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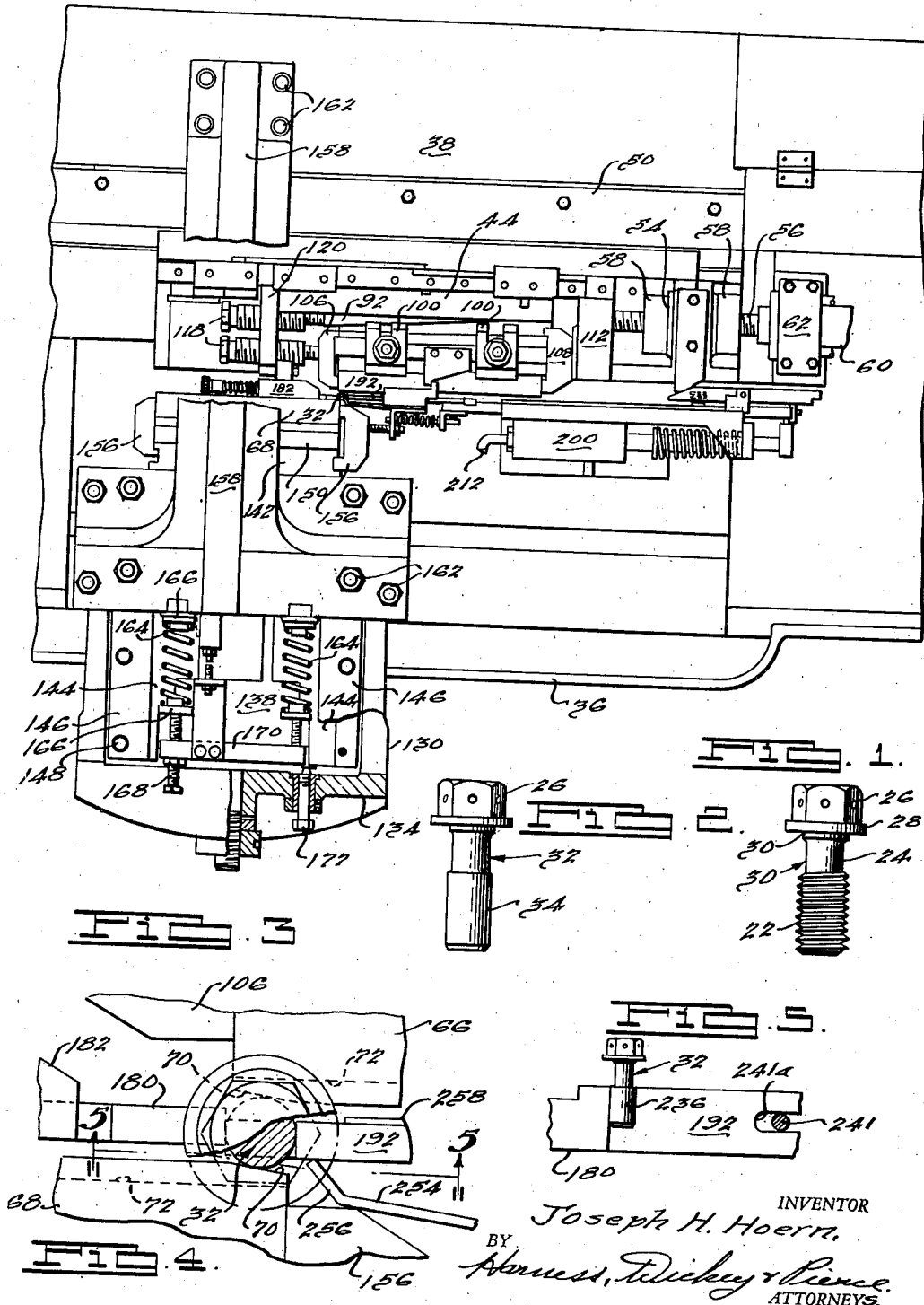
J. H. HOERN

2,367,398

THREAD ROLLING APPARATUS

Filed Aug. 5, 1943

4 Sheets-Sheet 1



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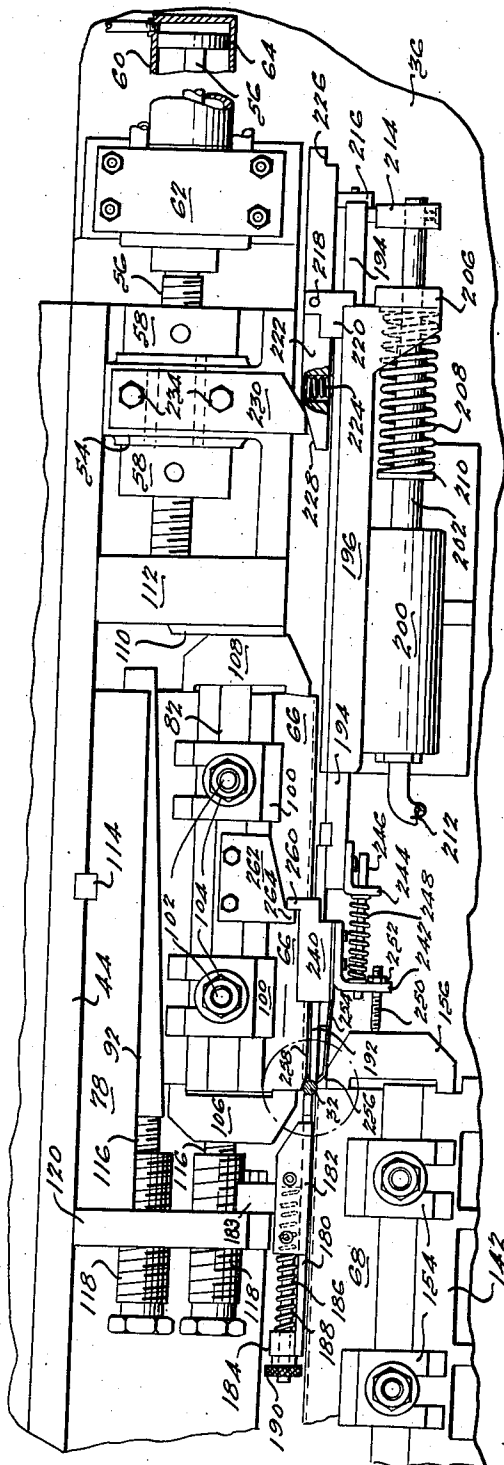
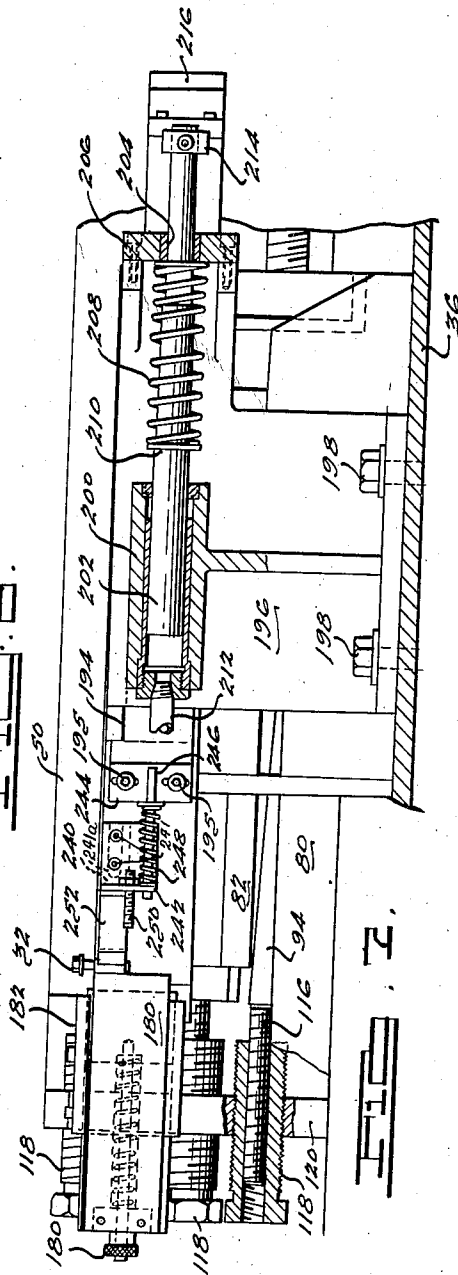
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THREAD ROLLING APPARATUS

Filed Aug. 5, 1943

4 Sheets-Sheet 2



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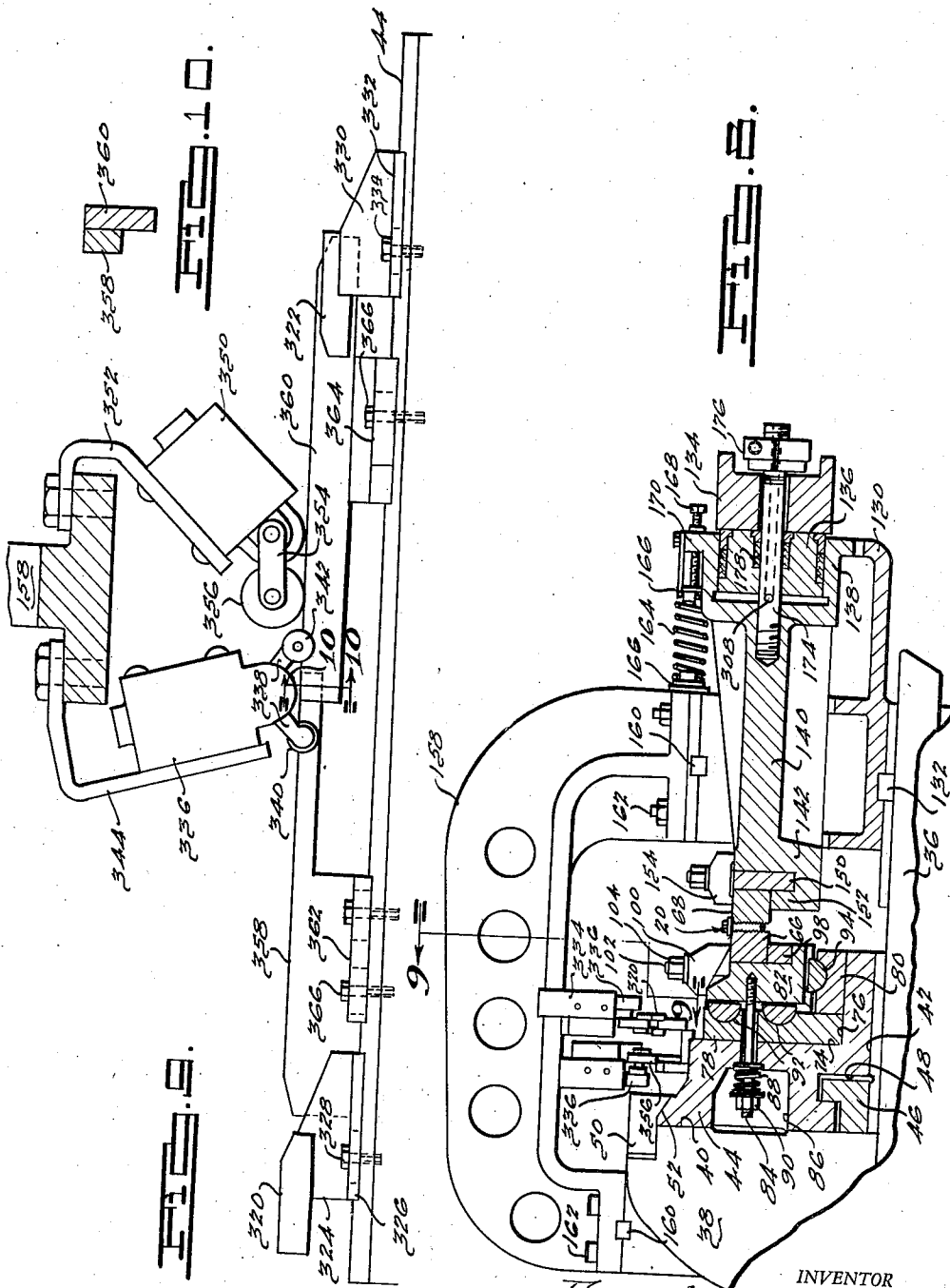
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THREAD ROLLING APPARATUS

Filed Aug. 5, 1943

4 Sheets-Sheet 3



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THREAD ROLLING APPARATUS

Filed Aug. 5, 1943

4 Sheets-Sheet 4

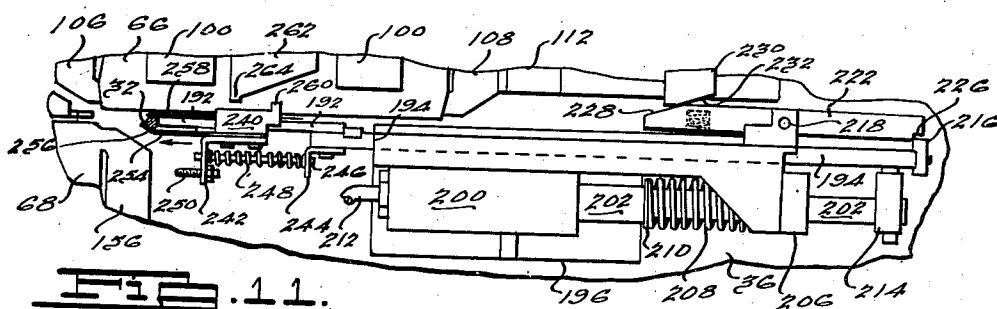


FIG. 11.

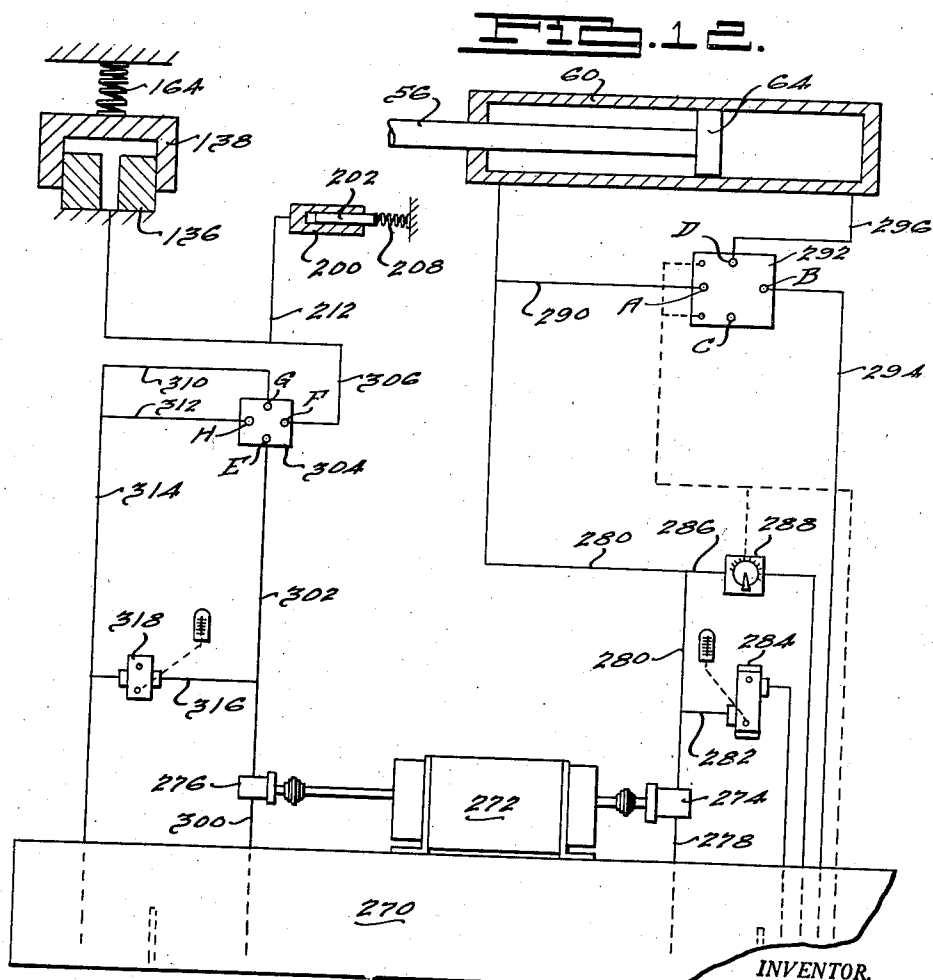


FIG. 12.

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UNITED STATES PATENT OFFICE

2,367,398

THREAD ROLLING APPARATUS

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Application August 5, 1943, Serial No. 497,417

15 Claims. (Cl. 80—8)

This invention relates to thread rolling apparatus and has for its principal object the provision of an improved apparatus of this type by the use of which more accurate and better finished threads may be provided upon a workpiece than is possible with conventional thread rolling apparatus.

Objects of the invention include the provision of thread rolling apparatus by means of which threads may be rolled upon workpieces in a highly accurate manner; the provision of apparatus of the type described in which distortion of the desired cross-sectional configuration of the work during the rolling operation is effectively eliminated; the provision of thread rolling apparatus of the type described in which the overlapping of metal in the threads of the workpiece may be effectively eliminated; and the provision of thread rolling apparatus in which the concentricity of the thread with respect to the axis of the work may be assured.

Other objects of the invention include the provision of a thread rolling machine including a pair of flat dies between which the part to be threaded is rolled, together with means for effecting relative longitudinal movement between the dies at a uniform speed; the provision of a thread rolling apparatus of the type described in which the relative longitudinal movement between the dies is effected by means of hydraulic pressure; the provision of thread rolling apparatus of the type described in which one of the dies is reciprocated longitudinally and the other of the dies is reciprocated laterally; and the provision of a construction as above described in which means are provided for controlling the relative reciprocatory movements of the two dies in timed relation with respect to each other and in which the rolling operation upon the work between the dies is initiated while the dies are relatively separated laterally from one another and the dies are advanced laterally with respect to each other before completion of the rolling operation upon a piece of work.

Further objects of the invention include the provision of apparatus of the type described including new and novel means for positioning and locating the blank with respect to the dies at the initiation of the rolling operation; the provision of apparatus of the type described including a novel form of work feeding mechanism; the provision of apparatus of the type described including a novel form of die adjustment and locking means therefor; and the provision of ap-

paratus of the type described including a novel form of control cam structure.

The above being among the objects of the present invention the same consists in certain novel details of construction and combinations of parts to be hereinafter disclosed with reference to the accompanying drawings, and then claimed, having the above and other objects in view.

In the accompanying drawings which illustrate a suitable embodiment of the present invention and in which like numerals refer to like parts throughout the several different views,

Fig. 1 is a side elevational view of a typical form of screw capable of being threaded by the apparatus of the present invention;

Fig. 2 is a side elevational view of the blank from which the screw shown in Fig. 1 is made;

Fig. 3 is a fragmentary, partially broken, partially sectioned plan view of my improved apparatus;

Fig. 4 is an enlarged, partially broken, partially sectioned view of a portion of the apparatus shown in Fig. 3 and including the advanced ends of the dies therefor, illustrating the dies in the position they assume at the moment of the initiation of the thread rolling operation upon a work blank gripped therebetween;

Fig. 5 is a reduced fragmentary sectional view taken on the line 5—5 of Fig. 4 and illustrating the manner in which the pusher bar engages the work blank and serves as a locating stop for controlling the axial position thereof;

Fig. 6 is an enlarged fragmentary, partially broken, partially sectioned plan view of that portion of the apparatus shown in Fig. 3 including the dies and more adjacent parts of the apparatus, the dies being illustrated in the position which they assume at the moment of gripping a piece of work between them to initiate a rolling operation upon the work;

Fig. 7 is a fragmentary partially broken, partially sectioned elevational view of the apparatus shown in Fig. 6;

Fig. 8 is a fragmentary vertical sectional view taken transversely through the apparatus shown in Fig. 3 with certain parts thereof broken away to better illustrate the construction of the same and particularly the hydraulic cylinder and piston assembly utilized for controlling the laterally shiftable position of one of the thread rolling dies;

Fig. 9 is an enlarged fragmentary, partially broken side elevational view, taken on line 9 of Fig. 8, showing the control cams and switches operated thereby for the apparatus shown in the preceding views;

Fig. 10 is a slightly enlarged transverse vertical sectional view taken on the line 10—10 of Fig. 9 and illustrating in greater detail the manner of constructing one of the cams;

Fig. 11 is a view somewhat similar to Fig. 6 but on a reduced scale and illustrating the mechanism for controlling the movement of the pusher bar in a different position of operation; and,

Fig. 12 is a more or less diagrammatic view illustrating the hydraulic system for controlling the movement of the various hydraulic cylinders and/or pistons.

The present invention relates to the apparatus which has been developed for commercially carrying out the method of rolling threads disclosed and claimed in my copending application for Letters Patent of the United States for improvements in Method of rolling threads, filed June 4, 1943, and serially numbered 489,639. The method disclosed in said copending application involves the use of flat dies which are relatively reciprocable in the direction of their length and in addition are relatively reciprocable toward and from each other transversely of their length. The dies are separated one from another by a distance less than that external diameter of the blank upon which the threads are to be rolled but by an amount greater than that required to form completed threads upon the work, relative longitudinal reciprocation of the dies is initiated while in laterally separated condition, the work or work blank is introduced between the dies and is caused to rotate through at least 180 degrees between them while in laterally separated condition, after which the dies are caused to laterally advance one toward the other during continued relative longitudinal reciprocation until they are laterally spaced from one another by a distance required to form the completed threads upon the work. It has been found that by following out this method threads may be formed on a workpiece with extreme accuracy and held to unusually close tolerances, in fact to an extent not possible by the use of thread rolling apparatus heretofore suggested.

It will, therefore, be appreciated from the above that the apparatus of the present invention contemplates the use of flat thread rolling dies, the opposed faces of which are longitudinally grooved in complementary relationship with respect to the cross-sectional configuration of the threads to be formed on the work, in which means are provided for effecting relative longitudinal reciprocation of the dies, specifically by reciprocating one of the dies longitudinally with respect to the other, and in which means are provided for effecting lateral reciprocation of the other dies by mounting the other of the dies for movement transversely of its length toward and from the path of movement of the first-mentioned die. It necessarily involves means for effecting the reciprocatory movement of the dies above referred to, for the support and adjustment of the dies themselves, for the proper locating of the work with respect to the dies, for the insertion of the work between the dies at the proper moment, for the control of the reciprocatory movement of the dies and work feeding means, and numerous other features of construction forming more limited phases of the present invention.

Referring now to the accompanying drawings and particularly to Fig. 1, there is there shown simply as a matter of illustration a screw that is typical of the type that may be provided with threads in accordance with the present invention.

The screw is indicated generally at 20 and as being provided with a threaded end portion 22, an unthreaded shank 24 of reduced diameter, and a head 26 of hexagonal cross-sectional configuration, the particular screw shown being provided with a circular flange 28 at the base of the head 26 followed by a short pilot portion 30 joining the shank 24. For the purpose of illustration it may be assumed that the threads 22 are of the conventional V-type.

The screw indicated generally at 20 in Fig. 1 is formed from a blank indicated generally at 32 in Fig. 2, the blank 32 being identical to the screw 20 with the exception that the threaded end portion 22 is not present but instead it is provided with a smooth cylindrical end portion 34 which is to be acted upon by the apparatus of the present invention to form the threads 22 thereon. The end 34, where the threads are to be of the conventional V-type, is of an external diameter substantially equal to and no greater than the maximum allowable pitch diameter for the screw 20, as will be appreciated by those skilled in the art. It will be understood that the particular screw 20 shown is merely indicative of one type of screw element that may be threaded by the apparatus of the present invention, minor changes being made as, for instance, in the pusher bar and in the dies, to adapt the apparatus to form any other size or type of screw element or type of threads thereon.

The machine or apparatus includes a base 36 having a substantially flat top surface from which an integrally formed and relatively massive part 38 projects upwardly along the rear edge thereof. The forward face of the part 38 is vertically disposed and finished to form a vertical way surface 40 parallel with the front face of the base and that portion of the base 36 immediately forwardly or outwardly of the way 40 is finished to provide a horizontal way portion 42 best brought out in Fig. 8. An elongated slide 44 is mounted for reciprocation on the ways 40 and 42. The slide 44 is maintained against outward movement with respect to the way 40 by means of an angle-shaped guide member 46 suitably fixed to the base of the machine at the junction of the ways 40 and 42 and slidably interfitted with a complementarily shaped groove 48 in the slide 40. The slide 44 is maintained in contact with the way 42 and also the upper end of the way 40 by means of a longitudinally extending guide bar 50 secured to the upper edge of the part 38 and having a downwardly and outwardly inclined lower face 52 fitting the complementarily shaped upper rear edge of the slide 44.

The righthand end of the slide 44 as viewed in the drawings is provided with an upstanding flange 54 extending transversely of the length thereof through which the threaded end of a piston rod 56, disposed in parallel relation with respect to the path of movement of the slide 44 on the ways 40 and 42, projects. Nuts 58 threaded on the piston rod 56 and bearing against opposite sides of the flange 54 serve to adjustably but rigidly secure the piston rod 56 to the slide 44. As best brought out in Fig. 6 the piston rod 56 projects into a cylinder 60, removably fixed to the base 36 by means of a clamp 62, and arranged in axially parallel relation with respect to the path of movement of the slide 44 on the ways 40 and 42. Within the cylinder 60 the piston rod 56 is provided with a conventional piston 64 thereon. Means which will hereinafter be more fully explained in connection with the

description of Fig. 12 is provided for introducing liquid under pressure to either one end of the cylinder 60 or the other end thereof and exhausting it from the remaining end so as to cause reciprocation of the piston 64 in the cylinder and through it effect reciprocation of the slide 44 on the ways 40 and 42.

The slide 44 carries one of a pair of cooperating thread rolling dies 66 and 68 which, as brought out in the drawings, have opposed flat side faces which are longitudinally grooved as brought out in Fig. 8 in cross-sectional conformation complementary to the cross-sectional conformation of the threads to be formed on the work, in this case shown as the screw 20. As best brought out in Fig. 4 the operative faces of the dies 66 and 68 are flat over their entire length except at their advanced ends where they are slightly beveled off as indicated at 70, preferably at an angle of approximately 15 degrees to the plane of the operative faces thereof, and to a depth less than the depth of the threads on the operative face thereof the bottoms of which are indicated at 72 in Fig. 4.

As best brought out in Fig. 8, in order to support the die 66 the slide 44 is formed to provide a pair of intersecting plane faces 74 and 76 in parallel relation with respect to the ways 40 and 42, respectively. A substantially flat plate 78 seats against the face 74 and a smaller plate 80 seats against the surface 76 and in abutting relationship with respect to the outer face of the plate 78. A die carrier 82 is received in the angle between the plates 78 and 80 and is constantly urged toward the plate 78 by means of one or more studs 84 which thread into its back face and extends into perpendicular relationship with respect to the surface 74 through the plate member 78 and the forward wall of the slide 44 through holes provided for therein and in which holes each stud 84 is freely received so as to permit a limited amount of displacement thereof both laterally of and angularly with respect to the axes of such holes. The rear face of the slide 44 is cored out to provide a pocket 86 in line with each stud 84 and within each pocket 86 a coil spring 88 surrounding the outer end of the stud 84 therein is maintained under compression between the righthand wall of the pocket 86, as viewed in Fig. 8, and a washer held on the outer end of the stud 84 by means of a nut 90.

The die 66 is supported from the members 78 and 80 within the angle formed thereby by means of adjusting wedges 92 carried by the member 78 and an adjusting wedge 94 carried by the member 80 and while in the broader aspects of the invention the die 66 might be formed to be directly receivable by the wedges 92 and 94, rather than employ the rather bulky die which would thus result and to eliminate the mass of high priced die material which would otherwise have to be employed, the die 66 is received and supported on the angularly sectioned member or die carrier 82 which is directly received by the wedges 92 and 94 and into which the stud 84 is threaded, the die 66 being spaced from the leg of the carrier 82 by means of a spacer block 98. The spacer block 98 is employed simply for the reason that in the particular case shown the die 66 is of less depth than the angle of the carrier 82 in which it is received, it being appreciated that where a die equivalent to the die 66 is employed and of a depth equal to the combined depth of the die 66 and spacer block 98 shown no spacer block will be required under such circumstances.

The die 66 is clamped in position on the carrier 82 by means of a pair of clamps 100 which bridge the upper edge of the carrier 82 and the upper face of the die 66 and are drawn downwardly with respect to the carrier by cooperating studs 102 and nuts 104.

As best brought out in Fig. 6, endwise movement of the die 66 with respect to the carrier 82 is prevented by means of clamps 106 and 108 bridging the opposite ends of the die 66 and carrier 82. The clamp 106 is suitably drawn inwardly of the carrier 82 by a suitable stud and nut (not shown) of the same character as the studs 102 and nuts 104. Also as best brought out in Fig. 6 the righthand clamp 108 is interposed between the corresponding ends of the carrier 82 and die 66 and a vertical surface 110 formed on an upwardly directed flange 112 fixed with respect to the slide 44, this serving to transmit the thrust of a working stroke on the die 66 directly to the slide. The member 78 is restrained against relative longitudinal movement with respect to the slide 44 by means of a key 114, shown in Fig. 6, interconnecting these members. The member 80 is similarly maintained against relative longitudinal movement with respect to the slide 44 by an equivalent key (not shown).

As best brought out in Fig. 8 the wedges 92 and 94 are formed from cylindrical stock which is flattened off on one side, as best brought out in Fig. 6. The thickness of the wedges 92 and 94 measured in a direction perpendicular to the flattened faces varies from one end thereof to the opposite end thereof in order to get the wedge-like effect. The semi-cylindrical seat in the members 78 and 80 for receiving the wedges 92 and 94, respectively, are arranged with their axes parallel to the faces 74 and 76 of the slide 44 and consequently parallel to the ways 40 and 42, respectively, the cooperating faces of the carrier 82 being tapered into conformity with the taper of the flat faces of the wedges. Thus not only may the wedges 92 and 94 rock about their axes to adjust their flat faces into flat contacting relationship with respect to the carrier 82 but they also rock when the wedges are adjusted to tip the carrier 82 and consequently the die 66 to adjust the operative face of the die 66 into parallelism with the operative face of the die 68, or at any desired angle with respect thereto. For instance, should it be desired to adjust the die 66 from the position shown in Fig. 8 in which its operative face is parallel to the operative face of the die 68 to a position for rolling pipe threads, for instance, on a workpiece, and which pipe threads are tapered in diameter as is conventionally understood, the upper wedge 92 would be withdrawn and the lower wedge 92 would be advanced. The carrier 82 and the die 66 carried thereby will thereby be adjusted to bring the lower edge of the die 66 into closer relationship with respect to the die 68 than the upper edge thereof. The opposed faces of the dies may thus be adjusted into conformity with the taper desired in the finally threaded product. Similarly if a taper is desired in the opposite direction the wedges 92 may be adjusted to tip the operative face of the die 66 to correspond with that desired. Equal adjustment of both wedges 92 in the same direction may be effected to bodily shift the die 66 toward or from the die 68 for the purpose of varying the lateral spacing between them, although this is best controlled by the stops for limiting the shifting

movement of the die 68 as will later be described. It will be understood, of course, that during such adjustment the clamps 106 and 108 will be loosened to permit the desired freedom of movement of the carrier 82 and the die 66 fixed with respect thereto.

Movement of the lower wedge 94 about its axis will, of course, occur during adjustment of the wedges 92 as above described so as to maintain its flat contacting relationship with respect to the lower face of the member 96. However, the importance of the wedge 94 is in adjusting the vertical position of the carrier 82 and die 66 so as to enable the threads on the operative face of the die 66 to be vertically adjusted with respect to those on the operative face of the die 68 so that both will be accurately located with respect to the threads being formed on a workpiece received between them. As will be appreciated in such case movement of the wedge 94 inwardly as viewed in Fig. 8 will raise the carrier 82 and die block 66 while withdrawal will lower it. This last-mentioned adjustment of the die 66 is of extreme importance inasmuch as unless the threads on the operative faces of the dies 66 and 68 are positioned vertically with respect to each other in an exact position the threads formed on a workpiece will not be perfect threads and unless so perfectly related to one another it may cause overlapping of the metal in the threads of the workpiece and other undesirable imperfections.

For the above reasons it is desirable that means be provided for an extremely fine adjustment of both the angularity and the vertical position of the carrier 82 and the die 66 carried thereby and in accordance with the present invention this adjustment, which is brought out in Fig. 6, is accomplished in the following manner. Each wedge 92 and 94 is provided at the large or lefthand end thereof as viewed in Fig. 6 with a threaded stud-like extension 116 which may be formed integrally therewith or formed separately therefrom and secured thereto. Threaded over each stud 116 is a hollow screw 118, the screws 118 being externally threaded and in turn threading into an upwardly directed flange 120 formed integrally with the slide 44. The threads on the studs 116 and in the bore of the screws 118 are of a finer pitch than the threads on the exterior of the screws 118 so that the connection between the slide 44 and the wedges 92 and 94 is a differentially threaded connection. In other words, it will be appreciated that as one of the screws 118 is threaded inwardly, for instance, in the flange 120 it is at the same time relatively threading inwardly on the stud 116 of the corresponding wedge 92 or 94 and tends to withdraw the latter, so that the real movement of the corresponding wedge 92 or 94 during each rotation of the corresponding screw 118 is equal to the difference in the pitch of the threads on the stud 116 and those on the screw 118. Preferably the pitch of the threads is so chosen that, for instance, where the screws 118 are provided with hexagonal heads as shown, a one-sixth of a turn of a screw 118 may advance the cooperating wedge 92 or 94 a sufficient distance to shift the die 66 an amount equal to 0.0001", in which case the hexagonal heads on the screws 118 serve as a means by which the actual amount of shifting movement of the die 66 thereby may be accurately determined. Any other suitable means may, of course, be employed to visually or otherwise indicate the shifting movement of the wedges and/or die 66. It will

be appreciated that by this form of adjusting means extremely fine and accurate adjustment of the die 66, both about its longitudinal axis and bodily laterally and vertically may be obtained.

As previously explained the die 68 is mounted for bodily shiftable movement transversely of its length toward and away from the plane of movement of the die 66. In order to support die 68 for this movement the following mechanism is provided. Referring particularly to Figs. 3 and 8 it will be noted that a relatively heavy casting in the form of a cradle 130 is suitably fixed to the upper face of the base 36 adjacent the outer edge thereof by bolts (not shown), a key 132 being employed between the cradle 130 and base 36 as indicated in Fig. 8 to accurately locate the cradle on the base and to prevent outward shifting movement thereof under the force of the thread rolling operation. The cradle 130 at the front end of the machine (at the right as viewed in Fig. 8) is provided with a relatively heavy cross-bar 134 which may be formed either integrally therewith, or separately therefrom and rigidly secured thereto.

As indicated best in Fig. 8 a piston 136 is rigidly fixed to the inner face of the cross-bar 134 by suitable means (not shown) with its axis disposed perpendicularly with respect to the plane of the way 40. Surrounding the piston 136 is a cylinder 138 the outer end of which is closed and which has formed integrally therewith an inwardly or rearwardly extending horizontal bar portion 140 terminating at its inner end in a die supporting head 142. The cylinder 138 and bar 140 are provided on opposite sides thereof as indicated in Fig. 3 with an outwardly projecting flange 144 parallel to the axis of the cylinder 138 forming slides which are received in ways provided on the cradle 130 for supporting and guiding the cylinder 138, bar 140, and head 142 for movement toward and from the die 66. Plates 146 overlying the flanges 144 and secured to the cradle 130 by means of screws 148 serve to maintain the flanges 144 in close sliding engagement with their cooperating ways on the cradle 130 in accordance with conventional practice.

The inner operative end face of the head 142 is notched out to provide a die receiving recess and in which notched out portion is received a block 150 which serves as a backing for the die 68 and a spacer block 152 below the die 68 which serves the same purpose as the spacer block 98 for the die 66. One or more clamps 154, shown in Fig. 3, acting in a downwardly direction serve to clamp the die 68 in position against the plate 150 and block 152 and similar clamps 156, shown in Fig. 3, engaged between the die 68 and the head 142 at each side of the latter serve to maintain the die 68 against longitudinal displacement on the head 142.

It will be appreciated that the cradle 130 must be held as securely as possible against springing away from the die 66 during operation and in order to aid in this respect a relatively heavy bridge member 158, of inverted U-shape in side elevation, is extended between the portion 38 of the base 36 and a suitable seat therefor formed on the upper portion of the cradle 130, it being secured to these parts by means of keys 160 and bolts or screws 162.

The cylinder 138 is constantly urged outwardly, in a direction to separate the die 68 from the die 66, by means of a pair of coil springs 164 each interposed between a pair of stops 166 one of which stops is carried by the bridge member 158

and the other of which is carried on the end of an adjusting screw 168 threaded through an up-standing flange 170 formed integrally with the outer end of the cylinder 138, the screws 168 being adjustable to vary the compressive force of the springs 164 tending to move the cylinder 138 outwardly as will be readily appreciated. The extent to which the cylinder may thus be moved outwardly under the influence of the springs 164 is controlled by means of one or more stop screws 172, shown in Fig. 3, each threaded through the cross-bar 134 and with its inner end arranged for engagement with the outer end of the cylinder 138 or one of the ways 144 therefor.

Inward movement of the cylinder 138 on the piston 136 is limited by means of a stud 174 which projects axially through the piston 136 and is threaded at its inner end into the bar 40. The outer end slidably projects through an opening in the cross-bar 134 provided therefor and outwardly of the cross-bar 134 is provided with a stop nut 176 thereon. Suitable packing 178 carried by the piston 136 seals the slidable joint between the stud 174 and piston 136 against leakage. The stud is hollow and forms the passage for introducing fluid under pressure to the space between the piston 136 and the blind end of the cylinder 138 as will hereinafter be more clearly brought out.

From the foregoing it will be appreciated that the mechanism thus far described provides means whereby the die 66 may be longitudinally reciprocated and the die 68 reciprocated in a direction perpendicular thereto, in other words, laterally. With this arrangement, in carrying out the method disclosed in my co-pending application above identified the stop screws 172, which limit the outward movement of the cylinder 138 on the piston 136, are so adjusted that the outward movement of the cylinder 136 under the influence of the springs 164 is limited so that the die 68 will be separated laterally from the die 66 by an amount such that the spacing between the dies 66 and 68 will be less than the diameter of the portion 34 of the blank 32 but greater than the root diameter of the threads on the threaded end 22 of the screw 20 to be formed, the distance or spacing between the dies 66 and 68 under such circumstances preferably being in the neighborhood of 0.020" less than the diameter of the end 34 of the blank 32 so that when the dies are in such position and the blank 32 is introduced between them they will cause grooves approximately 0.010" deep to be formed in the blank. The figures above given are those preferably employed for a bolt of approximately $\frac{5}{8}$ of an inch in diameter but may be varied to a greater or lesser extent depending upon the desires of the individual operator, the important point being that the amount of impression of the dies in the work or blank at the initiation of the thread rolling operation should be sufficient to positively initiate rolling of the work between the dies without endangering slippage with respect to the dies, this feature being utilized to insure absolute synchronization between the dies and the work which is required if perfect threads are to result. The relative relation of the blank 32 and the dies at the initiation of the thread rolling operation is best brought out in Fig. 4 from which it will be noted that the blank 32 is shown at the moment it is gripped between the beveled ends 70 of the dies 66 and 68. These beveled ends are cut away to a less depth than the depth of the threads on the dies and consequently the threads

of the dies will be imbedded only to a partial extent in the work during a continued movement of the die 66 to the left as viewed in Fig. 4 and while the die 68 remains in the position shown.

After the die 66 has moved longitudinally from the position illustrated in Fig. 4 to such an extent as to cause the blank 32 gripped between it and the die 66 to be rotated through at least 180°, which thus causes continuous but incomplete threads to be formed on the blank 32, then fluid pressure is introduced between the lefthand end of the piston 136, as viewed in Fig. 8, and the corresponding end of the cylinder 138. This fluid pressure acts to move the cylinder 138 and die 68 inwardly, to the left as viewed in Fig. 8, against the force of the springs 164. This operation occurs during longitudinal movement of the die 66 and the inward movement of the die 68 under such circumstances is limited by contact of the nut 176 on the stud 174 with the outer face of the cross-bar 134 to such position of the die 68 that the spacing between it and the die 66 is that required to form the completed thread on the blank and thus provide the end 22 illustrated in Fig. 1. The spacing of the dies 66 and 68 under the last-mentioned condition is, therefore, the same as the spacing of the dies in conventional thread rolling machines employing flat dies. The mechanism employed for controlling the position of the die 68 by application of the fluid pressure in the cylinder 138 during longitudinal movement of the die 66 will be described later.

The reciprocation of the slide 44 and die 66 by hydraulic pressure acting on the piston 54 in the cylinder 60 is of advantage as compared to conventional thread drilling apparatus employing flat dies as heretofore constructed in that by the use of hydraulic cylinder and piston the slide 44 and die 66 may be reciprocated at a constant speed over the full length of the operative and inoperative strokes thereof, while in the conventional crank operated type of construction, the speed of the die increases to the midpoint of the stroke and then decreases to the end of the stroke. There is, of course, a speed at which a die such as the die 66 should not exceed if it is to be operated continuously without undue breaking down of its threaded or grooved surface. In the conventional type of thread rolling apparatus this will be the maximum speed at the midpoint of the stroke and during the remaining portion of the stroke the speed will be less than that capable of being commercially employed. With the apparatus of the present invention the flow of hydraulic fluid to the cylinder 60 may be controlled so that the speed of the die 66 on the operating stroke will be the maximum safe operating speed over the entire length thereof. The construction, therefore, is one in which more work may be turned out in a given time than in conventional constructions. Furthermore, by suitably adjusting the flow of hydraulic fluid to the cylinder 60 the die 66 may be returned on its inoperative stroke at a speed in excess of that at which it operates on its operative stroke, thereby permitting a further increase in the speed of operation as compared to conventional constructions. Additionally, it will be appreciated that the speed of operation of the die 66 on its operative stroke will vary according to the character of the material from which the blanks are formed, the harder the material the slower the speed of operation. Thus by operating the die 66 hydraulically and controlling the rate of flow of the hydraulic fluid to the cylinder 60 the speed of operation of the die

66 may be readily and quickly varied to accommodate it to the characteristics of the material from which the blanks being formed are made. Any equivalent change in conventional thread rolling apparatus can only be obtained by changing gears or following out like operations which not only are inconvenient but which necessarily require a material amount of time to accomplish.

In order to insure that the threads which are formed on the blank will be concentric with the axis of the blank, and not eccentric thereto as so often occurs with screw parts made on conventional thread rolling apparatus, and to insure that the threads on both the dies 66 and 68 will be synchronized with each other in forming the threads on the blank, it is necessary that the blank in being introduced between the dies is introduced at a predetermined point in their relative longitudinal movement and centrally between the dies. To accomplish this a stop is provided for engagement with the blank and in cooperation with the die 66 such that when the blank is in engagement with the stop and the die 66 it will be located centrally between the dies 66 and 68 when the latter are in the laterally separated condition that they assume at the moment of initiation of the rolling operation, and means are provided for urging the blank against the stop at such time.

The above described stop consists of a flat bar-like element 180 arranged with the plane of its thickness vertical and parallel with the ways 40 and 42. It is positioned substantially centrally of the space between the dies 66 and 68 as best brought out in Fig. 6 and is mounted for longitudinal sliding movement in a block 182 fixed with respect to the slide 44 by means of a lug or ear 183 formed integrally therewith and bolted to the flange 120 formed integrally with the slide 44, as best brought out in Fig. 6. At its lefthand end it is provided with an inwardly projecting boss 184 in which a stud 186 arranged in parallel relation with respect to the path of movement of the stop 180, is slidably received. The righthand end of the stud 186 as viewed in Fig. 6 is fixed in the block 182 and a coil compression spring 188 surrounding the stud 186 between the block 182 and the boss 184 constantly urges the stop 180 to the left as viewed in Fig. 6. A nut 190 threaded on the stud 186 to the left of the boss 184 limits the outward movement of the stop 180 under the influence of the spring 188. The inner or righthand end of the stop 180, as best brought out in Fig. 5, is formed for engagement with the surface 34 of the blank 32 and so as to hold the blank 32 with its axis vertical when the latter is in contact therewith. Where the blank 32 is provided with a cylindrical end portion 34 to be threaded, it will be appreciated that the operative end of the stop 180 is, therefore, located in a plane perpendicular to the direction of reciprocation of the die 66.

The stop 180 is longitudinally adjusted by means of the nut 190 so that, as best brought out in Fig. 4, when the blank 32 is urged into contact with the operative end of the stop 180 and against the corresponding angular end portion 70 of the die 66 the blank 32 will be arranged centrally of the dies 66 and 68 at the moment the rolling operation is initiated, thus insuring that the blank 32 will be gripped equally by both the dies 66 and 68 and that, therefore, the threads which will be formed on the blank by the dies will be concentric with the axis of the blank.

It may be noted that Fig. 4 brings out the fact that the beveled end portion 70 of the dies 66 and

68 are parallel with each other and are straight instead of being curved surfaces, this feature insuring that the initial pressure acting between the dies and the blank will be in a plane passing through the axis of the blank and, therefore, will produce a maximum effort tending to rotate the blank and minimizing the tendency of the blank to slip with respect to the dies and which slippage would tend to disrupt the synchronization between the dies and the work required for forming perfect threads on the work. This feature, coupled with the fact that the initial imbedding of the dies in the work is only a fraction of that required to form full depth threads on the work, insures the required synchronism between the dies and the work for forming perfect threads. It will be appreciated that as soon as the rolling operation commences the blank 32 will roll to the left on the die 66 and will thus roll away from the stop 180, the stop 180, therefore, offering no interference during the rolling operation.

In actual practice the blank 32 is fed downwardly into position between the ends of the dies 66 and 68 while the latter are longitudinally separated at approximately the end of the inoperative stroke of the slide 44 by conventional means, not shown, and is then pushed forwardly into contact with the end of the stop 180 prior to the time the dies longitudinally approach each other to a sufficient extent to grip the blank between them. The pusher mechanism provided for effecting this last-mentioned movement of the blank is of novel construction and forms a part of the present invention and as best brought out in Figs. 4, 5, 6, 7, and 11 includes a pusher bar 192 of a cross-sectional configuration substantially the same as that of the stop 180 and as brought out in Fig. 4 arranged in a parallel relation with respect thereto. The pusher bar 192 is fixed to the lefthand end, as viewed in the drawings, of a slide bar 194 by means of screws 195 passing through vertical slots in the slide bar 194 and threading into the pusher bar 192, thus permitting bodily vertical adjustment of the pusher bar 192 to adapt it to different lengths of blanks. The slide bar 194 is mounted for longitudinal reciprocating movement in a direction parallel to the direction of movement of the slide 44 in the upper end of a casting 196 fixed to the upper surface of the base 36 by means of bolts 198 as shown in Fig. 7.

The casting 196 adjacent its upper end is provided with a cylinder 200 arranged with its axis parallel to the path of reciprocation of the slide bar 194 and is provided with a piston 202 reciprocable therein. The piston 202 extends to the right as viewed in Fig. 7 and beyond the cylinder 200 is reduced in diameter where it is supported and guided for reciprocable movement in a conventional bearing bushing 204 carried by a cross-flange member 205 suitably secured to the righthand end of the member 196. A coil spring 208 surrounds the piston 202 and is maintained under compression between the flange member 205 and the washer 210 fixed to the piston 202 outwardly of the cylinder 200. The spring 208, therefore, constantly urges the piston 202 to the left as viewed in Fig. 7 and movement of the piston 202 to the right against the force of the spring 208 is accomplished by introducing fluid under pressure to the lefthand end of the cylinder 202 through a suitable lead or pipe such as 212. To the right of the flange member 206 a member 214 fixed to both the piston 202 and slide 194

serves to connect these two members together for equal longitudinally reciprocable movement.

As best brought out in Figs. 6 and 11 the righthand end of the slide 194 has rigidly fixed thereto a relatively short member 216 which projects inwardly or rearwardly therefrom. Pivotally mounted between its ends by means of a pin 218 on a bracket 220 fixed to the member 196 at the righthand end of the latter for movement in a horizontal plane is a latch lever 222. A coil compression spring 224 partially housed within the lefthand end of the latch lever 222 constantly urges the latter in a clockwise direction of movement as viewed in Fig. 6. The righthand end of the latch lever 222 is constantly urged by the spring 224 toward engagement with the inner end of the catch member 216 secured to the righthand end of the slide 194 and is notched out as at 226 for interengagement therewith. Thus when fluid under pressure is introduced into the cylinder 200 to move the piston 202 to the right as viewed in Figs. 6 and 7 against the force of the spring 208, when the piston 202 moves to the right a sufficient distance to move the slide 194 and catch 216 into alignment with the notch 226 of the latch lever 222, the spring 224 causes the lever 222 to oscillate and to latch the catch member 216 in the notch 226 thereof so that when the fluid under pressure is relieved in the cylinder 200 the latch lever 222 prevents the spring 208 from projecting the slide 194 and pusher bar 192 to the left as viewed in the drawings.

Mechanism that will hereinafter be more fully described applies fluid under pressure to the cylinder 200 to move the slide 194 and pusher bar 192 to the right as viewed in the drawings after the die 66 has moved a sufficient distance to the left to initiate a thread rolling operation upon a blank such as 32 between it and the die 68 and before the slide 44 and die 66 have returned to their extreme righthand positions at the end of the inoperative stroke thereof. The application of fluid under pressure to the cylinder 200, of course, moves the slide bar 194 to the right as viewed in the drawings to a sufficient extent to enable the latch bar 222 to engage the member 216 in the notch 226 thereof and shortly thereafter and before the slide 44 and die 66 have returned to the extreme limit of its inoperative stroke to the right as viewed in the drawings, the pressure in the cylinder 200 is relieved thus conditioning the slide 194 for projection to the left under the influence of the spring 208 as soon as the latch bar 222 is released from the member 216. This latter is accomplished in the following manner.

The lefthand end of the latch bar 222 is beveled off as at 228 and a cam member 230 having a beveled end or cam portion is fixed to the flange 54 of the slide 44 by means of screws 234. The relation of the beveled end 228 of the latch bar 222 and the beveled end of the cam member 230 is such that as the slide 44 moves on its inoperative stroke to the right as viewed in the drawings, as it approaches the limit of its movement in such direction the beveled surfaces engage each other and the cam member 230 depresses the lefthand end of the latch bar 222, thus causing the latch bar 222 to pivot in a counterclockwise direction of rotation about its pin 218 and moves the righthand end of the latch bar out of engagement with the member 216. In Fig. 11 this relation of the parts is shown at the moment that the righthand end of the latch bar 222 is about to be released from the member 216. As

will be appreciated as soon as the latch bar 222 is withdrawn from engagement with the member 216 the spring 208 projects the slide 194 and pusher bar 192 to the left and projects the blank 32 which has just previously been positioned in advance thereof, toward engagement with the stop 180 as illustrated in Fig. 5. Fig. 5 also brings out the fact that the operative or lefthand end of the pusher bar 192 is notched as at 236 to a width and depth equivalent to the end 34 of the blank 32, the blank 32 resting against the bottom of the notch 236 to thereby locate it vertically in proper relation with respect to the dies 66 and 68. It will be appreciated that the mechanism thus described provides a means whereby the pusher bar 192 is operated in timed relation with respect to the reciprocatory position of the slide 44 and die 66 and that this is accomplished in a positive and simple manner.

In delivering the blank 32 into position for engagement with the pusher bar 192 it is necessary to provide means for holding the blank in proper position to be engaged and moved by the pusher bar. In accordance with the present invention this means is provided in the following manner. At block 240 is mounted for sliding movement on the pusher bar 192 between the member 196 and the die 68. As brought out in Fig. 7, screws 241 carried by the block 240 project through a slot 241a in the pusher bar 192 to limit the slidable movement of the block on the pusher bar. The block 240, as best shown in Figs. 6 and 11, is provided with an outstanding bracket 242 and a similar bracket 244 is fixed to the lefthand end of the pusher bar 194. A pin 246 is extended between the brackets 242 and 244 in parallel relation with respect to the path of movement of the pusher bar 192 and is fixed to the bracket 242 and slidably received by the bracket 244. A coil spring 248 surrounds the pin 246 between the brackets 242 and 244 and is maintained under compression between these brackets so as to constantly urge the block 240 to the left as viewed in the drawings, so as to urge it to the limit of its travel to the left on the pusher bar as determined by the screws 241 and slot 241a. A screw 250 is threaded through the bracket 242 in parallel relation with respect to the pin 246 and its lefthand end is adapted to abut against the adjacent clamp 156 employed for securing the die 68 to the head 142. The screw 250 thus forms a stop for limiting movement of the block 240 to the left as viewed in the drawings regardless of the relative relation of the screws 241 in the slot 241a. Its position may be adjusted by threading it one way or the other in the bracket 242 and it may be locked in its adjusted position by means of a lock nut 252.

Between the bracket 242 and the block 240 a flat spring finger member 254 is clamped. The spring finger 254 extends to the left as viewed in the drawings from the block 240 and its extreme left or free end is inwardly bent as at 256. The spring finger 254 is also biased towards the rear face of the machine. A second spring finger 258 is fastened to the block 240 on the rear side of the pusher bar 192 and extends to the left from the block 240 and terminates just short of the extreme free end of the spring finger 254. In this case the end of the spring finger 258 is straight. The spring fingers 254 and 258 are spaced from each other by a distance slightly less than the diameter of the blank to be received between them. When the pusher bar 192 is in the position in which it is locked by the latch

bar 222 the blank 32 is projected downwardly between the spring fingers 254 and 258 which thus resiliently grip and hold the blank 32 between them. When the cam 230 releases the latch bar 222 from the pusher bar 194, the spring 208 projects the slide 194, pusher bar 192 and the block 240 with the spring fingers 254 and 258 to the left as viewed in the drawings, carrying the blank 32 gripped between the fingers 254 and 258 to the left of them until the stop screw 250 strikes the clamp 156, after which, in view of the fact that the spring 208 is of greater strength than the spring 248, the spring causes the pusher bar 192 to continue its movement and to eject the blank 32 from between the fingers 254 and 258 and into engagement with the stop 180 where it holds it until the blank 32 is gripped between the dies 66 and 68 and the thread rolling operation on the blank 32 initiated.

In view of the fact that the blank 32 is initially located between the beveled ends 70 of the dies 66 and 68 it is not desirable to permit the block 240 and the spring fingers 254 and 258 carried thereby to move to the extreme limit of their position to the left as viewed in the drawings and to permit the pusher bar 192 to completely eject the blank from between the fingers 254 and 258 until immediately prior to the moment that the die 66, during its movement in an operative direction to the left as viewed in the drawings, initially grips the blank 32 between it and the die 68. To prevent the above occurrence the block 240 is provided with an inwardly extending lug portion 260 and the member 262 secured to the upper face of the carrier 82 between the clamps 100 is provided with a cooperating lug 264 arranged for travel in the same path of movement as the lug 260 with the block 240. The lugs 260 and 264 are so positioned that in event the spring 248 tends to advance the block 240 and the spring fingers 254 and 258 beyond the point where the bent end of the finger 254 will hold the blank 32 against the die 66, the lugs 260 and 264 will become inter-engaged and the lug 264 will restrain movement of the block 240 with the fingers 254 and 258 to equal movement with the slide 44 until the slide 44 has moved a sufficient distance on its operative stroke to bring the stop screw 250 into contact with the clamp 156, after which the pusher bar 192 will continue its movement as above described to eject the blank 32 from between the fingers 254 and 258. The stop screw 250 limits movement of the block 240 to such position that the free end of the spring finger 254 stops just short of the die 68. It will be observed that the block 240 is always capable of being withdrawn with the slide 94 to the right as viewed in the drawings regardless of the position of the member 262 upon the application of hydraulic pressure to the cylinder 200, as this movement is entirely independent of the movement of the slide 44 itself.

Referring now to Fig. 12 the hydraulic circuit for controlling the application of liquid under pressure to the cylinders 60, 138 and 200 is diagrammatically illustrated, these various cylinders and the cooperating pistons and springs where employed being also diagrammatically illustrated in this figure but bearing the same numerals as are employed to indicate the actual parts shown in the preceding views. In Fig. 12 the numeral 270 indicates an oil sump upon which the electric motor 272 is suitably mounted. An oil pump 274 is mounted at one end of the motor 272 and suitably connected thereto and a similar oil pump 276

is located at the opposite end of the motor 272 and suitably connected thereto.

The pump 274 is provided with an intake pipe 278 leading to a point adjacent the bottom of the sump 270 and is provided with a discharge pipe 280 which leads directly into the lefthand end of the cylinder 60. A branch 282 of the discharge pipe 280 leads back to the sump 270 and is provided with a pressure relief valve 284 therein which serves to limit the maximum pressure capable of being built up in the discharge line 280. The discharge pipe 280 is provided with a second branch 286 therein which also leads to the sump 270 and in this branch there is inserted a conventional speed control valve 288 which is adjustable and by means of which the rate of flow through the discharge pipe 280 to the cylinder 60 may be controlled.

The discharge pipe 280 is provided with a third branch 290 which leads to a conventional four-way valve 292 which is preferably of the high speed spool type and is solenoid actuated in a conventional manner. It is provided with four ports A, B, C, and D, the branch 290 leading to the port A. When the valve 292 is in its neutral position the ports A and B are connected directly together and the port B is connected by a discharge pipe 294 to the sump 270. The port C is plugged. The port D is connected by a pipe 296 to the righthand end of the cylinder 60. When the valve 292 is in one position it connects the ports A and D, when in another position connects the ports A and C, and when in a third or neutral position connects the ports A and B. When in the second-mentioned position, that is where the ports A and C are connected together, the branch 290 is plugged against the flow of fluid there-through and consequently the liquid under pressure delivered from the pump 274 is applied to the lefthand end of the cylinder 60 to thus move the piston 64 to the right as viewed in Fig. 12 thereby to effect a similar movement of the slide 44. The ports B and D are connected together at such a time so that the liquid discharged from the righthand end of the cylinder 60 flows through the pipe 294 to the sump 270.

When the valve 292 is moved to connect the ports A and D, then fluid under the same pressure is applied to both ends of the cylinder 60. In such case, because of the fact that the effective area of the righthand face of the piston 64, as viewed in Fig. 12, is greater than the effective diameter of the lefthand face thereof by an amount equal to the diameter of the piston rod 56, it will be appreciated that a differential of pressure is created tending to move the piston 64 to the left as viewed in Fig. 12 under such condition. The liquid in the lefthand end of the cylinder 60 under the last-mentioned condition simply flows back out through the pipe 280 and through the branch 290 through the valve 292 and into the righthand end of the cylinder 60 along with an additional amount of fluid supplied by the pump 274.

The above described mechanism thus provides means whereby the piston 64 may be reciprocated in the cylinder 60 with equivalent reciprocation of the slide 44 which is connected thereto through the piston rod 56, and the speed of reciprocation may be controlled through adjustment of the speed control valve 288.

The pump 276 is provided with an intake pipe 300 leading to a point adjacent the bottom of the sump 270 and is provided with a discharge pipe 302 which leads to a solenoid operated four-way

valve 304 and which, like the valve 292, is preferably of a conventional type of solenoid operated high speed spool valve. The valve 304 is provided with four ports, namely E, F, G, and H. The discharge pipe 302 connects into the port E. The port F is connected by a pipe 306 with the cylinder 138 through the hollow stud 174 previously described and which is provided with a cross-passage 308, shown in Fig. 8, leading to the space between the lefthand end of the piston 136 and the lefthand end of the cylinder 138. The pipe 212 leading into the cylinder 200 and previously described is provided as a branch in the line 306 so that fluid under pressure in the line 306 is transmitted both to the cylinder 138 and the cylinder 200 to actuate them simultaneously. The ports G and H are connected by lines 310 and 312, respectively, with the line 314 which discharges into the sump 270, and a branch 316 connecting the discharge pipe 302 with the line 314 is provided with a pressure relief valve 318 therein for the purpose of limiting the maximum amount of pressure capable of being built up in the pipe 302.

In one position of the valve 304 the ports E and F are connected together which thereby transmits the fluid under pressure in the discharge pipe 302 to both cylinders 138 and 200. When the valve 304 is in another position the ports G and F are connected together and the ports H and E are connected together. In this last-mentioned position it will be appreciated that the fluid under pressure in the discharge pipe 302 is discharged through the line 314 directly back to the sump 270 and any liquid in the cylinders 138 and 200 is returned through the lines 306 and 310 to the discharge line 314 and thence to the sump as a result of the pressure of the springs 154 and 208, respectively.

In order to control the operation of the valves 292 and 304 the mechanism best brought out in Figs. 8, 9, and 10 is employed. For operating the valve 292 a pair of cams 320 and 322 are provided. The cam 320 is carried at the upper end of a bracket 324 having a bottom flange 326 which is secured to the upper face of the slide 44 by means of a screw 328, the latter passing through a slot in the flange 326 elongated in the direction of movement of the slide 44 so as to permit the position of the cam 320 longitudinally of the slide to be varied. Similarly the cam 322 is supported at the upper end of a bracket 330 having a flange 332 fixed to the upper surface of the slide 44 by means of a screw 334 projected through a slot in the flange 332 elongated in the direction of length of the slide 44 to permit adjustment of the cam 322 longitudinally of the slide 44. It will be noted from an inspection of Fig. 9 that the adjacent upper corners of the cams 320 and 322 are inwardly and downwardly beveled off.

A conventional type of snap switch 336 provided with a pair of angularly related operating arms 338 carrying rollers 340 and 342, respectively, at their free ends in a position to engage with the cams 320 and 322, respectively, is supported in position from the bridge member 158 by means of a bracket 344. The cams 320 and 322 and the rollers 340 and 342 are not aligned with each other in the direction of movement of the slide 44 but are offset from one another as illustrated in Fig. 8. The roller 342 is aligned with the cam 320 in the direction of movement of the slide 44 and the roller 340 is aligned with the cam 322.

As the slide 44 reciprocates to the left as viewed in Fig. 9 the cam 322 will eventually contact the roller 340 and will swing the roller 340 upwardly and the roller 342 downwardly, thus to operate the switch 336 to reverse the position of the valve 292 so as to connect the ports A and C and connect the ports B and D, thus applying pressure only to the lefthand end of the cylinder 60 to thus move the piston 64 and consequently the slide 44 to the right as viewed in Fig. 9. As the slide 44 approaches the limit of its position in this direction the cam 320 will contact the roller 342 which will thus raise the roller 342 and drop the roller 340 to move the switch 336 to a position to actuate the valve 292 to connect the ports A, D which, as previously explained, serve to move the piston 64 and consequently the slide 44 to the left as viewed in the drawings because of the differential of pressure thus applied to opposite sides of the piston 64. The stroke of the slide 44 may, of course, be varied by shifting the cams 320 and 322 in either direction along the length of the slide 44 and if the slots in the flanges 326 and 332 are not long enough to provide the desired adjustment, additional screw holds may be provided at intervals along the length of the slide 44 for alternate reception of the screws 328 and 334, respectively.

The valve 304, similar to the valve 292, is also controlled by a switch actuated in accordance with the slidable position of the slide 44. This switch is illustrated at 350 in Fig. 9 and like the switch 336 is mounted on the bridge member 158 by means of a bracket 352. In this case the switch 350 is provided with a single operating arm 354 which carries a roller 356 at the free end thereof.

A cam structure carried by the slide 44 is adapted to engage the roller 356 thus to control the movement of the switch 350 to in turn control the position of the valve 304. While any suitable or conventional cam structure may be provided for this purpose, in accordance with one phase of the present invention, the cam structure shown consists of two cam parts 358 and 360 which adjustably cooperate with each other to provide a cam whose length may be readily varied to correspond with any desired condition. Both the cam portions or parts 358 and 360 are provided with mounting flanges 362 and 364, respectively, through longitudinally extending slots in which screws 366 project and thread into the upper face of the slide 44. The adjacent ends of the cams 358 and 360 are slightly offset from one another so that their ends overlap as illustrated in Fig. 10 and their upper faces are arranged to lie in the same plane. The roller 356 is of sufficient width to engage both cams 358 and 360 as brought out in Fig. 8. The remote upper corners of the cam parts 358 and 360 are beveled off as indicated in Fig. 9 for the desired type of engagement with the roller 356.

It may be noted that the switch 350 is of a conventional type which will close the circuit there-through upon alternate oscillations of the actuating arm 354 thereof in the same direction and is so arranged that as the slide 44 moves to the left and the cam 358 engages the roller 356, the arm 354 will be raised to close the circuit through the switch 350, thus to move the valve 304 to a position in which the ports E and F are connected, thereby to introduce fluid under pressure into the line 306 and not only cause the cylinder 138 and die 68 to move to the left as viewed in Fig. 8, but

also to effect reciprocation of the piston 202 so as to withdraw the pusher bar 192 to a position in which the latch bar 222 will retain the latter in its retracted position.

In order to carry out the method disclosed in my copending application referred to, and particularly to move the die 68 inwardly to its final position after the blank 32 has been engaged between the dies 66 and 68 and has been rotated through at least 180° therebetween, the cams 358—360 are so arranged longitudinally of the slide 44 that the valve 304 will not be actuated to apply pressure to the cylinder 138 until after the slide 44 has moved a sufficient distance to the left, as seen in the drawings, to grip the blank between the dies 66 and 68 and to effect the desired rotative movement thereof between the dies, upon which the cams 358—360 will engage the roller 356 and lift it to thus actuate the valve 304 to apply pressure from the pump 276 to the line 306.

It is also desirable, in order to prevent marking of the work by the heels of the dies 66 and 68, to release the pressure on the cylinder 138 before the blank has been ejected from the dies and, accordingly, the position of the cam 358 longitudinally of the slide 44 is so adjusted that the roller 356 will drop off of the cam 358 before the work has been discharged from between the dies 66 and 68. Although on the return stroke of the slide 44, the roller 356 will again be engaged by the cam to oscillate the arm 354 of the switch 350, the circuit through the switch will not again be closed at this time because of the type of switch 350 employed and will only be closed when the arm 354 is again oscillated upon the following operative stroke of the slide 44 to the left as will be readily appreciated.

The mechanism above described thus provides a means whereby the slide 44 may be reciprocated through a path of the desired length and at the desired speed, and the die 68 will be alternately shifted bodily laterally toward and from the path of movement of the die 66 and at the same time the pusher bar 192 will be caused to reciprocate in timed relation with respect to the reciprocation of the slide 44.

From the foregoing, it will be appreciated that the mechanism of the present invention provides thread rolling apparatus having many novel features of construction and operation and that by its use, threads of superior character may be consistently produced at a maximum rate.

Having thus described my invention, what I claim in my Letters Patent is:

1. Thread rolling apparatus comprising, in combination, a pair of cooperating dies having flat faces arranged in approximately parallel relation with respect to each other and serrated in complementary cross-sectional configuration to the cross-sectional configuration of threads to be formed on a workpiece received therebetween, means for supporting one of said dies for reciprocatory movement in the direction of its length and against movement in a direction perpendicular to its operative face, means for effecting reciprocation of said die, means for mounting the other of said dies for reciprocatory movement in a direction approximately perpendicular to its operative face, means for maintaining said other of said dies against movement in the direction of its length, yieldable means constantly urging said other of said dies in a direction away from the path of movement of said one of said dies, and means for moving said other of said dies

toward the path of movement of said one of said dies in opposition to said yieldable means, and means controlling the last-mentioned means limiting said movement to a time subsequent to initial reciprocatory movement of one of said dies sufficient to rotate a workpiece between said dies through at least 180°.

2. Thread rolling apparatus comprising, in combination, a base, a slide reciprocably mounted on said base, means for reciprocating said slide, a die carried by said slide and fixed against relative movement with respect thereto, said die having a flat operative face serrated in cross-sectional configuration complementary to the cross-sectional configuration of a thread to be formed thereby, a second slide mounted on said base for reciprocatory movement in a direction perpendicular to the direction of reciprocatory movement of the first-mentioned slide, a die fixed to said second-mentioned slide for movement therewith and having an operative face serrated in complementary cross-sectional configuration to the cross-sectional configuration of a thread to be formed on a workpiece thereby, yieldable means constantly urging said second slide in a direction away from the path of movement of said first-mentioned slide, fluid pressure means operative to move said second slide against the force of said yieldable means toward the path of movement of the first-mentioned slide, and means for controlling reciprocatory movement of said slides in timed relation with respect to each other, the last-mentioned means including means limiting initiation of movement of said second slide by said fluid pressure means to a time subsequent to the initiation of the operative stroke of said first-mentioned slide.

3. Thread rolling apparatus comprising, in combination, a base, a slide reciprocably mounted on said base, means for reciprocating said slide, a die carried by said slide and fixed against relative movement with respect thereto, said die having a flat operative face serrated in cross-sectional configuration complementary to the cross-sectional configuration of a thread to be formed thereby, a second slide mounted on said base for reciprocatory movement in a direction perpendicular to the direction of reciprocatory movement of the first-mentioned slide, a die fixed to said second-mentioned slide for movement therewith and having an operative face serrated in complementary cross-sectional configuration to the cross-sectional configuration of a thread to be formed on a workpiece thereby, yieldable means constantly urging said second slide in a direction away from the path of movement of said first-mentioned slide, fluid pressure means operative to move said second slide against the force of said yieldable means toward the path of movement of the first-mentioned slide, means limiting reciprocatory movement of said second slide under the influence of said yieldable means to a position in which the operative faces of said dies are separated by a distance less than the diameter of a blank to be received therebetween and greater than the root diameter of the threads to be formed on the workpiece between said dies, means for limiting the movement of said second slide toward the path of movement of said first slide to a position in which the operative faces of said dies are separated from one another by a distance equivalent to the root diameter of the threads to be formed on said workpiece, and means for effecting reciprocation of said slides in timed relation with respect to each other.

4. Thread rolling apparatus comprising, in combination, a base, a slide reciprocally mounted on said base, means for reciprocating said slide, a die carried by said slide and fixed against relative movement with respect thereto, said die having a flat operative face serrated in cross-sectional configuration complementary to the cross-sectional configuration of a thread to be formed thereby, a second slide mounted on said base for reciprocatory movement in a direction perpendicular to the direction of reciprocatory movement of the first-mentioned slide, a die fixed to said second-mentioned slide for movement therewith and having an operative face serrated in complementary cross-sectional configuration to the cross-sectional configuration of a thread to be formed on a workpiece thereby, yieldable means constantly urging said second slide in a direction away from the path of movement of said first-mentioned slide, fluid pressure means operative to move said second slide against the force of said yieldable means toward the path of movement of the first-mentioned slide, means limiting reciprocatory movement of said second slide under the influence of said yieldable means to a position in which the operative faces of said dies are separated by a distance less than the diameter of a blank to be received therebetween and greater than the root diameter of the threads to be formed on the workpiece between said dies, means for limiting the movement of said second slide toward the path of movement of said first slide to a position in which the operative faces of said dies are separated from one another by a distance equivalent to the root diameter of the threads to be formed on said workpiece, and control means operative to effect reciprocation of said second slide in opposition to said yieldable means when said first slide is at a predetermined position between the limits of its reciprocable positions.

5. Thread rolling apparatus comprising, in combination, a base, a slide reciprocally mounted on said base, means for reciprocating said slide, a die carried by said slide and fixed against relative movement with respect thereto, said die having a flat operative face serrated in cross-sectional configuration complementary to the cross-sectional configuration of a thread to be formed thereby, a second slide mounted on said base for reciprocatory movement in a direction perpendicular to the direction of reciprocatory movement of the first-mentioned slide, a die fixed to said second-mentioned slide for movement therewith and having an operative face serrated in complementary cross-sectional configuration to the cross-sectional configuration of a thread to be formed on a workpiece thereby, yieldable means constantly urging said second slide in a direction away from the path of movement of said first-mentioned slide, fluid pressure means operative to move said second slide against the force of said yieldable means toward the path of movement of the first-mentioned slide, means limiting reciprocatory movement of said second slide under the influence of said yieldable means to a position in which the operative faces of said dies are separated by a distance less than the diameter of a blank to be received therebetween and greater than the root diameter of the threads to be formed on the workpiece between said dies, means for limiting the movement of said second slide toward the path of movement of said first slide to a position in which the operative faces of said dies are separated from one another by a distance equivalent to the root diameter of the threads to

be formed on said workpiece, and control means operative to effect reciprocation of said second slide in opposition to said yieldable means when said first slide is at a predetermined position between the limits of its reciprocable positions and operative to permit reciprocation of said second slide under the influence of said yieldable means at a different point in the same operative stroke of said first-mentioned slide.

6. Thread rolling apparatus comprising, in combination, a base, a slide reciprocally mounted on said base, a hydraulic cylinder and piston assembly connected to said slide for effecting reciprocation thereof, a second slide reciprocally mounted on said base for movement in a direction perpendicular to the direction of movement of the first-mentioned slide on said base, a hydraulic cylinder and piston assembly for effecting reciprocation of said second slide in one direction, yieldable means for effecting reciprocation of said second slide in a direction opposite to that caused by said second-mentioned hydraulic cylinder and piston assembly, a die having a flat face serrated in complementary cross-sectional configuration to the cross-sectional configuration of a thread to be formed on a workpiece by said die mounted on the first-mentioned slide with its operative face in approximately parallel relation with respect to the path of movement of said first-mentioned slide for movement therewith, a second die having a flat face serrated in complementary cross-sectional configuration to the cross-sectional configuration of a thread to be formed on a workpiece thereby secured to said second slide for bodily movement therewith, the operative face of said second die being arranged in approximately parallel relation with respect to the operative face of the first-mentioned die and in laterally spaced and opposed relation with respect thereto, and means controlled by a reciprocable position of said first-mentioned slide for controlling the application of hydraulic pressure to said second-mentioned hydraulic cylinder and piston assembly.

7. In a thread rolling apparatus, in combination, a base, a slide reciprocable thereon, a die having a flat operative face serrated in complementary cross-sectional configuration to the cross-sectional configuration of threads to be formed on a workpiece thereby mounted on said slide for bodily reciprocable movement therewith, a pair of wedges interposed between the back face of said die and said slide independently movable in the direction of reciprocation of said slide, an additional wedge interposed between an edge face of said die and said slide and movable in the direction of reciprocation of said slide, each of said wedges comprising a member having a partially cylindrical surface arranged with its axis parallel to the direction of reciprocation of said slide and a flat face arranged in supporting relation with respect to said die, means forming a partially cylindrical seat for each of said wedges on said slide, and means for shifting the axial position of said wedges with respect to said slide.

8. In a thread rolling apparatus, in combination, a base, a slide reciprocable thereon, a die having a flat operative face serrated in complementary cross-sectional configuration to the cross-sectional configuration of threads to be formed on a workpiece thereby mounted on said slide for bodily reciprocable movement therewith, a pair of wedges interposed between the back face of said die and said slide independently movable in the direction of reciprocation of said slide, an

additional wedge interposed between an edge face of said die and said slide and movable in the direction of reciprocation of said slide, each of said wedges comprising a member having a partially cylindrical surface arranged with its axis parallel to the direction of reciprocation of said slide and a flat face arranged in supporting relation with respect to said die, means forming a partially cylindrical seat for each of said wedges on said slide, and means for shifting the axial position of said wedges with respect to said slide comprising a differentially threaded screw connection between each of said wedges and said slide.

9. Thread rolling apparatus comprising, in combination, a pair of dies having opposed and substantially flat faces serrated in complementary cross-sectional configuration to the cross-sectional configuration of threads to be formed on a work-piece passed therebetween, means for reciprocating one of said dies in the direction of its length, a slide mounted on said base for movement in the direction of movement of said reciprocating die, a pusher bar carried by said slide and positioned to engage a piece of work and position it between said dies, hydraulic means for moving said slide and pusher bar in one direction, spring means for moving said slide and pusher bar in the opposite direction, means for holding said pusher bar against movement under the influence of said spring means, and means controlled in accordance with the longitudinal position of said slide for releasing said holding means.

10. In thread rolling apparatus, in combination, a base, a slide mounted for reciprocatory movement on said base, a pair of dies having relatively flat faces serrated in complementary cross-sectional configuration to the cross-sectional configuration of the threads to be formed on a workpiece between said dies arranged with their operative faces in parallel relation with respect to the path of movement of said slide on said base, one of said dies being carried by said slide, a second slide on said base mounted for reciprocation in a direction parallel to the direction of reciprocation of the first-mentioned slide on said base, a pusher bar carried by said second slide, fluid pressure operated means for moving said second slide in one of its directions of reciprocation, spring means constantly urging said second slide in the opposite direction of reciprocation, latch means cooperating between said base and said second slide operable to latch said second slide against reciprocatory movement under the influence of said spring means, and means carried by the first-mentioned slide operable to release said latching means at a predetermined point in the reciprocable path of said first-mentioned slide.

11. Thread rolling apparatus comprising, in combination, a pair of relatively reciprocable thread rolling dies, a reciprocable pusher bar operable in timed relation with respect to the reciprocation of said dies for projecting a work blank into position to be gripped between said dies, and means for temporarily supporting said work blank comprising a pair of spring fingers mounted for reciprocatory movement on said pusher bar, spring means constantly urging said spring fingers in one direction of movement relative to said pusher bar, and means for limiting movement of said spring fingers with said pusher bar in one direction.

12. Thread rolling apparatus comprising, in combination, a base, a slide mounted on said base

for reciprocatory movement, a pair of thread rolling dies one supported for bodily movement with said slide and the other supported against movement in the direction of reciprocation of said slide, a pusher bar for positioning a piece of work in position to be gripped between said dies, a block mounted for reciprocatory movement on said pusher bar, a pair of spring fingers extending from said block and adapted to grip a piece of work between them for engagement by said pusher bar, spring means cooperating between said pusher bar and said block constantly urging said block in one direction of movement relative to said pusher bar, stop means carried by said block arranged for engagement with a part fixed with respect to said base for limiting movement of said block and spring fingers in one direction, and means cooperating between said slide and said block limiting movement of said block on said pusher bar beyond a predetermined relative reciprocatory relation between said block and said slide.

13. Thread rolling apparatus comprising, in combination, a base, a slide reciprocably mounted on said base, means for reciprocating said slide, a die carried by said slide and fixed against relative movement with respect thereto, said die having a flat operative face serrated in cross-sectional configuration complementary to the cross-sectional configuration of a thread to be formed thereby, a second slide mounted on said base for reciprocatory movement in a direction perpendicular to the direction of reciprocatory movement of the first-mentioned slide, a die fixed to said second-mentioned slide for movement therewith and having an operative face serrated in complementary cross-sectional configuration to the cross-sectional configuration of a thread to be formed on a workpiece thereby, yieldable means constantly urging said second slide in a direction away from the path of movement of said first-mentioned slide, fluid pressure means operative to move said second slide against the force of said yieldable means toward the path of movement of the first-mentioned slide, and means for controlling the reciprocatory movement of said second slide comprising a pair of cam parts fixed to said slide and relatively adjustable thereon longitudinally of said slide, said cam parts having overlapping end portions and coplanar operative faces, a switch fixed with respect to said base and having an operating member projecting into the path of movement of said cam parts with said slide and an electrically controlled valve controlled by said switch controlling the first-mentioned means.

14. Thread rolling apparatus comprising, in combination, a base, a slide mounted for reciprocatory movement on said base, a pair of thread rolling dies one carried by said slide for bodily movement therewith and the other of which is supported on said base against reciprocatory movement in the direction of reciprocation of said slide, means for urging a work blank into position between said dies, a guide fixed with respect to said slide and reciprocable therewith, a stop member slidably supported by said guide for movement in the direction of movement of said slide and positioned for engagement with a work blank urged to a position between said dies by the first-mentioned means so as to locate said blank for proper engagement by said dies during relative reciprocation thereof, and means for adjustably controlling the position of said stop member in said guide.

15. Thread rolling apparatus comprising, in combination, a base, a slide mounted for reciprocatory movement on said base, a pair of thread rolling dies one carried by said slide for bodily movement therewith and the other of which is supported on said base against reciprocatory movement in the direction of reciprocation of said slide, means for urging a work blank into position between said dies, a guide fixed with respect to said slide and reciprocable therewith, a stop member slidably supported by said guide

for movement in the direction of movement of said slide and positioned for engagement with a work blank urged to a position between said dies by the first-mentioned means so as to locate said blank for proper engagement by said dies during relative reciprocation thereof, spring means constantly urging said stop member in one direction in said guide, and screw means limiting the movement of said stop member under the influence of said spring means.

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