Sept. 20, 1960 M. E. CAILLAUD 2,953,029

KINEMATIC CONTROL SYSTEM, CHIEFLY FOR PUMPS HAVING AN ADJUSTABLE THROUGHPUT

Filed Jan. 14, 1957 2 Sheets-Sheet 1

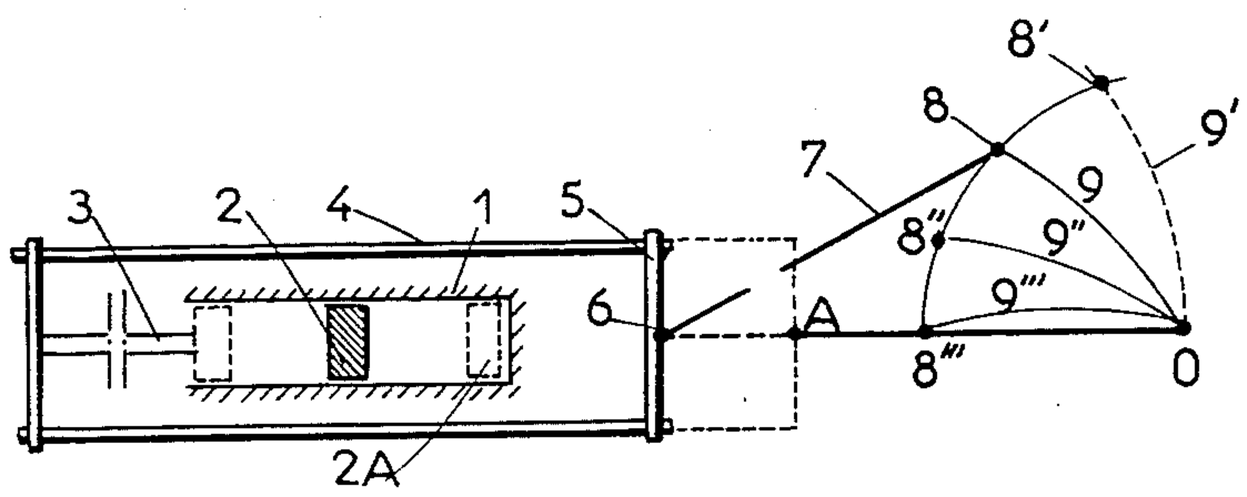


FIG.1

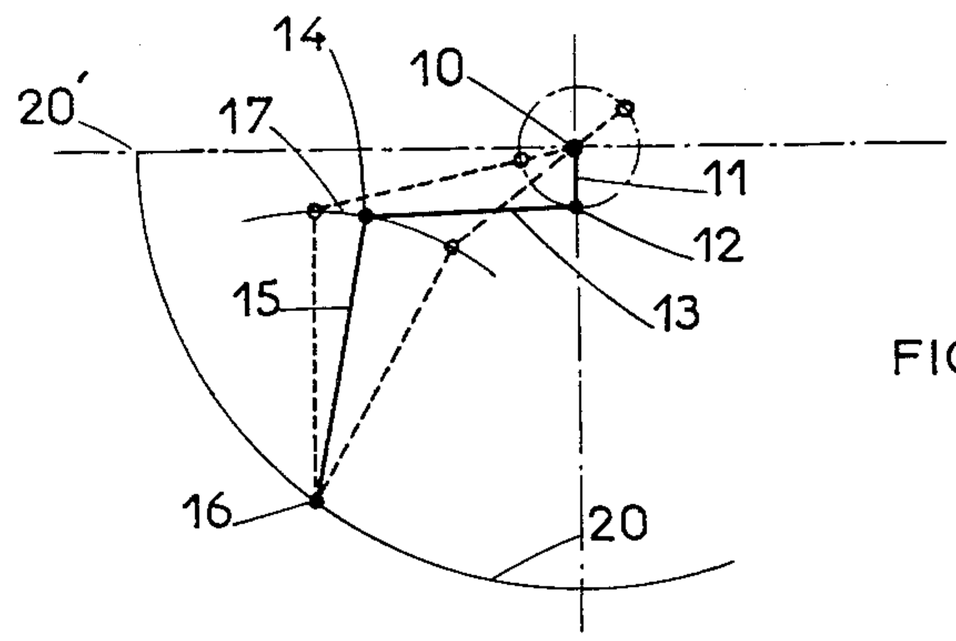


FIG. 2

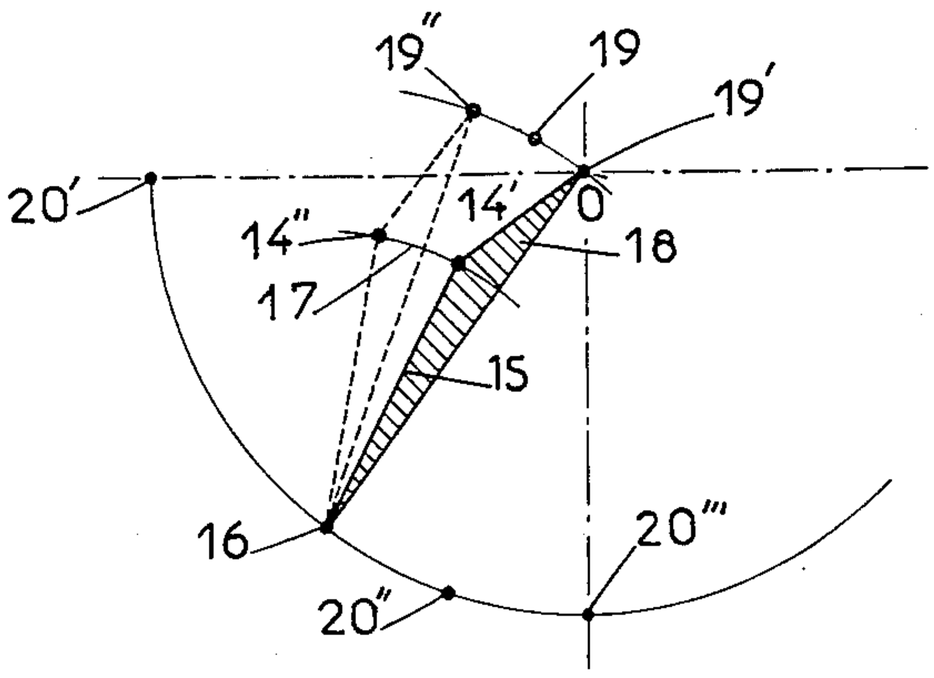


FIG. 3

INVENTOR
Michel Eugène CAILLAUD
BY
Mead, Browne, Schupfer & Beveridge
ATTORNEYS

Sept. 20, 1960 M. E. CAILLAUD 2,953,029

KINEMATIC CONTROL SYSTEM, CHIEFLY FOR PUMPS HAVING AN ADJUSTABLE THROUGHPUT

Filed Jan. 14, 1957 2 Sheets-Sheet 2

FIG. 4

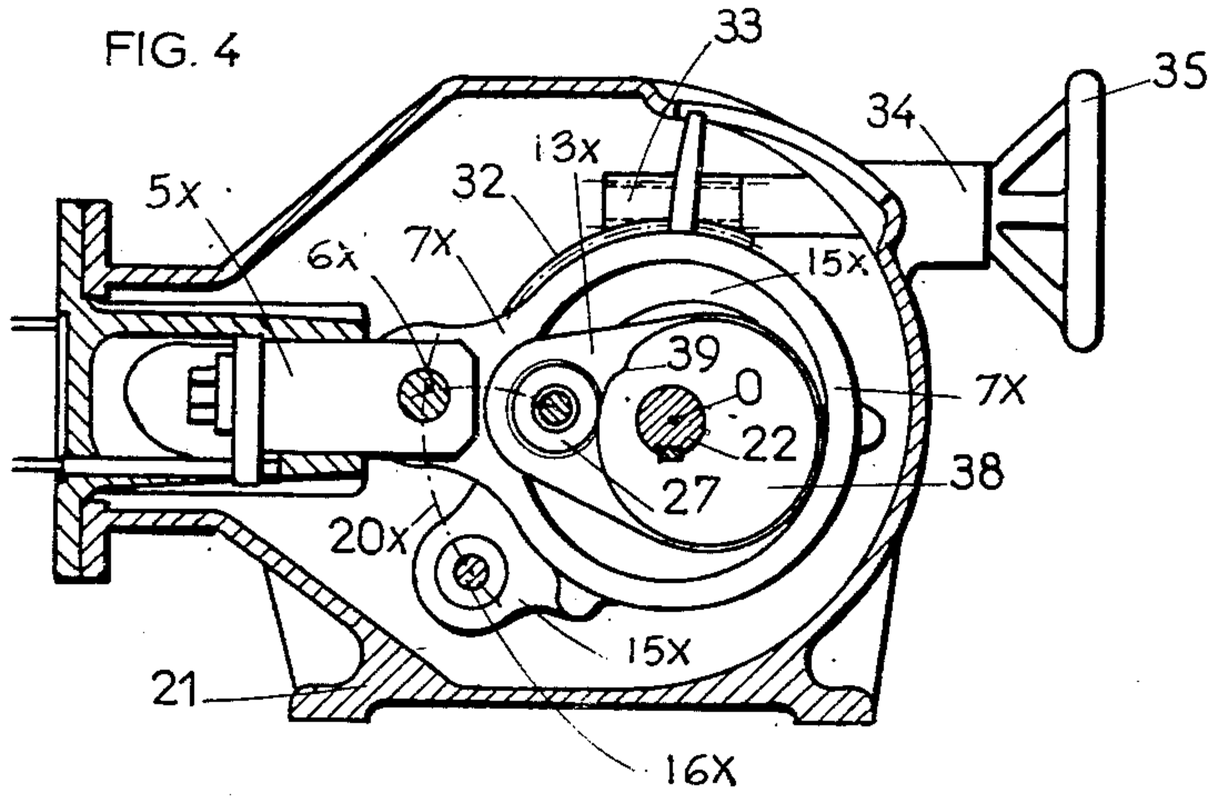
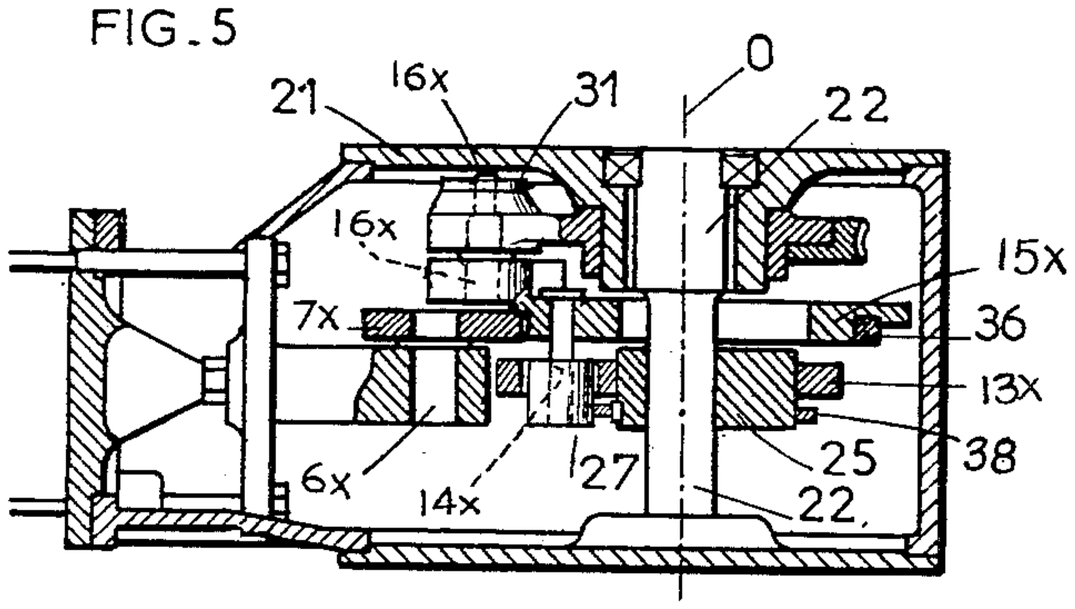


FIG. 5



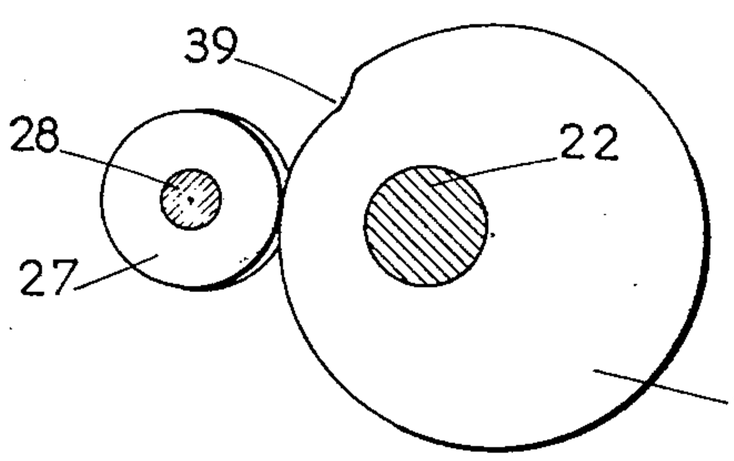


FIG. 6

INVENTOR
Michel Eugène CAILLAUD
BY
Mead, Browne, Schupbach & Beveridge
ATTORNEYS

United States Patent Office

2,953,029

Patented Sept. 20, 1960

2,953,029

KINEMATIC CONTROL SYSTEM, CHIEFLY FOR PUMPS HAVING AN ADJUSTABLE THROUGHPUT

Michel Eugène Caillaud, Suresnes, France, assignor to Societe Anonyme Francaise pour la Separation l'Emulsion et le Melange (Procédés S.E.M.), Paris, France, a French body corporate

Filed Jan. 14, 1957, Ser. No. 634,059

Claims priority, application France Jan. 16, 1956

4 Claims. (Cl. 74—40)

The present invention has for its object a kinematic control system applicable chiefly to measuring pumps of which it is desired to adjust the throughput without modifying the speed of the driving power unit.

Various types of measuring pumps of this kind have been proposed hitherto, chiefly pumps wherein the piston is controlled by a lever system such that it is possible to adjust the length of stroke of the piston and thereby the throughput of the pump. However in such pumps the modification in stroke length is obtained to either side of a medial position so that the dead or idle space of the pump, which is substantially equal to zero when the throughput is at a maximum, increases gradually between said maximum throughput and the minimum throughput, which forms a serious drawback.

My invention has for its object to cut out this drawback and to produce a measuring pump the piston of which is controlled by a lever system in a manner such that whatever may be the length of stroke of the piston, its dead center which corresponds to a minimum volume of the pump body may remain the same, whatever the adjusted length of the stroke may be, so that the dead space consequently retains permanently its minimum value.

The present invention has also for its object to produce an arrangement for controlling the piston, said arrangement producing, when required, a rapid movement of the piston at the beginning of the suction stroke so as to produce if desired an immediate unseating of the valves, which immediate unsealing is particularly advantageous.

These results are obtained in accordance with the invention by controlling the movements of the piston through the agency of a connecting rod pivotally secured to the piston, the movement of the end of the connecting rod further from the piston being along the arc of a circle passing through a stationary point and the radius of which is equal to the length of the connecting rod which length is also equal to the distance between the said stationary point and the pivotal connection between the connecting rod and the piston when said pivotal connection enters its dead point preceding its suction stroke. It is thus sufficient to make said arc of a circle turn through a suitable mechanism between a position for which its center coincides with the above-mentioned dead point and a position extending between the latter and that for which the other end of the arc of a circle is located on the line joining said stationary point with the pivotal connection between the piston and the connecting rod when at its dead point, so that it is possible to adjust the stroke of the piston within a range between zero and a maximum, the location of the dead point of the piston remaining the same whatever may be the length of its stroke.

The displacement along the arc of a circle of the end of the connecting rod may be obtained in various suitable manners and chiefly by means of a four-sided pivotal link system wherein, as well known in the art, one of

the pivots is subjected to a reciprocatory movement along the arc of a circle described around another pivot which is held fast during the movement of the piston. Any point rigid with said pivot will describe consequently an arc of a circle and it is sufficient to select as a pivotal axis for the connecting rod of the piston a point such that the end of this arcuate movement may coincide with the above-mentioned stationary point. It is then sufficient to make the whole four-sided pivoting link system referred to hereinabove rotate so as to obtain the above-mentioned desired adjusting movement.

Furthermore and for obtaining a rapid movement of the piston with a view to unseating the valves, it is sufficient to provide, according to the invention, a certain play in one of the pivotal connections of the system and to make a suitably shaped cam engage during the movement of the piston the corresponding pivotal connection at the desired moment in a manner such that, when said pivotal connection begins moving, this is performed at the desired speed.

Further objects and features of my invention will appear in the following description, reference being made to the accompanying drawings illustrating by way of example a preferred embodiment of the invention. In said drawings:

Figs. 1, 2 and 3 are explanatory diagrams illustrating the operation of the improved arrangement.

Fig. 4 is a view from below of an embodiment of said improved arrangement.

Fig. 5 is a vertical cross-section thereof through line V—V of Fig. 4.

Fig. 6 illustrates a detail on a larger scale.

Turning to Fig. 1, **1** designates a pump body inside which a piston **2** is slidingly movable, said piston being rigid with a piston rod **3** carried in its turn by a frame **4** of which one side **5** is pivotally secured at **6** to the controlling driven connecting rod **7**. The outer end **8** of said connecting rod is constrained under the action of a suitable mechanism to move along the arc of a circle **9** of which one end is shown at said outer end **8** while the other end of said arc is constituted by a stationary point O which may be positioned in alignment with the axis of the cylinder or in the vicinity of said axis. The arc of a circle **9** has a radius equal to the length of the connecting rod **7** between the pivotal axes thereof and when the outer end of the connecting rod enters during its reciprocation the position O, its other end lies at a point A on the axis of the pump cylinder, the position of which is such that the piston **2** lies in immediate proximity with the bottom of the cylinder on its dead point position preceding the suction stroke as illustrated at **2A**, the dead space having a size selected according to requirements and being preferably as small as possible.

It will be assumed that, through the agency of adjusting means, it is possible to make the arc of a circle **9** pivot bodily round the point O between a position **9'** shown in dotted lines for which it has its center at the point A and a position **9''** located between said position **9'** and an extreme theoretical position **9'''** for which the end **8** of said arc of a circle would lie at **8'''** on the line OA registering in the case illustrated with the axis of the cylinder.

As mentioned hereinabove, it will be assumed also that for a predetermined position given to the arc **9**, the end **8** of the connecting rod is adapted to move over said arc of a circle **9** under the action of a suitable power unit, said end reciprocating between the position **8** corresponding to the outer end of the arc and the stationary point O.

Thus, it will be readily ascertained that if the arc of a circle is in a position **9'**, the end **8** of the connecting rod

when moving over said arc of a circle will have its inner end remaining stationary in register with the point A, so that the pistons remains stationary at its dead point 2A and consequently the pump will not feed. In contradistinction, if the arc of a circle is shifted so as to enter the position 9 drawn in solid lines, the end of the connecting rod will move between the point 8 at the outer end of the arc and the point O so that the piston will move between its dead point position 2A for which the connecting rod is at AO and a terminal position forming a second dead point shown by a hatching at 2, said last-mentioned position corresponding to the position of the connecting rod 7 drawn in solid lines for which the outer end of the connecting rod is actually at said point 8. The pump will thus be adapted to operate with a certain throughput. By modifying the position of the outer end 8 of the connecting rod between the points 8′ and 8″, it is consequently possible to adjust the stroke of the piston and thus the throughput of the pump between a zero value corresponding to the location of the arc at 9″ and a maximum corresponding to the position 9″ assumed by the arc.

The movement of the outer end 8 of the connecting rod may be obtained for instance as illustrated in Figs. 2 and 3 which are two explanatory diagrams of a lever system, according to the invention adapted to produce the above described result, said two figures illustrating respectively two elements of the same pivoted link system arranged in two parallel planes at a certain distance from each other so as to make the operation of the system more clearly understandable.

In Fig. 2, 10 designates the axis of the driving shaft of the power unit controlling the pump, said power unit being constituted either by an electric motor or by a suitable engine. Said shaft 10 is rigid with a crank 11 to which is pivotally secured at 12 a driving connecting rod 13 the other end 14 of which is pivotally secured to a second crank 15 pivoting round a spindle 16 which is stationary for any predetermined pumping conditions, the position of the spindle being however adjustably movable over a circle 20 having its center at 10, which circle is the locus of the centers of the arcs 9 in Fig. 1. This provides thus a four-sided pivotal link system as defined by pivot points 10, 12, 14, 16. Two pivotal connections 10 and 16 are stationary and form the terminal ends of a link included as a part of the machine. This link, along with links 11, 13 and 15, form the sides of said link system. The pivotal connection 12 describes a circle of a small diameter round the axis 10. It will be readily ascertained that, under such conditions, the pivotal connection 14 reciprocates over an arc of a circle 17 for each revolution of the end 12 of the crank 11, i.e. for each revolution of the driving shaft 10. For sake of clarity of the drawing, the length of the crank 11 and consequently the diameter of the circle described by the end 12 have been considerably amplified. As a matter of fact, in practice, its diameter is such smaller and the crank 11 may be constituted by a mere eccentric as will be disclosed hereinafter. In all cases, it is apparent that the arc 17 has its center at the pivotal point 16. Turning now to Fig. 3, it is apparent that the crank 15 pivoting round the pivotal point 16 has its end 14 reciprocating over the arc 17 between the limit positions 14′ and 14″.

Considering now a solid mechanical element or link 18 illustrated in hatched lines on the drawing, said mechanical link being rigid with the crank 15, said link 18 will be subjected during the movement of said crank to a reciprocatory angular movement and in particular the point 19 of said link, which is located at 19′ in registry with the axis O when the pivotal connection 14 is at 14″, will move over the arc of a circle 19 between said position 19′ coinciding with the axis O and a further position 19″ over the circle 19 described by said point. This provides thus the possibility of producing the movement of a point on said arc of a circle 19 corresponding

to one of the arcs 9 of Fig. 1. It is then sufficient to make the terminal pivotal point 8 of the driven connecting rod 7 illustrated in Fig. 1 move over said arc 19 and this provides the desired movement. Furthermore and with a view to obtaining the rotation of the arc of a circle 19, so as to adjust the length of stroke of the piston, as explained hereinabove, it is sufficient to shift the point 16 over the arc of a circle 20 between predetermined limits constituted on the one hand by the point 20′ and on the other hand by a point 20″ located in the quadrant 20—20‴.

Reference being now made to Figs. 4 and 5, there will be given a description of a practical embodiment of a mechanical system illustrated diagrammatically in the preceding figures. In Figs. 4 and 5, elements corresponding to certain elements in diagrammatic representations in Figs. 1, 2 and 3 are distinguished therefrom by the letter *"x."*

In said Figures 4 and 5, the whole mechanism is enclosed inside a casing 21 filled with oil and through which passes a control shaft 22 the axis of which forms materially the point O of the preceding figures. 5*x* designates a sliding member rigidly connected with the piston and forming materially the frame 5 of Fig. 1. Said sliding member 5*x* is pivotally secured in its turn at 6*x* round a spindle forming materially the pivotal connection 6 of Fig. 1. To the shaft 22 is keyed on the other hand an eccentric disc 25 the axis of which, which is not shown, forms the pivotal axis 12 of Fig. 2, to which axis is secured a member 13*x* forming the driving connecting rod 13 of Fig. 2. This member 13*x* is pivotally secured, through the ball bearing 27 providing a certain play for a purpose to be disclosed hereinafter, to a spindle 14*x* forming the pivotal connection 14 of Fig. 2 and carried in its turn by a plate 15*x* forming the crank 15 in one with the link 18 of Fig. 2. Said plate is pivotally secured in its turn through an eccentric spindle 16*x* forming the pivotal connecting point 16 to a member 31 adapted to pivot with reference to the frame 21 coaxially with the shaft 22. The periphery of this member 31 carries a worm 32 forming an arcuate rack engaging a worm 33 fitted inside a casing 34 carried by the frame, said worm being controlled from the outside through a handwheel 35. It will thus be readily ascertained that it is possible through action on the handwheel 35 to shift the spindle 16*x* corresponding to the point 16 over the arc of a circle 20*x* and to bring it thus into the desired position of adjustment.

Furthermore there is pivotally secured to the spindle 6*x* a member 7*x* forming the actual driven connecting rod and surrounding the plate 15*x* so that it may pivot with reference to the latter round an axis which is not illustrated and which corresponds to the axis 19 of Fig. 3; in other words, said pivotal axis coincides with the axis O for the dead point position illustrated in Figs. 4 and 5, said pivotal axis moving however along the arc 19 (Fig. 3) when the driving shaft revolves. The operation of said arrangement is thus the same as that described with reference to Figs. 1, 2 and 3.

When the shaft 22 rotates, together with the eccentric member 25, the plate 15*x* rocking round the spindle 16*x* assumes a reciprocation over the arc of a circle having its center on the spindle 16*x*, said reciprocation being imparted thereto by the spindle 14*x* connecting it with the eccentric member; said plate 15*x* carries along with it in its turn the driven connecting rod 7*x* which produces finally through the spindle 6*x* the reciprocation of the member 5*x* rigid with the piston.

As mentioned hereinabove, it may be of advantage in certain cases to give the piston at the beginning of the suction stroke a comparatively sudden movement so as to unseat the suction valve. To this end, the member 13*x* (or connecting rod 13) is fitted with a clearance on the spindle 14*x* through the agency of a ball bearing 27

(Fig. 6) while on the other hand, the shaft **22** carries a cam **38** keyed coaxially to the eccentric member; the major part of the periphery of said cam is circular and coaxial with the eccentric member **25** with the inclusion of a receding section **39**. Said cam is adapted to cooperate with the roller bearing **27**. As long as the roller bearing is in contact with the circular section of the cam periphery, the member **13***x* cannot be shifted with reference to the spindle **28**; when however at the end of the delivery stroke of the pump, the piston reaches its dead point, it is driven positively by the eccentric member up to the position illustrated in Fig. 4, but from this moment onwards the receding section **39** of the cam engages the roller bearing **27** so that the latter leaves a slight clearance between it and the member **13***x*. The eccentric member continuing then its rotation, said spindle **14***x* and consequently the member **13***x* have a tendency to remain stationary at first as a consequence of this clearance.

However, after a short time, the cam acts again on the raceway of the roller bearing and gives the latter and consequently the entire mechanism a movement towards the left hand side (Fig. 4) which corresponds to a comparatively sudden movement of the piston which has for its result an unseating of the valves. Consequently, the mechanism continues its rotation so that the circular portion of the cam periphery engages again the raceway of the ball bearing and the member **13***x* is again driven along without any clearance. It should be remarked furthermore that the movement of the piston which is thus executed during the suction stroke requires only the work which is necessary for overcoming the passive resistances although the active section **39** of the cam operates only with a very reduced stressing.

It is obviously possible to bring various modifications to the arrangement disclosed without unduly widening the scope of the invention defined in the accompanying claims, without any limitation of the invention to the application referred to.

What I claim is:

1. A variable stroke mechanism for piston pumps, comprising a reciprocating piston rod rigid with the pump piston, guiding means forming a rectilinear path along which said piston rod is shifted between an unvarying end position and an adjustable end position, a rotary driving member adapted to revolve around an axis crossing at right angles the line defined by said rectilinear path beyond the unvarying end position of the piston rod on the latter with reference to its adjustable position, a normally stationary pivot, means for adjustably shifting said pivot into any selected position on an arcuate path surrounding coaxially the rotary axis of said rotary driving member and extending between a point aligned with said rectilinear path between the rotary driving member and the unvarying end position of the piston rod and a point lying on a line passing through the rotary axis of the driving member perpendicularly to the rectilinear path, a link pivotally secured to said normally stationary pivot and controlling the piston rod through a point of said link registering with the axis of the control member when the piston rod is in its unvarying end position, a lever system operatively connecting a further point of said link with the driving member and including a radial crank rigidly secured to the rotary driving member and a driving connecting rod pivotally connecting the outer end of the crank with said further point of the link with a clearance between said link and said driving connecting rod, the crank rotating in unison with the rotary member to constrain said driving connecting rod to make the link rock around the normally stationary pivot and thereby reciprocate the piston rod over said path, a cam rigid with the crank and adapted to shift the driving connecting rod into engagement with the link, and to cut out said clearance for all positions assumed by the driving connecting rod outside one of the dead points of its stroke, the shifting of the normally stationary pivot over its arcuate path adjusting the location of the adjustable end position of the piston rod on its path.

2. A variable stroke mechanism comprising a reciprocating member, guiding means forming a rectilinear path along which said reciprocating member is shifted between an unvarying end position and an adjustable end position, a rotary driving member adapted to revolve around an axis crossing at right angles the line defined by said rectilinear path beyond the unvarying end position of the reciprocating member on the latter with reference to its adjustable position, a normally stationary pivot, means for adjustably shifting said pivot into any selected position on an arcuate path surrounding coaxially the rotary axis of said rotary driving member and extending between a point aligned with said rectilinear path between the rotary control member and the unvarying end position of the reciprocating member and a point lying on a line passing through the rotary axis of the rotary driving member perpendicularly to the rectilinear path, a link pivotally secured to said normally stationary pivot and rotary driving the reciprocating member through a point of said link registering with the axis of the control member when the reciprocating member is in its unvarying end position, a lever system operatively connecting a further point of said link with the rotary driving member and including a radial crank rigidly secured to the rotary driving member and a driving connecting rod pivotally connecting the outer end of the crank with said further point of the link, the crank rotating in unison with the rotary driving member to constrain said driving connecting rod to make the link rock around the normally stationary pivot and thereby reciprocate the reciprocating member over said path, the shifting of the normally stationary pivot over its arcuate path adjusting the location of the adjustable end position of the reciprocating member on its path.

3. A variable stroke mechanism comprising a reciprocating member, guiding means forming a rectilinear path along which said reciprocating member is shifted between an unvarying end position and an adjustable end position, a driven connecting rod, the first end of which is pivotally connected to said reciprocating member, a rotary driving member adapted to revolve around an axis crossing at right angles the line defined by said rectilinear path beyond the unvarying end position of the reciprocating member on the latter with reference to its adjustable position, a normally stationary pivot, means for adjustably shifting said pivot into any selected position on an arcuate path surrounding coaxially the rotary axis of said driving member and extending between a point aligned with said rectilinear path between the rotary driving member and the unvarying end position of the reciprocating member and a point lying on a line passing through the rotary axis of the driving member perpendicularly to the rectilinear path, a link pivotally secured to said normally stationary pivot and controlling the second end of the driven connecting rod of the reciprocating member through a point of said link registering with the axis of the driving member when the reciprocating member is in its unvarying end position, a lever system operatively connecting a further point of said link with the rotary driving member and including a radial crank rigidly secured to the rotary member and a driving connecting rod pivotally connecting the outer end of the crank with said further point of the link, the crank rotating in unison with the rotary member to constrain said driving connecting rod to make the link rock around the normally stationary pivot and thereby reciprocate through said driven connecting rod the reciprocating member over said path, the shifting of the normally stationary pivot over its arcuate path adjusting the location of the adjustable end position of the reciprocating member on its path.

4. A variable stroke mechanism comprising a reciprocating member, guiding means forming a rectilinear path along which said reciprocating member is shifted

between an unvarying end position and an adjustable end position, a driven connecting rod, the first end of which is pivotally connected to said reciprocating member, a rotary driving member adapted to revolve around an axis crossing at right angles the line defined by said rectilinear path beyond the unvarying end position of the reciprocating member on the latter with reference to its adjustable position, a normally stationary pivot, means for adjustably shifting said pivot into any selected position on an arcuate path surrounding coaxially the rotary axis of said control member and extending between a point aligned with said rectilinear path between the rotary driving member and the unvarying end position of the reciprocating member and a point lying on a line passing through the rotary axis of the driving member perpendicularly to the recilinear path, a link the length of which is equal to that of the driven connecting rod, pivotally connected to said normally stationary pivot and controlling the second end of the driven connecting rod of the reciprocating member through a point of said link registering with the axis of the driving member when the reciprocating member is in its unvarying end position, a lever system operatively connecting a further point of said link with the control member and including a radial crank

rigidly secured to the rotary member and a driving connecting rod pivotally connecting the outer end of the crank with the said further point of the link, the crank rotating in unison with the rotary member to constrain said driving connecting rod to make the link rock around the normally stationary pivot and thereby reciprocate through said driven connecting rod the reciprocating member over said path, the shifting of the normally stationary pivot over its arcuate path adjusting the location of the adjustable end position of the reciprocating member on its path.

References Cited in the file of this patent

UNITED STATES PATENTS

1,112,832	Pierce	Oct. 6, 1914
2,183,436	Towler	Dec. 12, 1939
2,303,597	Adelson	Dec. 1, 1942
2,548,738	Orlich et al.	Apr. 10, 1951
2,587,395	Sheen	Feb. 26, 1952
2,737,896	Meyer	Mar. 13, 1956

FOREIGN PATENTS

291,295	Switzerland	Sept. 1, 1953
855,890	France	May 22, 1940