable for explosion chambers, comprising a cylinder, a fuel feeding piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, means for operating the piston, a valve associated with said cylinder space for by-passing a portion of the fuel sucked into the cylinder, means movable with the piston for operating the by-pass valve, hydraulically operated mechanism connected with said means for determining the position thereof relatively to the by-pass valve and thereby determining the effective fuel feeding stroke of the piston, a pressure fluid conduit connected with said mechanism, and means for regulating the pressure in said last-mentioned conduit and thereby predetermining the position of said valve operating means with respect to said valve.

9. A fuel pump system suitable for explosion chambers, comprising a cylinder, a fuel feeding piston reciprocable therein and having a fixed stroke, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, means for operating the piston, a valve associated with said cylinder space for by-passing a portion of the fuel sucked into the cylinder, hydraulically operated mechanism associated with the by-pass valve and operating to

determine the instant of opening of the valve with relation to the beginning of the feed stroke of the piston, a conduit for feeding a liquid under pressure to said mechanism, and speed responsive mechanism for regulating the pressure of the liquid in the last-mentioned conduit to cause the hydraulic mechanism to vary the effective feed stroke of the piston.

10. A fuel pump system suitable for explosion chambers, comprising a casing bored to provide a piston cylinder, a fuel feeding piston reciprocable in such cylinder, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, a motor piston connected with the fuel feeding piston to operate the latter, said casing being bored to provide a cylinder for such motor piston, a conduit for delivering a liquid under pressure for operating the motor piston, a slide valve housed within said casing and movable to regulate the feed of such pressure liquid to the motor piston, a conduit for supplying a liquid under pressure for operating the slide valve, timing mechanism connected with the last mentioned conduit for timing the operation of the slide valve, and hydraulically operated mechanism likewise housed within said casing for determining the effective fuel feeding stroke of the fuel feeding piston.

11. A fuel pump system suitable for explosion chambers, comprising a casing bored to provide a piston cylinder, a fuel feeding piston reciprocable in such cylinder, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, a motor piston connected with the fuel feeding piston to operate the latter, said casing being bored to provide a cylinder for such motor piston, a conduit for delivering a liquid under pressure for operating the motor piston, a slide valve housed within said casing and movable to regulate the feed of such pressure liquid to the motor piston, a conduit for supplying a liquid under pressure for operating the slide valve, timing mechanism connected with the last mentioned conduit for timing the operation of the slide valve, a valve for by-passing a portion of the fuel sucked into the first-mentioned cylinder, a member movable with the fuel feeding piston for opening the by-pass valve, and mechanism for determining the position of such member with respect to the by-pass valve at the beginning of the feed stroke of the fuel feeding piston, comprising a piston connected to said member, a spring acting on one side of the piston urging it in one direction, a conduit for feeding liquid under pressure to the other side of the piston, and means for regulating the pressure in said last-mentioned conduit.

12. A fuel pump system suitable for explosion chambers and comprising a cylinder, a fuel feeding piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space, means for operating the piston, and mechanism for determining the quantity of fuel charged by the piston into the fuel discharge conduit, said mechanism including a device associated with the piston and adjustable to determine the length of the fuel feeding stroke of the piston, a source of pressure liquid, a member controlled by said liquid and operative to adjust said device, and means for varying the pressure of the liquid charged to said member.

13. A fuel pump system suitable for explosion chambers and comprising a cylinder, a fuel feeding piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space, means for operating the piston, and mechanism for determining the effective feed stroke of the fuel feeding piston, comprising a device associated with the piston and movable to determine the length of the fuel feeding stroke of the piston, an auxiliary cylinder and piston for operating said device, a source of control liquid of substantially constant pressure connected with the auxiliary cylinder for moving said piston in one or the other direction, a control member for said operating oil associated with said auxiliary piston, and a source of variable liquid pressure connected with said control member to determine the position thereof and thereby regulating the flow of the constant pressure liquid to one or the other side of the auxiliary piston.

14. A fuel pump system suitable for explosion chambers and comprising a cylinder, a fuel feeding piston reciprocable therein and having a fixed stroke, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space, means for operating the piston, a by-pass valve associated with the cylinder space and hydraulically controlled mechanism for determining the instant of opening of the by-pass valve to thereby determine the amount of fuel fed by the fuel feeding piston during each stroke, said mechanism comprising an auxiliary piston and cylinder arranged to cause actuation of said valve, a source of operating liquid of substantially constant pressure for moving said auxiliary piston in one or the other direction, a control device for regulating the flow of said operating liquid to one or the other side of said auxiliary piston, and means for effecting movement of said control device to alter the position of said auxiliary piston and thereby altering the instant of opening of the by-pass valve during the feed stroke of the fuel feeding piston.

15. A fuel pump system suitable for explosion chambers, comprising a cylinder, a piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space, means for operating the piston, an adjustable device for determining the amount of fuel fed by the piston during each stroke, an auxiliary piston and cylinder for adjusting said device, a conduit for charging operating liquid at substantially constant pressure to said auxiliary cylinder to effect movement of the auxiliary piston in one or the other direction, hydraulic mechanism adapted and arranged to be operated by a separate body of control liquid of relatively low pressure for controlling the flow of said operating liquid, and means for charging such control liquid to said mechanism.

16. A fuel pump system suitable for explosion chambers comprising a cylinder, a piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, a motor cylinder and piston for operating said first piston, means for charging operating oil under relatively high pressure to said motor piston to move the same, hydraulic mechanism adapted and arranged to be operated by a separate body of control oil of relatively low pressure for controlling the flow of said operating oil, means for charging such control oil to said mechanism, and mechanism for determining the quantity of fuel fed by said first-mentioned piston during each pump cycle comprising a by-pass valve, a member connected with the fuel feeding piston for operating said valve, an auxiliary piston and cylinder associated with said member and capable of adjusting the posi-

tion thereof with respect to the by-pass valve to vary the instant of opening of such valve in relation to the feeding stroke of the fuel piston, a conduit for delivering said operating oil to said auxiliary piston to effect movement of the latter in one or the other direction, a member associated with said auxiliary piston for controlling the flow of said operating oil, said member having ports for admitting operating oil to one side of said auxiliary piston and simultaneously discharging oil from the opposite side of said piston, said ports being so disposed and arranged that said auxiliary piston follows the movements of the control member, a spring for urging said control member in one direction, a conduit for delivering control oil under pressure to said member to act thereon in opposition to said spring, and means for varying the pressure of said control oil in correspondence with a variable magnitude according to which the supply of fuel is to be regulated.

17. A fuel pump system suitable for explosion chambers, comprising a cylinder, a fuel feeding piston reciprocable therein, a fuel feed conduit and a fuel discharge conduit connected with the cylinder space at one end of the piston, means for operating the piston, and mechanism for regulating the quantity of fuel fed by the piston during its feeding stroke, including an adjustable member adapted to determine the length of the fuel feeding movement of the piston, a hydraulically operated device for adjusting said member, a conduit for charging a control liquid under pressure to said mechanism, and means for varying the pressure in said last-mentioned conduit.

WALTER GUSTAV NOACK.