March 8, 1960 F. C. PARRY 2,927,432

HYDRAULIC POSITIONING DEVICE

Filed March 18, 1958 3 Sheets-Sheet 1

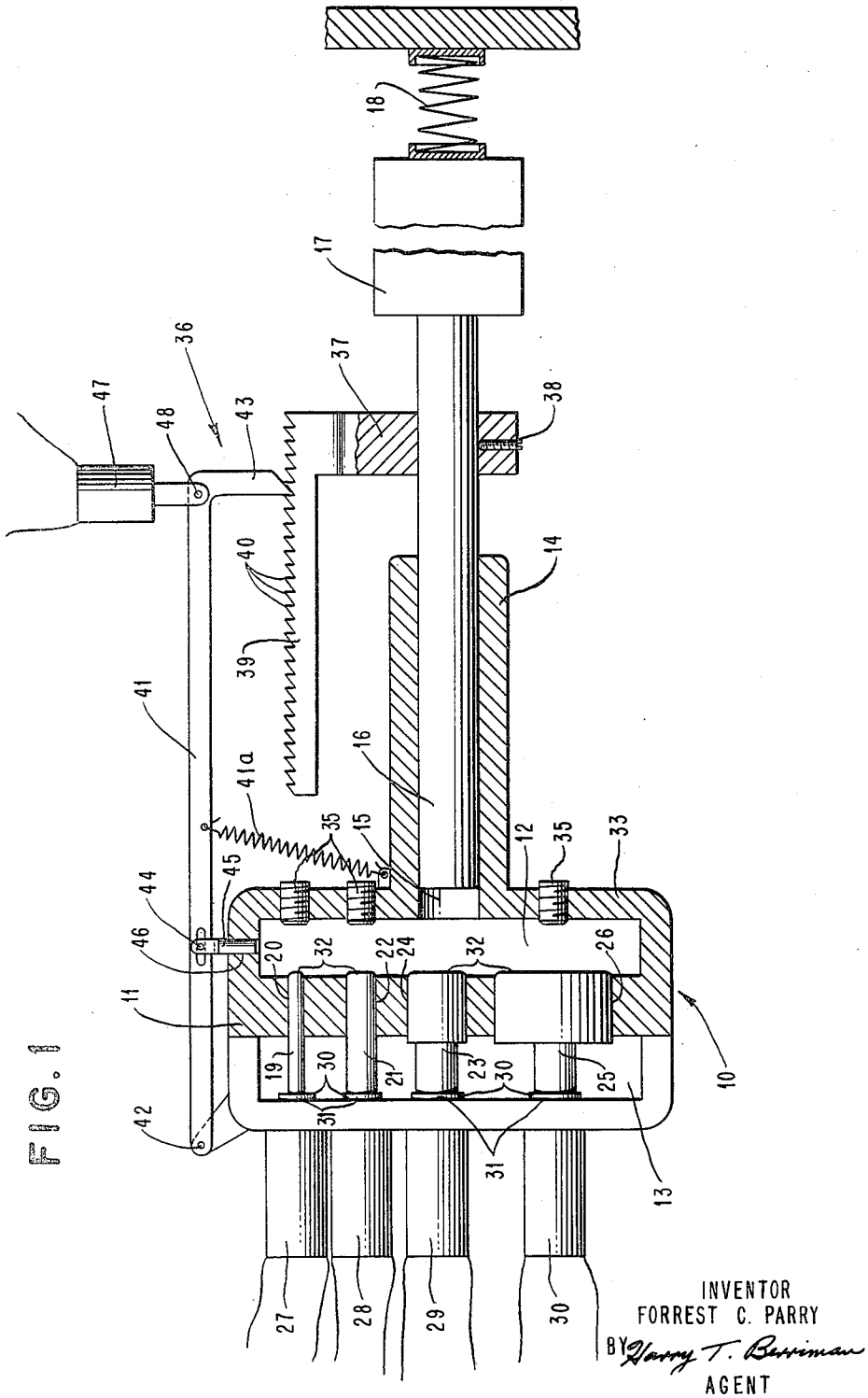

FIG. 1

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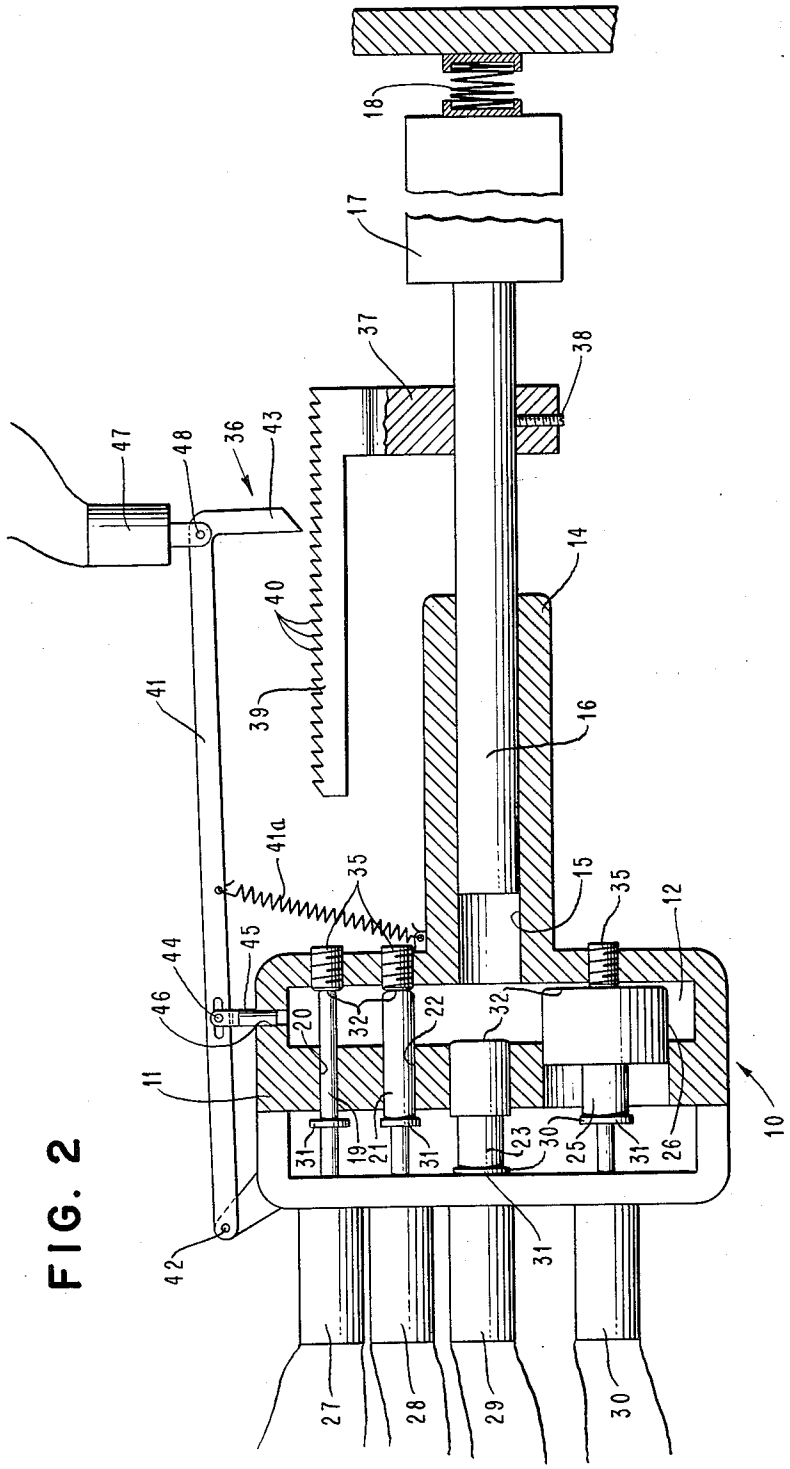

FIG. 2

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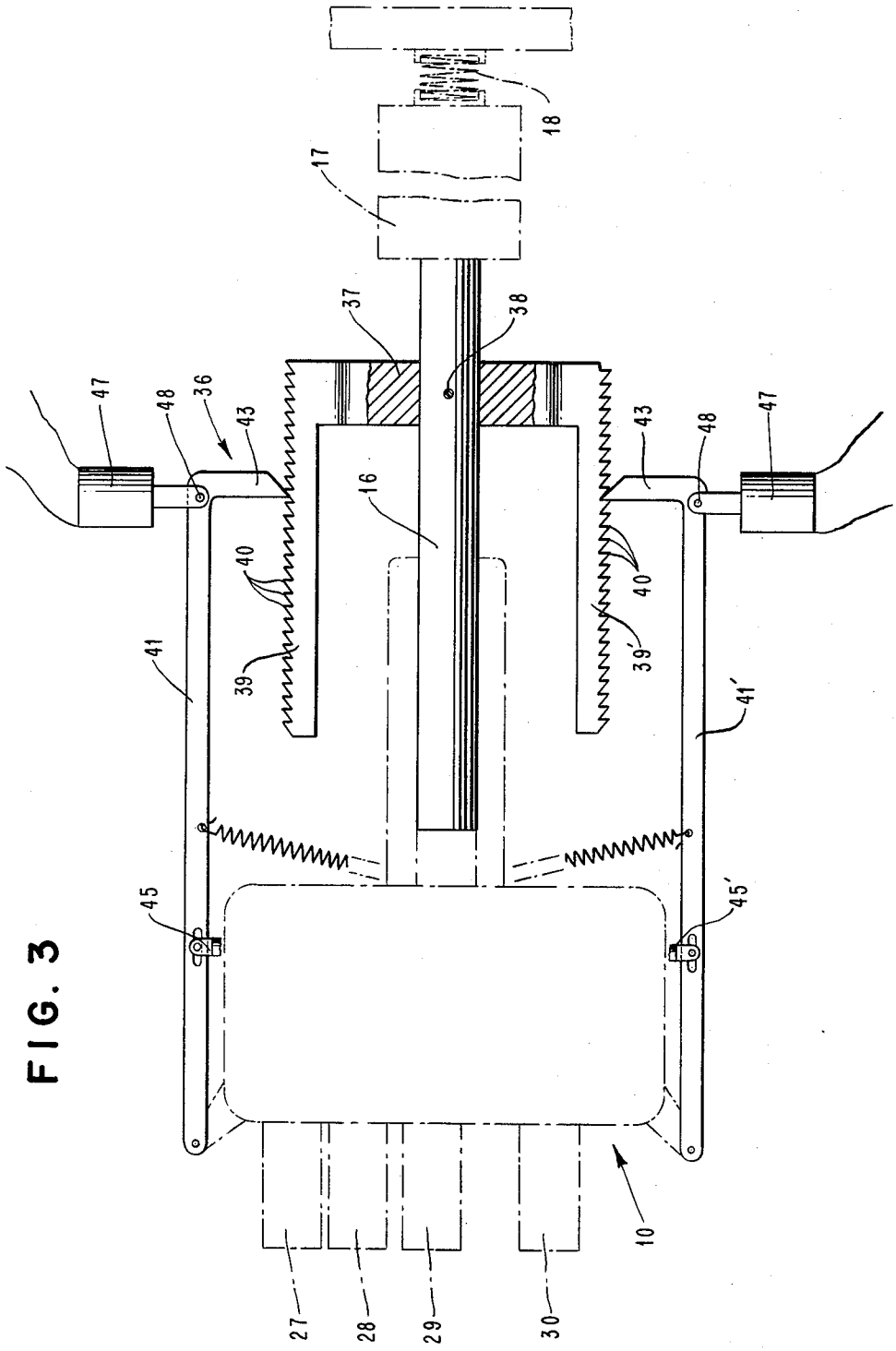

FIG. 3

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HYDRAULIC POSITIONING DEVICE

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8 Claims. (Cl. 60—54.5)

This invention relates to a variable hydraulic positioning device of an improved nature. The practical embodiment of the invention described herein is particularly applicable, for example, for very accurately actuating a hydraulic position and an operatively associated work table, work piece, work carriage or the like, in fixed increments for any predetermined distance.

The improved positioning device comprises a plurality of increment pistons which may be displaced fixed increments within a closed hydraulic chamber by the action of associated controlling solenoids or the like. The increment pistons are selectably operable singly or in combination to provide a variable output movement of a single working piston which is also operatively associated with the hydraulic chamber. In order to insure accurate positioning and to assure that the presence of slight volumes of air or gases in the hydraulic fluid in the hydraulic chamber does not cause an error in the position of the work piston as resulting from the increment piston or pistons actuation, there is provided a unique feedback device. This feedback device may comprise a rack secured to the work piston and as the piston approaches a particular incremental piston, a locking arm or dog is dropped into the rack. This dropping action effects the displacement of a so-called feedback piston into the hydraulic chamber to effect a small further displacement of the work piston into a final accurate position with the dog and a particular tooth of the rack fully engaged. This feedback arrangement insures very accurate positioning of extremely heavy loads with the precise and final positioning of extremely heavy loads with the precise and final positioning being effected through the same hydraulic medium by which the initial or rough positioning is effected. The improved positioning device, achieves rapid positioning into any selectable one of a plurality of possible very accurately defined displacement positions without backlash or hunting, the ability to handle extremely heavy loads, and minimum space requirements by reason of the compact parallel increment piston structure.

It is accordingly one of the objects of the invention to provide an improved hydraulic positioning device.

It is another object of the invention to provide an improved hydraulic positioning device capable of displacing work loads into any selectable one of a plurality of very accurately defined displacement positions.

It is a still further object to provide an improved hydraulic position device wherein a rough positioning of a work piston into any selected one of a plurality of possible displacement positions is effected by the actuation, singly or in combination, of a plurality of controlling incrementing pistons in a hydraulic chamber and wherein a final very accurate positioning is effected by the operation of a feedback piston acting through the main hydraulic chamber to increment the work piston to rigidly engage a pawl in a particular tooth of a rack associated with the work piston.

It is a further object of the invention to provide an improved hydraulic positioning device as in the immediately preceding claim and wherein by effecting the final free incrementing through the main hydraulic means rather than by an external spring source or the like acting against the rack to final position it, extremely heavy work loads associated with the work piston may be accurately and rapidly positioned.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawing, which disclose, by way of example, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a partly sectional diagrammatic elevation of the improved positioning device.

Fig. 2 is the same view as Fig. 1 but shows the position of some of the elements in effecting a representative positioning operation.

Fig. 3 is a partly sectional diagrammatic elevation of an alternate embodiment of the feedback fine positioning and latching apparatus.

Referring now to Fig. 1, the improved positioning device comprises a housing 10 having a separating wall 11 arranged to form a fluid chamber 12 and an increment piston chamber 13. The housing includes a piston sleeve 14 having a bore 15 extending therethrough and into communication with the fluid chamber 12. Reciprocably mounted in the bore 15 is a piston 16 having a work carriage 17 secured to the outer end thereof as indicated. Tensioning means indicated diagrammatically as a spring 18 acts on the right end of the carriage and biases the carriage 17 and in turn the piston 16 toward the left in Fig. 1, the piston accordingly maintaining a suitable hydraulic fluid in the chamber 12 engaged with all of the inner walls thereof.

Four reciprocable increment pistons 19, 21, 23 and 25 are arranged in piston chamber 13 and extend through respective passages 20, 22, 24 and 26 in separating wall 11 of the housing. Each of these increment pistons 19, 21, 23 and 25 has an operative linkage through the housing wall to a respective actuating solenoid 27, 28, 29 and 30 mounted on the external wall 31 of housing 10. Each of the increment pistons is indicated in Fig. 1 in a so-called unactuated position wherein an associated collar 30 engages the inner surface of housing wall 31. Upon an energization of an increment piston solenoid, the associated increment piston moves into the fluid chamber 12 until the corresponding piston head 32 engages the end of an associated adjusting screw 35 carried in the housing wall 33, only the screw 35 for the pistons 19, 21 and 25 being shown in Fig. 1.

As the piston head of an actuated increment piston moves into the fluid chamber, it displaces an equivalent volume of fluid from the chamber 12, this fluid being expressed through the port 15 to effect a displacement of the piston 16 against the work carriage 17 and its associated tensioning means 18. The operational volumes of each of the increment piston heads shown in Fig. 1 differ from each other but are related to each other in a binary fashion. Thus, an actuation of increment piston 21 effects twice the displacement of the work piston as effected by an actuation of the smallest piston 19, an actuation of piston 23 effects four times the displacement of piston 21, while an actuation of pistons 25 effects eight times the displacement of piston 21. The precision tolerances that would ordinarily be required to fabricate pistons to give accurate volume displacements as indicated above, is reduced by the utilization of the individual adjusting screw 35 for each piston, the screw 35 for

piston 23 not being shown in Fig. 1. Each adjusting screw 35 in permitting an adjusting of the stroke of the associated piston, permits, in turn, an accurate adjustment of the fluid volume displacement capabilities thereof.

Each of the increment pistons of the particular embodiment shown in Fig. 1, when actuated, effects a displacement in hundredths of an inch of the work piston 16 and associated carriage 17 as follows:

Piston:	Displacement of carriage 17, inches
19	.050
21	.100
23	.200
25	.400

Through actuation of a plurality of increment pistons, the following displacement values are possible.

Piston:	Displacement of carriage 17, inches
19, 21	.150
19, 23	.250
19, 25	.450
19, 21, 23	.350
19, 21, 25	.550
19, 23, 25	.650
19, 21, 23, 25	.750
21, 23	.300
21, 25	.500
21, 23, 25	.700
23, 25	.600

Thus in a typical operation when it is desired to move the carriage on work piece 17, a specified distance such as .650 inches, solenoids 27, 28 and 30 are all energized moving their related increment pistons 19, 21 and 25 into the fluid chamber 12 as indicated in Fig. 2. The resultant displacement of the hydraulic fluid contained in chamber 12 will, through bore 15, effect a displacement of the piston 16 to the right in Fig. 1 approximately the specified distance.

In order to insure accurate positioning and to assure that the presence of slight volumes of air or gases in the fluid will not cause an error in the positioning of the work piston 16, there is provided associated cooperating feedback and latching apparatus generally designated 36 in Fig. 1. This apparatus comprises an annular collar 37 secured to the piston 16 by a pin 38. A rack 39 having rack teeth 40 is rigidly secured to the collar 37 and extends parallel to and spaced from the piston sleeve 14 as indicated. A latch arm 41 pivotally supported at 42 on the housing has a nose or pawl portion 43 adapted to engage the rack teeth 40 under the urging of a spring 41*a* connected therefrom to the housing.

Pivotally attached at 44 to the latch arm 41 is a piston 45 arranged to reciprocate within a passage 46 extending through the housing 10 and into the fluid chamber 12. The one end of the plunger of a solenoid 47 is pivotally attached at 48 to the latch arm 41. With the solenoid 47 unenergized, the spring 41*a* biases the latch arm 41 clockwise in Fig. 1 so as to engage the nose 43 thereof with the rack as indicated. When an indexing of carriage 17 is desired, the solenoid 47 is first energized to lift the nose 43 of the latch arm clear of the rack 39 as indicated in Fig. 2, as the latch arm 41 pivots to free the latch, the operatively associated piston 45 is shifted outwardly in its respective port 46, the fluid in the chamber 12 following the retreating piston 45. Thereafter, with the energization of the desired one or ones of the increment pistons 19, 21 and 25 as in our representative operation shown in Fig. 2, the piston 16 is displaced correspondingly towards the right to the position indicated, as previously explained. After the displacement of the piston 16 resulting from the operation of the increment pistons has been achieved, the solenoid 47 is de-energized and the latch arm 47 rotates clockwise in Fig. 2 so as to displace the nose 43 of the latch into the plane of the rack 39. As the latch rotates, the associated piston 45 shifts inwardly in the associated port 46 and displaces a small amount of the fluid in the chamber 12, this action displacing the work piston 16, a slight distance towards the right to forcibly engage the flat area of the leading edge of the adjacent tooth 40 of the rack with the nose 43 of the pawl, as indicated in Fig. 1, thus precisely fixing the final displacement position of the piston 16 and work carriage 17. The leading edge of each of the teeth is a planar area which extends substantially transverse to the displacement path of the work piston 16. The area of the pawl nose 43 adapted to engage the tooth leading edge is similarly a planar area. When the leading edge of the tooth and the planar area of the pawl nose are fully engaged, a desired accurate position of the work piston is achieved. The precision of the final positioning piston 16 is, of course, a function of the spacing of the teeth 40 in the rack 39 and may be made to suit the particular application to which the positioning device is applied.

It will be appreciated that as the spring 41*a* rotates the latch arm nose into the place of the rack teeth 40, it is the action of the associated feedback piston 45 which imparts the motion to effect the final precise positioning. The camming action of the nose 43 on the trailing edge of the adjacent rack tooth 39 is of little or no importance in shifting the carriage to its final precise position, since the spring tension 41*a* is insignificant in comparison to the tension of yieldable means 18 and the weight of the carriage 17.

The binary parallel arrangement of the incrementing pistons provides a very compact hydraulic system, while the feedback and latch system permits very heavy loads such as machine tool tables and the like to be very rapidly and precisely positioned. It will be appreciated that the number of incrementing pistons and the binary arrangement thereof is an arbitrary selection and other code systems and numbers of incrementing pistons may be utilized. It will also be appreciated that additional intermediate displacement values can be obtained in the specific embodiment shown in Fig. 1 by proper adjustment of the screws 35 to thereby provide a rapid means of modifying the system for specific requirements. It will also be appreciated that although each of the increment pistons 19, 21, 23 and 25, and also the feedback piston 45, is indicated in Fig. 1 as being operated by associated solenoids, any other type of well known actuating means such as air cylinders, hydraulic pressure, cams, etc. or combinations thereof would suffice equally well. No piston sealing means are shown for the various pistons in the arrangement, however, any well known piston sealing method would be satisfactory.

Referring now to Fig. 3, there is shown an alternate arrangement of latching and effecting the feedback displacement of the working piston 16, when the displacement increments are to be very small. Thus, in Fig. 3, rather than the single rack 39, there is provided a pair of racks 39 and 39′ each secured to the collar 37 as indicated, and each having associated latch arms 41, 41′ controlling solenoids 47 and 47′ and associated feedback pistons 45 and 45′ for cooperation with the fluid chamber 12 as indicated. In the twin feedback and latch arrangement, each of the structures operate simultaneously in a similar manner to the single feedback structure described in reference to Figs. 1 and 2. However, the rack teeth of the two racks are actually offset ½ tooth relative to each as indicated, thus only one of the racks is actually effective in finally arresting the piston 16. Thus in Fig. 3, only the lower rack 40*a* is arresting the work piston for the particular displacement position indicated. By this alternate feedback and latch arrangement it is possible to keep the tooth size of the racks 41 and 41′ reasonable and yet still obtain the desired degree of accuracy for the various incremental positions of the piston.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A positioning mechanism comprising, in combination, a closed hydraulic housing containing a volume of substantially incompressible liquid, a work piston reciprocably arranged in a port in said housing and displaceable in said port a varying distance by a displacement of corresponding volumes of said liquid from said housing into said port, means tensioning said work piston towards a home position wherein said liquid occupies the spaces in said housing and said port, increment piston means operable in said housing for effecting selective displacements of desired volumes of said liquid into said port to effect corresponding selective displacements of said work piston against said tensioning means, a toothed rack means secured to said work piston and displaceable therewith, pawl means reciprocable in a plane substantially transverse to the displacement path of said rack, said pawl being adapted to intercept said rack for each of said selectable displacement position to rigidly engage and define each displacement position selected, means for lifting said pawl means clear of said rack during the operation of said increment piston means, means for subsequently shifting said pawl into the operational plane of said rack, a feedback piston means reciprocably arranged in said housing for action on said liquid, and means operatively linking said pawl and said feedback piston means wherein the shifting of said pawl into the plane of said rack actuates said feedback piston to effect a further displacement of said work piston sufficient to forcibly and rigidly engage said associated rack and said pawl means and achieve the rigidly defined selected displacement position.

2. A positioning mechanism comprising, in combination, a closed hydraulic housing containing a volume of substantially incompressible liquid, a work piston reciprocably mounted in a bore communicating with said housing and displaceable in said bore a varying distance by a displacement of corresponding volumes of said liquid from said housing into said bore, means tensioning said work piston towards a home position wherein said liquid occupies the space in said housing and bore, control piston means operable in said housing for effecting selective displacements of desired volumes of said liquid into said bore to effect corresponding selective displacements of said work piston against said tensioning means, rack means associated with said work piston and displaceable therewith, pawl means engageable with said rack when said associated work piston fully reaches any selected one of said selectable displacement positions to rigidly define said selected displacement position, pawl control means removing said pawl means from the operational plane of said rack means during each operation of said control piston means and then repositioning said pawl means in the plane of said rack means after the operation of said control piston means, and feedback piston means reciprocably arranged in said housing and operationally responsive to said pawl control means, said feedback piston means displacing a volume of said liquid as said pawl is repositioned to further displace said work piston and associated rack means to rigidly engage said rack means and pawl means at the desired selected displacement position.

3. A positioning mechanism comprising, in combination, a hydraulic pump including a work piston displaceable into selected positions through the operation of control piston fluid displacement means acting through an intervening hydraulic medium, a toothed rack means secured to said work piston and displaceable therewith, pawl means shiftable from a first position clear of the operational plane of said rack means to a secured position in the operational plane of said rack means, means shifting said pawl means to said second position during the operation of said control piston means and to said first position after the work piston is displaced in response to said control piston means, feedback piston means reciprocable in said hydraulic medium from a maximum to a minimum fluid displacement position, and means operatively linking said shifting means to said feedback piston means for reciprocating said feedback piston means from the minimum to the maximum fluid displacement position as said pawl shifts from said second to first position, the fluid displacement effected by said feedback piston further displacing said work piston and rack means to rigidly engage said rack means and said pawl and rigidly define said selected displacement position.

4. A positioning mechanism comprising, in combination, a hydraulic pump including a work piston displaceable into rough incremental positions through the operation of control piston fluid displacement means acting through an intervening hydraulic medium, fine positioning increment piston means reciprocably operable in said hydraulic medium to effect a fine positioning of said work piston subsequent to the rough incremental positioning of said work piston, a latching mechanism for positively latching said work piston in the fine position for each said rough incremental positions, said latching mechanism including a first operational member carried with said work piston, and a second operational member reciprocable from a position free of cooperation with said first operational member to a position adapted for cooperation with said first operational member for effecting said latching when said work piston reaches a corresponding fine position, and a common driving means for reciprocating said second operational member and said fine increment piston means in synchronism with said second operational member moving into said cooperating position as said fine increment piston effects said fine incrementing.

5. A hydraulic position mechanism comprising, in combination, a closed hydraulic housing containing a volume of substantially incompressible liquid, a plurality of increment pistons each having a particular diameter, the diameters of the increment pistons being related to each other in correspondence to related elements of a predetermined code, each increment piston being reciprocably supported in an associated port in said housing and adapted to be accurately reciprocated between a first position wherein it displaces a minimum of liquid in said chamber to a second position wherein it displaces a maximum of liquid in said chamber, a work piston reciprocably supported in another port in said housing, means tensioning said work piston towards a home position, means for actuating said incrementing pistons singly or in combination to the maximum fluid displacement positions, to effect through said fluid and the work piston port a corresponding increment or number of increments of displacement of said work piston against said tensioning means, a rack secured to said work piston and displaceable therewith, said rack having a plurality of spaced teeth, a pawl arranged for reciprocation from a position free of the operational plane of said rack to a position into the operational plane of said rack, said pawl when in said rack operational plane being within the range of a particular related one of rack teeth for each possible increment position of said work piston, a feedback piston adapted for reciprocable action on said hydraulic fluid, the maximum fluid displacement action of said feedback piston being such as to effect a displacement of said work piston no more than the spacing between two adjacent teeth of said rack, means re-

ciprocating said pawl clear of said rack prior to an operation of said increment piston or pistons, and into said rack operational plane after the resulting displacement of said work piston is completed, and means for reciprocating said feedback piston into its fluid displacement position as said pawl is displaced into said rack operational plane, said feedback piston action displacing said work piston so as to rigidly engage said particular rack tooth for that particular increment position with said pawl.

6. A positioning mechanism comprising, in combination, a hydraulic pump including a work piston displaceable into selected incremental positions through the operation of control piston fluid displacement means acting through an intervening hydraulic medium, a toothed rack means secured to said work piston and displaceable therewith, a pawl arranged for reciprocation from a position free of the operational plane of said rack to a position in the operational path of said rack, said pawl when in said rack operational plane being within the range of a particular related one of the teeth of said rack for each possible increment position of said work piston, a feedback piston arranged for reciprocable action on said hydraulic medium, the maximum fluid displacement action of said feedback piston being such as to effect a displacement of said work piston no more than the spacing between two adjacent teeth of said rack, means reciprocating said pawl clear of said rack prior to each operation of said control piston fluid displacement means, and into the operational plane of said rack after the resulting displacement of said work piston is completed, and means timed with said pawl reciprocating means for reciprocating said feedback piston to its maximum fluid displacement position as said pawl moves into the operational plane of said rack, said feedback piston effecting a further displacement of said work piston to rigidly engage said particular rack tooth for that particular increment position with said pawl.

7. A positioning mechanism comprising, in combination, a hydraulic pump including a work piston displaceable into rough incremental positions through the operation of control piston fluid displacement means acting through an intervening hydraulic medium, a toothed rack medium carried with said work piston as it is displaced, a pawl mechanism adapted for cooperation with said rack mechanism when said work piston completely reaches a fine incremental position associated with each said rough incremental positions for accurately latching said work piston in said fine position, means for reciprocating said pawl mechanism from a position clear of any possible cooperation with said rack as said work piston is incremented to any one of said rough incremental positions, to a position of possible cooperation with said rack subsequent to said rough incremental positioning, fine increment piston means operable in said hydraulic medium to effect a fine positioning of said work piston, and means synchronizing the operation of said fine increment piston means with the reciprocation of said pawl means into the position of possible cooperation with said rack with said work piston being accordingly finely incremented into the position to be accurately latched by said pawl means.

8. A positioning mechanism comprising, in combination, a hydraulic pump including a work piston displaceable into selected incremental positions through the operation of control piston fluid displacement means acting through an intervening hydraulic medium, a toothed rack means secured to said work piston and displaceable longitudinally therewith, each of the teeth of said rack having a leading edge having a planar face extending substantially transverse to the displacement path of said work piston, a pawl mechanism arranged for reciprocation from a position free of the operational path of said rack with said work piston to a position into the operational path of said rack, said pawl mechanism having a planar face area which extends substantially transverse to the displacement path of said work piston with said pawl when in said rack operational plane being within the range of a particular one of the teeth of said rack for each of said possible incremental positions of said work piston, a feedback piston arranged for reciprocable action on said hydraulic medium, the maximum fluid displacement action of said feedback piston being such as to effect a displacement of said work piston no more than the spacing between two adjacent teeth of said rack, means reciprocating said pawl mechanism to move it clear of said rack prior to each operation of said control piston fluid displacement means, and back into the operational plane of said rack after the resulting displacement of said work piston is completed, and means operatively linked to said pawl reciprocating means for reciprocating said feedback piston in synchronism with said pawl mechanism, with said feedback pawl moving into its maximum fluid displacement position as the pawl moves into the operational plane of said rack, said feedback piston effecting a further displacement of said work piston to rigidly engage in a face to face relationship the said pawl planar face area and the leading edge of the tooth immediately following the particular rack tooth for that particular increment position of the work piston.

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