April 10, 1951 T. SIMPSON ET AL 2,548,501

HYDRAULIC PUMP

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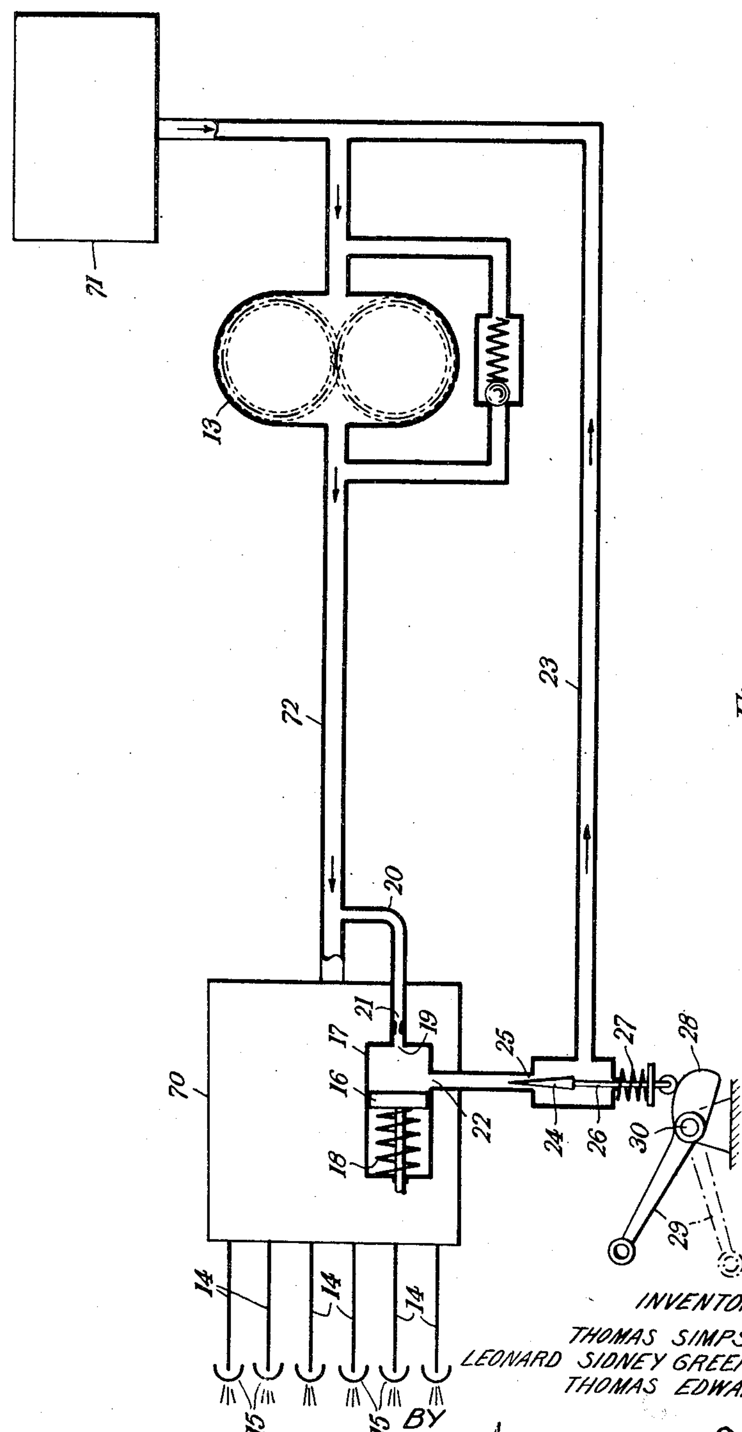

Fig. 8.

INVENTORS
THOMAS SIMPSON
LEONARD SIDNEY GREENLAND
THOMAS EDWARDS

BY Moses, Nolte, Crews & Berry
ATTORNEYS

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HYDRAULIC PUMP

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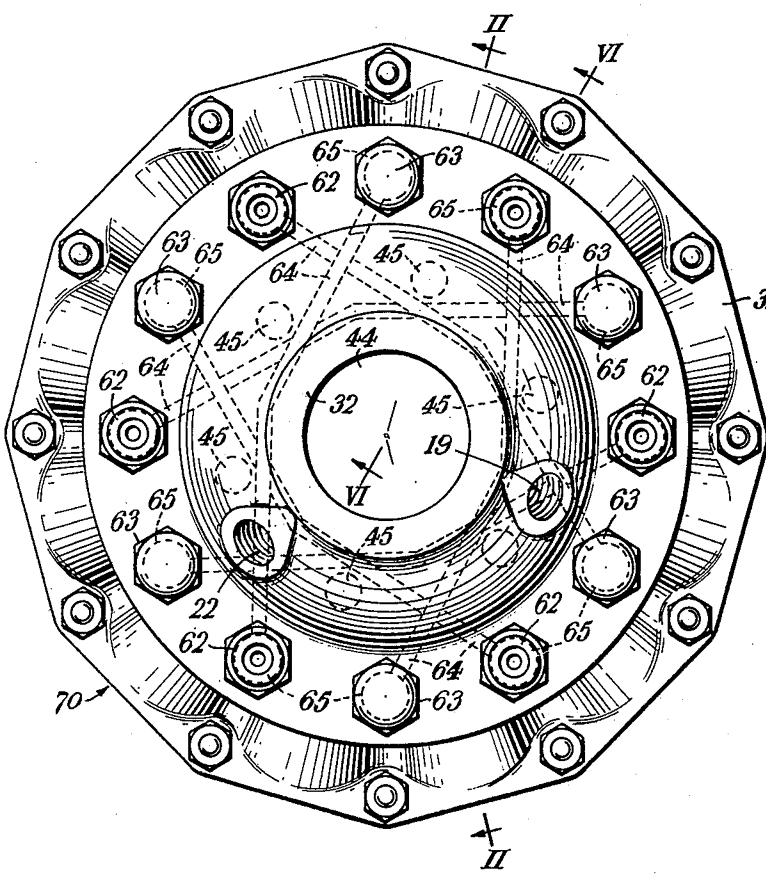

Fig. 1.

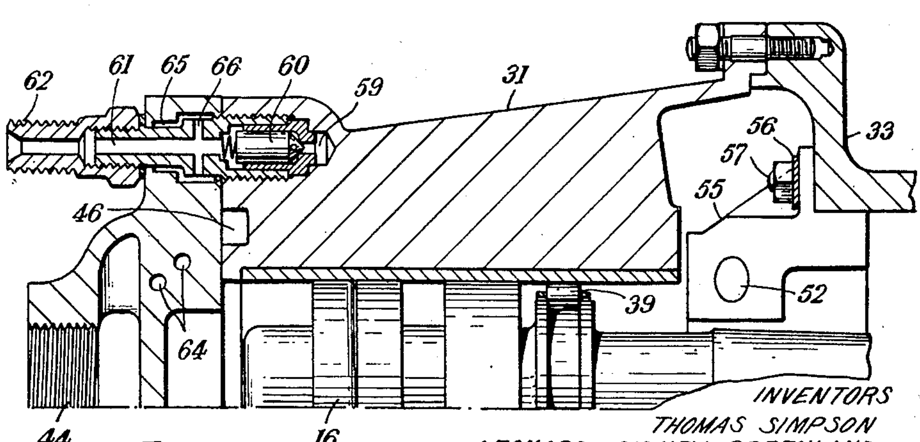

Fig.6.

INVENTORS
THOMAS SIMPSON
LEONARD SIDNEY GREENLAND
THOMAS EDWARDS
BY Moses, Nolte, Crews & Berry
ATTORNEYS

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HYDRAULIC PUMP

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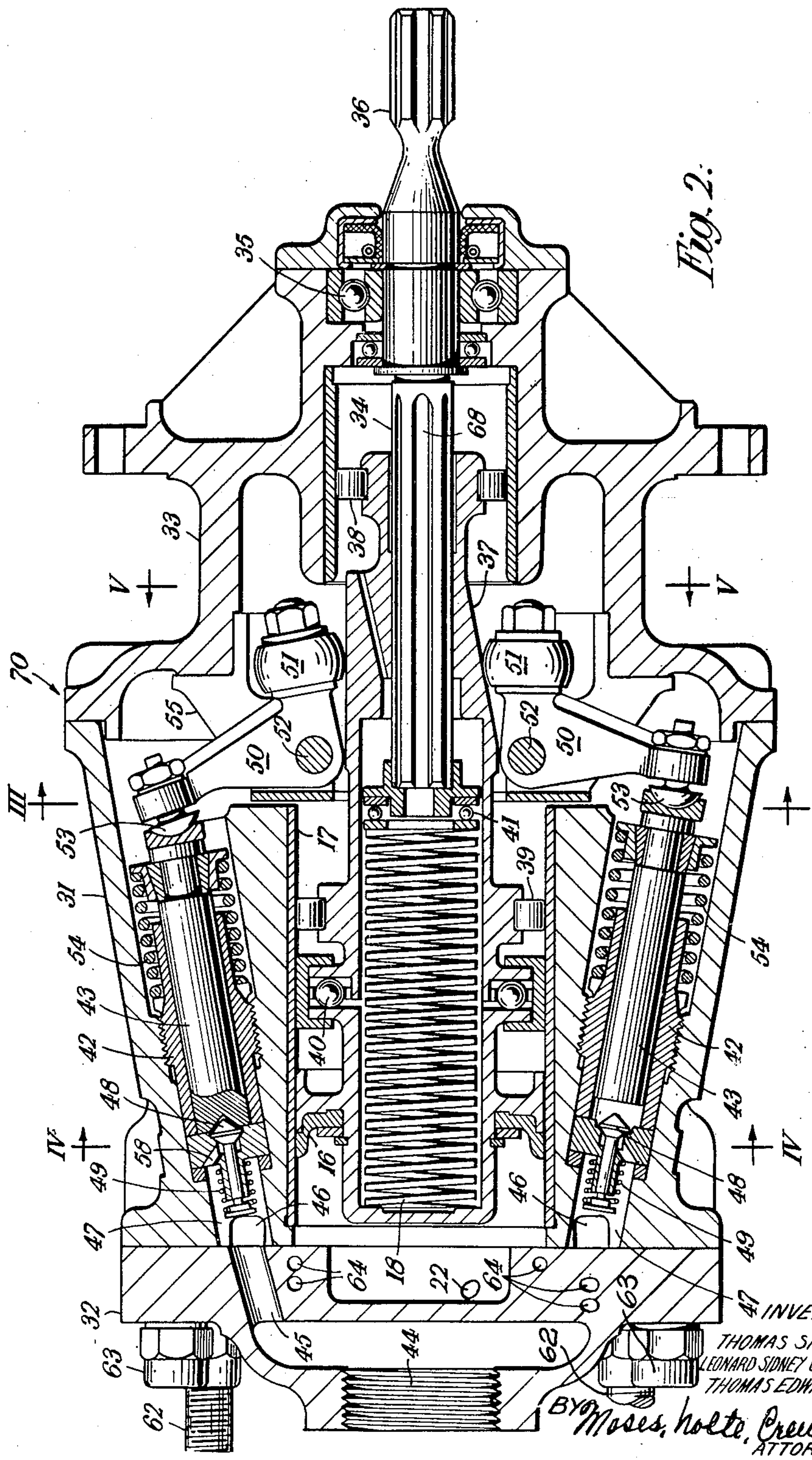

INVENTORS
THOMAS SIMPSON
LEONARD SIDNEY GREENLAND
THOMAS EDWARDS
BY Moses, Nolte, Crews & Berry
ATTORNEYS

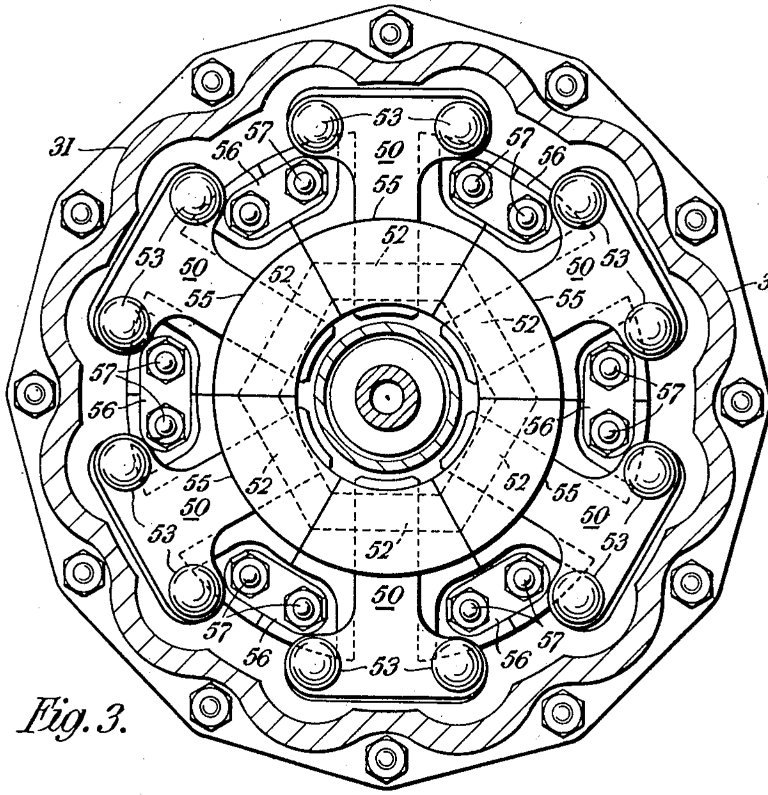

Fig. 3.

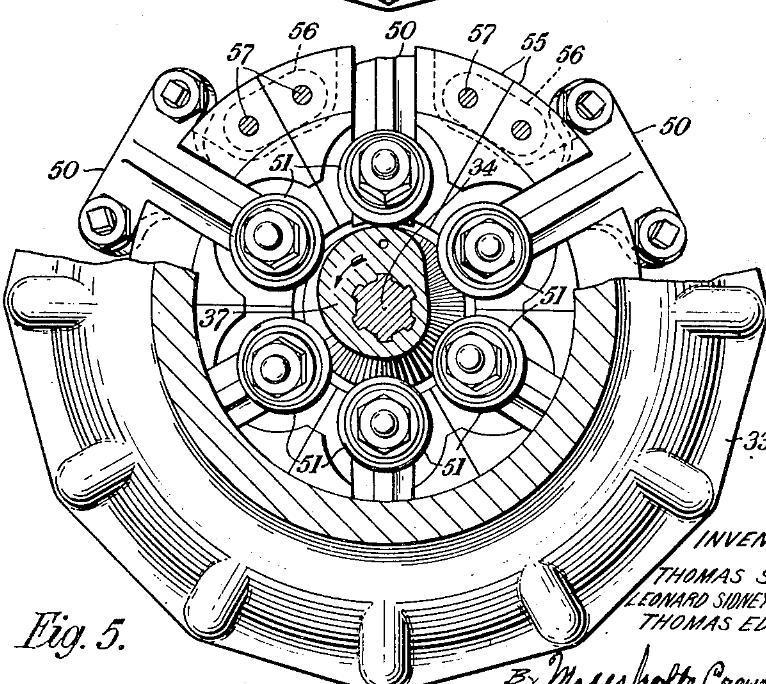

Fig. 5.

INVENTORS
THOMAS SIMPSON
LEONARD SIDNEY GREENLAND
THOMAS EDWARDS
By Moses, Nolte, Crews & Berry
ATTORNEYS

April 10, 1951 T. SIMPSON ET AL 2,548,501

HYDRAULIC PUMP

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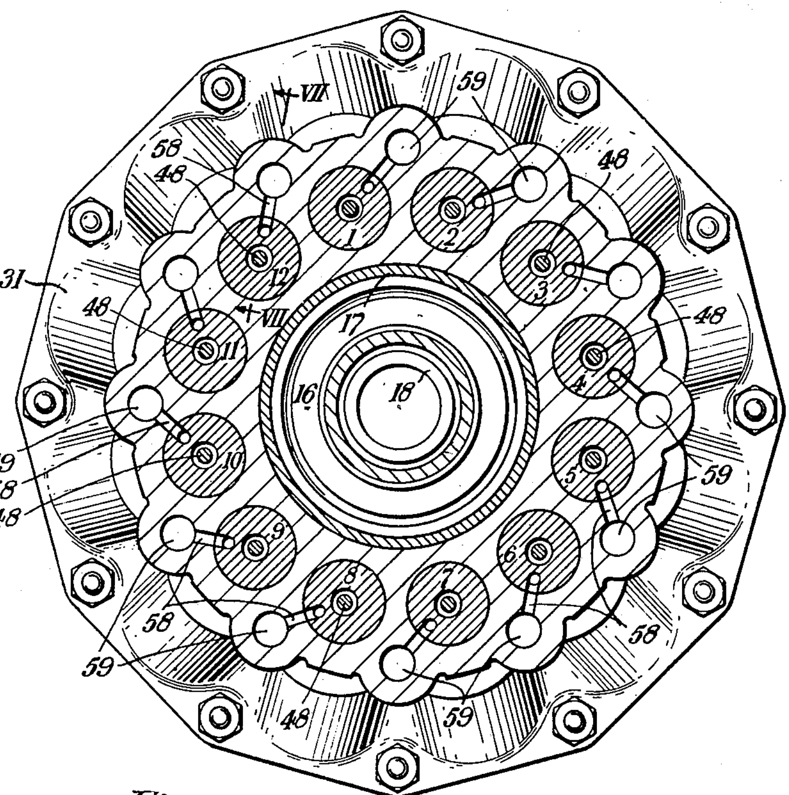

Fig. 4.

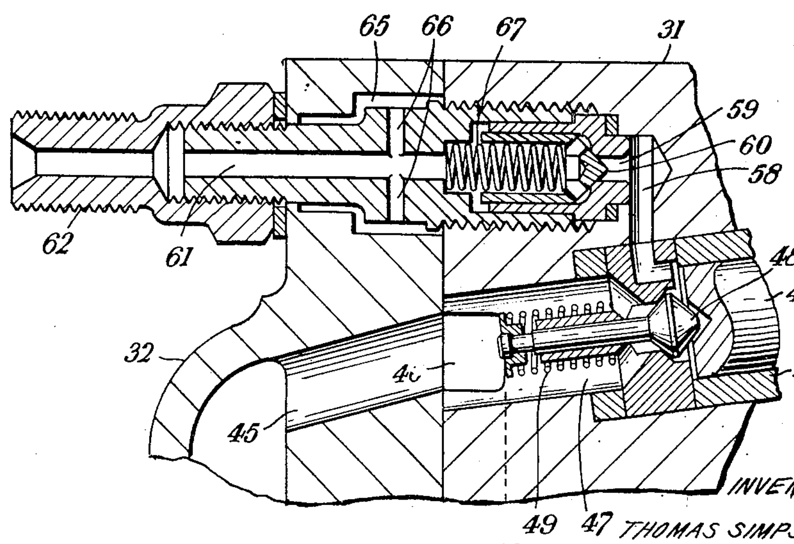

Fig. 7.

INVENTORS
THOMAS SIMPSON
LEONARD SIDNEY GREENLAND
THOMAS EDWARDS

BY Moses, Nolte, Crews & Berry

ATTORNEYS

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UNITED STATES PATENT OFFICE

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HYDRAULIC PUMP

Thomas Simpson, Pattingham, near Wolverhampton, Leonard Sidney Greenland, Wolverhampton, and Thomas Edwards, Bilbrook, near Wolverhampton, England, assignors to H. M. Hobson Limited, London, England, a British company

Application December 3, 1947, Serial No. 789,494
In Great Britain August 19, 1947

7 Claims. (Cl. 103—38)

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This invention relates to hydraulic pumps, and has for its object to provide means whereby the delivery of the pump may be varied. The invention relates particularly, though not exclusively, to a variable delivery hydraulic pump which produces a constant flow of liquid at a rate determined by the setting of a delivery controlling means.

The hydraulic pump according to the invention comprises a rotary cam shaft and a cam on said shaft arranged to actuate the pump to cause it to deliver liquid, said cam being adjustable lengthwise of the shaft and being profiled so that the stroke of the pump varies with and is determined by the position of adjustment of the cam on the shaft.

One form of pump according to the invention comprises a pair of pump units of the barrel and plunger type, having their outlets connected to a common delivery line, a cam mounted on a cam shaft to turn therewith and operating to reciprocate both plungers in their respective barrels, and means for adjusting the cam longitudinally in relation to the cam shaft, the cam being shaped so that, in all positions of adjustment, it causes differential operation of the two pump units so that the two units together produce a constant rate of flow of liquid in the delivery line, while as the cam is moved in relation to the shaft the stroke of each plunger in its barrel, and therefore the delivery of the pump, is progressively increased or diminished according to the direction of movement of the cam.

Preferably the pump comprises a number of pairs of pump units grouped around the cam shaft with their barrels nearly parallel thereto, the output of each pair of pump units being taken to a common delivery line allotted to that pair of pump units and the cam acting on the plungers through the agency of pivoted rocker arms carrying rollers or the like for engaging the cam and tappets for actuating the plungers, the arrangement being such that each pair of pump units produces a constant flow of liquid in its delivery line at a rate determined by the position of the cam on the cam shaft. The rate of flow of liquid of course also depends on the speed of rotation of the cam shaft.

The cam may conveniently be connected to a piston working in a cylinder and spring urged in one direction, the spring being counterbalanced by fluid pressure in the cylinder acting on the piston. By varying this fluid pressure the position of the cam, and therefore the delivery of the pumping units, can be varied.

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A preferred form of variable delivery constant flow hydraulic pump according to the invention for use in injecting fuel into the combustion chamber of a gas turbine, will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a front elevation of the pump,

Fig. 2 is a section on the line II—II in Fig. 1,

Figs. 3, 4 and 5 are respectively sections taken on the lines III—III, IV—IV and V—V in Fig. 2,

Fig. 6 is a section taken on the line VI—VI in Fig. 1,

Fig. 7 is a diagrammatic sectional view on a larger scale, taken on the line VII—VII in Fig. 4, and

Fig. 8 is a diagrammatic view showing the means for supplying controlling pressure to the mechanism for varying the delivery of the pump.

Like reference characters denote like parts throughout the figures.

Turning first to Fig. 8, the variable delivery constant flow hydraulic pump 70 is supplied with fuel at a suitable pressure, from a tank 71 through an inlet line 72 by a gear pump 13. The pump 70 comprises, as later described, six pairs of pumping units, each of which pairs is arranged to discharge fuel at constant speed into a delivery line 14 common to that pair, and leading to an injection nozzle 15. The delivery of the pump is controlled, also as later described, by a piston 16 housed in a cylinder 17 and exposed to the pressure of a spring 18. The cylinder 17 has an inlet port 19, communicating, via a pipe 20 having therein a restriction 21, with the inlet line 72, and an outlet port 22 communicating with a pipe 23 through which liquid is returned to the tank 71. The liquid pressure acts on the piston 16 in opposition to the spring 18, and therefore the position of the piston 16 in its cylinder 17, is determined by the position of a needle valve 24, which in turn controls the effective area of an orifice 25 through which the fuel flows from the outlet port 22 to the return line 23. The stem 26 of the needle valve 24 is pressed by a spring 27 into contact with a cam 28, the position of which can be adjusted to alter the liquid pressure acting on the piston 16, by moving a pilot's control lever 29 about a pivot 30.

Turning now to Fig. 2, the casing of pump 70 is constituted by a centre member 31, and a pair of end members 32, 33 suitably secured together. The cylinder 17 is provided in the centre member 31. The pump 70 is actuated by a cam shaft 34, mounted in a bearing 35 and having a splined end 36 to carry a gear wheel through which rotary motion is imparted to the cam shaft from the turbine. The cam shaft 34 is formed with splines 68 engaging corresponding splines on a cam 37, which is supported in bearings 38, 39 and the forward or left hand end of which is coupled by a thrust bearing 40 to the piston 16. As shown in Fig. 2, the spring 18 is mounted in compression within the hollow interior of piston 16, a thrust bearing 41 being disposed between the rear end of the spring 16 and the forward end of the cam shaft 34.

The spring 18 thus tends to move the piston 16 and therefore the cam 37 forwardly, or to the left as seen in Fig. 2. As the liquid pressure exerted on the piston 16 is varied, by adjustment of the needle valve 24 (Fig. 8), the cam 37 will be adjusted lengthwise in relation to the cam shaft 34.

The pump 70 includes twelve pumping units of the barrel and plunger type, each comprising a barrel 42 and a plunger 43 mounted to reciprocate in the barrel 42 so as to execute alternate suction and delivery strokes. The barrels 42 are mounted within the centre member 31 and are equally spaced around the cylinder 16, being inclined to the axis of the cylinder with their forward ends nearer said axis than their rear ends. Fuel is admitted to the forward ends of the barrels 42 through an inlet 44, for connection to the inlet line 72 (Fig. 8). The fuel passes from inlet 44 via passages 45 to an annular duct 46 and thence into a plurality of passages 47 aligned with the barrels 42. The admission of fuel from each passage 47 to the associated barrel 42 is controlled by an inlet valve 48 normally held closed by a spring 49. When, however, any of the plungers 43 is executing a suction stroke, the associated valve 48 opens to allow fuel to enter the forward end of the associated barrel. Inlet valves 48 of course close when their associated plungers 43 are executing delivery strokes.

The plungers 43 receive reciprocating movement from the cam 37, as the latter rotates, through the agency of six rocker arms 50, each rocker arm being associated with a pair of adjacent plungers. Each rocker arm 50 is pivoted on a pin 52 and carries a roller 51 which contacts with the cam 37. The rocker arms 50 are, see Fig. 3, of T-shape and each carries a pair of tappets 53 for actuating the associated pair of plungers 43. Springs 54 (Fig. 2) associated with the plungers 43 maintain the rollers 51 in contact with the cam 37 and urge the plungers in the direction to execute a suction stroke, the plungers being positively actuated by the cam 37 to perform delivery strokes against the action of their springs 54. The pivot pins 52 (see Fig. 3) are accommodated each in one of six rocker supports 55 which fit side by side in the interior of the casing member 31 and are held in position by plates 56 and bolts 57.

Leading from the forward end of each barrel 42 (see Figs. 4 and 7) is a lateral passage 58 communicating with an outlet port 59 normally held closed by an outlet valve 60 loaded by a spring 67. On the delivery stroke of any plunger 43, its associated outlet valve 60 opens to allow fuel to pass to an outlet passage 61. Of the twelve outlet passages 61, six terminate in outlet spigots 62, while the other six are sealed by screw plugs 63, the spigots 62 and plugs 63 being arranged alternately around the circumference of the pump as clearly shown in Fig. 1. The six outlet spigots 62 are connected to the six delivery lines 14 (Fig. 8).

Each of the closed outlet passages 61 is connected to one of the spigoted outlet passages 61 by a channel 64 (Fig. 1). Each channel 64 communicates at its opposite ends in annular spaces 65 (Figs. 1 and 7), surrounding the outlet passages 61 and communicating therewith via radial passages 66.

Considering the barrels 42 as being numbered clockwise consecutively from 1–12, as seen from the front end, as marked in Figs. 3 and 4, it will be noted that the rocker arms 50 (see Fig. 3) are common to the following adjoining pairs of barrels 1, 2; 3, 4; 5, 6; and so on. The channels 64, which connect the barrels in pairs to the common outlet spigots 62, extend between the following pairs of barrels (see Fig. 1) 1, 8; 2, 7; 3, 10; 4, 9; 5, 12; and 6, 11.

The cam 37 is so shaped that, for each position thereof in relation to the cam shaft 34, the delivery from each pair of coupled barrels 42 into its common delivery line 14 through spigot 62 is at a constant rate throughout the cycle. Due to the shaping of cam 37, the one plunger 43 of the pair will be executing a suction stroke while the other is executing a delivery stroke at constant delivery; and an increase or decrease of delivery by either plunger, as it changes from a suction to a delivery stroke or vice versa, is compensated by a corresponding decrease or increase in the delivery from the other plunger. As the rocker arms 50 are common each to a pair of barrels 42, two adjoining plungers at any time will be executing a suction stroke and the diametrically opposite pair of adjoining plungers will be executing a delivery stroke. Thus, when the plungers in barrels 1 and 2 are executing a suction stroke those in barrels 8 and 7 will be executing a delivery stroke. As however barrels 1 and 8 have a common delivery line, and barrels 2 and 7 likewise have a common delivery line, the rate of flow in each delivery line will be constant and determined in magnitude by the position of the cam 37 in relation to the cam shaft 34, which, in turn, as already explained, is determined by the liquid pressure acting on the piston 16.

When the cam 37 is in its most rearward position on the cam shaft 34, no delivery is taking place and the plungers are at the forward ends of their barrels, a circular section of cam operating on the rocker arms 50. When the pilot's lever 29 (Fig. 8) is moved to lower the needle valve 24, and increase the effective area of orifice 25, the liquid pressure acting on the piston 16 is reduced. As the cam 37 is, in consequence, shifted forwardly on the cam shaft 34 by the spring 18, portions of the cam 37 of progressively diminishing cross sectional area, but always of shape appropriate for constant rate of flow from each coupled pair of barrels, are brought progressively into cooperation with the rocker arms 50. The strokes of the plungers 43 are thus progressively increased, with consequent progressive increase in the rate of flow through the delivery lines 14 and to the injection nozzles 15 coupled thereto.

It will be noted that, when no discharge is taking place, the plungers 43 are at the forward ends of their barrels 42, i. e. the ends at which the inlets are provided. As delivery commences, the quantity of fuel in the barrels 43 gradually increases from substantially zero to that corresponding to maximum stroke. There is therefore no danger of disturbance arising from cavitation, due to trapped air, in the fuel at the minimum delivery condition, when such cavitation would be particularly harmful.

What we claim as our invention and desire to secure by Letters Patent is:

1. A hydraulic pump comprising a cam shaft, a plurality of barrels grouped around the cam shaft, a reciprocating plunger in each barrel, a cam mounted on the cam shaft to turn therewith and operative on the plungers to impart alternate suction and delivery strokes to the plungers, and means for adjusting the cam on the cam shaft in the axial direction of the cam shaft, to vary the stroke imparted by the cam to the plungers, said barrels being grouped in pairs with the barrels constituting each pair located on opposite sides of the cam shaft and arranged to discharge into a common delivery line and the cam being profiled so that the rate of flow of liquid in each delivery line is constant and determined in magnitude by the position of axial adjustment of the cam in relation to the cam shaft.

2. A hydraulic pump comprising a cam shaft, a plurality of barrels grouped around the cam shaft, each having an inlet and an outlet port at the same end thereof, a cam mounted on the cam shaft, to rotate therewith and capable of axial adjustment in relation to the cam shaft, rockers between the plungers and the cam for imparting delivery strokes to the plungers on rotation of the cam shaft, and springs for returning the plungers to enable them to execute suction strokes. said cam having a circular portion adapted in one position of axial adjustment of the cam to coact with the rockers to maintain all the plungers in end-of-delivery stroke position and thus adjust the pump for zero delivery, and said cam being effective, when moved axially of the cam shaft and away from said position, progressively to increase the stroke of said plungers.

3. A hydraulic pump as claimed in claim 1, wherein each barrel has inlet and outlet ports at the same end of its barrel, and comprising rockers for imparting delivery strokes from the cam to the plunger and springs for returning the plungers to enable them to perform suction strokes, said cam having a circular portion adapted in one position of axial adjustment of the cam to coact with the rockers to maintain all the plungers in end-of-delivery stroke position and thus adjust the pump for zero delivery and said cam being effective, when moved axially of the cam shaft and away from said position, progressively to increase the stroke of said plungers.

4. A hydraulic pump comprising a cam shaft, a plurality of barrels grouped around the cam shaft, a reciprocating plunger in each barrel, a cam mounted on the cam shaft to turn therewith and operative on the plungers to impart alternate suction and delivery strokes to the plungers, a piston coupled to said cam, a cylinder housing said piston, a spring for urging said piston in one direction in its cylinder, means for subjecting the piston to liquid pressure to balance the spring pressure, and means for varying the magnitude of said liquid pressure and so adjusting the cam on the cam shaft in the axial direction of the cam shaft, said barrels being grouped in pairs

with the barrels constituting each pair located on opposite sides of the cam shaft and arranged to discharge into a common delivery line and the cam being profiled so that the rate of flow of liquid in each delivery line is constant and determined in magnitude by the position of axial adjustment of the cam in relation to the cam shaft.

5. A hydraulic pump comprising a cam shaft, a plurality of barrels grouped around the cam shaft, each barrel having an inlet port and an outlet port at the end thereof remote from the cam shaft, a reciprocating plunger in each barrel arranged to execute therein alternate suction and delivery strokes, a cam mounted to turn with the cam shaft and arranged to impart delivery strokes to the plungers as the cam shaft rotates, springs for returning the plungers to enable them to execute suction strokes, a piston coupled to said cam, a cylinder housing said piston, a spring for urging said piston in one direction in its cylinder, means for subjecting the piston to liquid pressure to balance the spring pressure, and means for varying the magnitude of said liquid pressure and so adjusting the cam axially of the cam shaft, said cam having a circular portion adapted in one position of axial adjustment of the cam to maintain all the plungers in end-of-delivery stroke position and thus adjust the pump for zero delivery, and said cam being effective, when moved axially of the cam shaft and away from said position, progressively to increase the stroke of said plungers.

6. A hydraulic pump as claimed in claim 5, comprising a pump for feeding liquid into the cylinder to exert pressure on the piston in opposition to the spring, an outlet line for leading liquid away from the cylinder, a valve for controlling the effective area of an orifice in the outlet line, and means for adjusting the position of said valve so as to vary the liquid pressure exerted on the piston.

7. A hydraulic pump as claimed in claim 5, comprising an inlet line for supplying fuel under pressure to the pump, a pipe connecting the cylinder to the inlet line so as to supply fluid pressure to the piston, an outlet line for leading fuel away from the cylinder, a valve for controlling the effective area of an orifice in the outlet line and means for adjusting the position of said valve so as to vary the liquid pressure exerted on the piston.

THOMAS SIMPSON.
LEONARD SIDNEY GREENLAND.
THOMAS EDWARDS.

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