July 10, 1951 T. EDWARDS 2,559,952

VARIABLE STROKE PUMP

Filed Nov. 19, 1947 4 Sheets-Sheet 1

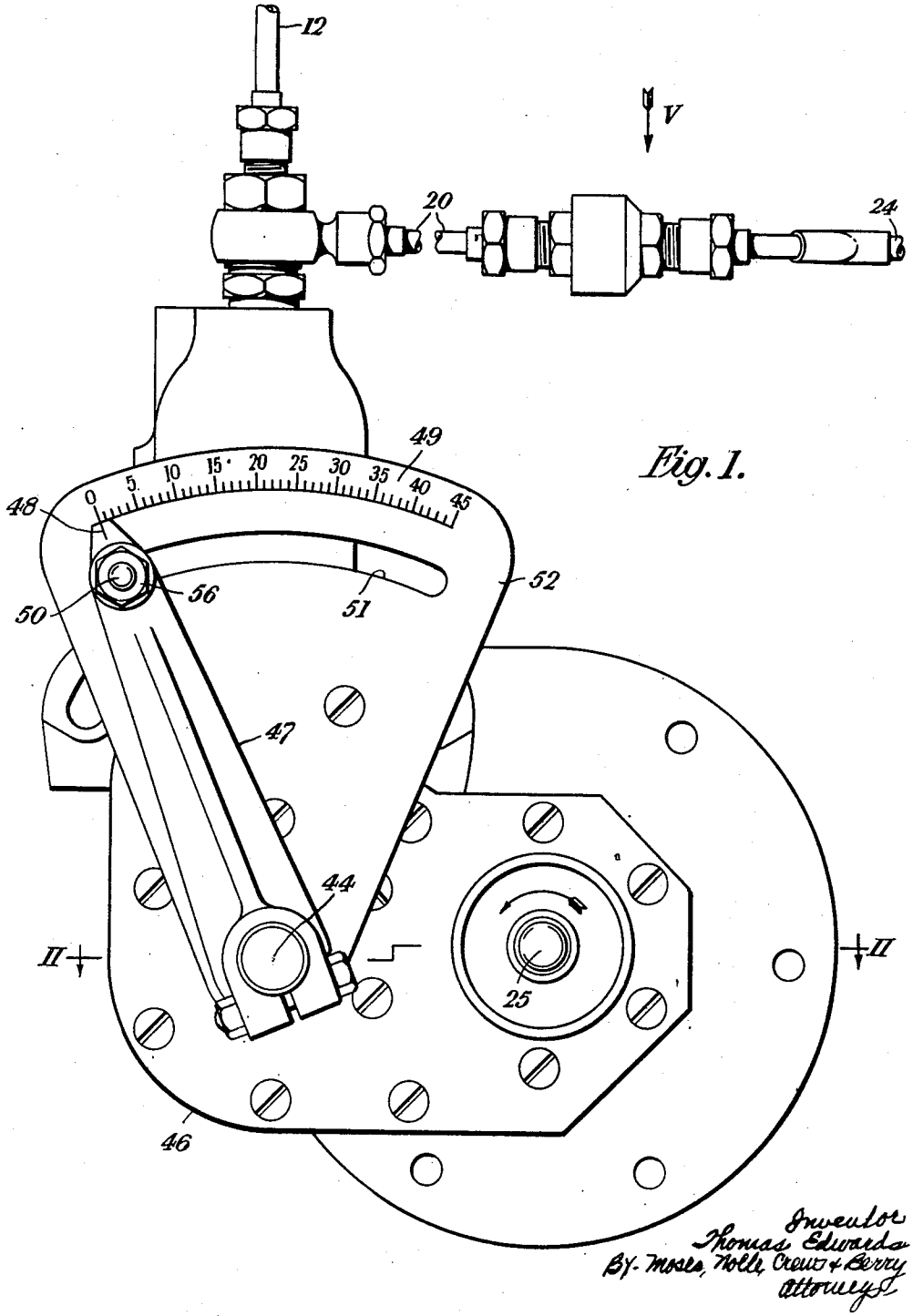


Fig. 1.

Inventor
Thomas Edwards
By- Moses, Rolli, Crews & Berry
Attorneys

July 10, 1951 T. EDWARDS 2,559,952

VARIABLE STROKE PUMP

Filed Nov. 19, 1947 4 Sheets-Sheet 2

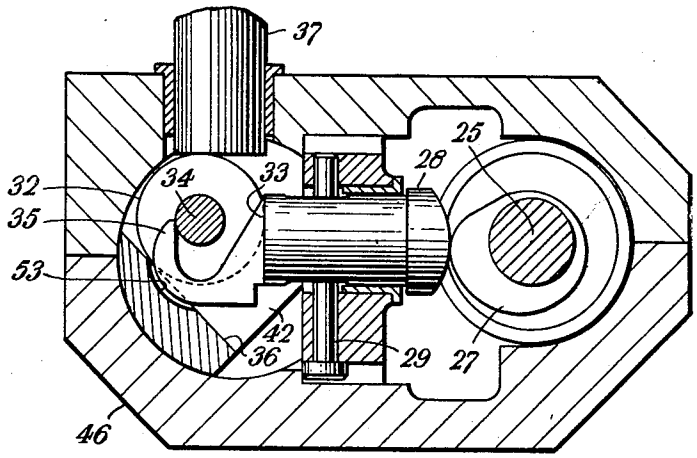


Fig. 4.

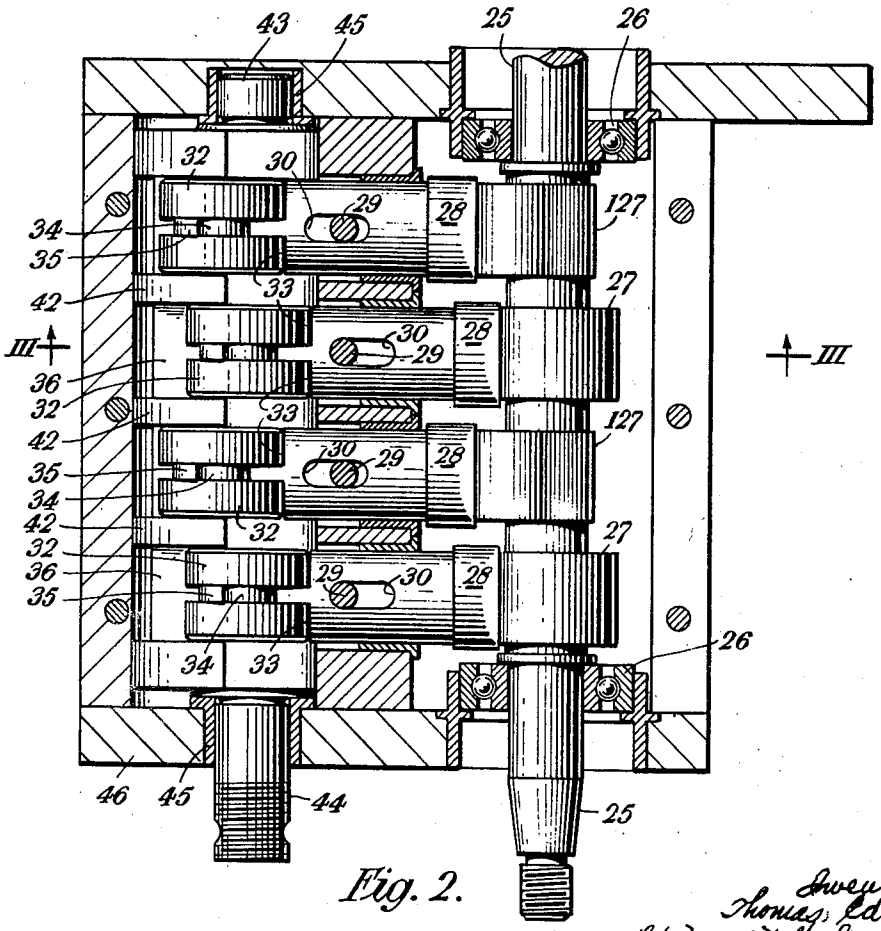


Fig. 2.

Inventor
Thomas Edwards
By- Moses Nolte Owen & Berry
Attorneys

July 10, 1951 T. EDWARDS 2,559,952

VARIABLE STROKE PUMP

Filed Nov. 19, 1947 4 Sheets-Sheet 3

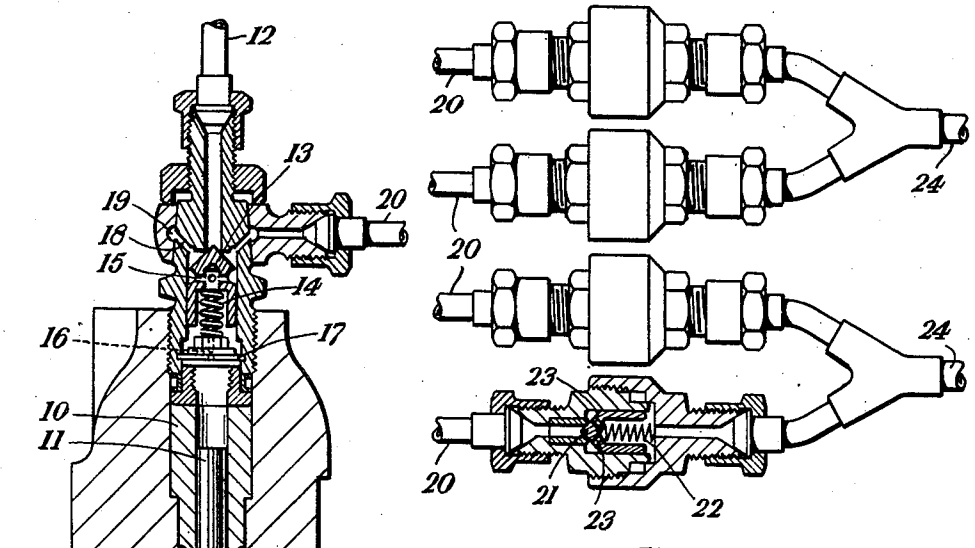


Fig. 5.

Fig. 3.

Inventor
Thomas Edwards
By Moses, Rolle, Cross & Berry
Attorneys

July 10, 1951 T. EDWARDS 2,559,952

VARIABLE STROKE PUMP

Filed Nov. 19, 1947 4 Sheets-Sheet 4

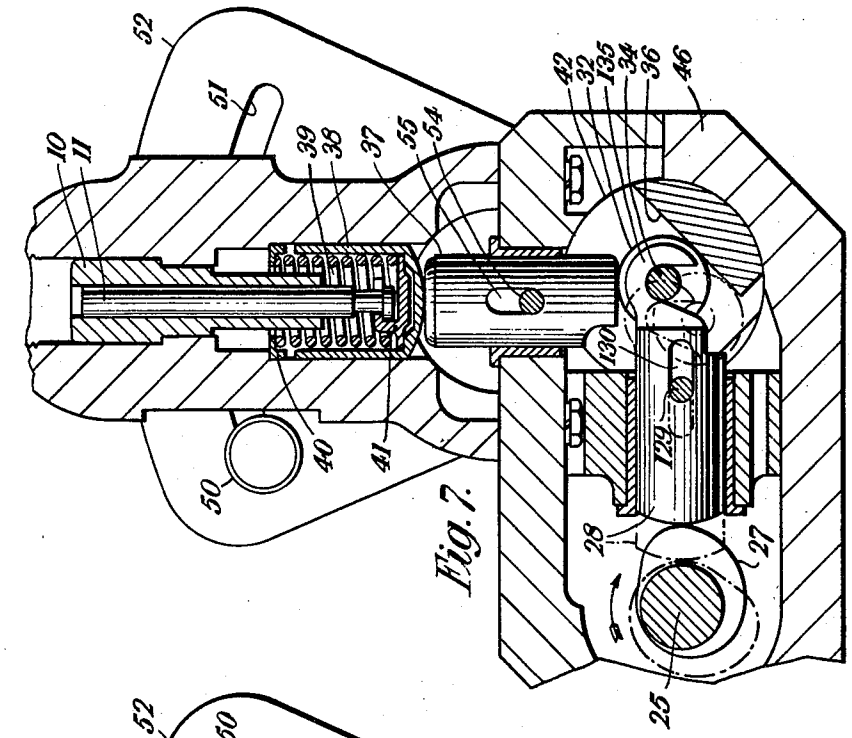


Fig. 7.

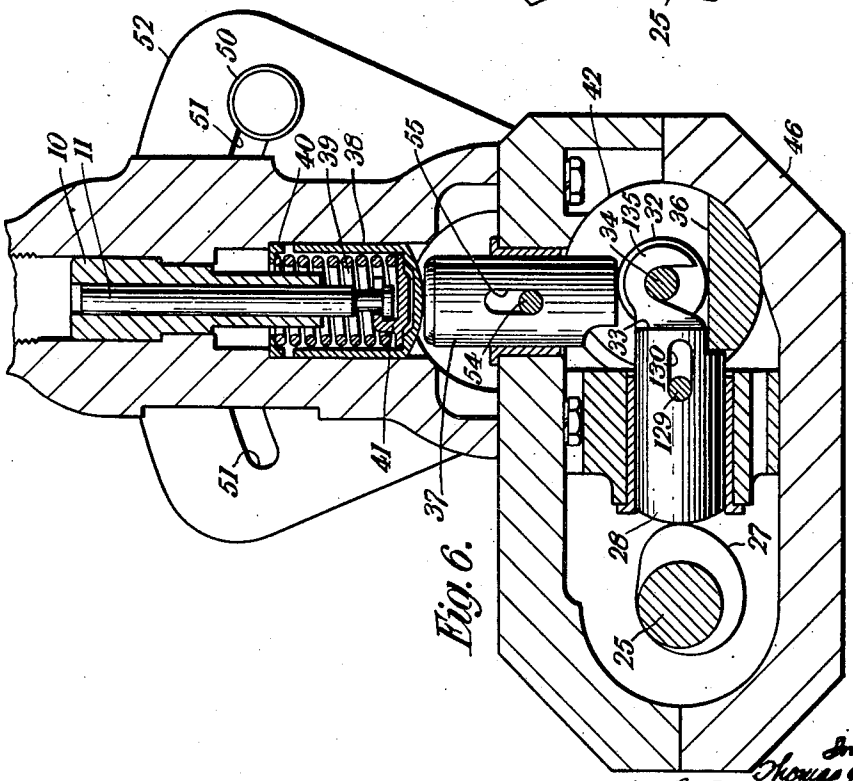


Fig. 6.

Inventor
Thomas Edwards
By Mason, Fenwick, Lawrence & Bennett
Attorneys

Patented July 10, 1951

2,559,952

UNITED STATES PATENT OFFICE

2,559,952

VARIABLE STROKE PUMP

Thomas Edwards, Bilbrook, near Wolverhampton, England, assignor to H. M. Hobson Limited, London, England, a company of Great Britain

Application November 19, 1947, Serial No. 786,946
In Great Britain August 13, 1947

11 Claims. (Cl. 103—38)

1

This invention has for its object to provide a mechanism whereby a driven reciprocating member may be given a variable stroke from a fixed stroke driving reciprocating member.

The mechanism according to the invention comprises, in combination, a fixed stroke driving member mounted to reciprocate in one path, a driven member mounted to reciprocate in a path inclined at an angle to that of the driving member, an inclined plane, a roller or ball operatively associated with the driving member and with the plane so that it will roll along the plane as the driving member reciprocates, said roller being also operatively associated with the driven member so as to reciprocate the same as the level of the roller on the plane changes, and means for varying the angle of inclination of the plane.

When the plane is parallel to the path of the driving member the stroke of the driven member will be zero. As, however, the angle of inclination of the plane to the path of the driving member increases, so will the stroke imparted to the driven member increase. Where the driven member moves in a path at right angles to that of the driving member the ratio of the stroke of the driven member to that of the driving member is equal to the tangent of the angle at which the plane is inclined to the path of movement of the driving member.

The invention is of particular utility for the purpose of varying the delivery of a fuel injection pump for use with gas turbines or other types of internal combustion engines. Normally, in an injection pump of the plunger and barrel type, the plunger is reciprocated by a cam contacting the plunger, directly or through the agency of a tappet, the plunger being returned on the suction stroke by a spring, and variation of delivery is effected by altering the effective stroke of the plunger (e. g. by means of an adjustable spill port) as distinct from its actual stroke.

This method of varying the delivery of the pump is not available, in the case of continuous delivery constant flow pumps of the type comprising two units, delivering into a common delivery line, the plungers of the two units being driven by cams shaped to provide a constant rate of flow in the common delivery pipe at all times in the cycle. If part of the stroke of the plungers were rendered ineffective, constant rate of flow would no longer be obtained. By utilising the present invention, however, interposing a roller and variable angle inclined plane between each cam and its plunger, the actual stroke of each plunger can be varied, thereby altering the delivery of the two unit pump while maintaining a constant rate of flow.

2

Two forms of variable delivery constant flow hydraulic pump according to the invention will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a side elevation of the first form of pump,

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

Fig. 3 is a section on the line III—III in Fig. 2, showing the inclined plane at zero inclination and the pump plunger at the bottom of the stroke,

Fig. 4 is a similar view to Fig. 3, but showing the inclined plane at maximum inclination and one of the rollers in the position it occupies with the associated plunger at the top of its stroke,

Fig. 5 is a view looking in the direction of the arrow V in Fig. 1,

Fig. 6 is a vertical section, similar to Fig. 3 but looking in the opposite direction, showing a modified construction, the plunger being at the top of its stroke and the inclined plane at zero inclination, and

Fig. 7 is a view similar to Fig. 6, showing the plunger at the top of its stroke and the inclined plane at maximum inclination.

Like reference characters designate like parts throughout the figures.

The pump shown in Figs. 1–5 comprises four units, mounted in line, and each comprising a vertical barrel 10, in which is disposed a plunger 11. Fuel is fed under pressure, e. g. at 15 lbs./sq. in., to each barrel through an inlet line 12 (Fig. 3) controlled by an inlet valve 13 which is normally held closed by a spring 14. As, however, the plunger 11 moves downwards in its barrel to execute a suction stroke, the pressure of the fuel in the inlet line 12 causes valve 13 to open, allowing fuel to enter the barrel through holes 15 in the valve and a passage 16 in a member 17 constituting a bottom abutment for the spring 14.

On the upward or delivery stroke of the plunger 11, valve 13 closes and fuel is forced out of the barrel 10 through passage 16, holes 15, passages 18 and an annular groove 19 into an outlet pipe 20. As shown in Fig. 5, each outlet pipe 20 contains an outlet valve 21, normally held closed by a spring 22. On the delivery stroke of the plunger, the associated valve 21 is forced open allowing fuel to pass, through holes 23 in the valve, to a delivery line 24 common to two adjoining pumping units and leading to an injection nozzle.

Reciprocating movement is imparted to the plungers 11, as later described, from a cam shaft 25, mounted in bearings 26 (Fig. 2) in the pump

casing 46 and rotated by a suitable source of power, not shown. Associated with each pair of adjoining pumping units is a pair of cams 27, 127. These cams are so shaped, and positioned in relation to the cam shaft, as to cause the two pumping units of the pair to maintain a constant rate of flow in the associated common delivery line 24.

Associated with each cam is a driving member 28 (Fig. 3) mounted to reciprocate in a path at right angles to the path of movement of the associated plunger 11. A spring 31 in the hollow interior of the driving member 28 holds the same in contact with its associated cam, and the member 28 is guided in its movement by a fixed pin 29 engaging diametrically opposite slots 30 in the member 28.

Associated with each driving member 28 is a roller 32 which abuts at its right hand side against shoulders 33 (see Figs. 2 and 4) on the driving member 28, and has a central waisted portion 34 engaged by a hook-shaped extension 35 of the driving member. As the member 28 is moved to the left, as seen in Figs. 2–4, by its cam, the shoulders 33 will push the roller 32 to the left, while on the return stroke of member 28, the hook 35 will return the roller to the right. The undersurfaces of the rollers 32 rest on an inclined plane 36, and the waisted portions 34 of the rollers are able to rise and fall in the hook shaped extensions 35 of the driving members 28, as shown in Fig. 4, as they roll along the plane 36. The upper surface of each roller 32 contacts with a tappet 37, interposed between the roller and a cap 38 fitted to the lower end of the associated pump plunger 11. A spring 39, mounted in compression between an abutment 40 and a footpiece 41 fitted to the lower end of the plunger 11, maintains the cap 38 in contact with the tappet 37.

The inclined plane 36 is common to the four rollers 32, and is constituted by parts cut from a body 42 (Fig. 2) having trunnions 43, 44 journalled in sleeve bearings 45 in the pump casing 46. To the trunnion 44 is fixed a handle 47 (Fig. 1) by means of which the body 42 may be rotated in the pump casing so as to vary the angle of inclination of the inclined plane 36 to the direction of movement of the driving members 28. As shown in Fig. 1, the handle 47 has an index mark 48 which is movable over a scale 49 on a quadrant 52, the scale bearing graduations which show the angle of inclination of the inclined plane 36 to the horizontal. The handle 47 carries a stud 50 (see also Figs. 6 and 7) which projects through an arcuate slot 51 in the quadrant 52, a nut 56 on a threaded part of the stud 50 serving to hold the handle in adjusted position.

In the position of the handle 47 shown in Fig. 1, the angle of inclination of the inclined plane 36 to the horizontal is zero, as shown in Fig. 3. Consequently no movement is imparted to the plungers 11 by the driving members 28 and the pump delivery is zero. When however the handle 47 is moved from the position shown in Fig. 1, the inclined plane will be set at a positive angle of inclination to the horizontal, and it is shown in Fig. 4 as set at its maximum positive angle of inclination, namely 45°. Then, as an increasing radius of cam 27 comes into play, and driving member 28 moves to the left, the roller 32 will ride up the inclined plane 36, as shown in Fig. 4, to impart a delivery stroke to the plunger 11, the roller 32 riding down the plane 36, when the driving member 28 returns to the right, to enable

the plunger 11 to execute a suction stroke under the action of spring 39. The amplitude of the stroke imparted to each plunger, and consequently the delivery of the pump, will of course be determined by the angle of inclination to the horizontal of plane 36. The inclined plane 36 is formed with a cut-away portion 53 opposite each driving member 28, to accommodate the hook 35 (see Fig. 4) as it moves to the limit of its travel on the delivery stroke of the plunger.

In the construction shown in Figs. 1–4, the rollers 32 are concentric with the trunnions 43, 44 when the plungers 11 are at their lowermost positions in the barrels 10.

As an alternative to providing for variation of the stroke of the plungers from a fixed datum point represented by the lowermost limit of travel of the plungers to their respective barrels, provision may be made, as shown in Figs. 6 and 7, for varying the stroke of the plunger from a fixed datum point represented by the uppermost limit of travel of the plungers. In this case the centre about which the inclined plane 36 rotates is altered so as to be concentric with the roller 32 when the plunger 11 is at the top of its stroke, i. e. when the cam 27 is at maximum radius. When the inclined plane is horizontal, as shown in Fig. 6, rotation of the cam 27 to bring a smaller radius into play will cause the roller 32 to travel horizontally, and the plunger 11 will execute no suction stroke, and the pump delivery will be zero. When, however, the inclined plane 36 is set, as shown in Fig. 7, at a positive angle of inclination to the horizontal, rotation of the cam 27 to bring a smaller radius into play will cause the roller 32 to ride down the inclined plane, as shown in chain-dotted lines in Fig. 7, with the result that the plunger will execute a suction stroke of magnitude determined by the inclination to the horizontal of the plane 36. This is shown in Fig. 7 at the maximum angle of inclination of 45°. As the radius of the cam increases, and the driving member 28 moves to the right as seen in Fig. 7, the plunger 11 will, of course, execute a delivery stroke.

As in the case of Figs. 1–4, the cams associated with each pair of adjacent pumping units are so shaped that whatever the angle of inclination of the plane 36 to the horizontal, the two units will produce a constant rate of flow of fuel in their common delivery line.

The arrangement of Figs. 6 and 7 has the advantage that, at minimum delivery, the pump barrels 10 will be nearly empty of fuel, instead of full as will be the case with the arrangement of Figs. 1–4. Consequently, difficulties, arising from the possibility of cavitation in the fuel due to trapped air, which is particularly harmful under minimum stroke conditions, are eliminated. It differs in detail from that of Figs. 1–4, in that the hooks 135 on the driving members 28 extend downwardly instead of upwardly, no cut-away portions being required in the inclined plane 36 to accommodate them, in that the fixed guide pins 129 engaging slots 130 in the driving members 28 are horizontal instead of vertical, and in that fixed guide pins 54, engaging slots 55 in the tappets 37, are provided for guiding the movements of the tappets.

What I claim as my invention and desire to secure by Letters Patent is:

1. A hydraulic pump, comprising two pumping units aranged in line and each comprising a barrel having an inlet and an outlet, a plunger arranged to execute alternate suction and delivery

strokes in the barrel, a common delivery line to receive the discharge from the outlets of the two barrels, a cam shaft, a pair of cams on the cam shaft, a driving member associated with each cam and arranged to receive reciprocating movement therefrom as the cam shaft rotates in a path at right angles to the direction of movement of the plungers, an inclined plane, and a pair of rollers, one associated with each driving member, arranged to move up and down the inclined plane as the driving members reciprocate, the rollers being associated one with each plunger and being arranged to impart movement to the plungers as they move in relation to the plane, the inclined plane being rotatably mounted so that its angle of inclination to the path of movement of the driving member may be varied, and the cams being shaped so that the plungers will maintain a constant rate of flow of liquid in the common delivery line.

2. The combination of a housing, a fixed stroke driving member mounted to reciprocate in relation to said housing in one path, a variable stroke driven member mounted to reciprocate in relation to said housing in a path inclined at an angle to that of the driving member, a normally stationary member mounted in the housing and having thereon a surface normally inclined to the path of said driving member, a rollable member operatively associated with said driving member and said surface so that it will roll along said surface as said driving member reciprocates, said rollable member bearing against said driven member and serving to reciprocate the same as the level of said rollable member on said surface changes, and means for rotating said normally stationary member in said housing to vary the inclination of said surface to the path of said driving member.

3. The combination of a housing, a fixed stroke driving member mounted to reciprocate in relation to said housing in one path, a variable stroke driven member mounted to reciprocate in relation to said housing in a path at right angles to that of the driving member, a normally stationary member mounted in the housing and having thereon a surface normally inclined to the path of said driving member, a rollable member operatively associated with said driving member and said surface so that it will roll along said surface as said driving member reciprocates, said rollable member bearing against said driven member and serving to reciprocate the same as the level of said rollable member on said surface changes, and means for rotating said normally stationary member in said housing to vary the inclination of said surface to the path of said driving member.

4. The combination of a fixed stroke driving member mounted to reciprocate in one path, a variable stroke driven member mounted to reciprocate in a path inclined at an angle to that of the driving member, a housing, a normally stationary member having thereon a plane surface normally inclined to the path of said driving member, a roller bearing against both the driving member and the driven member and arranged, as the driving member reciprocates, to move to and fro along said plane surface and thereby to impart reciprocating movement to the driven member, and means for rotating said normally stationary member in said housing to vary the angle at which said plane surface is inclined to the path of said driving member.

5. A hydraulic pump comprising a barrel having an inlet and an outlet, a plunger mounted

to reciprocate in the barrel to perform alternate suction and delivery strokes, a cam, a driving member reciprocable by the cam in a path inclined to the path of movement of the plunger, a housing, a normally stationary member having thereon an inclined plane, a roller engaging in a slot in the driving member which extends parallel to the path of movement of the plunger, said roller being arranged to travel up and down the plane as the driving member reciprocates and thereby to impart reciprocating movement to the plunger, and means for rotating said normally stationary member in said housing about an axis transverse to the path of the driving member to vary the angle of inclination of said plane to said path and therefore the stroke imparted to the plunger.

6. A hydraulic pump comprising a barrel having an inlet and an outlet, a plunger mounted to reciprocate in the barrel to perform alternate suction and delivery strokes, a cam, a housing, a driving member reciprocable by the cam in relation to said housing in a path at right angles to the path of movement of the plunger, a normally stationary member in said housing having thereon an inclined plane, a roller contacting the driving member and arranged to travel up and down the plane as the driving member reciprocates and a tappet interposed between the roller and the plunger and serving to reciprocate the plunger as the roller moves up and down the plane, said normally stationary member being rotatable in said housing so as to vary the inclination of said plane to the path of movement of the driving member.

7. A hydraulic pump as claimed in claim 6, in which the roller is formed with a waisted portion and the driving member has a shoulder abutting against the roller and a hook engaging the waisted portion of the roller, said shoulder serving to move the roller in one direction in relation to the plane and said hook serving to move the roller in the other direction in relation to the plane.

8. A hydraulic pump as claimed in claim 5, in which the roller, when the plunger is in position to start its delivery stroke, is coaxial with the axis of rotation of said normally stationary member.

9. A hydraulic pump as claimed in claim 5, in which the roller, when the plunger is in position to start its suction stroke, is coaxial with the axis of rotation of said normally stationary member.

10. A hydraulic pump comprising a pump casing, a barrel having an inlet and an outlet, a plunger mounted to reciprocate in the barrel to perform alternate suction and delivery strokes, a cam, a driving member reciprocable by the cam in the pump casing in a path inclined to the path of movement of the plunger, a stroke-adjusting member, trunnions on the stroke-adjusting member by which said stroke-adjusting member is mounted for rotation in the pump casing about an axis transverse to the path of said driving member, said stroke-adjusting member having thereon a plane surface, a roller engaging in a slot in the driving member which extends parallel to the path of movement of the plunger, said roller being arranged to travel along said plane surface as the driving member reciprocates and thereby to impart reciprocating movement to the plunger, and a lever fixed to one of said trunnions externally of the pump casing, said lever constituting a manual operating member

for rotating said stroke-adjusting member to vary the delivery of said pump.

11. The combination of a housing, a fixed stroke driving member, mounted to reciprocate in the housing in one path, a cam for imparting reciprocating movement to said driving member, a variable stroke driven member mounted to reciprocate in the housing in a path inclined at an angle to that of the driving member, a stroke adjusting member angularly adjustable in said housing and having thereon a surface normally inclined to the path of said driving member, and a rollable member, engaging a slot in said driving member which extends parallel to the path of said driven member, and arranged, as the driving member reciprocates, to roll to and fro along said surface and thereby to impart to the driven member, in all positions of said stroke-adjusting member in which the surface

thereon is inclined to the path of the driven member, reciprocating movement which is continuous throughout the cycle of rotation of the cam and varies in effective stroke in accordance with the angular adjustment of said stroke-adjusting member.

THOMAS EDWARDS.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,771,907	Abramson	July 20, 1930

FOREIGN PATENTS

Number	Country	Date
24,367	Australia	1929