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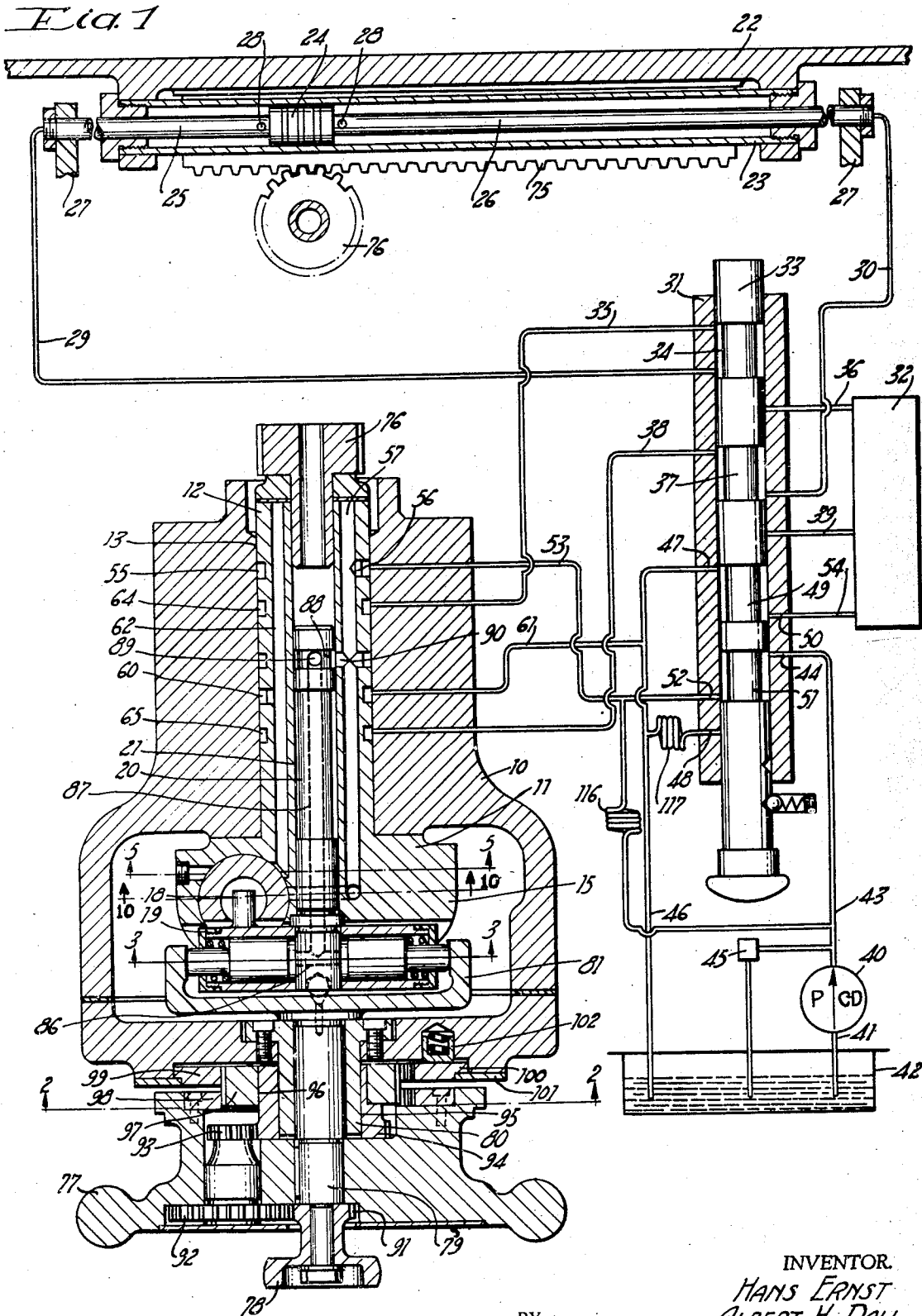
H. ERNST ET AL

2,271,817

MICROMETER MECHANISM

Filed Sept. 9, 1938

3 Sheets-Sheet 1



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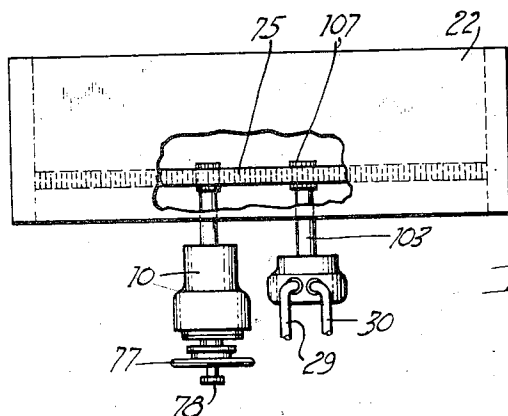
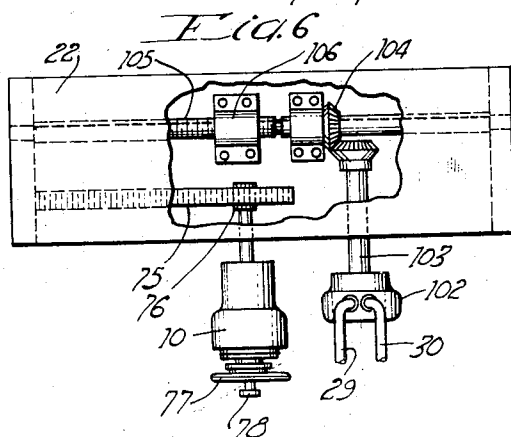
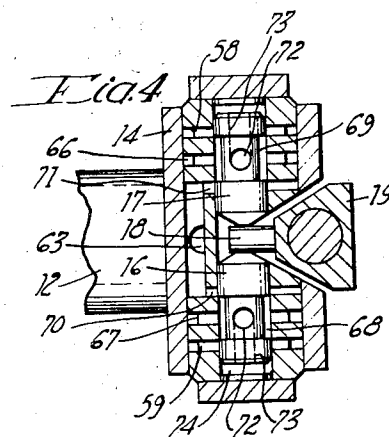
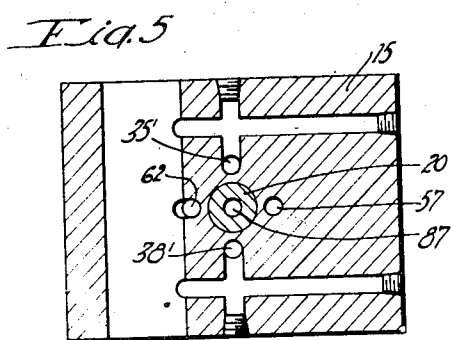
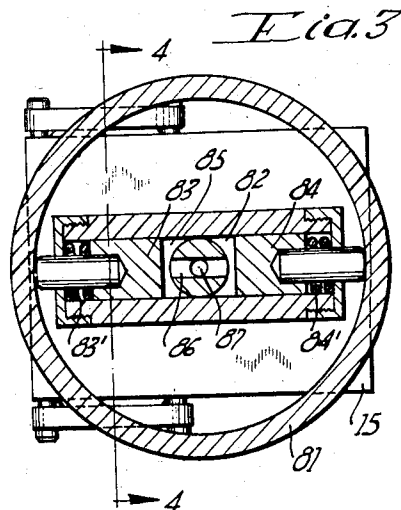
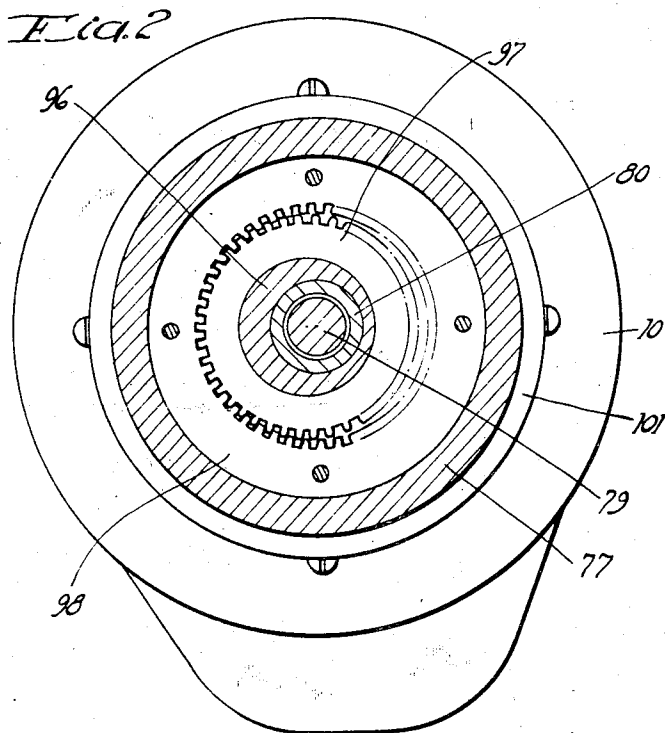
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3 Sheets-Sheet 2



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Fig. 8

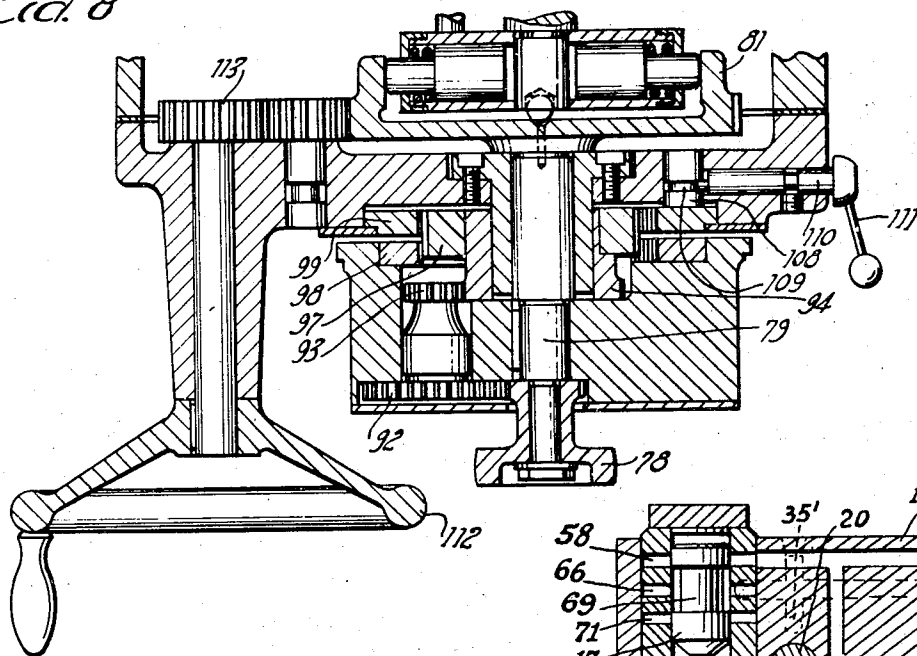


Fig. 10.

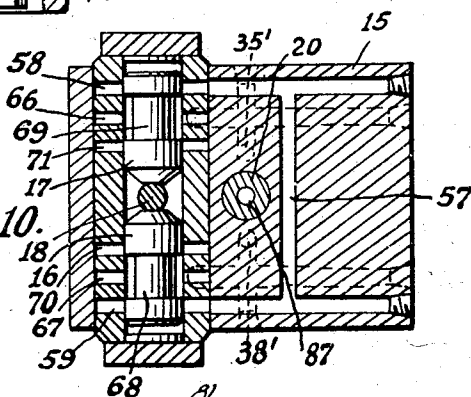
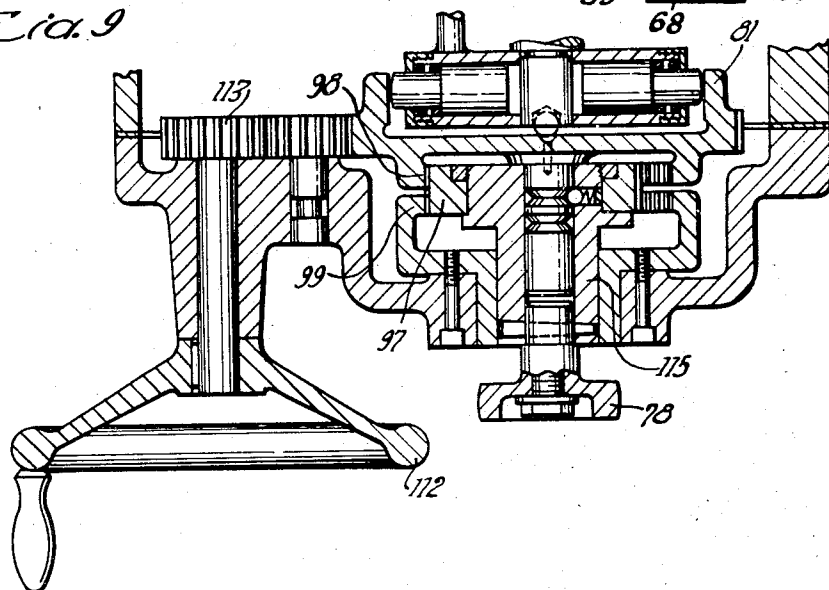


Fig. 9



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UNITED STATES PATENT OFFICE

2,271,817

MICROMETER MECHANISM

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Application September 9, 1938, Serial No. 229,136

15 Claims. (Cl. 121—45)

This invention relates to machine tools and more particularly to improvements in a micrometer mechanism for adjusting a fluid operable slide.

One of the objects of this invention is to provide a micrometrically adjustable servo-valve control for a fluid operable machine tool slide.

Another object of this invention is to provide a micrometer mechanism for a servo-control valve which has coarse and fine adjustment.

A further object of this invention is to provide a micrometer servo-control mechanism for a hydraulic motor which may be selectively connected to the motor at any time for adjustment thereof.

An additional object of this invention is to provide improved retroaction between a moved member and a servo-motor control valve therefor, whereby any lost motion in the mechanical connection between the moved member and the valve is automatically removed before the valve can function.

Other objects and advantages of the present invention should be readily apparent by reference to the following specification considered in conjunction with the accompanying drawings illustrative of one embodiment thereof, but it will be understood that any modifications may be made in the specific structural details within the scope of the appended claims without departing from or exceeding the spirit of the invention.

Referring to the drawings in which like reference numerals indicate like or similar parts:

Figure 1 is a sectional view through the control mechanism constituting this invention, together with a control circuit illustrating one manner of operatively connecting the mechanism for control of a hydraulically actuated slide.

Figure 2 is a section on the line 2—2 of Figure 1.

Figure 3 is a section on the line 3—3 of Figure 1.

Figure 4 is a section on the line 4—4 of Figure 3.

Figure 5 is a section on the line 5—5 of Figure 1.

Figures 6 and 7 are views showing the application of this invention to other forms of machine tool drives.

Figures 8 and 9 are modified forms of the coarse and fine adjusting mechanisms.

Figure 10 is a detail section on the line 10—10 of Figure 1.

In the operation of machine tools having relatively movable slides for feeding a tool in op-

position to a work piece, it is desirable and often necessary that, in addition to the normal power means for effecting the feeding movements, manually operable means be provided for set-up and adjustment purposes. Although this has been done in connection with mechanically operated slides, it is more difficult of accomplishment in connection with fluid operable slides, and this invention deals with a mechanism whereby manual adjustment of a fluid operable slide may be effected with great precision.

Referring to Figure 1 of the drawings, the reference numeral 10 indicates a fixed housing which may be an integral part of the machine frame, or made separately and attached thereto. Within the housing is a rotor 11 having a tubular portion 12 bearing in the bore 13, and an enlarged head 15 in which is mounted a servo-valve. The servo-valve, as shown in Figure 4, has a pair of plungers 16 and 17 which are urged toward one another by hydraulic pressure and into engagement with an operating pin 18. The pin is carried by a radial arm 19 which is integral with a shaft 20 rotatably mounted in the bore 21 of the sleeve 12.

Means are provided whereby this servo-valve may be selectively connected hydraulically to an actuating motor of a machine tool slide, and mechanically connected to an adjusting mechanism which is capable of effecting either coarse or fine adjustment of one part of the valve relative to the other.

In Figure 1, a conventional machine tool slide is indicated by the reference numeral 22, and a hydraulic motor of the piston and cylinder type is provided for translating the same comprising a cylinder 23 which is integral with the slide, and a piston 24, which is connected by oppositely extending piston rods 25 and 26 to a fixed part of the machine indicated by the reference numeral 27. The piston rods may be of the hollow type having cross bores 28 at the piston ends through which fluid may flow either to or from the ends of the cylinder, while axial bores terminating at the fixed ends of the piston rods may be connected by channels 29 and 30 to a selector valve indicated generally by the reference numeral 31. It will now be apparent that if a source of pressure fluid is connected to channel 29, and channel 30 connected to exhaust, that the slide 22 will move toward the left; and if pressure is connected to channel 30, and channel 29 connected to exhaust, that the slide will move toward the right.

The selector valve serves to connect the motor

channels 29 and 30 either to a conventional reversing valve indicated diagrammatically by the reference numeral 32, or to the servo-valve. This is accomplished by providing a plunger 33 with a first annular groove 34, which, in the position shown, will connect the motor channel 29 to the servo-valve controlled channel 35; or, when shifted to its other position, will connect the motor channel 29 to the reversing valve channel 36. The plunger 33 has a second annular groove 37 for connecting the motor channel 30 either to the servo-valve controlled channel 38, or to the reversing valve channel 39.

Fluid pressure for operating the motor is supplied by a pump 40 which has an intake channel 41 through which fluid may be withdrawn from the reservoir 42, and a delivery channel 43 for conducting the fluid under pressure to port 44 of the selector valve. If desired, a by-pass emergency relief valve 45 may be connected to channel 43 for relieving high pressures therein. A return line 46 is connected to ports 47 and 48 of the selector valve. When the plunger 33 is in the position shown, the reservoir port 47 is connected by an annular groove 49 to port 50, and when in the other position, the port 47 is closed while the port 48 is connected by an annular groove 51 to port 52.

It will now be evident that when the plunger 33 is in the position shown, that the pressure port 44 is connected to port 52 whereby the pump delivery will flow through the connected channel 53 to the servo-valve, and that the servo-valve control channels 35 and 38 are connected respectively to the motor channels 29 and 30. This makes it possible for the servo-valve to control the flow of fluid pressure to the hydraulic motor. When the plunger 33 is shifted downward into its other position, the pressure port 44 is connected to port 50 whereby the pump delivery will flow through channel 54 to the reversing valve 32, and channels 36 and 39 leading from this valve are connected respectively to channels 29 and 30. This will place the reversing valve in control of actuation of the slide.

The channel 53 terminates in an annular groove 55 formed in the periphery of the sleeve 12, and this annular groove is connected by a radial port 56 to a longitudinal bore 57 interdrilled in the sleeve 12. This bore is connected by interdrilled passages to ports 58 and 59 of the servo-valve, as shown in Figure 4. The sleeve 12 has an annular groove 60 which is connected by channel 61 to the exhaust line 46. This annular groove is connected by a radial passage to a longitudinal bore 62 terminating in an exhaust port 63 of the servo-valve. The two channels 35 and 38 terminate in annular grooves 64 and 65 in the sleeve 12, and these grooves are interconnected by longitudinal passages 35' and 38', Figure 5, to ports 66 and 67 of the servo-valve. The plungers 16 and 17 of the servo-valve have annular grooves 68 and 69 respectively formed therein, which are of sufficient length to slightly overlap the pressure ports 58 and 59 and the exhaust ports 70 and 71 when in a central position whereby a predetermined and equal pressure will exist in each annular groove. These pressures will be communicated to opposite ends of the cylinder to thereby hold the slide in any predetermined position. Upon movement of the radial arm 19 downward, as viewed in Figure 4, the pressure port 59 will be opened further, thereby allowing a greater flow to one end of the cylinder and the exhaust port 71 will be opened further to

allow a greater flow to reservoir from the other end of the cylinder. When the arm 19 is moved upward, the reverse effect is produced and the slide will be caused to move in the opposite direction.

It will be noted that a diametrical hole 72 is formed in each annular groove which intersects with an axial bore 73. These bores terminate in the opposite ends of the respective plungers. Thus, when the pressure port 59 is opened, the fluid pressure will flow to chamber 74 tending to urge the plunger 16 back to its central position, and this urge is sufficient to provide a counterforce which opposes movement of the servo-valve plungers and thereby tends to prevent the plungers from being moved too fast. This means also acts to automatically centralize the valve plungers.

When the selector valve plunger 33 is in a position to connect the servo-valve for control of the hydraulic motor, movement of the servo-valve plungers 16 and 17 will cause admission of fluid pressure to the motor, and means are provided whereby the subsequent movement of the slide will retroact and control the follow-up movement of the servo-valve housing and stop the flow of fluid pressure to the motor. This retroactive control mechanism consists of a rack bar 75 which is attached to the slide and a pinion 76 which is connected to the end of the rotor 11.

Considering again the centralizing pressure in chamber 74 from another point of view, it will be apparent that, if the member 11 were free to move, this pressure would be sufficient to transmit a turning force to the valve housing, upon actuation of the pin 18. Thus, the two parts of the valve would turn as a unit without relative displacement, and continue to do so until all lost motion between the pinion 76 and rack bar 75 is removed. This insures that all backlash is removed between the actuating pin 18 and the rack 75, before relative displacement is effected in the valve. After the backlash has been removed, the member 11 is restrained against movement, and relative displacement between the valve parts can be effected. The hydraulic connections established are such as to cause movement of the slide and connected rack bar in the same direction that the pinion 76 tended to move the rack in removing the backlash. As the slide and rack move under hydraulic pressure, the rack would tend to move ahead of the pinion, but the hydraulic pressure in the ends of the valve cause the pinion to continuously follow up the rack. Thus, instead of the slide providing the motive power for turning the pinion, as is usual in conventional feed-backs to a servo-valve, the pinion is caused to follow-up the movement of the rack. This provides a method of operation which insures that all backlash is removed before the servo-valve functions, and due to the method of follow-up, greater accuracy in stopping can be obtained.

The mechanism for effecting coarse or fine adjustment of the servo-valve plunger includes a hand wheel 77 for effecting coarse adjustments, and an operating knob 78 for effecting fine adjustments. The hand wheel 77 is keyed to the end of a shaft 79 which is supported for rotation in a bushing 80 mounted in the support 10. This shaft has an annular flange 81 formed on the end thereof. The flange circumscribes the ends of the arm 19 and serves as one part of a friction clutch. The arm 19 has a bore 82 containing plungers 83 and 84 radially movable

into frictional engagement with the interior of the flange 81. Springs 83' and 84' serve to retract the plungers. The space 85 between the inner ends of the plungers 83 and 84 is connected by a diametrical hole 86 in the shaft 20 with a longitudinal bore 87 extending axially of the shaft. The bore 87 is connected to an annular groove 88 formed on one end of the shaft by a cross bore 89. The annular groove 88 is in constant communication with a port 90 formed in the sleeve 12. The port 90 communicates with the longitudinal bore 57 which, it will be remembered, is connected to pressure by the selector valve 31. Therefore, when the servo-valve is connected for control of the hydraulic motor, the bore 57 is continuously under pressure, and this pressure fluid flows through the interconnected channels just mentioned to the space 85 between the ends of plungers 83 and 84 urging the same outward into frictional engagement with the flange 81 whereby whenever the selector valve is moved to a position to connect the servo-valve to the servo-motor, the clutch is engaged to connect the servo-valve plungers to the shaft 79 and thereby to the hand wheel 77. Since the hand wheel 77 is keyed directly to the shaft 79, it will be apparent that when the clutch is engaged, that the hand wheel 77 can effect direct adjustment of the servo-valve and thereby coarse adjustment of the slide.

The mechanism for effecting fine adjustment of the slide includes a pinion 91 which is connected by reduction gearing, comprising a large gear 92 which intermeshes with the pinion 91 and a small gear 93 integral with the gear 92, to a gear 94. The knob 78 is supported for free rotation on the end of shaft 79. Thus, the gearing just described may be rotated independently of the hand wheel 77. The gear 94 has a bore 95 and is supported on the exterior of the bushing 80. The gear 94 has an eccentric hub 96 upon which is fixed a wide-faced pinion 97 intermeshing with a pair of concentric gears 98 and 99. The gear 98 is fixed with the hand wheel 77, while the gear 99 is carried by the support 10, and means are provided for frictionally holding the gear 99 against rotation during operation of the fine adjustment control knob 78.

The gear 99 is provided with an annular shoulder 100 which underlaps a plate 101 secured to the support 10, and spring pressed friction plungers 102 are mounted in the support 10 for urging the gear into frictional engagement with the plate 101 to thereby hold the same against rotation. The gears 98 and 99 have a one-tooth differential whereby, upon rotation of the eccentric gear 97, the gear 98 will be caused to advance one tooth relative to the gear 99 for each revolution of the gear 97. The frictional force developed by the plungers 102 is sufficient to hold the gear 99 against rotation during operation of the fine adjustment knob. When the hand wheel 77 is rotated to effect coarse adjustment, the gear 97 is substantially locked against rotation due to the reduction gearing connections with the pinion 91, and this causes joint rotation of the gears 98 and 99. Thus, either a coarse adjustment or a fine adjustment may be made without any preselecting operations.

In Figure 8 of the drawings a modified form of means is shown for connecting the coarse and fine adjustment members to the flanged member 81. The fine adjustment mechanism operated by the hand wheel 78 is the same as before,

with the exception that a releasable friction locking means for the internal gear 99 is provided. This consists of a slidable friction locking member 108 which has an annular groove 109 in which is fitted the reduced end of a rotatable shaft 110. The reduced portion being eccentric to the axis of the shaft 110, it is possible by rotating the handle 111 to actuate the locking member.

The coarse adjustment hand wheel 112 is connected through spur gear 113 to a gear 114 formed on the periphery of the member 81. When coarse adjustment is to be effected, the friction member 108 is released, thereby relieving the drag of the gear 99 and permitting freer operation. When the fine adjustment member 78 is to be operated, the friction member 108 is clamped to hold the gear 99 against rotation.

Another modified form is shown in Figure 9 in which the coarse adjustment hand wheel 112 is connected to the member 81 in the same manner as shown in Figure 8. In this form the gear 99 is continuously fixed against rotation and the movable internal gear 98 is formed integral with the member 81. The eccentric gear 97 is fixed on a sleeve 115 to the end of which is attached the manually operable control 78 and during operation by the coarse adjustment hand wheel, the sleeve 115 is pulled out to disengage the eccentric gear 97 from the internal gear 98 to thereby permit free actuation of the member 81. For fine adjustment the sleeve 115 is moved inward so that the gear 97 will engage both of the internal gears.

Whenever the servo-valve is disconnected from control of the motor, it is still desirable that the servo-valve plungers 16 and 17 remain in a central position so as to prevent any possible jump of the table when the servo-valve is reconnected, which might happen if the servo-valve plungers were off center at the time of reconnection. A sufficient hydraulic pressure can be maintained for this purpose by connecting a bleeder coil 116 between the pressure line 43 and the channel 53, and a second bleeder coil 117 between the port 48 of the selector valve and the return channel 46. These two bleeder coils act as a hydraulic resistance to flow into channel 53, and the hydraulic resistance to flow out of channel 53, thus making it possible to create an intermediate pressure between the adjacent ends of the hydraulic resistances of any desirable value, depending upon the values selected for the hydraulic resistances. Thus, a sufficient pressure may be established in channel 53 which will be communicated to the servo-valve plungers and maintain them in a central position when the servo-valve is not in use. Attention is invited to the fact that this pressure should not be high enough to overcome the resistance of springs 83' and 84' of the hydraulically operated clutch.

Although the invention has been described in connection with a fluid operable slide having a piston and cylinder type of actuator, the invention is equally applicable to other types of hydraulic actuators. For instance, as shown in Figure 6, the channels 29 and 30 could be connected to a rotary motor 102 having an output shaft 103 which is connected by bevel gearing 104 to a splined screw 105. The lead screw may be supported for rotation in opposite ends of the slide 22 and threaded in a fixed nut 106 whereby upon rotation of the motor, the slide will be traversed. This traversing movement may be

fed back to the servo-valve through rack 75 and pinion 76 in the manner previously described.

A simplified form of construction is shown in Figure 7 in which the output shaft 103 is connected directly to the rack 75 by means of a pinion 107 attached to the shaft 103. It will be understood that, if necessary, suitable well-known conventional backlash eliminating means may be provided to take up any slack that may exist in these drives.

There has thus been provided an improved and accurate micrometer adjusting mechanism for a fluid operable slide of a precision machine tool.

What is claimed is:

1. In a machine tool having a support and a slide movable relative to said support, the combination of a servo-motor having one part fixed and the other part operatively connected to said slide, a servo-control valve for said motor having one part operatively connected for actuation by said slide, an actuator for the other part of said valve, a fluid operable clutch for connecting said actuator to said other part, a source of fluid pressure, and means for connecting said fluid pressure to said valve and to said clutch.
2. In a machine tool having a translatable slide, the combination of means for effecting translation of said slide comprising a servo-motor mechanism operatively coupled with the slide, and including a control valve having a part connected to the slide to cause a follow-up action, a second manually actuatable part, an actuator for the second part of the valve, a hydraulic clutch for connecting said actuator to said valve, a source of fluid pressure, and manually operable means for connecting said source to said valve and simultaneously connecting said source to effect engagement of said clutch.
3. In a machine tool having a translatable slide, the combination of means for effecting translation of said slide, including a piston and cylinder, one of which is operatively connected to the slide, a source of fluid pressure, a valve having relatively movable parts, one of which is connected for movement by said slide, an actuator for the other part, a fluid operable clutch for connecting said actuator to said other part, a second control valve for said translating means, and a selector valve having a first position for connecting said source of pressure to one of said valves, and a second position for connecting said source of pressure to the other valve, said servo-valve having means therein for causing actuation of said hydraulic clutch when pressure is connected thereto.
4. In a machine tool having a translatable slide and a fluid operable motor for effecting translation of said slide, the combination of means for controlling actuation of said motor, including a source of fluid pressure, a reversing valve for coupling said source of pressure for opposite actuation of said motor, a servo-valve having one part operatively connected to said slide, a micrometer adjusting mechanism, a clutch for connecting said mechanism to another part of the servo-valve, means to disconnect the motor from said reversing valve and connect it to said servo-valve and simultaneously to disconnect said source of pressure from said reversing valve and connect it to said servo-valve, and means to utilize the pressure supplied to the servo-valve to effect engagement of said clutch.
5. In a machine tool having a translatable slide, the combination of means for effecting minute adjustments of said slide, including a

servo-motor having one part operatively connected to said slide and the other part fixed, a servo-valve having relatively movable parts, one of which is connected to said slide, and a micrometer adjusting mechanism connected to the other part of said valve, including a shaft, clutch means for connecting the shaft to said other part, a manual actuator, and a one-tooth differential mechanism connecting said actuator to said shaft.

6. In a control mechanism for an actuated part, the combination of a hydraulic servo-motor operatively connected to said part, a servo control valve for said motor including a tubular housing having a pair of spaced ports hydraulically connectible to said motor, independent plungers for controlling the connection of said ports to pressure or exhaust, a servo-valve actuator having a portion interposed between the adjacent ends of said plungers, fluid pressure operable means continuously urging said plungers into contact with said portion, and means operable upon movement of said plungers in a given direction to increase the pressure opposing movement in that direction and thus hamper fast movement of the valve.

7. In a servo control mechanism, the combination with a hydraulic motor having a movable member of a servo control valve therefor, including relatively movable parts, one of which is operatively connected to the movable member of said motor, the other of said movable parts being composed of two sections, an actuator interposed between said sections, fluid pressure means holding said sections in engagement with said actuator, a manually operable mechanism for effecting movement of said actuator to cause operation of the motor, said fluid pressure means acting to centralize said sections to stop operation of said motor and prevent subsequent inadvertent movement thereof.

8. In a machine tool having a slide and a fluid operable motor for actuating said slide, the combination of means for controlling actuation of said motor, including a source of pressure, a reversing valve for reversibly connecting said source of pressure to the motor, a rotor permanently connected with the slide for actuation thereby, a servo control valve mounted in said rotor, said servo-valve having relatively movable parts for controlling flow to said motor, an actuator for effecting said relative movement, means to transfer the source of pressure connection from said reversing valve to said servo-valve, and means in the servo-valve responsive to fluid pressure being connected thereto to centralize said relatively movable parts of said servo-valve whereby said servo-valve is conditioned for control of said motor.

9. In a servo-motor control mechanism for a machine tool slide, the combination with a hydraulic motor operatively connected for moving the slide in opposite directions, of a control valve having relatively movable parts for determining the quantity and direction of fluid flow to said motor, a follow-up connection from one of said parts to the slide, an independent control member for moving the other of said parts, hydraulic means potentially effective for preventing relative movement between said parts whereby upon actuation of said independent control the parts will move as a unit until any lost motion in said follow-up connection is removed, and a source of pressure connected to said control valve for

delivery to said motor upon subsequent relative movement between said parts.

10. In a servo-motor control mechanism for a machine tool slide, the combination of a hydraulic motor operatively connected for movement of the slide, a servo-control valve having relatively movable valve parts, means for opposing relative movement between said valve parts from a normally closed position, a manually operable control for effecting relative movement between said valve parts to connect a source of pressure to said motor, retractable means responsive to actuation of the motor for determining the movement of the other valve part and thereby the extent of movement of the slide and an auxiliary hydraulic motor controlled by movement of one of said valve parts for maintaining the other valve part in engagement with said retractable means.

11. In a control mechanism for a movable slide of a machine tool, the combination with an hydraulic motor connected to the slide, of a source of hydraulic pressure, a reversing valve, a servo-control valve, a selector valve for operatively connecting either one of the first two named valves in serial relation between the source of pressure and said motor, a micrometer adjusting mechanism for the servo-valve including coarse and fine adjustment controls, and means for automatically connecting the mechanism to the servo-valve upon connection of hydraulic pressure thereto.

12. In a mechanism of the character described, the combination with a reversible hydraulic motor and a source of pressure, of means intervening said parts for determining the direction and extent of actuation of the motor, including a casing having a valve chamber, a pair of oppositely disposed valves in the chamber respectively oppositely shiftable for determination of directional coupling of the source of pressure with the motor, said valves having piston portions reactable to shift the valves into closed position, means for effecting displacement of the valves, means for connecting pressure with the piston portions of the valves when displaced into pressure coupling position whereby the coupled pressure will react against the valve shifting means to move the valve into closed position on release of said shifting means, means mounting the valve chamber for movement in the general direction of movement of the actuator for the valves, and a feed back connection from the motor to the valve chamber unit progressively limiting the extent of movement thereof.

13. The combination with a hydraulic motor

and a source of actuating pressure therefor, of a servo-type mechanism for accurate determination of the extent of actuation of the motor including a member coupled with the motor for operation in synchronism therewith, a valve casing carried by and shiftable with the member, means coupling the pressure source with said casing, conduits coupling the motor with said casing, a valve member disposed in the casing for selective determination of the coupling of the pressure source to the motor conduits, said valve members including a piston portion and a reduced portion providing a pressure coupling cannellure, and means effective when the cannellure is in pressure coupling position to connect said pressure with the piston portion of the valve whereby said pressure reacts on the valve urging the same into closed position.

14. The combination with a movable slide of a machine tool, of means for controlling the movement thereof including a hydraulic motor connected to the slide, a rack movable with the slide, a pinion meshing with the rack, a servo-valve mechanism including a first shiftable member and a follow-up mechanism including a second member movable relative to the shiftable member and including the pinion, and means controlled by the shiftable member for effecting hydraulic actuation of the pinion and slide motor in a common direction, whereby the effect of backlash between the rack and pinion in the effective controlled direction is eliminated.

15. The combination with a movable slide of a machine tool, of means for controlling the movement thereof including a rack movable with the slide, a pinion meshing with the rack, a servo-valve mechanism including a first shiftable member and a follow-up mechanism including a second member movable relative to the shiftable member and including the pinion, means controlled by the shiftable member for effecting hydraulic actuation of the pinion and slide in a common direction, said means including separate hydraulic motors hydraulically coupled in parallel, means mechanically coupling one of said motors with the slide for actuation thereof, and additional means mechanically coupling the other of said motors with the pinion for actuation of the pinion, whereby the effect of backlash between the rack and pinion in the effective controlled direction is eliminated.

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