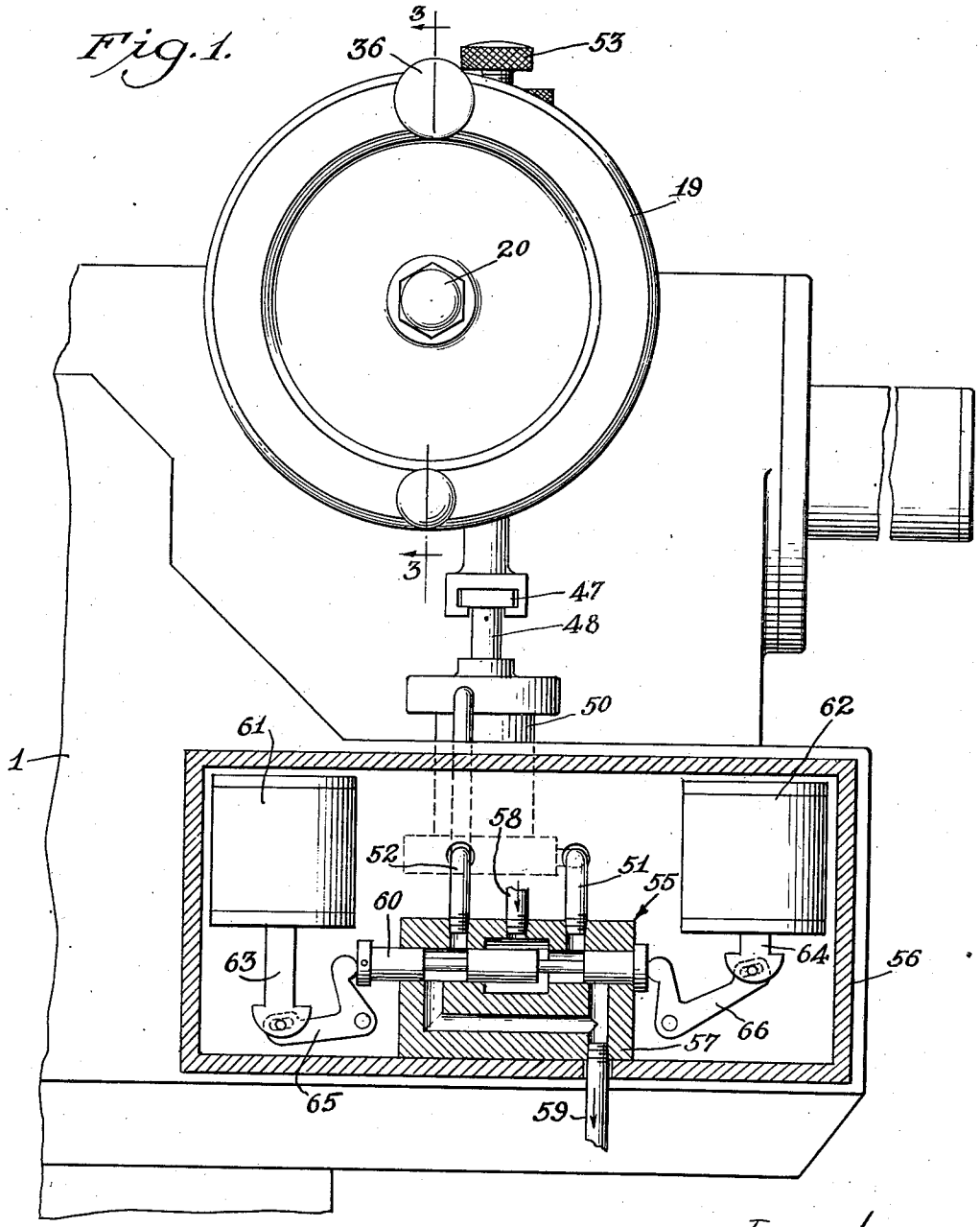
Sept. 29, 1942. G. BRINKMANN 2,297,047

BACKLASH COMPENSATOR

Filed March 3, 1941 3 Sheets-Sheet 1

Fig. 1.



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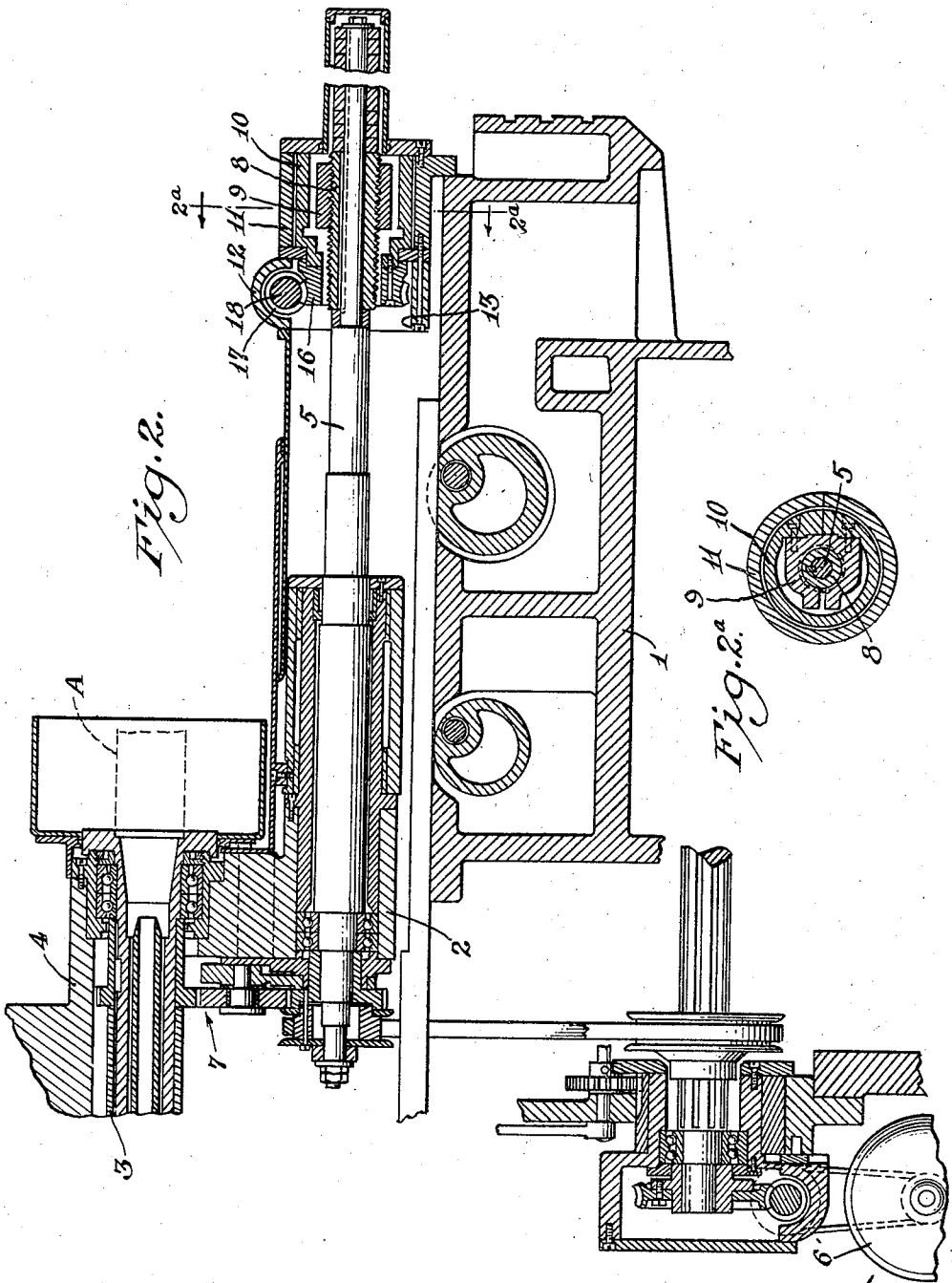


Fig. 2.

Fig. 2a.

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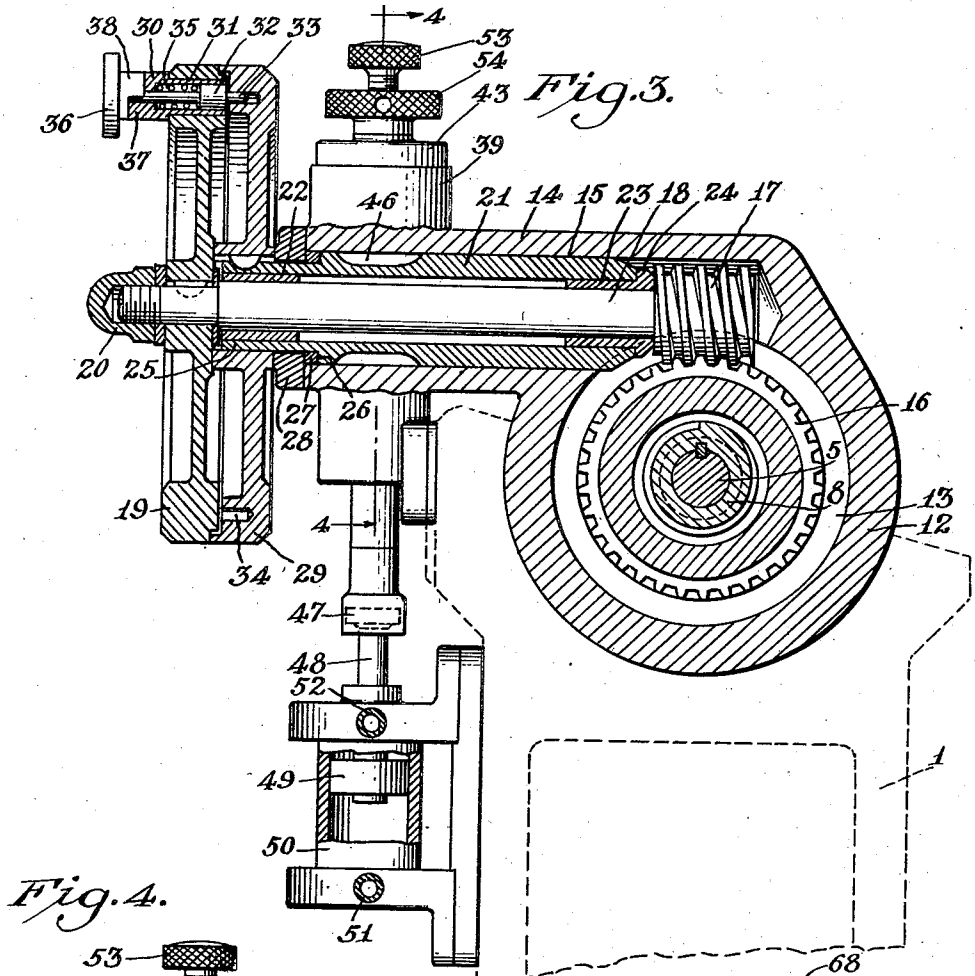
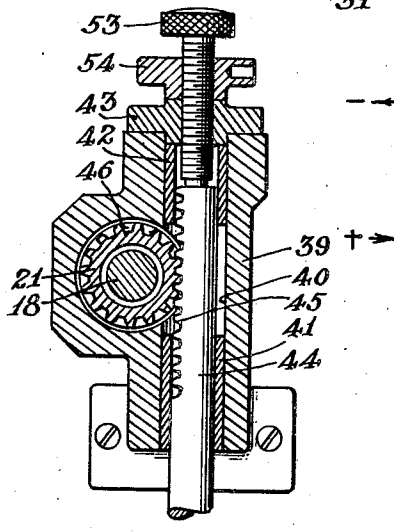


Fig. 3.

Fig. 4.



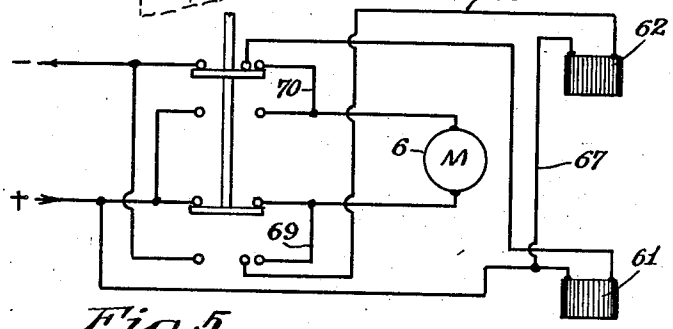


Fig. 5.

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UNITED STATES PATENT OFFICE

2,297,047

BACKLASH COMPENSATOR

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Application March 3, 1941, Serial No. 381,443

11 Claims. (Cl. 74—409)

The present invention relates to improvements in automatic backlash compensators for mechanical drives.

The primary object of the present invention is to provide a novel automatic backlash compensator which is operable to impart a predetermined movement to a mechanical drive for a machine element upon reversal of the drive, the movement being of an amount and in a direction to compensate or offset the effect of the backlash in the drive.

Another object is to provide a new and improved automatic backlash compensator which is readily adjustable to vary the amount of movement imparted to the drive, and which may be rendered functionally ineffective at will.

Further objects and advantages will become apparent as the description proceeds.

In the accompanying drawings,

Figure 1 is a fragmentary elevational view of a machine tool including the backlash compensator embodying the features of my invention.

Fig. 2 is a fragmentary vertical sectional view of the machine.

Fig. 2ª is a cross sectional view taken along line 2ª—2ª of Fig. 2.

Fig. 3 is a side elevational view of the backlash compensator, partially in vertical section substantially along line 3—3 of Fig. 1.

Fig. 4 is a vertical sectional view of the compensator taken along line 4—4 of Fig. 3.

Fig. 5 is a diagrammatic representation of the electric circuits for controlling the compensator.

Referring more particularly to the drawings, the backlash compensator, constituting the present embodiment of the invention, may be utilized in various types of mechanical drives for machine elements, and for purposes of illustration is shown as employed in a thread grinding machine. This machine comprises a base 1 supporting a reciprocatory slide 2. A spindle 3 is suitably journaled in a headstock 4 on the slide 2 and is adapted to support a work blank A. The spindle 3 is rotated and translated axially in timed relation relative to a grinding wheel (not shown) to grind on the work blank A a thread of a predetermined lead.

A screw shaft 5 is suitably journaled in the slide 2 against relative axial movement and extends in the direction of reciprocation of the slide. One end of the screw shaft 5 is suitably connected for rotary drive to a reversible electric motor 6. The spindle 3 is connected through a train of gears 7 to the screw shaft 5 so that the two will rotate in positive timed relation.

To provide means for translating the slide 2 and, therefore, the spindle 3 in timed relation to the rotation of the spindle, a master lead screw 8 is fixed on the screw shaft 5 and is in thread engagement with a nut 9 normally anchored in fixed position on the base 1. In the present instance, the nut 9 is rigidly secured coaxially within a hollow cylindrical supporting member 10 which is secured in a fixed axial position for rotation within a housing 11 on the base 1. Connected to the housing 11 is a gear housing 12 having a circular space 13 about the lead screw 8, and formed with an elongated bearing sleeve 14 having a bore 15 opening tangentially to the space. A worm wheel 16 is rigidly connected to one end of the supporting member 10 for rotation therewith within the space 13, and meshes with a worm 17 on the inner end of an adjusting shaft 18 journaled in and extending through the bearing sleeve 14. A hand wheel 19 is keyed to the outer end of the shaft 18 for rotation therewith and is secured in position by a suitable clamp nut 20. It will be seen that when the adjusting shaft 18 is not rotated, the worm 17, through engagement with the worm wheel 16 will lock the nut 9 against rotation. Consequently, rotation of the lead screw 8 through coaction with the nut 9 will effect translation of the spindle 3 in timed relation to the spindle rotation and in a direction determined by the direction of drive from the electric motor 6.

Upon reversal of the lead screw 8, any backlash between the screw and the nut 9 and also in the train of gears 7 would normally disturb the phase relationship between the spindle rotation and translation. An automatic backlash compensator is provided for adjusting the nut 9 upon each reversal of the lead screw 8 to compensate for this backlash so that the thread lead defined by the rotation and translation of the spindle will remain accurately in phase in both directions of translation.

The backlash compensator in its preferred form comprises a tubular shaft 21 rotatably supported in the bore 15 and projecting from the forward end thereof. Two plain tubular bushings 22 and 23 are tightly fitted in opposite ends of the shaft 21 and support the adjusting shaft 18. The innermost bushing 23 has an external peripheral end flange 24 disposed between the inner end of the tubular shaft 21 and the contiguous end of the worm 17. The outer end of the tubular shaft 21 has a reduced portion 25 defining a shoulder 26. A seal 27 is positioned about the reduced shaft portion 25 against the

shoulder 26, and a plate 28 encircles the shaft portion externally of the seal and is secured to the outer end of the bearing sleeve 14 to confine the tubular shaft 21 in axial position. Splined to the outer end of the reduced shaft portion 25 for rotation therewith is a compensator wheel 29 confined in position between the hand wheel 19 and the plate 28. Consequently, the worm 17, the clamp nut 20 and the plate 28 serve to maintain the various parts in assembled relation with the bearing sleeve 14.

Suitable means is provided for connecting the hand wheel 19 and the compensator wheel 29 for joint rotation or for disconnecting them so that the hand wheel may be rotated independently to adjust the nut 9. In the present instance, this means comprises a tubular guide sleeve 30 fixed in a bore 31 in the rim of the hand wheel 19. A plunger 32 is reciprocable in the bore 31 and has a detent pin 33 adapted for engagement with any one of a plurality of holes 34 in the rim of the compensator wheel 29. The plunger 32 is urged toward the wheel 29 by a coiled compression spring 35 seated in the bore 31, and is provided on the outer end with a hand knob 36 whereby the pin 33 may be withdrawn from the selected hole 34. Two complemental projections 37 and 38 are formed respectively on the adjacent ends of the sleeve 30 and hand knob 36, and are movable selectively either into interfitting engagement to release the pin 33 for engagement with the hole 34, or into end abutting engagement to lock the pin in retracted position.

Rigid with the bearing sleeve 14 is a perpendicular sleeve 39 having a longitudinal bore 40 intersecting one side of the bore 15. Plain tubular bushings 41 and 42 are fitted in opposite ends of the bore 40, and one end of the latter is closed by a cap 43. A plunger 44 extends into the other end of the bore 40 and is guided for reciprocation by the bushings 41 and 42. The plunger 44 is formed in one side with a longitudinal gear rack 45 which meshes with a gear 46 formed in the periphery of the tubular shaft 21. It will be seen that when the hand wheel 19 and the compensator wheel 29 are connected, reciprocation of the plunger 44 will effect rotation of the nut 9 to adjust the axial position of the lead screw 8, and therethrough the axial position of the spindle 3 relative to the position of rotation.

The outer end of the plunger 44 is connected through a floating coupling 47 to a piston rod 48. A piston 49 on the rod 48 is reciprocable in a cylinder 50 rigidly mounted on the base 1. A suitable motive fluid, such for example as air under pressure, is adapted to be supplied alternately through lines or flow passages 51 and 52 to opposite ends of the cylinder 50 so as to reciprocate the piston 49. The extent of movement is limited at one end by engagement of the piston 49 with one end wall of the cylinder 50, and is limited at the other end by a screw 53 adjustably threaded through the cap 43 for end engagement by the plunger 44. It will be seen that the screw 53 affords means for adjusting the extent of movement of the plunger 44 so that the compensating movement imparted to the nut 9 may be accurately correlated to the amount of backlash. When no backlash compensation is desired, the adjusting screw 53 may be turned down to confine the piston 49 against one end of the cylinder 50. A lock nut 54 on the adjusting screw 53 is adapted to be turned against the cap 43 to secure the screw in position of adjustment.

The supply of fluid under pressure to the cylinder 50 is under the control of a direction valve 55 supported on a plate 56 on the base 1. In the present instance, the valve 55 has a casing 57 with port connections to the lines 51 and 52 and also to a pressure supply line 58 and an exhaust line 59. A valve piston 60 is reciprocable in the casing 57 and projects from opposite ends thereof.

To provide suitable means for automatically reversing the direction valve 55 in timed relation to reversal of the rotary drive to the spindle 3 and the lead screw 8, two solenoids 61 and 62 are mounted on the plate 56 at opposite ends of the valve. These solenoids have plungers 63 and 64 respectively which are pivotally connected at their outer ends to the alined arms of two bell crank levers 65 and 66 mounted on the plate 56. The other arms of the bell crank levers 65 and 66 extend laterally into position respectively for engagement with opposite ends of the valve piston 60. The solenoids 61 and 62 have exciting circuits 67 and 68 adapted to be connected in parallel respectively with the electric circuits 69 and 70 for energizing the electric motor 6 for operation in reverse directions.

In operation, upon excitation of the solenoid 61, the plunger 63 will actuate the bell crank lever 65 to shift the valve piston 60 into one end position, thereby connecting the pressure line 58 to the line 51, and the line 52 to the exhaust line 59. As a result, the plunger 44 will be shifted into one end position against the adjusting screw 53 to impart a predetermined rotation to the nut 9 of an amount and in a direction to compensate for the backlash between the nut and the lead screw 8 and in the train of gears 7. Upon energization of the solenoid 62, the plunger 64 will shift the valve piston 60 into its other end position, thereby connecting the pressure line 58 to the line 52 and the line 51 to the exhaust line 59. As a result, the plunger 44 will be moved into its opposite end position so as to impart a predetermined rotary movement to the nut 9 the same in amount as before but in the opposite direction. Since the excitation of the solenoids 61 and 62 is controlled in accordance with the direction of operation of the motor 6, backlash is compensated for automatically upon each reversal of the spindle 3. By retracting the detent pin 33, the drive connection between the plunger 44 and the nut 9 may be interrupted so that the hand wheel 19 may be operated manually to effect any desired independent adjustment of the nut. Such adjustment may be resorted to on occasion to effect lead pick-up between the work blank A and the grinding wheel.

I claim as my invention:

1. A backlash compensator comprising, in combination with a rotary axially movable screw element and means for reversibly rotating said element, an axially stationary screw threaded element in threaded engagement with said first mentioned element, and means for automatically rotating said last mentioned element a predetermined extent upon reversal of rotation of said first mentioned element.

2. A backlash compensator comprising, in combination with a rotary axially movable lead screw and means for reversibly rotating said lead screw, an axially stationary nut in threaded engagement with said lead screw, and means for automatically rotating said nut a predetermined extent upon reversal of rotation of said lead screw.

3. A backlash compensator comprising, in com-

bination with a rotary axially movable lead screw and means for reversibly rotating said lead screw, an axially stationary nut in threaded engagement with said lead screw, and means normally locking said nut against rotation and being automatically operable to rotate said nut a predetermined extent upon reversal of rotation of said lead screw.

4. A backlash compensator comprising, in combination with a rotary axially movable lead screw and means for reversibly rotating said lead screw, an axially stationary nut in threaded engagement with said lead screw, means including a shaft for rotatably adjusting said nut, a plunger reciprocable transversely of said shaft and geared to said shaft to rotate the latter in timed relation to its reciprocation, and means for automatically reciprocating said plunger through a predetermined extent in opposite directions respectively upon reversal of rotation of said lead screw in opposite directions.

5. A backlash compensator comprising, in combination with a rotary axially movable lead screw and means for reversibly rotating said lead screw, an axially stationary nut in threaded engagement with said lead screw, means including a reciprocatory member movable transversely of said nut to rotate said nut, adjustable means for determining the extent of reciprocation of said member, and a fluid motor operable to move said member into one end position upon reversal of rotation of said lead screw in one direction and to move said member into the other end position upon reversal of rotation of said lead screw in the other direction.

6. A backlash compensator comprising, in combination with a base, a support reciprocable on said base in a rectilinear direction, a spindle journaled on said support and extending in said direction, a lead screw rotatably anchored to said support for movement therewith and extending in said direction, gear means interconnecting said spindle and said lead screw for timed rotation, and reversible drive means for rotating said spindle and lead screw, a nut rotatably anchored on said base in threaded engagement with said lead screw, a worm wheel coaxially fixed on said nut, a shaft journaled in said base and having a worm meshing with said worm wheel, a coaxial shaft, releasable means interconnecting said shafts for joint rotation, and means for automatically rotating said coaxial shaft a predetermined extent in opposite directions respectively upon reversal of said drive means to rotate said lead screw in opposite directions, whereby to rotate said nut to an amount and in a direction to compensate for backlash between said lead screw and said nut and in said gearing.

7. A backlash compensator, comprising, in combination with a base, a support reciprocable on said base in a rectilinear direction, a spindle journaled on said support and extending in said direction, a first screw element rotatably anchored to said support for movement therewith and extending in said direction, gear means interconnecting said spindle and said screw element for timed rotation, and reversible drive means for rotating said spindle and screw element, a second screw element rotatably anchored on said base and in threaded engagement with said first screw element, a worm wheel coaxially fixed on said second screw element, a shaft journaled in said base transversely of said screw elements and having a worm meshing with said worm wheel, a coaxial shaft, means interconnecting said shafts for joint rotation, and means for automatically rotating said coaxial shaft an adjustable predetermined extent in opposite directions respectively upon reversal of said drive means to rotate said first screw element in opposite directions, whereby to rotate said second screw element to an amount and in a direction to compensate for backlash between said first and second screw elements.

8. A backlash compensator comprising, in combination with a rotary axially movable first screw element and means for reversibly rotating said element, an axially stationary second screw element in threaded engagement with said first screw element, two concentric shafts mounted for rotation transversely of said second screw element, a worm on one of said shafts and meshing with a worm wheel coaxially fixed on said second screw element, a hand wheel fixed on said one shaft, a compensator wheel fixed on the other of said shafts, releasable means for engaging and disengaging said wheels, a gear on said other shaft, a reciprocatory plunger mounted for movement transversely of said other shaft and having a longitudinal gear rack meshing with said gear, means for adjustably limiting the extent of movement of said plunger in one direction, a fluid motor for reciprocating said plunger and for limiting the extent of movement of said plunger in the other direction, a source of fluid under pressure, a reversing valve for connecting said source alternately to opposite sides of said motor, and means for reversing said valve automatically upon reversal of the rotation of said first screw element, whereby to impart to said second screw element a predetermined rotation.

9. A backlash compensator comprising, in combination with a rotary axially movable first screw element and means for reversibly rotating said element, an axially stationary second screw element in threaded engagement with said first screw element, two concentric shafts mounted for rotation transversely of said second screw element, a worm on one of said shafts and meshing with a worm wheel coaxially fixed on said second screw element, a hand wheel fixed on said one shaft, a compensator wheel fixed on the other of said shafts, releasable means for engaging and disengaging said wheels, a gear on said other shaft, a reciprocatory plunger mounted for movement transversely of said other shaft and having a longitudinal gear rack meshing with said gear, means for adjustably limiting the extent of movement of said plunger, a fluid motor for reciprocating said plunger and for limiting the extent of movement of said plunger in the other direction, a source of fluid under pressure, a reversing valve for connecting said source alternately to opposite sides of said motor, and means for reversing said valve.

10. A backlash compensator comprising, in combination with a base, a slide on said base reciprocable in a predetermined direction, a lead screw anchored for axial movement with said slide, and means for reversibly rotating said lead screw, a housing mounted in fixed position on said base, a cylindrical member mounted for rotary adjustment in said housing, a nut secured coaxially to said member and in threaded engagement with said lead screw, a worm wheel fixed coaxially on said member, a gear housing rigid with said first mentioned housing and having a bearing sleeve opening tangentially to said worm wheel and a second bearing sleeve trans-

versely intersecting said first mentioned bearing sleeve, a tubular shaft journaled in said first mentioned sleeve and having a peripheral gear, a shaft journaled in said tubular shaft, a worm on said last mentioned shaft and meshing with said worm wheel, releasable means interconnecting said shafts for joint rotation, a plunger reciprocable in said second sleeve and having a longitudinal gear rack meshing with said gear, and means for reversibly shifting said plunger a predetermined extent.

11. A backlash compensator comprising, in combination with a base, a slide on said base reciprocable in a predetermined direction, a lead screw anchored for axial movement with said slide, and means for reversibly rotating said lead screw, a housing mounted in fixed position on said base, a nut mounted for rotary adjustment in said housing and in threaded engagement with said lead screw, a worm wheel fixed coaxially on said nut, a gear housing enclosing said worm wheel and having a bearing sleeve opening tangentially to said worm wheel and a second bearing sleeve transversely intersecting said first mentioned bearing sleeve, a tubular shaft journaled in said first mentioned sleeve and having a peripheral gear, a shaft journaled in said tubular shaft, a worm on said last mentioned shaft and meshing with said worm wheel, means interconnecting said shafts for joint rotation, a plunger reciprocable in said second sleeve and having a longitudinal gear rack meshing with said gear, and means for reversibly shifting said plunger a predetermined extent.

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