

July 15, 1947.

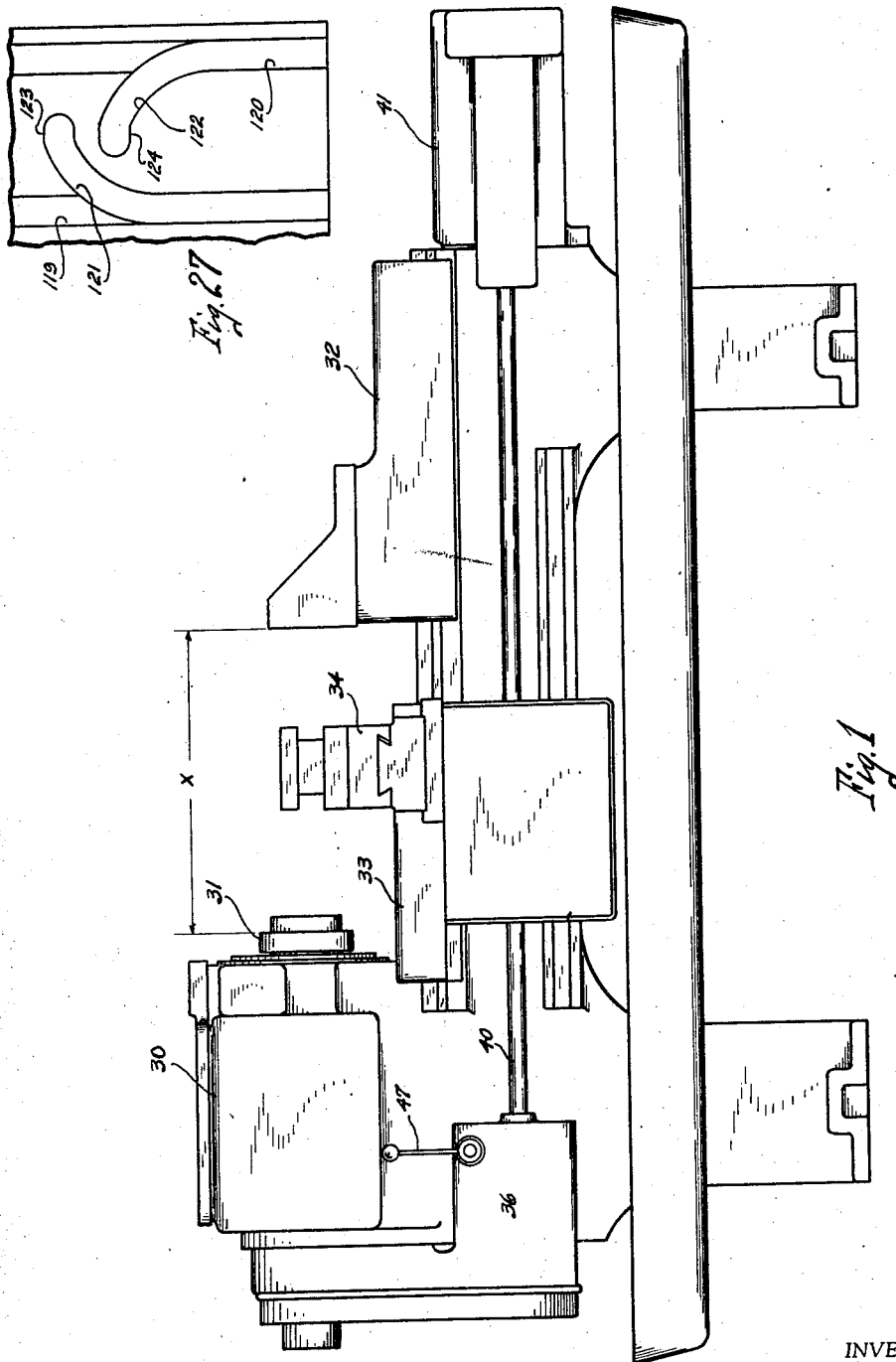
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2,424,153

CONNECTING AND POSITIONING DEVICE

Filed May 7, 1943

7 Sheets-Sheet 1



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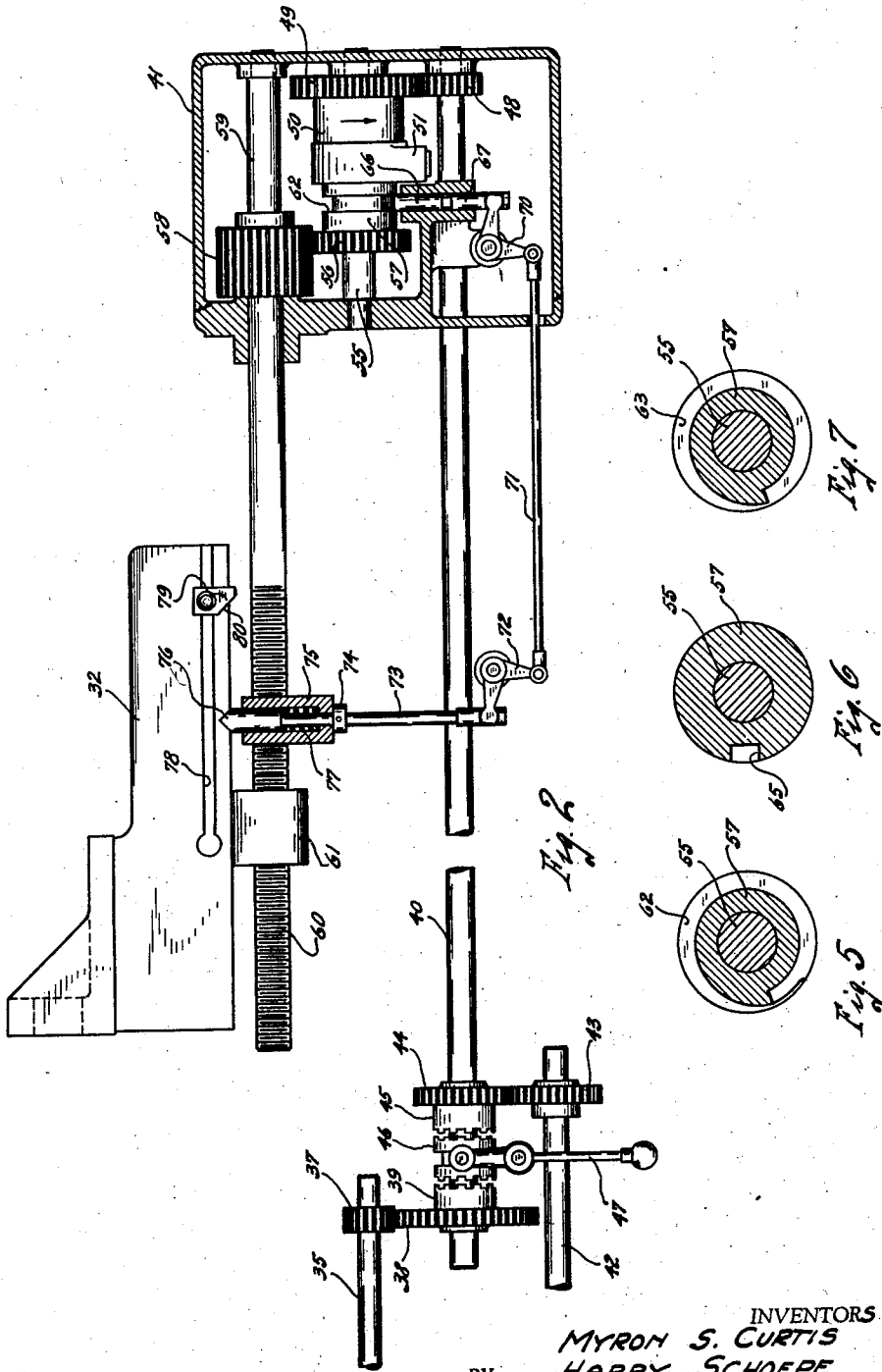
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7 Sheets-Sheet 2



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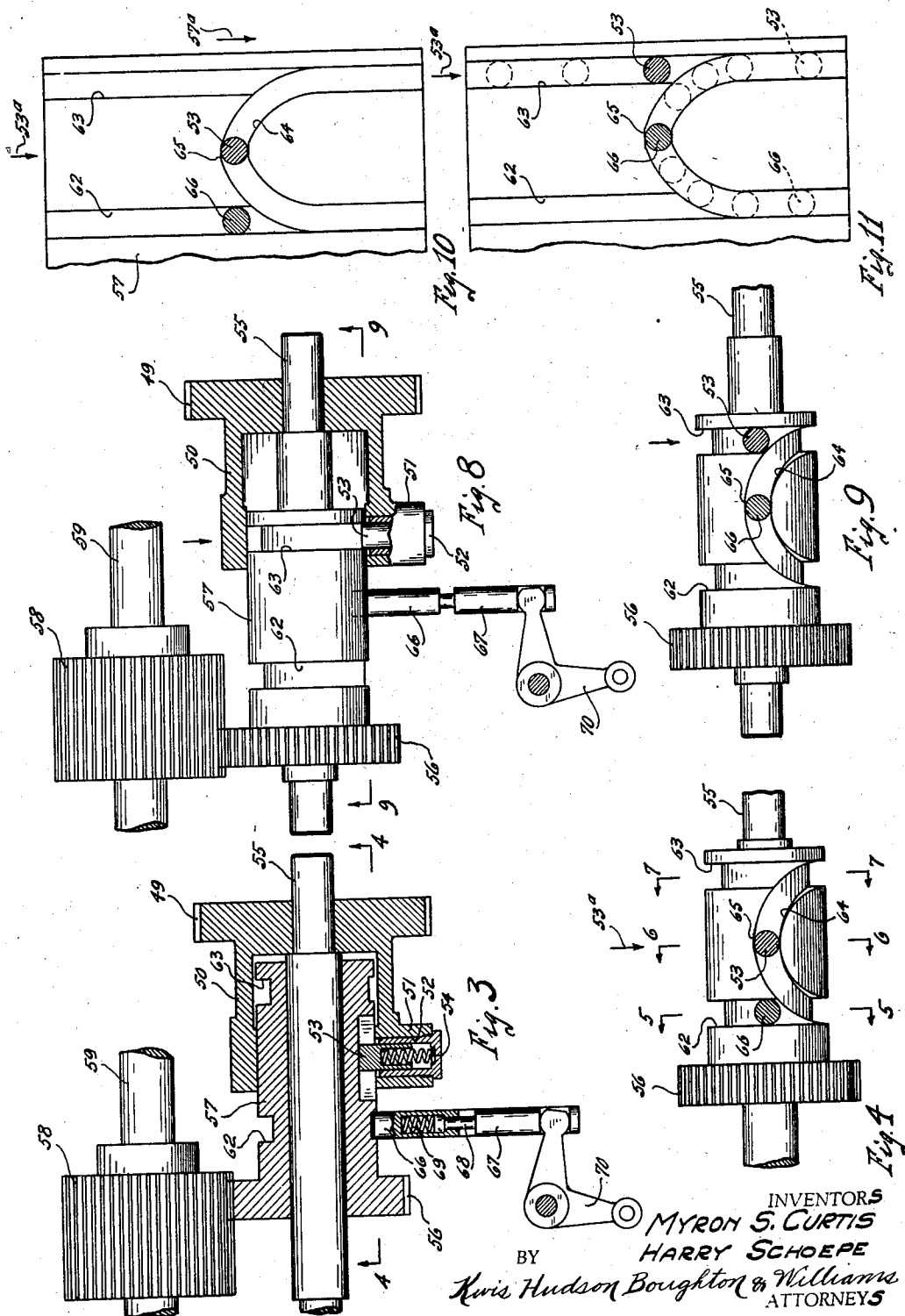
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7 Sheets-Sheet 3



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7 Sheets-Sheet 4

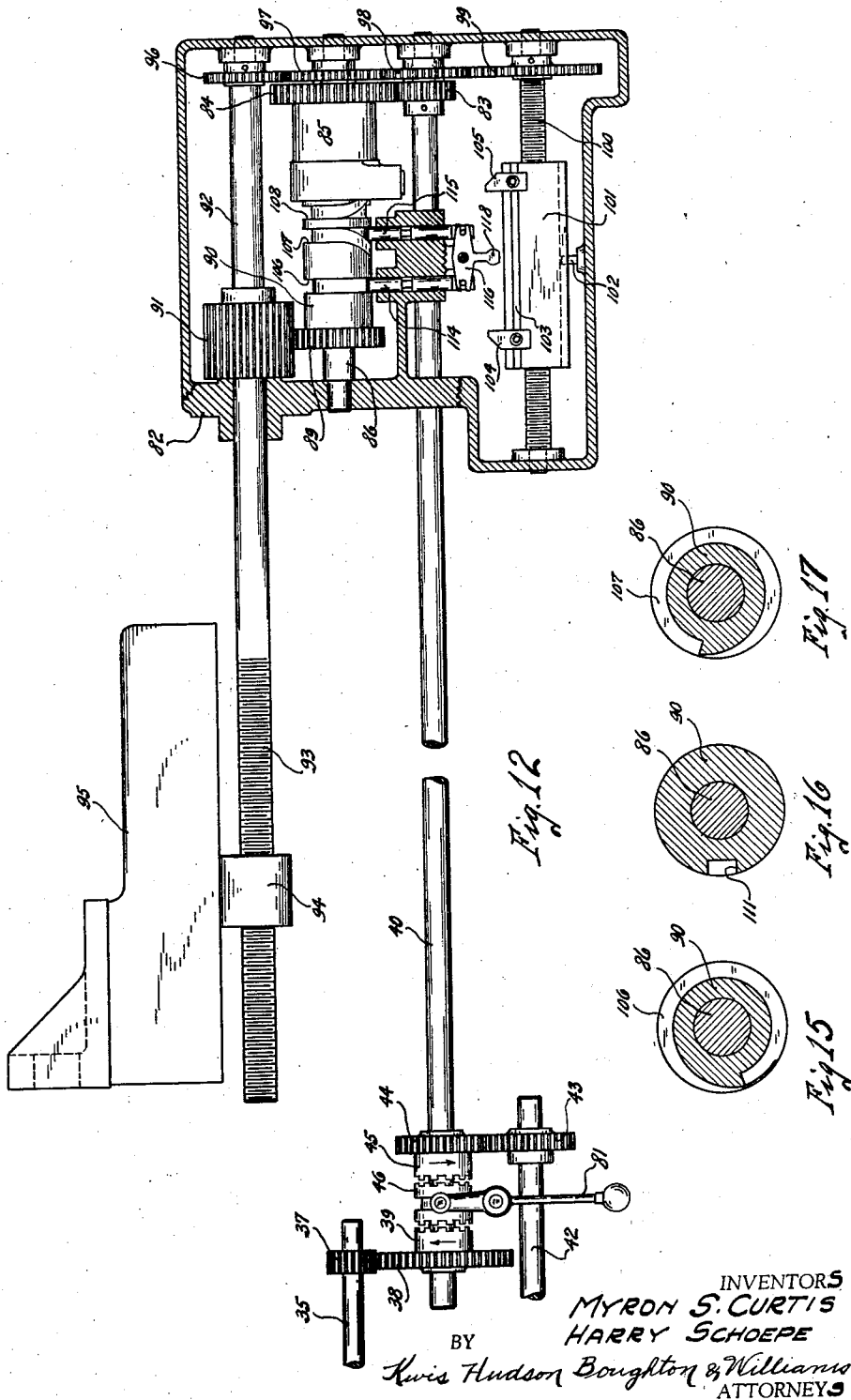


Fig. 12

Fig. 17

Fig. 16

Fig. 15

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2,424,153

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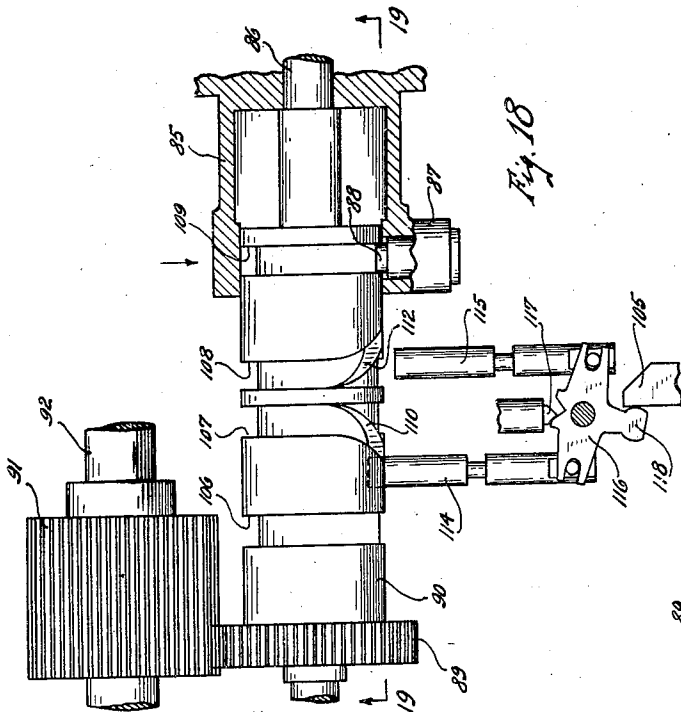


Fig. 18

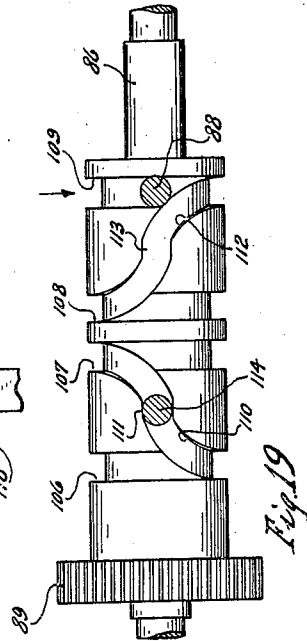


Fig. 19

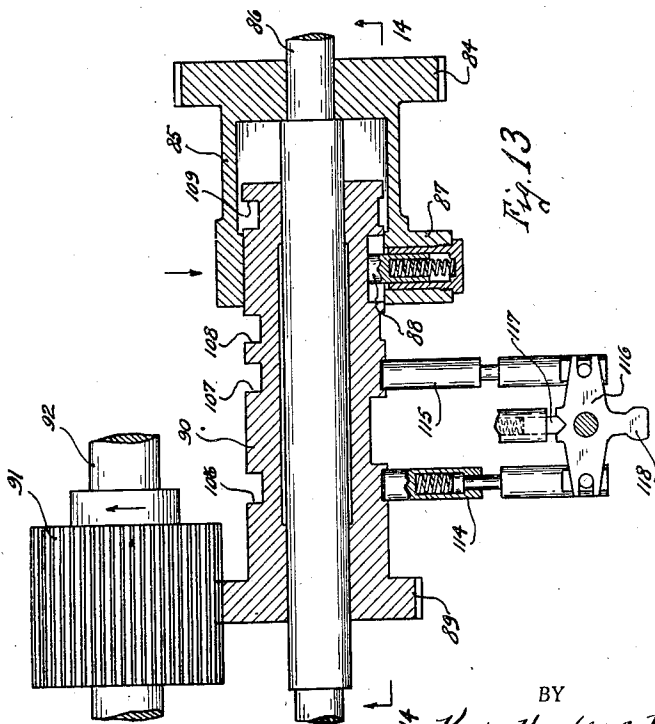


Fig. 13

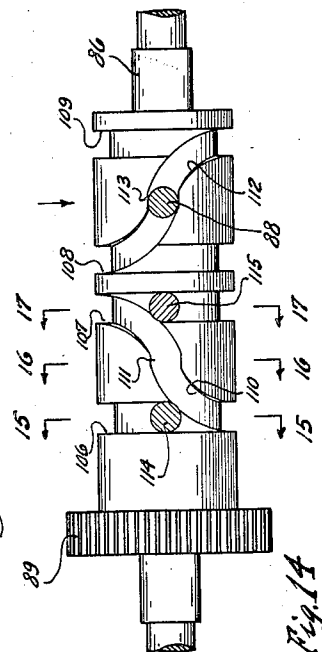


Fig. 14

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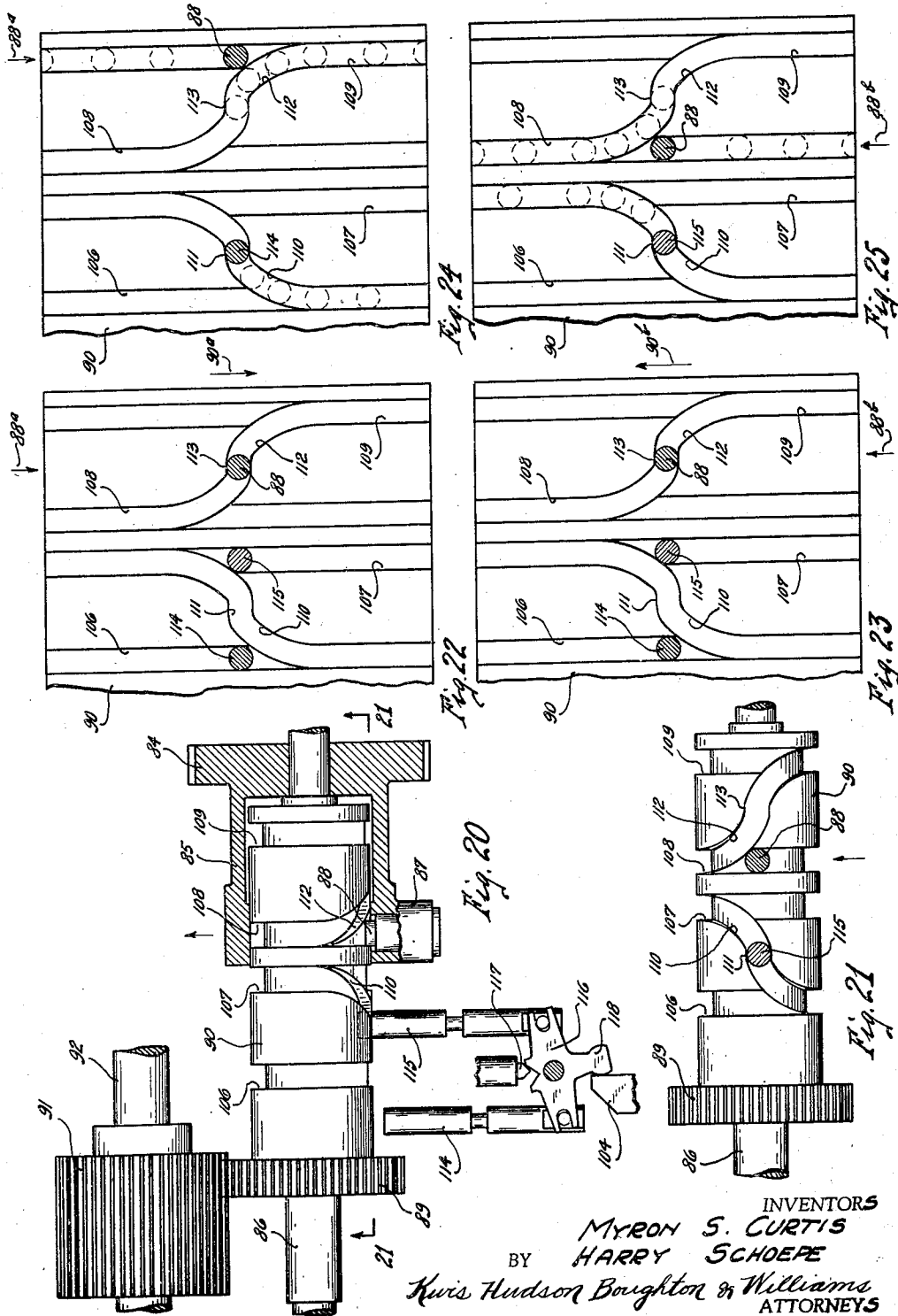
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2,424,153

CONNECTING AND POSITIONING DEVICE

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7 Sheets-Sheet 7

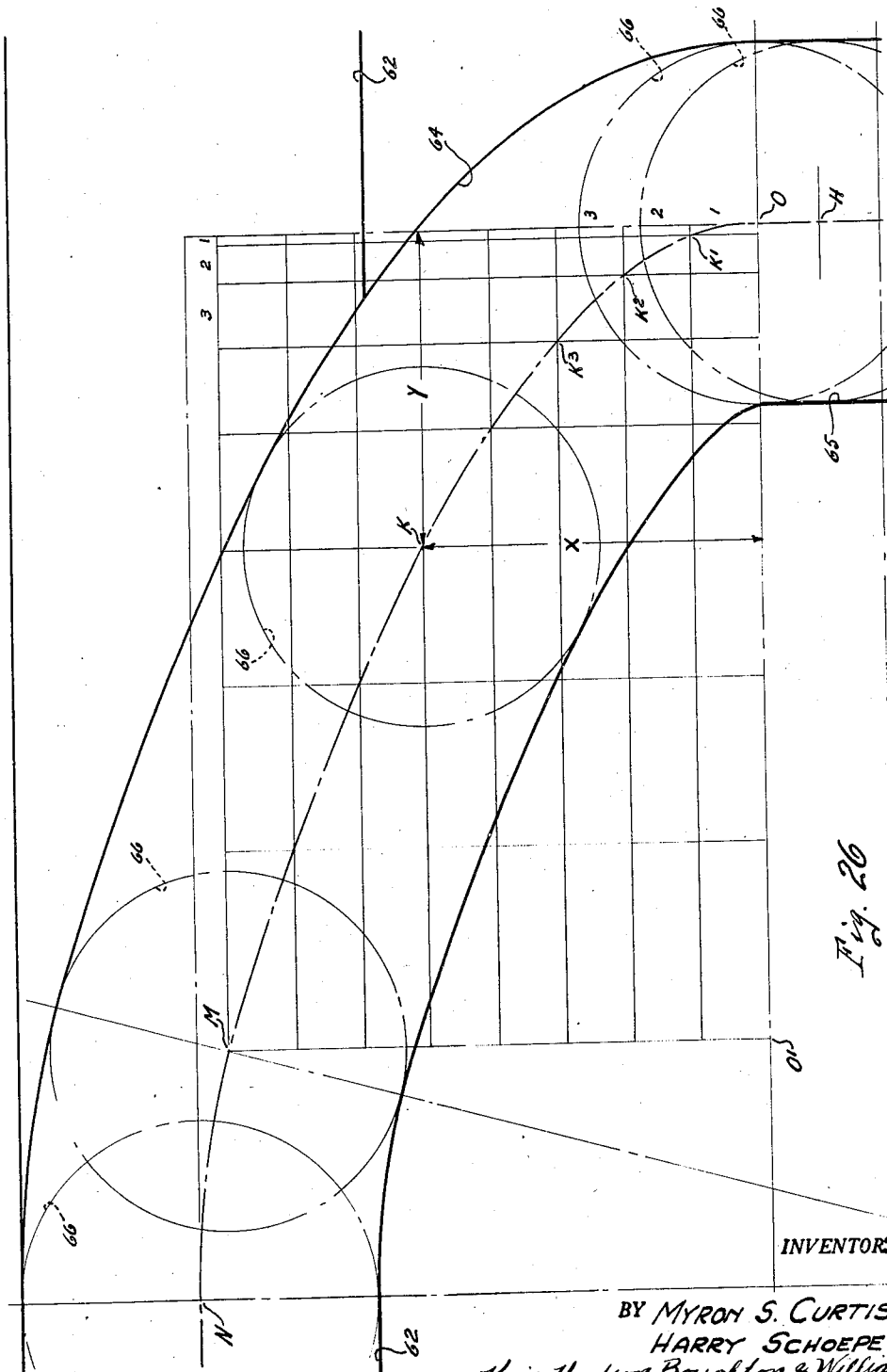


Fig. 26

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UNITED STATES PATENT OFFICE

2,424,153

CONNECTING AND POSITIONING DEVICE

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Application May 7, 1943, Serial No. 485,980

22 Claims. (Cl. 192—139)

1

This invention relates to a connecting and positioning device arranged between a driving member and a movable element and said device functions with a positive driving action to move said element.

One of the important objects of the invention is to provide a device of the character specified and which is so constructed that the movable element can be disconnected from the driving member and stopped always in the same predetermined definite position.

Another object is to provide a device of the character specified which is so constructed that said device after connecting the movable element with the driving member remains in this condition to give said element a predetermined movement and then automatically functions to disconnect said element and member and stop the element always in the same predetermined position.

Another important object is to provide a device of the character specified and which device does not employ the structure usually present in clutch mechanisms but is constructed in such a manner that the connection and disconnection of the driving member and the movable element results in a predetermined acceleration and deceleration of the movement of said element and causes the latter to stop or start its movement upon disconnection or connection gradually and smoothly and without a hammer blow effect.

A further object is to provide a device of the character specified and which device is particularly useful in a machine tool structure for actuating the feeding mechanism of a slide or similar element to successively impart to such slide or element a predetermined feeding movement and to stop such movement of the slide or element repeatedly in the same definite position.

Another object is to provide a device of the character specified for use in a machine tool to obviate the employment therein of positive stops for terminating the feeding movements of slides or other elements of the machine tool at the exact end of a machining operation.

A still further object is to provide a device of the character specified and which device when utilized in a machine tool in the drive train to a tool or work carrying slide eliminates the necessity of the operator manually completing the feeding movement of the slide at the end of a machining operation.

Further and additional objects and advantages not hereinbefore specified will become apparent

2

during the detailed description which is to follow of several embodiments of the invention.

Referring to the accompanying drawings,

Fig. 1 is a front elevational view of a machine tool, in this instance a lathe, and wherein there is included a device embodying the present invention and which by way of example may be used for connecting the actuating mechanism of a main slide to a driving source and for stopping and positioning the slide in predetermined positions.

Fig. 2 is a diagrammatic view partly in elevation and partly in section showing the slide, the actuating mechanism therefor and the device embodying the invention associated with said mechanism.

Fig. 3 is a vertical sectional view through a portion of the slide actuating mechanism shown in Fig. 2 and through the connecting and positioning device.

Fig. 4 is a detached elevational view taken substantially from the line 4—4 of Fig. 3, looking in the direction of the arrows, with certain portions of the device shown in section.

Figs. 5, 6 and 7 are sectional views taken respectively along lines 5—5, 6—6 and 7—7 of Fig. 4, looking in the direction of the arrows.

Fig. 8 is a view similar to Fig. 3 but with certain of the parts of the connecting and positioning device disposed in a different relationship.

Fig. 9 is an elevational view taken substantially from line 9—9 of Fig. 8, looking in the direction of the arrows, with certain portions of the device shown in section.

Figs. 10 and 11 are developed views of the circumference of the shiftable cam member of the device with the pins shown in section; Fig. 10 illustrating the relationship of the parts as disclosed in Figs. 3 and 4; while Fig. 11 discloses the relationship of the parts as illustrated in Figs. 8 and 9.

Fig. 12 is a diagrammatic view, partly in elevation and partly in section, and is similar to Fig. 2 but illustrates a modified form of connecting and positioning device from that shown in Fig. 2, it being noted that the device shown in Fig. 2 is a single acting device functioning automatically to position the slide at the end of its movement in one direction only, while the device shown in Fig. 12 is a double acting device functioning automatically to position the slide at the end of its movement in both directions.

Fig. 13 is a view similar to Fig. 3 but illustrating the connecting and positioning device shown in Fig. 12.

Fig. 14 is an elevational view taken substantially from line 14—14 of Fig. 13, looking in the direction of the arrows, with certain of the parts shown in section.

Figs. 15, 16 and 17 are sectional views taken, respectively, along lines 15—15, 16—16 and 17—17 of Fig. 14, looking in the direction of the arrows.

Fig. 18 is a view similar to Fig. 13 but illustrating a different relationship between the parts than that shown in Fig. 13.

Fig. 19 is an elevational view taken substantially from line 19—19 of Fig. 13, looking in the direction of the arrows, with certain of the parts shown in section.

Fig. 20 is a view similar to Figs. 13 and 18 but showing a still different relationship between the parts of the device than those shown in said Figs. 13 and 18.

Fig. 21 is an elevational view taken substantially from line 21—21 of Fig. 20, looking in the direction of the arrows, with certain of the parts shown in section.

Figs. 22 and 23 are developed views of the circumference of the driven cam member of the device shown in Fig. 12 with the pins shown in section and the parts corresponding in relationship as shown in Figs. 13 and 14, with the driving pin in driving relationship; Fig. 22 showing the cam member being driven in one direction while Fig. 23 illustrates said member as driven in the opposite direction.

Fig. 24 is a developed view of the circumference of the driven cam member of the device shown in Fig. 12 and corresponds to the position of the parts as shown in Figs. 18 and 19.

Fig. 25 is also a developed view of the circumference of the driven cam member of the device shown in Fig. 12 with the parts corresponding in relationship to that shown in Figs. 20 and 21.

Fig. 26 is a diagrammatic view showing the way in which a preferred curvature may be developed for the cam groove.

Fig. 27 is a developed view similar to Fig. 10, of a modified form of track system.

The connecting and positioning device of the present invention can be employed advantageously in various types of machines wherein it is desired to connect a driving member with a movable element of the machine to move the same and then to automatically disconnect the member and element and stop the movement of the element repeatedly in the same predetermined position or positions. Inasmuch as the device has particular utility when used in a machine tool to connect the actuating mechanism of a slide or other movable element of the machine tool with a driving source, the device is illustrated and described herein as employed in that relationship, it being understood, however, that this is merely by way of illustration and not by way of limitation.

Heretofore mechanical drives to a movable element of a machine have had the disadvantage that the element does not always come to a stop repeatedly in the same position or location each time the drive is interrupted due to the varying velocities of the members of the drive and also to different friction and load factors to which said members are subjected.

This disadvantage is particularly serious in machine tools where it is desired to stop the feeding movement of a slide which carries the work or a cutting tool repeatedly in a definite predetermined position in order that the work piece

may be accurately machined within close tolerances, as for example to stop the movement of a slide actuated by a screw and nut mechanism. Heretofore it has been necessary to employ positive stops in the form of stop rolls for positively and accurately locating the tool or work carrying slide at the end of the machining operation. Ordinarily the power feed drive to the slide is released just prior to the completion of the machining operation and then the operator by means of the hand wheel manually moves the slide into contact with the positive stop to properly position the slide and complete the machining operation.

The manual operation of the slide by the operator is objectionable since the operator cannot always apply the same degree of force in moving the slide against the positive stop and the result is the work piece may not be machined within the close tolerance called for due to the variations in pressure exerted on the slide by the operator.

The connecting and positioning device embodying the present invention does away with the necessity of using the positive stops for the work or tool holding slide of a machine tool since said device functions automatically to stop the movement of the slide repeatedly in exactly the same location for the same tool setup and thus the work piece is machined within the close tolerance limits demanded at the present time.

The use of the device of the present invention in a machine tool also eliminates the requirement that the operator manually move the work or tool slide against the positive stop above referred to and thus increases the efficient operation of the machine and the accurate machining of the work pieces within close tolerance limits.

Inasmuch as it is preferable, particularly for high operating speeds, to provide gradual and smooth acceleration and deceleration of the movable element in order to avoid any hammer blow effects in the starting and stopping of said elements, an important aspect of the invention is the arrangement employed for such purpose and which will later be fully explained.

As previously stated, the connecting and positioning device of the present invention is illustrated herein, by way of example, as applied to a machine tool in this instance a lathe. The lathe is shown in Fig. 1 and comprises a headstock 30 having a rotatable work spindle 31. The bed of the lathe is provided with ways for a main slide 32 and a cross slide carriage 33 which supports a cross slide 34 as is well understood in the art. The spindle 31 may be driven at different speeds by a suitable variable speed transmission not shown as it is well known. The spindle 31 is operatively connected through suitable gearing or other means to a shaft 35 (see Fig. 2) carried by a gear box 36 mounted on the front of the machine. The shaft 35 has fixed thereto a gear 37 which meshes with a gear 38 formed on a clutch member 39 freely rotatable on a shaft 40 extending along the front of the bed of the lathe and in this instance through the apron of the cross slide carriage and into a gear box 41 secured to the end of the bed, as clearly indicated in Fig. 1. A shaft 42, also carried by the gear box 36, has a gear 43 fixed thereto which meshes with a gear 44 formed on a clutch member 45 also freely rotatable on the shaft 40. The shaft 42 is driven by a suitable power source, not shown, at a relatively higher speed than is the shaft 35 and functions to drive the shaft 40 during the idle movements of the main slide 32. A shiftable clutch member 46 is splined on the shaft 40 interme-

diate the clutch members 39 and 45 and can be shifted by the lever 47 from a neutral position into one operative position wherein it is clutched to the clutch member 39 for effecting feeding movement of the main slide or into a second operative position wherein it is clutched to the clutch member 45 for effecting idle movement of the slide, in this instance, in the reverse direction only.

The shaft 40 within the gear box 41 has fixed thereto a gear 48 and said gear 48 meshes with a gear 49 formed integral in this instance with a sleeve-like portion 50 (see Figs. 2 and 3). The sleeve-like portion 50 is provided with a boss 51 having a radially extending bore into which a cup-shaped member 52 is screwed. A plunger 53 is slidably mounted in the cup-shaped member 52 and is normally urged in a radially inward direction by a spring 54. The gear 49 is freely rotatable on a stationary shaft 55 mounted in the gear box 41 and extending parallel to the shaft 40.

It will be noted that the gear 49 is mounted on a reduced portion of the shaft 55 and is held against endwise movement by the shoulder of the shaft 55 formed by the reduced portion and by the bearing boss for the shaft formed internally of the gear box 41. The shaft 55 also carries a second freely rotatable gear 56 which is provided with an elongated hub portion 57 that extends into the sleeve-like portion 50 of the gear 49. The purpose of the elongated hub portion 57 extending into the sleeve-like portion 50 and the other parts associated therewith will subsequently be explained.

The gear 56 and hub portion 57 are slidable axially of the shaft 55 as well as being freely rotatable thereon and said gear meshes with an elongated gear 58 fixed to a shaft 59 rotatably supported in the gear box 41 and extending outwardly therefrom along the bed and toward the headstock. The shaft 59 is threaded for a portion of its length as indicated at 60 and constitutes the actuating screw for the main slide 32. The main slide 32 is provided in this instance with a depending nut 61 which receives the threaded portion 60 of the shaft 59 and causes said shaft when rotating to impart linear movement to the slide 32 in either direction depending upon the direction of rotation of the shaft.

The hub 57 is provided with a track system shown, in this instance, as spaced annular grooves 62 and 63 and these grooves are connected with camming portions in the form of a curved groove 64 having a straight walled driving and stopping portion indicated at 65 and parallel to the axis of the hub, see Figs. 4 and 10 and located midway between the grooves 62 and 63. Of course the camming portions of the track system could be other than curved portions, as for instance they might be straight portions angularly disposed to the annular portions. The major segments of the annular grooves 62 and 63 are of uniform depth and correspond in depth to the depth of the curved groove 64. However, the remaining segments of the grooves 62 and 63 are of varying depth and decrease in depth toward the points where the curved groove 64 merges with the annular grooves 62 and 63, as clearly shown in Figs. 3, 4, 5 and 7.

The plunger 53 carried by the sleeve portion 50 of the gear 49 constitutes a driving plunger or element and rides in the groove 63 or in the right hand half of the curved groove 64 as viewed in the drawings, that is in or to the right of the

straight walled portion 65 of said curved groove for a purpose later to be explained.

The gear box 41 is provided interiorly with a supporting bracket in which is slidably mounted a plunger formed of two interconnected parts 66 and 67, with the latter part having a shouldered extended portion 68 passing into a recess in the part 66 and engaging a spring 69 located in said recess, wherefore the part 66 can have movement relative to the part 67, but normally said part 66 and 67 will move together as a unit.

The part 66 of the two part plunger is adapted to extend into and travel in the annular groove 62 and the left hand portion of the curved groove 64 up to and including the straight walled portion 65 thereof for a purpose later to be explained. The part 67 of the two part plunger is provided near its outer end with a slot which receives the rounded free end of one arm of a bell crank lever 70 that is rockably mounted in the gear box 41. The free end of the other arm of said bell crank lever 70 is pivotally connected to a link 71 which extends outwardly of the gear box 41 and has its outer end pivotally connected to the free end of one arm of a bell crank lever 72 which latter lever is rockably supported by a bracket on the bed of the machine, see Fig. 2. The free end of the other arm of the bell crank lever 72 is of rounded formation and is located in a slot formed in the enlarged lower end of a cam rod 73 which carries a collar 74 to limit its upward movement, and said rod extends into a cup-shaped housing 75 carried by the bed. The rod 73 at its upper end is provided with an enlarged portion 76 which slidably fits the cup-shaped housing 75 and has its outer or free end of tapered or beveled formation as clearly indicated in Fig. 2. A spring 77 located in the housing 75 surrounds the rod 73 between the base of the housing and the enlarged portion 76 of the rod and normally maintains said rod in its uppermost position, with the collar 74 abutting the lower end of the housing 75.

The slide 32 is provided in its side with an elongated T-slot 78 and a cam lug 79 is adjustably supported by said slot 78 and can be clamped in various adjusted positions therein. The cam lug 79 is provided on one side with a beveled surface 80 that cooperates with the beveled end of the enlarged portion 76 of the cam rod 73 when the slide 32 is moving in a forward or feeding direction. The cam lug 79 is positioned in the slot 78 in accordance with the length of feeding movement to be imparted to the slide 32 and the location of said cam lug determines the position in which the feeding movement of said slide is to be stopped.

It will be understood that as the slide 32 is moved forwardly in a feeding direction by the screw 60 the beveled surface 80 of the lug 79 will contact the beveled upper end of the cam rod 73 and depress said rod against the action of the spring 77. This depression of the cam rod 73 will be transmitted through the bell crank lever 72, link 71, and bell crank lever 70 to the two part plunger 66, 67 to move the same radially inward for a purpose later to be explained.

However, it should be noted that except when the cam rod 73 is depressed by the cam lug 79 the two part plunger 66, 67 is in the position shown in Fig. 3, at which time the inner end of the plunger extends slightly into the annular groove 62 for a distance less than the minimum depth of said groove. The purpose of this normal or inactive arrangement is to have the plunger

hold the hub 57 and gear 56 against axial shifting movement.

Assuming that the slide 32 is having feeding movement imparted thereto by the screw 60 and that the shiftable clutch member 46 is in engagement with the clutch element 39 and the shaft 40 and gears 43 and 49 are rotating to impart rotation to the shaft 59 through the device already described, the parts of said device will be in the relative positions indicated in Figs. 2, 3, 4 and 10. At this time the driving plunger or element 53 carried by the sleeve portion 50 of the gear 49 will be located in the straight walled driving and stopping portion or section 65 of the curved groove 64 of the hub 57 (see Figs. 4 and 10) and will be engaged on diametrically opposite sides by the straight walls of said portion 65. Therefore the forward rotation of the sleeve portion 50 will cause the plunger 53 to move in a circular path as indicated by the arrows 53a of Figs. 4 and 10 and this movement of the plunger 53 at right angles to the straight walls of the portion 65 of the groove 64 will impart rotary movement to the hub 57 in the direction indicated by the arrow 57a, with a resultant rotation of the gears 56 and 58 and the screw 60 to move the slide 32 in a forward or feeding direction.

It will be noted that the location of the drive plunger 53 in the straight walled portion 65 of the curved groove 64 while driving, as just referred to, has no tendency to cause axial shifting movement to the hub 57. Furthermore, at this time the two-part plunger 66, 67 extends slightly into the annular groove 62 (see Fig. 3) and sufficiently to hold the hub 57 positively against axial shifting movement. This is the normal inactive position of the two-part plunger 66, 67 and in such position said plunger in no way interferes with the free rotation of the hub 57 as previously explained.

It will be observed that when the drive plunger 53 is in the position just explained and is driving the hub 57 a positive uninterrupted timed relation drive exists between the work spindle 31 and the screw 60 and the main slide 32 thus assuring the desired feeding rate for said slide and the work or tools carried thereby. The slide continues its feeding movement until the beveled surface 80 of the cam lug 79 engages the beveled upper end of the cam rod 73 and depresses said rod to cause the two-part plunger 66, 67 to be moved radially inwardly of the groove 62. This movement of the two-part plunger radially inwardly of the groove 62 results in the inner end of the plunger following or riding into the left hand section of the curved groove 64 as the hub 57 rotates and as indicated by dash lines in Fig. 11. The inner end of the two-part plunger riding into the curved groove 64, as just referred to, effects an axial shifting movement of the hub 57 toward the left, as viewed in the drawing, with a resultant relative movement of the driving plunger 53 out of the straight walled section 65 of the curved groove 64 and into the right hand curved section of said latter groove, as indicated by dash lines in Fig. 11. As soon as said driving plunger has moved out of the straight walled section 65 of the curved groove said plunger travels in the right hand curved section of the groove 64 until it is in the annular groove 63 where it has idling movement in the direction of arrow 53a of Fig. 11 with respect to said groove as the sleeve 50 continues to rotate, it being understood that the driving plunger 53 will be de-

pressed against the spring 54 as the plunger rides over the high point of the groove 63. By the time that the driving plunger 53 has traveled through the right hand section of the curved groove 64 and into the annular groove 63 the hub 57 has been shifted axially so that the two-part plunger 66, 67 will have completed its travel through the left hand section of the curved groove and will have its inner end located in the straight walled driving and stopping section or portion 65 thereof and will have brought the rotation of the hub portion 57 to a positive stop and the parts will be in the position indicated in Figs. 8, 9 and 11. The arrangement of the plungers and the annular grooves is such that if either plunger is in the straight walled driving and stopping section or portion 65 of the curved groove the other plunger will be in its respective annular groove.

It will be seen that the positioning of the two-part plunger 66, 67 in the straight walled section 65 definitely and positively stops the rotation of the hub 57, gears 56, 58, shaft 59 and screw 60, with a resultant stoppage of the feeding movement of the slide 32 and the location of the latter in a predetermined definite position which will always be the same for each feeding movement during the same adjustment of the cam lug 79. It will later be explained that the curvature of the groove 64 on both sides of the straight walled section 65 is such that the movement of the plunger 66, 67 into the groove effects a gradual smooth deceleration in the speed of rotation of the hub 57 and brings the latter to a stop without a hammer blow effect.

The feeding movement of the slide 32 has now stopped, but the shaft 40, gears 43 and 49 and sleeve 50 continue to rotate with the plunger 53 traveling idly around in the groove 63. The operator in order to bring the slide back to its rear-most position moves the shiftable clutch element 46 by the control lever 47 out of engagement with the clutch member 39 and into engagement with the clutch member 45, whereupon the shaft 40 is rotated in the reverse direction by the shaft 42 through the gears 43 and 44 and at a faster rate of speed than when it was rotating in the forward feeding direction. The gear 49 and sleeve 50 now start to rotate in the reverse direction, whereupon the driving plunger 53 traveling in a direction opposite to the arrow 53a shown in Fig. 11 enters the right hand section of the curved groove 64 in the hub 57, as indicated by dash lines in Fig. 11. As the driving plunger 53 travels in the right hand section of the curved groove 64 toward the straight walled section 65 thereof it shifts the hub 57 axially toward the right as viewed in the drawing and at the same time the two-part plunger 66, 67 moves out of the straight walled section 65 and travels in the left hand curved section of the groove 64 until it is in the annular groove 62 as indicated by dash lines in Fig. 11. The instant that the stopping two-part plunger 66, 67 moves out of the straight walled section 65 of the curved groove the hub 57 commences to rotate and accelerate under the action of the driving plunger 53. During this accelerating rotation of the hub 57 the driving plunger 53 moves into the straight wall section 65 of the groove 64 without a hammer blow effect since the acceleration of the hub 57 has brought the latter into synchronized rotation with the sleeve 50. As soon as the hub 57 commences its rotation in the reverse direction the screw 60 rotates in the reverse direction and the slide 32 commences to move rearwardly. This rearward movement of

the slide causes the beveled surface 80 of the cam lug 79 to move out of cooperative engagement with the beveled upper end of the cam rod 73 to allow the spring 77 to move said rod upwardly and to restore the two part plunger 66, 67 to its normal inactive position as indicated in Fig. 3, wherein it is just slightly engaged in the groove 62 to prevent axial shifting movement of the hub 57 while the hub is rotating in the reverse direction. In case the two-part plunger has traveled out of the curved groove 64 and into the annular groove 62 before the cam lug 79 is completely out of engagement with the beveled end of the cam rod 73 then for one or more turns of the hub 57 in the reverse direction the part 66 of the plunger will be compressed against the spring 69 and telescope relative to the shouldered portion 68 of the part 67 of the plunger each time the end of the plunger contacts the minimum depth segment of the groove. The operator allows the rearward movement of the slide to continue until the cutting tools have cleared the work sufficiently to allow the latter to be removed and a new work piece loaded in the work holder, whereupon the operator by means of the control lever 47 shifts the movable clutch element 45 into neutral position and terminates the rotation of the shaft 40 and stops the rearward movement of the slide 32.

It will be understood that when the rotation of the shaft 40 stops, as just explained, the sleeve portion 50 of the gear 49 and the hub 57 also stop rotation with the driving plunger 53 located in the straight walled section 65 of the groove 64 and with the two-part stopping plunger 66, 67 extending into the annular groove 62, as shown in Figs. 3, 4 and 10. When the operator has loaded a new work piece into the work holder he can again cause forward feeding movement to be imparted to the slide 32 to machine such new work piece. He accomplishes this by shifting the control lever 47 to move the shiftable clutch element 45 into engagement with the clutch element 39 and start the rotation of the shaft 40 in the forward direction. Immediately the sleeve portion 50 rotates in the forward direction and the driving element or plunger 53 drives or rotates the hub 57 in a forward direction with a resultant forward rotation of the screw 60 and a forward feeding movement of the slide 32. The forward movement of the slide 32 continues until the cam lug 79 again depresses the cam rod 73, which action as explained above, causes the driving plunger 53 to move out of the curved slot and into the annular slot 63, while the holding plunger 66, 67 moves out of the annular slot 62 into the curved slot 64 and comes to rest in the straight walled section 65 thereof to positively stop the rotation of the hub 57 and the feeding movement of the screw 60 and the slide in exactly the same position that the slide was stopped in as previously explained.

It will be seen that the slide may have feeding movement imparted thereto time after time and will always be stopped upon completion of its feeding movement in the same predetermined position.

It will be recalled that the two-part holding plunger 66, 67 is slidably supported in a bore formed in a fixed bracket portion interiorly of the gear box 41, and, therefore, said plunger cannot be displaced circumferentially of the hub 57 and when said plunger engages in the straight walled section 65 of the groove 64 it will positively stop the rotation of the hub 57 in exactly the same position each time the cam rod 73 is depressed

by the cam lug 79 as the slide reaches the end of its feeding movement. Consequently, since the gears 56, 58 the screw 60 and the slide 32, constitute an unbroken drive train, they will all be decelerated and then stopped and locked repeatedly in exactly the same position each time the plunger 66, 67 has engaged in the straight walled section 65 of the groove 64 of the hub 57 without allowing any further rotation or coasting of the parts. Therefore the feeding movement of the slide 32 will be terminated and the slide located in exactly the same position at the end of each feeding movement and the tools carried by said slide will terminate their cutting movement and will be positioned in the same accurate relationship to the work each time the feeding movement is terminated. As a result of this repeated accurate positioning of the tools relative to the work the machining of the work piece can be kept within extremely close tolerances and it will be unnecessary for the operator to manually move the slide against positive stops in order to complete the machining operation on the work piece. In other words, the slide can be repeatedly stopped in the same predetermined position to maintain the distance X indicated in Fig. 2 by the arrowed line to within a thousandth part of an inch, it being noted that said line represents the distance between the adjacent end surface of the slide and the end surface of the spindle.

In Figs. 2 to 11 inclusive the connecting and positioning device of the invention disclosed therein and previously described in detail constitutes a device for automatically and positively stopping and positioning the movement of the slide at the end of its forward or feeding movement only, while the stopping of the slide during its return movement is manually controlled by the operator, who also controls the direction of movement of the slide.

In Figs. 12 to 25 inclusive the connecting and positioning device of the invention shown therein is a device wherein the movement of the slide is automatically stopped and the slide positioned in both directions of its linear movement, while only the direction of movement of the slide is under the manual control of the operator.

There may be instances where it is desirable not only to repeatedly stop and locate the slide in exactly the same predetermined position at the end of its movement in one direction, but also at the end of its movement in the opposite direction, and in such instances the connecting and positioning device shown in Figs. 12 to 25 inclusive would be advantageously employed. As illustrative of instances where this form of device could be advantageously used reference is made to the situation wherein the slide might have feeding movements in opposite directions, or might have only forward feeding movement but at the end of its return movement have additional functions to perform.

Referring to Fig. 12, it will be seen that the shaft 40 is selectively operatively connected to the shafts 35 and 42 by identical mechanism as that used for the same purpose in the embodiment of the invention already described and, therefore, similar reference characters are employed to identify the identical parts or elements, except that the control lever for shifting the shiftable clutch element 45 will be identified by the numeral 81.

The shaft 40 in Fig. 12 extends into and is rotatably supported by a gear box 82 similar to the gear box 41 previously described, in that it houses

the connecting and positioning device. The shaft 40 within the gear box 82 has fixed thereto a gear 83 which meshes with a gear 84, in this instance formed integral with a sleeve portion 85 and freely rotatable on a non-rotatable shaft 86 supported internally of the gear box 82 and parallel to the shaft 40. The gear 84 and sleeve portion 85 are held against endwise movement on the shaft 86 by a shoulder formed on said shaft and engaging one side of the gear 84 and by a gear later to be referred to freely rotatable on the shaft 86 and engaging the other side of the gear 84. The sleeve portion 85 is provided at its end with a radially extending boss 87 having a bore therein in which is slidably mounted a spring pressed driving plunger 88, similar to the driving plunger 53 previously described. Also freely rotatable on the shaft 86 is a gear 89 which has an elongated hub 90 extending axially of the shaft 86 and into the sleeve portion 85 of the gear 84. The gear 89 and hub 90 are axially shiftable on the shaft 86 and said gear 89 constantly meshes with an elongated gear 91 fixed to a shaft 92 which is rotatably supported in the gear box 82 and extends outwardly thereof toward the headstock and is provided with a screw threaded portion 93 that cooperates with the depending nut 94 carried by the slide 95 which slide is similar to the slide 32, shown in Figs. 1 and 2.

The shaft 92 within the gear box 82 has fixed thereto a gear 96 which meshes with a gear 97 freely rotatably mounted on the shaft 86 intermediate one face of the gear 84 and the inner face of a bearing boss for said shaft 86. The gear 97 meshes with a gear 98 that is freely rotatable on the shaft 40 and is located within the gear box intermediate one face of the gear 83 and the bearing boss for said shaft 40. The gear 98 meshes with a gear 99 that is fixed to a screw threaded shaft 100 that is rotatably supported in suitable bearing bosses formed in the gear box 82 and extends, in this instance, parallel to the shafts 40, 86 and 92. The gears 96, 97, 98 and 99 cause the screw shaft 100 to rotate in timed relation to the shaft 92 but at a different speed, in this instance.

An elongated block 101 is threadedly mounted on the screw threaded shaft 100 and is provided in its lower face with a longitudinal groove into which extends a fixed pin 102, wherefore said block 101 is held against rotation or rocking movement but is free to move endwise on the screw threaded shaft 100 when the latter is rotated.

It will be seen that since the shaft 100 rotates in timed relation to the shaft 92 and screw 93 the block 101 will move linearly on the shaft 100 in timed relation to the linear movement of the slide 95 on the screw, but in this instance at a slower rate of movement. The block 101 is provided with a longitudinal T-slot 103 which carries a pair of cam lugs 104 and 105 that can be relatively adjusted in said slot and then clamped in adjusted position for a purpose later to be explained.

The hub 90 is provided with a track system, in this instance shown as including four circumferential grooves 106, 107, 108 and 109. The grooves 106, 107 are interconnected by a curved groove 110 which has a straight walled portion or section 111 midway between the grooves 106, 107 with said straight walled section extending in a direction axially of the hub, or at right angles to the hub's rotation, see Fig. 22.

The annular groove 106 has a segment of var-

iable depth with the high point of said segment at the juncture of the curved groove 110 with the groove 106, see Figs. 14 and 15. The groove 107 also has a segment of variable depth with the high point of said segment at the juncture of the curved groove 110 with the groove 107, see Figs. 14 and 17.

It will be noted that the curved groove 110 has two curved portions or sections on opposite sides of the straight walled section 111 but that such curved sections extend in opposite directions and therefore the high points of the grooves 106, 107 are oppositely disposed with respect to their relation with the curved groove 110, as clearly indicated in Figs. 15 and 17.

The annular grooves 108 and 109 are connected by a curved groove 112 having a straight walled portion or section 113 midway between the grooves 108, 109. The curved groove 112 is identical with the curved groove 110 but has its curved portions or sections oppositely disposed with respect to said groove 110. Likewise the grooves 108, 109 each have a segment of variable depth with the high point thereof at the junction of the curved groove 112 with said annular grooves similar to the high points of the grooves 106, 107.

It will be noted that the grooves 106, 107 and the curved groove 110 are symmetrical with respect to the grooves 109, 108 and the curved groove 112 and therefore only the sectional views of Figs. 15 to 17 inclusive have been shown in the drawing illustrating the various depths of the annular grooves 106, 107 and the straight walled portion or section 111 of the curved groove 112.

The form of the curved portions or sections of the grooves 110, 112 preferably will follow a predetermined and desired curvature as will later be explained, and as previously stated with respect to the curvature of the curved groove 64 of the earlier described embodiment of the invention.

The gear box 82 is provided with an internal bracket having a pair of parallel bores in which are slidably mounted identical two-part plungers identified in their entireties at 114, 115. These two-part plungers are each similar to the two-part plungers 66, 67 of the previously described form and each comprises inner and outer plunger parts operatively interconnected and held in extended relationship with respect to each other by a coil spring. The outer parts of the two-part plungers 114, 115 are provided at their outer ends with forks which are embraced by the forked outer ends of the opposite arms of a lever 116 which is rockably supported by the internal bracket that carries the two-part plungers. The lever 116 intermediate its ends and on its inner edge is provided with a V-notch with which a spring point 117 cooperates to hold the lever in its inactive position, as indicated in Fig. 13. The lever 116 is also provided intermediate its ends and on its outer edge with a laterally extending arm 118 which has its outer end of spherical formation. The arm 118 extends between the adjustable cam lugs 104, 105 of the block 101 and said cam lugs will abut one side or the other of said arm as said block moves linearly in opposite directions to rock the lever 116 in one direction or the other to move either the two-part plunger 114 inwardly and the two-part plunger 115 outwardly or vice versa as will later be further explained.

When the lever 116 is in its inactive position

13

as shown in Fig. 13, the two-part plungers 114 and 115 will have their inner ends extending slightly into the grooves 106, 107 of the hub 90 and said two-part plungers at such time prevent any axial shifting movement of the hub but permit the free rotation thereof.

It will further be noted that the driving plunger 88, depending upon the axial position of the hub 90, extends at all times either into the annular grooves 108, 109 or into the curved groove 112 of the hub, said driving plunger 88 being shown in Fig. 13 as extending into the straight walled section 113 of the curved groove 112.

In order to clearly explain the purpose of the construction shown in Figs. 12 to 25 inclusive and herein described the manner in which said construction functions will now be explained. Assuming that the operator has disengaged the shiftable clutch element 46 from the clutch element 39 to stop the movement of the slide before it has completed its forward feeding movement and while it was in feed as indicated in Fig. 12, it will be seen that at this time the two-part plungers 114, 115 extend slightly into the annular grooves 106, 107 to prevent axial shifting of the hub while the driving plunger 88 is in the straight walled section 113 of the curved groove 112 of the hub 90 as indicated in Fig. 13. At this time the arm 118 of the lever 116 is situated intermediate the cam lugs 104, 105 of the block 101 and which lugs have been positioned in accordance with the desired extent of travel of the slide 95 in opposite directions. At this time also the lever 116 is in its inactive position and is held in such position by the spring point 117. When the operator wishes to continue the forward feeding movement of the slide 95 and the parts being in the relationship shown in Fig. 12 he moves the control lever 81 to engage the shiftable clutch element 46 with the clutch element 39, whereupon the shaft 40 again rotates in timed relation to the rotation of the work spindle with a resultant rotation of the hub 90 and shaft 92 and screw 93 due to the driving action of the plunger 88 in the straight walled section 113 of the curved groove 112 and the fact that said hub portion is held against axial movement by the two-part plungers 114 and 115.

It will be noted by reference to Fig. 22 that the plunger 88 drives in the direction of the arrow 88a and that the hub revolves in the direction of the arrow 90a. The slide 95 is now moving forward in feed and the screw threaded shaft 100 is rotating in timed relation to the shaft 92 and the block 101 is moving linearly toward the left, as viewed in Fig. 12, in timed relation to the movement of the slide. As the slide 95 approaches the point at which its feeding movement is to be terminated the block 101 has moved sufficiently far so that the cam lug 105 has started to contact the arm 118 of the lever 116. The continued movement of the slide 95 and the block 101 causes the cam lug 105 to rock the lever 116 from the position shown in Figs. 12 and 13 to the position shown in Fig. 18, with a resultant radial inward movement of the two-part plunger 114 into the groove 106 and a withdrawal of the two-part plunger 115 from the groove 107.

The slight rotary movement of the hub 90 after the plunger 114 has moved into the groove 106 causes the plunger 114 to relatively travel out of the annular groove 106 and into the curved groove 110 as indicated by dash lines in Fig. 24 until said plunger has reached the straight walled section

14

111 of the curved groove at which time the rotation of the hub 90 is positively stopped.

It will be understood that the extent of the continued rotation of the hub 90 after the plunger 114 has been moved inwardly depends upon the position in which the plunger moves radially inwardly of the groove 106 with respect to the curved groove 110. It will be understood that should the plunger 114 move into the segment of the groove 106 of variable depth, the plunger will simply be momentarily depressed against its coil spring until it is in the part of the groove which is of maximum and constant depth.

It will also be understood that as the plunger 114 moves into the curved groove 110, as indicated by dash lines in Fig. 24, the hub 90 will be shifted axially toward the left, it being recalled that the plunger 115 has been moved entirely clear of the hub 90. This axial shifting of the hub 90 toward the left causes the driving plunger 88 to move out of the straight walled segment 113 of the curved groove 112 and through the latter as indicated by dash lines in Fig. 24 and into the annular groove 109, said driving plunger 88 reaching the annular groove simultaneously with the arrival of the two-part plunger 114 in the straight walled section 111 of the curved groove 110.

After the driving plunger 88 has moved into the annular groove 109 the continued rotation of the sleeve portion 85 simply causes said plunger 88 to travel around in the groove 109 in the direction indicated by the arrow 88a in Fig. 24 with the portion of the groove of varying depth acting to compress the plunger against its spring upon each revolution of the sleeve portion 85.

It will be understood that the arrangement of the plunger 114 in the straight walled section 111 of the curved groove 110 instantly and positively stops the rotation of the hub 90, screw 93 and the feeding movement of the slide 95 which is connected to the hub by an uninterrupted drive train. The stopping of the rotation of the hub 90 also results in stopping the linear left hand movement of the block 101 which likewise is connected to the hub through an uninterrupted drive train.

When the operator wishes to initiate the rearward movement of the slide 95 he shifts the control lever 81 to disengage the clutch element 46 from the clutch member 39 and engage said element with the clutch member 45, whereupon the shaft 40 will rotate in the opposite direction and at a more rapid rate. This reverse rotation of the shaft 40 causes the sleeve 85 and the driving plunger 88 to rotate in the opposite direction from that indicated in Figs. 22 and 24, with the result that the plunger 88 moves out of the annular groove 109 and into the curved groove 112 until it reaches the straight walled section 113 of the latter groove, as indicated in Fig. 22. This movement of the driving plunger 88 in the curved groove 112 and into the straight walled section 113 effects an axial shifting movement of the hub 90 toward the right with a resultant relative movement of the two-part plunger 114 out of the straight walled section 111 of the curved groove 110 and through the latter groove and into the annular groove 106. The instant that the driving plunger 88 engages in the curved groove 112 and the two-part plunger 114 rides out of the straight walled portion 111 the driving plunger 88 positively drives or rotates the hub 90 in the reverse direction with a gradual acceleration and this

reverse rotation of the hub results in a reverse rotation of the shaft 92, screw 93 and the screw threaded shaft 100, with the result that the slide 95 moves linearly rearwardly while the block 101 moves linearly toward the right. The movement of the block 101 results in the cam lug 105 moving out of engagement with the arm 118 of the lever 116 which allows the spring point 117 to act and restore the lever 116 to its inactive position as shown in Fig. 13, with the result that the two-part plunger 114 is moved radially outwardly and the two-part plunger 115 radially inwardly until both plungers are in the position shown in Fig. 13 wherein they act to hold the hub 90 against axial shifting movement but allow it to rotate freely.

It will be understood that when the two-part plunger 114 is moving radially outwardly from the position shown in Fig. 18 to the position shown in Fig. 13 the cam lug 105 controls the rate of such movement until the lever 116 has fully reached its inactive position and should the plunger 114 during this controlled movement contact the high portion of the groove 106 said plunger will be momentarily compressed against its spring. The slide 95 continues its rearward movement while the block 101 continues its linear movement toward the right until the cam lug 104 contacts the arm 118 of the lever 116.

When the slide 95 is near its predetermined limit of rearward movement the cam lug 104 has been brought by the movement of the block 101 into contact with the arm 118 of the lever 116. The continued rearward movement of the slide and the right hand movement of the block 101 results in said lever 116 being rocked from its inactive position shown in Fig. 13 into the position shown in Fig. 20. The rocking of the lever 116 to the active position of Fig. 20 withdraws the two-part plunger 114 completely from the groove 106 and moves the two-part plunger 115 radially inwardly of the groove 107, whereupon said two-part plunger 115 and the hub 90 are relatively displaced to cause the plunger 115 to ride out of the groove 107 and into the curved groove 110 until it is in the straight walled section 111 of the latter groove, this relative movement of the plunger being shown in Fig. 25 by dash lines.

The relative movement of the plunger 115 just referred to brings about the displacement of the hub in a right hand axial direction, with the result that the driving plunger 88 moves relatively to the curved groove 112 from the straight walled section 113 thereof and into the annular groove 108, such movement being indicated by dash lines in Fig. 25 and occurring simultaneously with the relative movement of the two-part plunger 115 into the straight walled section 111 of the curved groove 110, wherefore the instant that the two-part plunger 115 is in the straight walled section 111 said plunger functions to stop the reverse rotation of the hub 90 (indicated in Fig. 23 by arrow 90b) while the driving plunger 88 travels idly around in the groove 108 in the direction indicated by arrow 88b in Fig. 25, it being understood that the driving plunger 88 is compressed momentarily against its spring each time said plunger travels over the high part of the groove 108.

The stoppage of the reverse rotation of the hub 90 immediately acts through the uninterrupted drive trains to the screw 93 and slide 95 and to the block 101 to stop and position the same in their predetermined rearward locations. The

operator may allow the shaft 40 and the sleeve 85 to continue rotating idly in the reverse direction, but most probably he will shift the control lever 81 to disengage the movable clutch element 46 from the clutch member 45 and thus terminate the rotation of the shaft 40 and sleeve 85. He then can remove the finished work piece and insert a new work piece, after which he will shift the control lever 85 to engage the clutch element 46 with the clutch member 39 and start the rotation of the shaft 40 and sleeve 85 in the forward or feeding direction.

As soon as the sleeve 85 starts to rotate in the forward direction as indicated by the arrow 88a in Fig. 22 the driving plunger enters the curved groove 112 and travels relatively therein until it is in the straight walled section 113 of the groove as indicated by dash lines in Fig. 25. The relative movement of the driving plunger 88 into the curved groove 112 effects a left hand axial shifting of the hub 90, with the result that the two-part plunger 115 moves relatively in the curved groove 110 from the straight walled section 111 of the latter groove and into the annular groove 107 as indicated by dash lines in Fig. 25 and which movement of the two-part plunger 115 is simultaneous with the movement of the driving plunger 88. In other words, the instant that the driving plunger 88 rides into the curved groove 112 and the two-part plunger 115 rides out of the section 111 the hub 90 is free to rotate and the plunger 88 will so rotate the hub in the forward direction with a gradually accelerated movement. The rotation of the hub 90 in the forward direction immediately starts the feeding movement of the slide 95 and the linear movement of the block 101 toward the left. As the block 101 moves toward the left the cam lug 104 moving therewith allows the lever 116 to be rocked by the spring point 117 from the position shown in Fig. 20 to its inactive position as shown in Fig. 13 and at this latter time the two-part plungers 114 and 115 extend slightly into the grooves 106, 107 and hold the hub 90 against axial shifting and the condition indicated in Fig. 22 is now current.

It will be understood that during the movement of the lever 116 from the position of Fig. 20 to its inactive position as shown in Fig. 13 the two-part plunger 115 will be compressed each time it strikes the high point of the groove 107 until the lever 116 has reached its inactive position and such compression of the two-part lever 115 will assist the spring point 117 in restoring the lever to its inactive position. The slide 95 is again in feeding movement and the block 101 is moving linearly toward the left in timed relation to the feeding movement of the slide and the cycle of operation previously described will be repeated and the slide stopped and positioned accurately and repeatedly at the end of each of its forward movements and at the end of each of its rearward movements.

Although the slide 95 has been shown as not provided with an indexible turret for the sake of simplicity, it will be understood that the invention is readily adaptable for use in a machine tool employing an indexible turret on the side. In such case the indexing mechanism which is well known could be operatively connected to the block 101 to index the latter in a well known manner and such block would then be provided with a plurality of faces for sets of cam lugs 104, 105 and corresponding in number to the faces of the indexible turret.

It will be understood that although the invention has been shown as used in connection with the main slide of a machine tool it could be employed with equal facility in connection with other slides of a machine tool and including the cross slide carriage and cross slide and can also be employed in any other mechanism where such a clutching device is desirable.

It will be understood that the forward rotation of the shaft 40 need not be entirely in timed relation to the rotation of the work spindle, since said shaft can be rotated in the forward direction at a faster rate as is well known in the art in order to impart a fast forward movement to the slide and then a feeding movement and in such an arrangement the connecting and positioning device of the invention would function in the identical manner.

The grooves in the hubs 57 and 90 which connect the annular grooves in said hubs have been illustrated as curved grooves with intermediate straight walled sections extending axially of the hubs. It should be understood that said connecting grooves might have various forms of curvature or even might be straight angularly disposed forms of camming grooves interconnecting the annular grooves. However, in order to avoid a hammer blow effect in the starting and stopping of the parts and to provide a desirable and smooth acceleration and deceleration of the parts it is preferable and important to employ curved connecting grooves. Tests have indicated a particular form of curvature which may be followed in forming the curved portions of the grooves of the track system and which curvature is such that the movements of the driving plunger and the holding plunger therein will result in a gradual and smooth acceleration or deceleration in the speed of rotation of the hub and will avoid hammer blow effects. The particular form of curve just referred to is derived from a formula analogous to the law of falling bodies, since the degree of curvature of progressive portions of the curve decreases from the point of origin of the curve in proportion to the square of the distance traveled on the circumference of the hub. The foregoing statement refers to the curvature of the center line of the curved portions of the grooves.

The relative movement of the driving or holding plungers in the path of the groove from the straight walled sections of the groove toward the annular grooves of the track system is such that the circumferential distance which the plungers travel during progressive increments of their movements relative to the hub and axially thereof increases from the straight walled section in proportion to the square of the relative axial distance which they travel.

Fig. 26 illustrates the development of the preferred curve employed in forming the curved portions of the grooves constituting the track system in the peripheries of the hubs and in which curved portions the driving and holding plungers relatively travel. The point of origin of the curve of the curved portions is indicated at O and that portion of the curve derived from the formula extends to the point M, while the portion MN of the curve is formed on a radius. The equation employed in plotting the curve OM is as follows. $X^2=2PY$ where the quantity 2P is determined by the desired rate of hub acceleration or deceleration. In this instant case the quantity 2P is taken as .64 for one inch axial shifting of the hub. This formula enables each point of the

curve to be determined and plotted by assigning the actual values to the coordinates, for example to determine point K of the curve and either the distance X or Y as indicated in Fig. 26 being known, its actual value is substituted in the formula to determine the actual distance of the other. In laying out the curve OM a sufficient number of additional points can be located similarly by means of the formula to accurately define said curve.

Since the movement of the holding plungers from the straight walled section of the track system through the curved portion of the groove to the annular groove controls the rate of acceleration which can be imparted to the hub by the driving plunger, Fig. 26 illustrates by dash and dot lines such movement of the holding plunger 66. It will be understood that when the holding plunger 66 is moving from the straight walled section of the track system through the curved portion thereof to the annular groove the driving plunger is moving from an annular groove through a curved portion and toward the straight walled section and that such movement of the driving plunger in its respective curved portion of the groove is governed by the movement of the holding plunger in its respective curved portion of the groove. Therefore since the movement of the holding plunger is a controlling factor and in order to facilitate the description of the curve the action of the holding plunger 66 in the curved groove will be described. When the holding plunger 66 is retaining the hub stationary the center of said plunger is approximately at point H and when said plunger has moved its center to the point of origin O of the curve due to the axial shifting of the hub by the driving plunger said holding plunger is still in the straight walled section 65 of the groove 64. As the center of the plunger 66 moves from point O to point K1 it has traveled the distance of vertical increment 1, as indicated in Fig. 26, and which distance represents the axial displacement of the hub and said plunger has also traveled the slight distance of horizontal increment 1 and which distance represents the permitted relative rotation of the hub under the action of the driving plunger which is moving relatively in its respective curved portion of the groove as will be understood. The movement of the center of the holding plunger 66 from point K1 to point K2 takes place during the axial displacement of the hub by the driving plunger for the equal vertical increment 2 and such movement of the holding plunger permits a relative rotative movement of the hub under the action of the driving plunger as indicated by the larger horizontal increment 2. In the same way when the center of the holding plunger 66 moves from point K2 to point K3 as the hub is axially displaced a third equal vertical increment by the driving plunger, the permitted relative rotation of the hub under the action of the driving plunger is equal to horizontal increment 3 which is substantially greater than horizontal increments 1 and 2. As the center of the holding plunger moves relatively along the curve from point K3 toward point M as the hub is axially displaced in equally vertical increments for each successive relative movement of the holding plunger, as clearly shown in Fig. 26, the allowed relative rotation of the hub under the action of the driving plunger progressively increases for each such increment until the center of the holding plunger has reached point M of the curve. When the center of the holding

plunger has reached point M the hub will be rotating at substantially the speed of the driving plunger, as it will be recalled that the driving plunger 53 by this time has reached the straight walled section 65 of the groove. In other words, when the holding plunger 66 is in the straight walled section 65 of the groove said plunger is holding the hub against rotation while the driving plunger is idling in the annular groove 63. When rotation of the sleeve 50 is reversed the holding plunger 66 moves out of the straight walled section 65 and into the curved portion 64 of the groove due to the driving plunger 53 simultaneously moving out of the annular groove 63 and into the curved portion and exerting both driving and axially shifting effects upon the hub with the holding plunger controlling this driving effect and permitting the acceleration of the hub from zero to its maximum driving speed in the reverse direction as explained above. It will also be understood that conversely when the driving plunger 53 moves out of the straight walled section 65 and into the curved portion of the groove under the action of the holding plunger moving into the curved portion of the groove toward the straight walled section thereof, the rotation of the hub under the action of the driving plunger is controlled by the holding plunger and gradually decelerated from maximum speed to zero. Consequently the smooth acceleration and deceleration incident to starting and stopping the rotation of the hub eliminates hammer blow effects between the driving and holding plungers and the hub, since said plungers enter the straight walled section of the groove when the hub has reached full driving speed or has had its rotation substantially diminished.

Referring again to Fig. 26, it will be seen that the curve developed from the formula terminates at point M and from said point onward to point N the curvature is formed by a pure radius and merges into the annular grooves of the hub and provides for a smooth action when the plungers enter or leave the curved groove.

It will be understood that although the description relating to Fig. 26 has referred specifically to the curved groove 64 this was merely by way of example and that the same curvature is utilized for all of the curved grooves illustrated and described herein with respect to all of the embodiments of the invention.

Fig. 27 shows a different form of track system than those shown in the previous views. In this latter form the annular grooves are not interconnected by curved groove portions or sections with the latter joined by straight walled portions or sections. Referring to Fig. 27 it will be noted that the hub shown therein has annular grooves 119 and 120 from which extend, respectively, curved groove portions 121 and 122. The portion 121 has at its end a straight walled section 123 while the portion 122 similarly has a straight walled section 124. The sections 123 and 124 would constitute driving and stopping sections if this form of track system were substituted for that shown in Figs. 1 to 11 inclusive and would constitute separate stopping sections if used in place of the grooves 106, 107, 110 and 111 of the form shown in Figs. 12 to 25 inclusive.

Although several embodiments of the invention have been illustrated and described herein it will be understood that the invention is susceptible of such modifications and adaptations as come within the scope of the appended claims.

Having thus described our invention, we claim:

1. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position after a selected predetermined movement thereof and including a track system on one of said members and having endless portions and interconnecting portions therebetween, a driving element carried by the other of said members, and a stopping element mounted independently of said members, both of said elements cooperating with said track system the said driving element continuously engaged with said track system.

2. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position after a selected predetermined movement thereof and including a track system on one of said members and having endless portions and interconnecting portions therebetween with the latter portions including camming sections and a straight section, a driving element carried by the other of said members, and a stopping element mounted independently of said members, both of said elements cooperating with said track system the said driving element continuously engaged with said track system.

3. A device of the character described comprising a driving member, a member shiftable relative to said driving member and also movable therewith, and means selectively functioning to operatively connect the members for movement together and to positively stop said movable member in a predetermined position after a selected predetermined movement thereof with said driving member and including a track system on one of said members and having endless portions and interconnecting portions therebetween with the latter portions including camming sections and a straight section, a driving element carried by the other of said members, and a stopping element mounted independently of said members, said elements cooperating with said track system to cause shifting movement of said second named member relative to said driving member or movement thereof with said driving member or to stop said second named member, said driving element being continuously in engagement with said track system.

4. A device of the character described comprising a driving member, a second member shiftable relative to the driving member and also movable therewith, and means selectively functioning to operatively connect the members for movement together and to positively stop said second member in a predetermined position and including a track system on one of said members and having endless portions and interconnecting portions therebetween with the latter portions including camming sections and a straight section, a driving element carried by the other of said members and a stopping element mounted independently of said members, both of said elements cooperating with said track system to shift the second member relative to the driving member and into a stopping position or a driving position wherein each element may perform, respectively, its stopping or driving function, said driving element being continuously in engagement with said track system.

5. A device of the character described comprising a driving member, a movable member, and

means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position and including a system of endless grooves formed in one of said members, a driving element carried by the other of said members, and a stopping element mounted independently of said members, both of said elements cooperating with said system of endless grooves with said driving element continuously engaged in said grooves.

6. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position, and including a track system on one of said members and provided with a driving portion and with a stopping portion, a driving element carried by the other of said members and continuously cooperating with said track system and with the driving portion thereof, and a pair of elements mounted independently of said members and cooperating with said track system and alternately with said stopping portion thereof depending upon the direction of movement of the movable member.

7. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position and including a system of endless grooves formed in one of said members and provided with a driving and stopping portion, a driving element carried by the other of said members and continuously extending into and cooperating with said grooves and said portion thereof and another element mounted independently of said members and continuously extending into and cooperating with said grooves and with said portion thereof.

8. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position and including a system of endless grooves formed in one of said members and having a driving portion and a stopping portion, a driving element carried by the other of said members and continuously cooperating with said grooves and with the driving portion thereof, and a stopping element mounted independently of said members and cooperating with said grooves and with the stopping portion thereof.

9. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position and including a system of endless grooves formed in one of said members and having a driving portion and a stopping portion, a driving element carried by the other of said members and continuously cooperating with said grooves and with the driving portion thereof, and a pair of elements mounted independently of said members and cooperating with said grooves and alternately with the stopping portion thereof depending upon the direction of movement of said movable member.

10. A device of the character described comprising a reversible driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predeter-

mined position after a selected predetermined movement thereof in one direction and including a driving element carried by one of said members, a stopping element mounted independently of said members, and a track system on the other of said members and cooperating with both said driving and stopping elements, said driving element automatically cooperating with said track system when said driving member is reversed to render inactive said stopping element and to operatively interconnect said members to move the movable member in the reverse direction.

11. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position and including a driving element carried by one of said members, a stopping element mounted independently of said members, and a track system on the other of said members with which said elements cooperate with said driving element continuously engaging said track system, said track system comprising annular portions and interconnecting portions therebetween with the latter portions including curved sections and a straight section.

12. In a device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position and including a track system on one of said members and having a pair of annular portions and an interconnecting portion therebetween with said interconnecting portion including curved sections joined by a straight driving and stopping section, a driving element carried by the other of said members and continuously cooperating with said track system and with the driving and stopping section thereof to operatively interconnect the members, and a stopping element mounted independently of said members and continuously cooperating with said track system and with the driving and stopping section thereof to stop the movement of said movable member.

13. A device of the character described comprising a driving member, a second member capable of shifting movement relative to the driving member and also driven movement therewith, and means selectively functioning to operatively connect the members and to positively stop said second member in a predetermined position after a predetermined driven movement thereof and including a track system on one of said members and having a pair of annular portions and an interconnecting portion therebetween with the latter portion including curved sections joined by a straight driving and stopping section, a driving element carried by the other of said members, and a stopping element mounted independently of said members, each of said elements cooperating with said track system, with the driving element cooperating with one of the curved sections to shift the movable member and relatively displace the stopping element with respect to the driving and stopping section while the stopping element cooperates with the other curved section to shift said movable member and relatively displace the driving element with respect to said driving and stopping section.

14. In a device of the character described comprising a driving member, a second member

capable of shifting movement relative to the driving member and also of driven movement therewith, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position after a predetermined driven movement thereof and including a track system on one of said members comprising two pairs of annular portions with the annular portions of each pair interconnected by a connecting portion, each connecting portion including curved sections joined by a straight section, a driving element carried by the other of said members and cooperating with one pair of annular portions of said track system and with the curved sections of the interconnecting portion thereof to shift said movable member and with the straight section to drive said movable member, and a pair of stopping elements mounted independently of said members and cooperating with the other pair of annular portions of said track system and alternately with the curved sections of the connecting portions therebetween to shift said movable member and with the straight section to stop the movement of said movable member.

15. In combination, a slide, means for moving said slide in opposite directions and for positively stopping the movement thereof in predetermined positions and including a single driving member, a movable member, an uninterrupted operative connection between said movable member and said slide, and means for operatively connecting said members and for positively stopping the movable member and slide in a predetermined position and including a track system on one of said members, a driving element on the other of said members and cooperating with said track system to operatively interconnect the members, and a pair of stopping elements mounted independently of said members and alternately cooperating with said track system to stop the movement of the movable member and the slide in opposite directions, and control means moving in timed relation to said slide and operatively associated with said stopping elements for alternately rendering one or the other active depending upon the direction of movement of the slide.

16. A device of the character described comprising a driving member, a second member capable of shifting movement relative to the driving member and also capable of driven movement therewith, and means selectively functioning to operatively connect the members and to positively stop said second member in a predetermined position after a predetermined given movement thereof and including a track system on one of said members and having a pair of annular portions each of which connects with a curved section and a straight section, a driving element carried by the other of said members and cooperating with one of said annular portions of said track system to prevent shifting movement of said second member and with one of said curved sections to cause shifting movement of said member and with said straight section to drive said member, and a stopping element mounted independently of said members and cooperating with the other annular portion of said track system to prevent shifting movement of said second member and with the other curved section thereof to cause shifting movement of said second member and with the other straight section to stop the driven movement of the second member.

17. A device of the character described comprising a driving member, a second member capable of shifting movement relative to the driving member and also driven movement therewith, and means selectively functioning to operatively connect the members and to positively stop said second member in a predetermined position after a predetermined driven movement thereof and including a track system on one of said members and having annular portions, straight driving and stopping sections, and curved portions connecting said straight sections and said annular portions, a driving element carried by the other of said members and cooperating with certain of said annular portions, curved portions and straight sections of said track system, and a stopping element mounted independently of said members and cooperating with the other of said annular portions, straight sections and curved portions of said track system, said curved portions of said track system following a predetermined curvature such that the cooperation between said portions and the driving and stopping elements effects a smooth and gradual acceleration and deceleration of the second member in commencing the movement of said member and in stopping the movement thereof.

18. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position after a selected predetermined movement thereof and including a track system on one of said members and having endless portions communicating with camming portions and driving and stopping sections, a driving element carried by the other of said members and continuously cooperating with said track system and a stopping element mounted independently of said members and also cooperating with said track system, said camming portions having a predetermined contour such that the movement of the movable member is gradually and smoothly accelerated or decelerated upon the initiation of its movement by the driving element or upon the initiation of the stopping effect thereon by the stopping element.

19. A device of the character described comprising a driving member, a movable member, and means selectively functioning to operatively connect the members and to positively stop said movable member in a predetermined position after a selected predetermined movement thereof and including a track system on one of said members and having endless portions and curved portions and driving and stopping sections, a driving element carried by the other of said members, and a stopping element mounted independently of said members, both of said elements cooperating with said track system, the curvature of said curved portions following a formula based on the law of falling bodies, namely $X^2 = 2PY$ where the quantity $2P$ is determined by the rate of acceleration or deceleration desired for the movable member while X and Y represent the values of the coordinates for locating the points along the desired curve.

20. A device of the character described comprising a fixed shaft, a driving member freely rotatable on said shaft, a movable member freely rotatable and endwise movable on said shaft, and means selectively functioning to operatively connect the members and to positively stop rotation of said movable member in a predetermined po-

25

on and including a driving element, a stopping element and a track system cooperating with both of said driving and stopping elements.

21. A device of the character described comprising a fixed shaft, a driving member freely rotatable on said shaft, a movable member freely rotatable and endwise shiftable on said shaft, and means selectively functioning to operatively connect the members and to positively stop rotation of said movable member in a predetermined position after a selective predetermined movement thereof and including a track system on one of said members and having endless portions and interconnecting portions therebetween, a driving element carried by the other of said members, and a stopping element mounted independently of said members, both of said elements cooperating with said track system.

22. In combination a rotatable shaft, an elongated gear fixed thereto, a fixed shaft, a driving member freely rotatable on said fixed shaft, a movable member freely rotatable and endwise shiftable on said fixed shaft, gear means opera-

26

tively connected with said movable member and intermeshing with said elongated gear, and means selectively functioning to operatively connect the members and to positively stop rotation of said movable member in a predetermined position after a selective predetermined movement thereof and including a track system on one of said members and having endless portions and interconnecting portions therebetween, a driving element carried by the other of said members, and a stopping element mounted independently of said members, both of said elements cooperating with said track system.

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REFERENCES CITED

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

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Number	Name	Date
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