UNITED STATES PATENT OFFICE

METHOD OF ROLLING THREADS

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Application June 4, 1943, Serial No. 489,639

13 Claims. (Cl. 80—61)

This invention relates to the rolling of screw threads on machine parts such as bolts, screws and the like by means of flat dies and has for its principal object the provision of a method of rolling threads in this manner by the practice of which threads may be produced on a part as accurately as has hitherto been possible by grinding operations.

Objects of the invention include the provision of a method of rolling screw threads on a part to be provided therewith by the practices of which threads of an extremely accurate character may be formed within extremely close tolerances; the provision of a method of rolling screw threads on a part between flat dies by the practices of which the possibility of metal overlapping in the threads of the work is effectively eliminated; the provision of a method as above described in which perfect alignment of the threads on the dies with respect to the threads being formed on the work is assured at all times; the provision of a method as above described in which diametrical distortion of the body of the work under the force of the dies is effectively eliminated; and the provision of a method of rolling screw threads by flat dies in which the life of the dies is materially extended as compared with those employed in conventional methods.

Other objects of the invention include the provision of a method of rolling screw threads on workpieces by means of flat dies including the steps of insuring initiation of the rolling movement of the work between the dies when the dies are in a predetermined position with respect to each other in the direction of their movement longitudinally with respect to each other, by first effecting only partial imbedding of the dies in the work and thereafter effecting a complete imbedding of the dies in the work; the provision of a method as above described in which the final imbedding of the dies in the work is accomplished gradually; the provision of a method as above described in which the final imbedding of the dies in the work is accomplished by a bodily shiftable movement of one of the dies laterally with respect to the other thereof; the provision of a method as above described in which the dies are separated from one another prior to the time the workpiece is discharged from between them; the provision of a method as above described in which the dies are initially separated from one another by a distance greater than that required to form complete threads on the work but less than the external diameter of the work blank, initiation of the rolling movement of the work between the dies is effected while the dies are so laterally separated from one another, and then the dies are caused to laterally approach each other to complete the imbedding thereof in the work; the provision of a method as above described including the steps of initially locating the workpiece centrally between the two relatively movable die parts prior to gripping the workpiece between such parts; and the provision of a method of rolling threads as above described in which the relative movement of the die parts laterally with respect to each other is effected by the use of fluid pressure.

Still further objects of the invention include the provision of a new and novel method of checking the position of one die part with respect to the other to determine the accuracy of alignment between them; the provision of a method of checking the accuracy of alignment of flat thread rolling dies with respect to each other including the steps of initially effecting a partial imbedding of the dies in the work and then checking the alignment of the relatively shallow grooves thus formed in the work; and the provision of a method as herein described in which the alignment of the relatively shallow grooves is checked by the use of an optical projector.

Additional objects of the invention include the provision of a method of rolling threads between substantially flat dies in which the dies are moved longitudinally relative to each other at a constant speed whereby to result in better work and longer life of the dies than in accordance with conventional methods; and the provision of a method in which the speed of operation of the dies may be simply varied to enable the highest safe speed of operation to be maintained between the dies and the work commensurate with the hardness of the work and the practical life of the dies.

The above being among the objects of the present invention, the same consists in certain novel step or steps of operation to be hereinafter described with reference to the accompanying drawings, and then claimed, having the above and other objects in view.

In the accompanying drawings which illustrate more or less diagrammatically apparatus by means of which the method of the present invention may be carried out, and the association of the work therewith,

FIG. 1 is a fragmentary, broken and partially sectioned plan view of thread rolling apparatus by means of which the method of the present invention may be carried out, and illustrating a
piece of work in operative relation with respect thereto;

Fig. 2 is an enlarged fragmentary, plan view of that portion of the apparatus shown in Fig. 1 within the circle 2 thereof;

Fig. 3 is a vertical sectional view taken on the line 3—3 of Fig. 2 and illustrating the work in the position which it assumes with respect to the thread rolling dies at the moment that initiation of the thread rolling movement of the dies on the work begins;

Fig. 4 is a view similar to Fig. 2 illustrating the use of a modified and preferred form of die structure employed in the method;

Fig. 5 is an enlarged, fragmentary sectional view taken on the line 5—5 of Fig. 4 and illustrating the conformation of the threads of the dies at the advanced ends thereof;

Fig. 6 is a more or less diagrammatic view illustrating the manner in which an optical projector is employed to check the accuracy of the alignment of the dies by employing a workpiece in which the dies have been initially engaged only;

Fig. 7 is a side elevational view of a typical form of workpiece in blank form; and

Fig. 8 is a side elevational view of the workpiece shown in Fig. 7 after it has been threaded.

In the conventional method of rolling threads on workpieces between flat dies, the dies are located laterally with respect to each other at such a distance that when a workpiece is passed between them it will be provided with threads of the desired pitch diameter, the dies are caused to relatively reciprocate with respect to each other longitudinally thereof and each time the movable die member is separated from the stationary die member at one end of its stroke the workpiece is fed into position and is gripped between the dies, and while the dies are so separated the operation is continued.

While the advanced ends of the dies are usually curved outwardly away from the plane of the threaded face thereof and the threads of the dies are curved outwardly therewith, nevertheless it will be appreciated that the dies in operation are sunk almost immediately to full depth in the work. I have found that where accuracy in the final product is important this is undesirable for several reasons. One reason is that, because of the curvature of the ends of the dies, it is impossible to get perfect-threading of the dies into the work, an effect is produced similar to a heavy blow which is often sufficient not only to displace the surface metal of the workpiece from which the threads are to be formed but to actually deform the entire body of the workpiece throughout its full diameter. Egg-shaped sections of the work often result from this cause. Furthermore, because of the almost immediate sinking of the threads of the dies into the workpiece by such practice and the resistance offered thereto, the workpiece often slips with respect to the dies with the result that the threads on the workpiece and both of the dies get out of synchronism with each other, resulting in so-called drunken threads or else resulting in overlapping of the metal of the threads and consequently rough, as well as imperfect, threads on the finished piece. Additionally, it will be appreciated that where the advanced ends of the dies are curved outwardly from the plane of the operative faces thereof and the threads of the dies are carried outwardly therewith, unless the threads are also properly curved transversely of such curved advanced ends, the impressions formed thereby in the workpiece will not be at the same helix angle as the impressions formed by the straight threads on the dies over the flat portion thereof and in consequence errors in the work will frequently arise.

Another disadvantage of rolling threads on screws or the like in accordance with conventional practice is that when the work is first introduced between the dies it often becomes imbedded to a greater extent in one of the dies than in the other and this defect carries through the complete thread rolling operation with the result that in such cases the threads on one side of the screw or bolt are deeper than those on the other side thereof and the outside diameter of the threaded portion of the bolt or screw is concentric with the axis of the pitch diameter of the threads. Under such circumstances it will be appreciated that the head of the bolt having been concentric with that portion of the blank on which the threads have been formed, the head of the bolt is not concentric with the outer diameter of the threaded portion of the bolt in the final product and this leads to many disadvantages in practice. Apparently one of the reasons why this condition occurs is that due to the outwardly curved entering end portions of conventional thread rolling dies and the absence of means for holding the work centrally between the dies at the moment it becomes engaged by them, there is a tendency for the work, or at least the work is capable of being imbedded to a greater extent in one of the dies than in the other and that the dies are gripped between the curved end portions thereof.

The inaccuracies resulting in the threads produced on workpieces in accordance with conventional practice as heretofore followed has resulted in threads of such inaccurate character that generally such workpieces are thrown away or discarded, except those which are perfectly abraded or recognized by bolts, screws, or the like, are usually accepted for only the roughest kind of work and are not permitted to be used in the better class of mechanisms such as machine tools, engines, and devices where even more accuracy of fit is required. At the present time great quantities of accurately formed screw elements are being used. In many of these screw elements the tolerated variations from the true pitch diameters are 0.003" or less in which case, in order to obtain screw threaded elements that are lying properly in the holes or threads have the desired smooth thread surfaces, it has been necessary to grind such threads, which operation involves a relatively great expense. If such accurately threaded screw elements could be threaded by means of dies so as to eliminate the grinding operation, the cost of forming such threads would be a small proportion involved in forming such accurate threads in accordance with conventional practice.

It is, therefore, the principal object of the invention to provide a method by the practice of which the threads of screw threaded parts may be formed by flat dies in such a manner that the accuracy and finish thereof are comparable to the accuracy and finish of threads now produced by grinding and may actually be employed for any use which ground threads and extreme accuracy are used. The above objects are obtained by the use of flat dies which not only are reciprocable longitudinally relative to each other in the same manner as in conventional methods, but further in which the dies are relatively movable with respect to each other laterally thereof. In this connection it is to be
understood that when the term "relative movement between the dies" or equivalent expression is employed herein to refer to the movement of the dies either longitudinally or laterally with respect to each other, it is to be interpreted to mean movement of either one or both dies to effect such movement either longitudinally or laterally thereof, respectively. In this connection it may be stated that while each die may be capable of both longitudinal and lateral movement, it is preferable to provide one of the dies against longitudinal movement and one against lateral movement, and preferably one against longitudinal movement and the other against lateral movement in carrying out the practice of the present invention, the dies in such case having relative movement with respect to each other in accordance with the definition given above.

In following out the method of the present invention, the dies are laterally spaced from one another at the time the workpiece or blank is introduced between them by a distance greater than that required to form full depth or complete threads on the blank but by a distance less than the outside diameter of the blank itself, so that when the blank is first gripped between the dies during longitudinal movement of the dies, the threads of the dies will be only partially imbedded in the surface of the blank. This step is for the purpose of insuring rolling of the blank between the two dies the moment it becomes gripped between them, thus insuring against any possible slippage between the blank and the dies, which slippage would throw the workpiece out of synchronism with the threads of both of the dies and result in the disadvantages heretofore described. It will also be appreciated that, in order to maintain the synchronized condition between the work blank and the dies above referred to, and particularly where the movable die is moved by fluid pressure, it is necessary that initiation of the rolling movement of the blank between the dies must occur when the dies are substantially in a predetermined relative longitudinal position with respect to each other during relative longitudinal movement between them, and the present invention contemplates the provision of steps by which this feature is assured. Furthermore, the invention provides for accurately locating the blank midway between the dies at the moment of engagement thereof between the dies. This feature combined with the fact that the threads on the advanced ends of the dies are preferably not curved outwardly as in conventional practice, insures even imbedding of both dies in the work and eliminating the off-center relation between the outside diameter and pitch diameter of the threads so often occurring in screw threaded parts formed by conventional practice.

In accordance with the present invention, the partial imbedding of the teeth of the dies in the work preferably continues after initiation of the rolling movement of the work blank between the dies forming at least half a turn so that a continuous but partially formed thread is formed in the work blank thereby. Upon the attainment of such condition and during the relative longitudinal movement of the dies with respect to each other, the dies are moved more or less gradually laterally toward one another. In view of the fact that the dies have already acted upon the work blank to partially form the threads thereon, and particularly where the dies are moved laterally toward one another more or less gradually, the sudden imbedding of the dies occurring in accordance with conventional practice to full depth in the workpiece does not occur by the practices of the present invention and the possibility of slippage between the dies and the work blank is, therefore, effectively eliminated. This insures, assuming, of course, that the dies have been accurately formed, a truly helical thread on the workpiece which is free from overlapping of metal and, in fact, of its companion lateral thread that normally obtained by a grinding operation.

Although, under the above described conditions, after the initially imbedded threads of the dies have formed partial threads in the work blank and have been moved laterally toward one another to the apparent extent of such movement, it has been found that, due to the resistance offered by the workpiece to the complete imbedding of the threads of the dies therein, the inherent yield of the mechanism employed to advance the dies toward one another and other machines employed prevents complete sinking of the dies into the work until more than one revolution of the work has occurred under such conditions and the metal of the workpiece has had a chance to flow under the pressure of the dies to assume its final condition. It is important to appreciate that the character of the finish of the threads on the workpiece is important, to a great extent, to determine how the dies from one another before the workpiece has reached the end of at least one of the dies and has been discharged therefrom, otherwise one or both dies, depending upon the point at which the workpiece becomes disengaged from between the dies, may leave an imprint of its end surface on the threads of the workpiece.

While in the broader aspects of the invention it is more or less important what type of mechanism is employed to reciprocate the dies longitudinally with respect to each other and to move them laterally with respect to each other, it is in accordance with a narrower phase of the present invention the lateral movement of the dies with respect to each other is accomplished by fluid pressure, means. This is particularly desirable in that in accordance with a further phase of the present invention the force exerted by such fluid pressure means is preferably such as to be incapable of completely sinking the threads of the dies into the workpiece while the dies and workpiece are stationary, but is sufficiently great so that during the continued rolling movement of the workpiece between the dies, the dies are more or less gradually sunk home to their final position. This feature not only provides the gradual sinking of the threads of the dies into the workpiece, but further acts as an aid in insuring against slippage between the dies and the workpiece because of such rapid sinking of the dies into the workpiece as to engender danger of slippage between the workpiece and the dies and, therefore, throwing the workpiece out of synchronism with the dies.

Referring now to the accompanying drawings, in Fig. 8 is shown a typical screw which may be advantageously formed in accordance with the method of the present invention. It is to be understood that the screw shown in Fig. 8 is arbitrarily selected from a large class of screws or other threaded elements that may also be advantageously formed in accordance with the
present invention and is selected in this case simply as a matter of illustration. It will be noted that the screw illustrated in Fig. 8 includes a threaded end portion 10 joined at one end to a shank 12 of a diameter preferably slightly less than the root diameter of the threads on the end 12. The shank 12 is enlarged at that end thereof opposite the threaded end 12 as at 14 to approximately the outside diameter of the threaded end 10 and joins with a conical disc-like flange 16 on the opposite face of which the usual head 18 is formed. The work blank from which the screw shown in Fig. 8 is formed in accordance with the present invention is illustrated in Fig. 7 generally by the numeral 7, from which it will be noted that it is identical to the screws shown in Fig. 8 except that the threaded end here indicated at 10' has a smooth cylindrical surface. It will be understood that where the threads to be formed are of the usual V-type, then the diameter of the end 10' of the workpiece or blank 7 will be substantially equal to the pitch diameter of the threads in the finished workpiece. The tolerance or permitted variation of the dimensions in the end 10' of the work blank 7 will, of course, de- pend on a certain extent upon the tolerances permitted in the finished workpiece, although greater tolerances are always permitted in the diameter of the end 10' than in the pitch diameter of the finished piece inasmuch as the outside diameter of the threads formed is not of great importance and is desirably terminated short of a perfect point. Rather, it is of major importance in the forming of the blank 7 that the end 10' is of such diameter that the metal thereof will not completely fill the threads of the dies to the very roots thereof for it will be appreciated that if the diameter of the end 10' of the workpiece or blank 7 is so great as to provide more metal than is required to completely fill the space between the threads of the dies, the only avenue of escape for such excess metal is in a direction parallel with the faces of the dies and intermediate the two dies, thus causing the final workpiece to be egg-shaped in cross section. Otherwise the precautions necessary in making the blank 7 are not at all unusual.

In order to form the workpiece shown in Fig. 8 from the blank 7 shown in Fig. 7 in accordance with the method of the present invention, a pair of dies, illustrated in Figs. 1 to 3, inclusive, at 22 and 24, respectively, are employed. The dies 22 and 24 may be more or less of conventional character having, as illustrated in Fig. 3, threads 24 formed on their opposed faces complementary in section to the section of the threads desired on the workpiece and, of course, disposed at an angle to the horizontal equivalent to the helix angle desired in the workpiece. The height of the threaded portions of the dies is preferably only slightly in excess of the length of the end 10' of the blank and the dies 20 and 22 are extended upwardly from the threads 24 such a distance, as brought out in Fig. 8, that the flange 16, in resting upon the upper edges of the dies, serves to locate the end 10' in proper relation with respect to the threads 24.

The principal difference between the dies 20 and 22 and conventional dies is that preferably the roots of the threads 24 in each die lie in a single plane and are not curved outwardly as in conventional practice, thereby eliminating the need of laterally curving the threads 24 in such outwardly curved end portion to compensate for the change in the helix angle caused thereby and which lateral curvature is always a matter of more or less guesswork on the part of the maker. It may be noted that, principally for the purpose of more clearly bringing out certain desirable features of the present invention, the advanced ends of the dies 20 and 22 are the motion of their relative movement with respect to each other during a working stroke are shown as being square with respect to the plane of the threaded faces thereof, whereas in actual practice it is preferable to bevel the threads of such entering ends of the dies as illustrated in Fig. 8 and as will hereinafter be more specifically described. For this reason, it will be sufficient to consider that the entering end faces of the dies 20 and 22 join with the threaded faces of the dies through a sharp corner or in points as illustrated in Figs. 1 and 2.

While the mechanism employed for moving the dies 20 and 22 relative to each other both longitudinally and laterally thereof may be of any suitable character in accordance with the broader aspects of the present invention, in the present case shown the die 20 is assumed to be rigidly fixed to a reciprocable head 26 suitably guided, for movement in a direction longitudinally of the die 20 by means of a suitable surface or way indicated generally at 28 and rigidly supported against lateral movement particularly in a direction away from the die 22. The head 26 may be caused to reciprocate in any desired manner but, in accordance with a more limited phase of the invention, it is shown as being con- nected to the piston rod 30 of a piston 32 reciprocally received within a cylinder 34 mounted upon the machine with its axis parallel to the path of movement of the head 26. It may be assumed that the piston 32 is caused to operate in the cylinder 34 by means of fluid and preferably liquid under pressure introduced through a con- duit 36 equipped with a throttle valve 37 to a control valve 38 from which tubes 40 lead to the opposite ends of the cylinder 34 and from which a discharge tube 42 leads to a suitable reservoir. It will be appreciated that when the valve 37 is at one limit of its movable position fluid pressure will be introduced into one end of the cylinder 34 and exhausted from the opposite end and when at the opposite end of its movable position the flow of fluid will be reversed. The importance of employing a hydraulic piston and cylinder assembly for moving the die 20 longitudinally with respect to the die 22 is as follows. In the past it has been conventional practice to move one die with respect to the other by a crank arm and pitman construction with the result that the speed of the movable die varies in accordance with the point of connection of the pitman with the crank pin on the crank pin circle, the dies moving relatively slowly with respect to each other when the work is first engaged between the dies, then increasing to a maximum extent at the time the length of the pitman is at right angles to a line connecting the crank pin to the axis of rotation of the crank arm, and then decreasing toward the end of the stroke. The crank is ordinarily rotated at the fastest speed possible at which the dies will satisfactorily stand up for a workpiece of average hardness but in such case the speed of relative movement between the dies is either much lower than necessary at the beginning and end of the operation or else it exceeds the safe linear speed between the dies and the work during the cen-
tral portion of each stroke and which in the latter case is detrimental to the life of the dies. Furthermore, it is extremely difficult, if not impractical, in most cases, to change the speed of relative reciprocation between the dies to accommodate them to work pieces of different size. By employing a hydraulic cylinder and piston for effecting relative reciprocation between the dies longitudinally thereof it provides a constant speed of the dies relative to one another over the entire stroke and by employing a throttle valve such as 37 controlling the relative speed of the inlet pipe 38 the relative speed of reciprocation between the dies may be varied so as to maintain the highest safest speed in every case. In other words the speed of reciprocation may be varied by the valve 37 so that the speed of the dies is the fastest, practically possible for any given piece of work with due regard to the life of the dies. When workpieces made from different hardnesses of material are being worked upon the speed of reciprocation may be adjusted through the valve 37 to correspond. In this connection it will be appreciated that the softer the metal the higher the permissible linear speed between the dies and the work, and the harder the material the smaller the linear speed desirable employed. Thus by the employment of the hydraulic cylinder and piston and the throttle valve 37 these advantageous characteristics may be obtained.

Any suitable means may be provided for reversing the valve 38 at predetermined points in the cyclical movement of the die 20, the particular means shown by way of illustration only consisting of a rod 44 arranged in parallel relation with respect to the path of movement of the head 26 and supported on the head 26 as by means of bearing arms 46. Stops 48 fixed in spaced relation to each other on the rod 44 cooperate with an actuating member 50 secured to and reciprocable with the head 26 and extending into embracing relationship with respect to the rod 44 between the stops 48. Engagement of the member 50 with either stop 48 causes the rod 44 to be moved in the direction of movement which the head 26 is then moving and acts through the valve arm 52 to shift the valve 38 from one limit of its movable position to the opposite limit thereof, thereby to reverse the direction of movement of the head 26.

The die 22 is, of course, arranged with its threaded face in parallel relation with respect to the threaded face of the die 20 where the threaded end of the screw element to be formed is cylindrical and not tapered, but, of course, tapered where the latter condition obtains. In this connection, for the purpose of simplicity in description in the following specification and claims, it is to be understood that where reference is made to the dies as having parallel faces and/or the blank as having a cylindrical portion to be threaded, it is to be understood broadly enough to relate to and to cover a condition wherein the faces of the dies are inclined in conformance with the taper of a tapered part to be threaded and in which that portion of the blank to be threaded is correspondingly tapered. The die 22 is shown fixed to the outer end of a relatively rigid piston or plunger 60 which is reciprocable received within a cylinder 62 rigidly fixed with respect to the bed of the machine and with its axis substantially perpendicular to the plane of the threaded face of the die 20. The die 22 is thus mounted for movement in a direction perpendicular or substantially perpendicular to its threaded face and, therefore, laterally with respect to the die 20. Means are provided for limiting the movement of the die 22 laterally towards the die 20 and this is shown more or less diagrammatically in Fig. 1 as comprising a stud 64 threaded centrally into the outer end of the piston 60 and projecting outwardly through the blind end of the cylinder 62 where it receives a stop nut 66 and lock nut 68, the former being engageable with the outer end of the cylinders 62 for limiting outward movement of the piston 60 in the cylinder 62. It will be appreciated, of course, that where such a construction is employed, suitable packing means will be provided about the stud 64 in its passage through the blind end of the cylinder 62.

Means are also provided for constantly urging the piston 60 inwardly of the cylinder 62, in the present case this being shown by way of illustration as comprising a pair of springs 76 disposed on diametrically opposite sides of the cylinder 62 and tensioned between a hook or the like 72 fixed to the rear face of the die 22 and another hook 74 fixed to the cylinder 62.

In accordance with the present invention, means are also provided for limiting the lateral movement of the die 22 away from the die 20 and in Fig. 1 this is more or less diagrammatically shown as consisting of a stop screw 78 threadably mounted in a lug 79 on the side of the cylinder 62 and arranged with its inner end in a position to abut the rear face of the die 22 when the latter has moved laterally away from the die 20 under the influence of the springs 76. It will be appreciated that the stop nut 66 will be so positioned on the stud 64 as to limit lateral movement of the die 22 towards the die 20 to such a lateral spacing between the dies 20 and 22 as to result in the forming of threads on a work-piece engaged between the dies to the desired pitch diameter, the spacing of the dies 20 and 22 in such position being equivalent to the permanent spacing which the general types of dies are spaced from one another in accordance with conventional practice. On the other hand the stop screw 78 will limit lateral movement of the die 22 away from the die 20, in accordance with the present invention, to a distance such that the points of the threads 24 on the dies 20 and 22 are separated laterally from one another by a distance greater than that required to form threads on the blank of pitch diameter equal to that desired in the completed work-piece but less than the outside diameter of that portion of the blank upon which the threads are to be formed thereby.

The distance which the die 22 may thus reciprocate with the piston 60 laterally with respect to the die 20 will, of course, be somewhat less than the difference between the pitch diameter of the finished piece and the outside diameter of the end portion 10 of the work blank or piece. In Fig. 1 the die 22 is shown at the outer limit of its reciprocable position as determined by the position of the stop screw 78. The clearance between the stop nut 66 and stud 64 and the end of the cylinder 62 which, therefore, represents the permissible lateral movement of the die 22, is shown in greatly exaggerated amount simply for the purpose of clarity in illustration.

The piston 60, together with the die 22, is moved outwardsly in the cylinder 62 by means of fluid pressure and preferably liquid under
pressure and while any suitable mechanism may be provided for controlling the application of fluid pressure to the piston 60, in the particular case shown by way of illustration a conventional valve mechanism indicated generally at 80 is assumed to be connected by a tube 82 to a suitable source of liquid under pressure, by a tube 84 to a suitable point of discharge such as a reservoir or the like, and a tube 86 with the outer end of the cylinder 62. The valve 80 is provided with an actuating handle 88 which, when at one extremity of its movable position, connects the tube 86 with the tube 82 and, when at the opposite end of its movable position, connects the tube 86 with the tube 84.

Any suitable means may be provided for operating the valve 80 in timed relation with respect to the longitudinally reciprocable position of the die 20. In the particular case shown by way of illustration, this means comprises a solenoid unit 89 connected by a link 90 to the free end of the operating handle 88 of the valve 80. The solenoid unit 89 is in connected in an electrical circuit with a conventional switch 92 mounted on the frame of the machine and having an actuating arm 94 positioned in intersecting relationship with respect to the path of movement of the head 26 on the ways 28. As will hereinafter be more fully explained, the switch 92 is so positioned in the path of movement of the head 26 that the work will be gripped between the dies 20 and 22 while the dies 20 and 22 are at the extreme outer limit of their relative movement in direction lateral to their operative faces before the head 26 engages the switch 92 to connect the tube 82 with the tube 86 and thus move the dies 20 and 22 to the inner limit of the relative lateral movement with respect to each other. Where the die 20 continues to move longitudinally in the same direction, the head 26 will pass beyond and become disengaged from the switch 92, thereby causing the switch 92 to be operated to disconnect the tube 86 from the tube 82 and connect it to the tube 84 and thereby separate the dies 20 and 22 laterally with respect to each other. The last separating movement of the dies preferably occurs before the work is discharged from between the dies so that the ends of the dies will not mark the work.

It will be appreciated that with the particular mechanism shown for controlling the movement of the die 22 laterally with respect to the die 20, upon the ensuing stroke of the head 26 in a reverse direction as soon as the head 26 again engages the switch 92 the die 22 will be moved laterally towards the die 20, this during an incomplete stroke of the machine and, therefore, not essential and ordinarily not desirable. It will thus be understood that the operating mechanism shown and described is more or less a diagrammatic representation which will ordinarily be modified in actual practice to eliminate the last-mentioned reciprocatory movement of the die 22 during the incomplete stroke of the machine.

The work, assumed to be the blank 7 shown in Fig. 1, is introduced between the dies 20 and 22 in accordance with conventional practice and a reciprocating spring-pressed pusher rod 100 of conventional construction is preferably provided for forcefully urging the work 70 into position between the dies at the initiation of the rolling operation. In accordance with the present invention, however, it is desirable to so position the work 7 laterally with respect to the dies 20 and 22 that the pressure exerted on the work-piece at the time the dies first grip it between them is exerted in a plane passing diametrically through the work-piece, thus reducing the tendency towards relative slippage of the work with respect to the dies to a minimum at this time and to insure perfect synchronization of the rolling movement of the work with respect to the dies. In this connection it will be appreciated that the work must begin to roll when the dies are in a predetermined position with respect to each other if the threads formed on the work by the dies in the subsequent phases of operating on the work helically aligned with each other and that if, for instance, the work should slip with respect to the dies, even to the slightest extent, the synchronized relation of the threads of the dies and the threads on the work will be destroyed and result either in drunken threads being formed on the work or threads in which the metal of the work-piece is overlapped, thus resulting not only in a weak thread but one which is inherently rough. At the same time this locating or positioning means is so arranged as to cause the work to pass through a plane intersecting relationship with respect to the path of movement of the head 26 on the ways 28. As will hereinafter be more fully explained, the switch 92 is so positioned in the path of movement of the head 26 that the work will be gripped between the dies 20 and 22 while the dies 20 and 22 are at the extreme outer limit of their relative movement in direction lateral to their operative faces before the head 26 engages the switch 92 to connect the tube 82 with the tube 86 and thus move the dies 20 and 22 to the inner limit of the relative lateral movement with respect to each other. Where the die 20 continues to move longitudinally in the same direction, the head 26 will pass beyond and become disengaged from the switch 92, thereby causing the switch 92 to be operated to disconnect the tube 86 from the tube 82 and connect it to the tube 84 and thereby separate the dies 20 and 22 laterally with respect to each other. The last separating movement of the dies preferably occurs before the work is discharged from between the dies so that the ends of the dies will not mark the work.

To thus locate the work 7 with respect to the dies 20 and 22 so that they will engage the work-piece 7 in a plane passing diametrically through the work and centrally thereof, a suitable stop is associated with the die 20 so as to limit the position to which the work-piece 7 may be project-ed or positioned with respect to the die 20 under the influence of the pusher bar 100 at the initiation of the forming operation. While any suitable stop means may be provided for this purpose, in the drawings by way of illustration such stop means comprises a bracket 102 rigidly fixed with respect to the head 26 and provided with two or more stop screws 104 arranged with their axes parallel to the path of movement of the die 20 and head 26 and centrally between the opposed faces of the dies 20 and 22 when the latter are in their laterally separated condition illustrated in Figs. 1 and 2. Where stop screws such as 104 are employed it will be appreciated that two or more of them are arranged in the bracket 102 longitudinally of the axis of the work-piece 7 so as to be capable of engaging the work-piece and locating it accurately in parallel relationship with respect to the advanced ends of the dies 20 and 22. By suitably adjusting the screws 104, it will be appreciated that the work-piece, in simultaneously engaging the inner ends of the screws 104 and the advanced corner of the die 20, as illustrated in Figs. 1 and 2 in particular, will be limited in its forward movement with respect to the operative face of the die 20. The stop screws 104 are preferably so adjusted that the axis of the work-piece 7 will be located exactly midway between the operative faces of the dies 20 and 22 when the dies 20 and 22 are separated laterally to a maximum extent as controlled by the stop screw 76 acting on the die 22. When this condition prevails, and as particularly brought out in Fig. 2, when the work-piece 1 is first gripped between the points of the dies 20 and 22 during reciprocatory movement of the die 20 to the left as viewed in Fig. 2, these gripping points will lie on a line indi-
located at 106 which passes through the axis of the workpiece 7 and the workpiece 7 will be positioned exactly midway between the dies, resulting in a condition in which the tenement of the workpiece 7 to slip relative to either the die 26 or 22 or to be imbedded in one die to a greater extent than in the other is at a minimum.

The depth to which the threads 24 of the dies 20 and 22 are imbedded in the surface of the workpiece 7 during the initial movement of the dies 20 and 22 longitudinally with respect to each other is preferably about only that which will insure immediate rotation of the workpiece when engaged by the dies. Obviously, it will depend to a greater or lesser extent upon the diameter of the workpiece and particularly the diameter of the portion 10" thereof in the particular workpiece shown. I have found it ordinarily advisable to imbed the teeth of the dies into the work during this initial stage of movement for a distance which may vary, in a workpiece having a diameter equivalent to the diameter 10" of the workpiece shown in Fig. 7 of one-half inch to one inch, somewhere between 0.005" and 0.015", and to even a greater depth in some cases, a distance of 0.010" having been found quite satisfactory in service. Where the dies are such as illustrated in Figs. 1 and 2, are employed, then such initial imbedding of the dies in the work may be even less than that stated.

In actual practice it will be appreciated that at the time the workpiece 7 is introduced against the stop screws 104, the die 20 will be withdrawn to the right from the position illustrated in Figs. 1 and 2, the work being introduced against the stop screws 104, the pusher bar 100 moving forward to resiliently hold it in such position, and the die 20 will be moved with the head 26 to the left as viewed in Figs. 1 and 2. As soon as the die 20 has moved to the left a sufficient distance to cause the workpiece 7 to be gripped between the opposed leading edges of the dies 20 and 22, the workpiece 7 will begin to roll with respect to the dies, it rolling relatively rearward on the die 20 away from the stop screws 104. At this time, because the head 26 has not yet engaged the operating member 64 of the switch 52, no pressure will be exerted in the cylinder 62 and, consequently, the springs 70 will have moved the die 22 laterally outwardly or returned to their normal extent in the workpiece 7, such distance as previously explained being sufficient to positively insure the desired rolling movement of the workpiece 7 with respect to both the dies 20 and 22 but insufficient to endanger relative slippage of the work with respect to either of the dies. It is also important to bear in mind that, because of the character of engagement of the work between the dies 20 and 22, the work will begin to rotate immediately and precisely at the moment the die 20 reaches a predetermined position in its stroke longitudinally with respect to the die 22, this insuring the proper synchronization of the movement of the work with respect to both of the dies which is necessary to provide the true helix for the threads on the work and the prevention of overlapping of the metal of the threads on the work.

During this initial movement of the dies 20 and 22 longitudinally of each other at the time they are laterally spaced from each other by the maximum permissible distance, the threads 24 of the dies will, of course, form threads of only partial depth in the workpiece and the longitudinal movement of the dies relative to each other while thus separated is preferably imbedded in one die to a greater extent than in the other is at a minimum.

After such partial threads have been formed in the workpiece, the head 26 engages the end 64 of the switch 52, the effect of which is to immediately connect the pressure tube 82 of the valve 80 with the tube 86 leading to the cylinder 62 upon which fluid under pressure is transmitted to the piston 60 to cause the die 22 to be moved laterally towards the die 20, thus to cause the threads of the dies 20 and 22 to be imbedded to their full extent in the surface of the workpiece 7.

It is not desired that this movement of the die 22 laterally with respect to the die 20 be an instantaneous movement, in fact, such type of movement is to be avoided insomuch as any such sudden imbedding would increase the tendency of the work to slip relative to the dies and increase the tendency of the dies to work the metal of the workpiece clear to its center and tend to distort the true section thereof. The movement of the die 22 laterally toward the die 20 is preferably of a more or less gradual nature so as to avoid the tendencies above referred to and so that substantially full imbedding of the teeth of the dies in the workpiece will not occur until the workpiece has rotated to preferably one complete revolution and preferably from one to three revolutions while pressed between the dies. This more or less gradual inner movement of the die 22 may be effected in any suitable manner, such as by restricting the rate of flow of the liquid in the cylinder 62 to the piston 60 and this is accomplished in the following manner.

It will be appreciated that if a chisel, to which the teeth 24 of the dies 20 and 22 may be likened as a matter of illustration, is pressed against the surface of a stationary piece of work a relatively great amount of pressure will be required to cause it to be imbedded to any appreciable extent in the work. On the other hand, if, while the chisel is being pressed against the work, the work is rotated with the chisel point rolling upon it, a materially less amount of pressure will be required to effect an equivalent amount of imbedding of the chisel in the work. This same feature is preferably employed in effecting the gradual imbedding of the teeth 24 of the dies 20 and 22 into the workpiece 7. In other words, the amount of pressure which is applied to the piston 60 once the initial action of the dies on the workpiece is completed is such that if the workpiece and dies were stationary, the pressure would be insufficient to effect the complete imbedding of the teeth of the dies into the work but, under the conditions actually existing, the rolling movement of the work between the dies in combination with the pressure employed is sufficient to effect the substantially complete imbedding of the teeth 24 of the dies into the work during the number of revolutions of the work mentioned. Even then it has been found in actual practice that when the stop nut 66 actually comes into firm engaging re-
relationship with respect to the cylinder 22, or the equivalent condition results, the threads of the dies are not immediately imbedded in the work to the full extent desired because of the inherent resiliency that is present in all machines regardless of their apparent rigidity and that further rolling movement between the dies and the work must be continued before it is insured that the threads of dies are completely imbedded to the desired extent in the work. Under ordinary conditions it is desirable that the work be caused to be rotated, at least seven or more times after the dies have apparently become fully imbedded in the work in order to positively eliminate the effects of the spring of the machine and to obtain the desired accuracy in the finished product. It will be appreciated, of course, that the amount of pressure which is introduced into the cylinders 2 and/or the number of turns of the work under such pressure required to apparently fully imbed the teeth of the dies into the work will vary according to the pitch and therefore the depth of the teeth which are formed in the work, the diameter of the work, the hardness of the metal of the particular workpiece being operated upon, and similar obvious conditions.

As previously mentioned, it is preferable to separate the dies 20 and 22 laterally with respect to each other, prior to the time that the workpiece is discharged from between them, to a sufficient extent to relieve the pressure of the dies on the workpiece, as otherwise the trailing points of the dies might undesirably mark the workpiece. In the present instance shown, the length of the head 26 is less than the combined length of the teeth 20 and 22 so that the operative end 94 of the switch 92 will drop off the dies 26 during an operative stroke of the latter before the workpiece is discharged from the ends of the dies, this separation of the dies 20 and 22 under such conditions relieving the pressure of the dies on the work and eliminating the possibility of any such marking.

In actual practice, it is usually undesirable that the dies be separated at all, particularly at the ends thereof, terminate in a square edge at their advanced ends, this for the reason that such square edges produce sharp points for initial engagement with the workpiece and these sharp edges, when subjected to unduly high pressures in operation which tend to foster early destruction thereof. In practice it is preferable to bevel off the end 24 of the die at the advanced end of the die so that the workpiece will be initially engaged by the beveled surfaces rather than by the points thereof, as illustrated in Fig. 4.

The construction illustrated in the preceding figures except that the equivalent dies here illustrated at 20' and 22' each have the teeth 24 thereof at the advanced ends thereof beveled off at 21, preferably at an angle of approximately 15 degrees with respect to the plane of the corresponding teeth. It is to be noted that the roots of the teeth 24 of the dies 20' and 22' are not similarly beveled off and, as usually occurs in conventional constructions, the outer portions of the teeth 24 only being beveled in this case. This is brought out in Fig. 5, which illustrates the initial contacting relationship between the die 22 and the workpiece 1 before imbedding of the die in the workpiece has occurred. This eliminates the necessity of attempting to laterally curve the beveled ends of the teeth to compensate for the change in helix angle which would otherwise occur.

The amount which the advanced ends of the teeth 24 of the dies 20' and 22' are thus beveled is, as illustrated in Fig. 4, greater than the distance which the teeth 24 are initially imbedded in the workpiece 10 so that at the time the workpiece 7 is first engaged between the dies 20' and 22' it is engaged between the beveled surfaces 21. These beveled surfaces 21 being of the same angularity, and the stop screws 104 being adjusted to locate the workpiece 7 a distance away between the opposed faces of the dies, it will be appreciated that in this instance the points of contact between the dies 20' and 22' with the workpiece 7 will be in a plane which, as in the first-mentioned construction, passes axially through the workpiece 1 as on the line 106' in Fig. 4. Thus in this case, as in the case first described, the pressure which is initially exerted by the dies upon the workpiece is at substantially exactly the diametrically opposite points which thus exerts a maximum of pressure on the workpiece 7 to rotate the work and aids in preventing possible slippage between the dies and the work.

From the above it will be appreciated that in following out the method of the present invention the principal causes which have heretofore been requisted in the rolling of threads on workpieces by flat dies and which have resulted in objectionable inaccuracies in threads produced by such method, have been effectively eliminated. In fact, threads produced on workpieces in accordance with the present invention are now authorized for use on all parts capable of being threaded by such dies equally with threads which have heretofore been required to be ground in order to obtain the necessary accuracy in dimensions and surface finish. When it is appreciated that the method of rolling threads in accordance with the present invention requires no greater time than that required in accordance with conventional practices, and ordinarily less time because of the controllable constant speed of relative reciprocation between the dies and the dies, the enormous amount of saving in time, cost, man power, and machines will be readily appreciated.

In the rolling of threads in accordance with the method of the present invention and as in all conventional methods employing flat dies, it will be appreciated that in setting up a machine with new dies it is necessary to accurately correlate one of the dies with respect to the other so that the threads produced by the teeth on one of the dies will be synchronized exactly with the threads produced by the teeth on the other of the dies if any semblance of accuracy in the threads of the workpieces formed thereby is to be maintained. The method of rolling such threads in accordance with the present invention provides a method by means of which the accuracy of the setting of the dies may be checked in a quick and accurate manner so that, if inaccuracies are thus found, the relative positions of the dies may be varied to overcome the same.

In accordance with this further phase of the present invention, when a new set of dies is applied to a machine and it is desired to check the accuracy of the relative locations thereof, a work blank such as 7 is introduced between the dies and a partial rotation thereof is effected, preferably an amount of rotation less than one half revolution comprising the minimum amount of rotation during the initial stage of
movement between the dies. As will be appreciated, this forms partial threads in opposite sides of the workpiece but if the dies are properly located with respect to each other do not overlap one another. The workpiece is then removed from the machine and is then checked to determine if the partially formed threads formed by one die are in the same true helix as the partially formed thread formed by the other die, and if not other dies are then shifted to correct the error. While any suitable means may be employed to check the blank with partially formed threads under such circumstances, in accordance with the preferred method the workpiece with the partially formed threads thereon is inserted in an optical projector, indicated diagrammatically at 120 in Fig. 6, with the partially completed thread produced by one of the dies at the top, and the partially completed thread produced by the other of the dies at the bottom, and is adjusted axially until the vertical hair line 122 of the projector is located centrally of a partially completed thread on one side of the workpiece, or centrally of the groove between adjacent partially completed threads of such workpiece. Under such conditions, if the dies are properly located with respect to each other, the hair line 122 will be located centrally of the groove between the threads at the opposite side of the workpiece in the first instance or centrally of a partially completed thread at the diametrically opposite side of the workpiece in the second instance which will thus disclose the accuracy of the setting of the dies. It will be appreciated that, unless the hair line 122 falls in such location, it will indicate that the dies are not properly aligned with each other and the offsetting of the hair line with respect to its proper position in either of the cases mentioned will indicate in which direction one of the dies must be adjusted with respect to the other to correct the inaccuracies. One of the dies may then be adjusted in accordance with conventional practice or otherwise with respect to the other thereof to overcome such inaccuracies, the operation may be repeated upon another workpiece and re-checked to determine the accuracy of the adjustment, and such checking and re-checking continued until the final accurate location of one of the dies members with respect to the other is definitely established. In carrying out this method, after one partially formed thread or groove has been aligned with the hair line 122, the blank may be shifted axially until the groove or thread at the opposite side of the blank is aligned with the hair line 122, and the amount of this shifting movement measured accurately by a micrometer or other reading. This will indicate exactly the amount which one die must be shifted vertically with respect to the other to obtain the required synchronized positions of the dies and aids in eliminating trial and error methods of attaining the desired results. In such case if means are provided whereby one of the dies may be shifted vertically with respect to the other and such movement is indicated by a micrometer scale or otherwise, then it will be appreciated that one re-setting will ordinarily be all that is required to correct any inaccuracy that may be found in the relative positioning of the dies. By the above described means it will be appreciated that a quick and accurate method is provided by means of which the accuracy of location of the two die halves with respect to each other may be determined.

Formal changes may be made in the specific steps of operation and combinations of steps of operation herein disclosed without departing from the spirit or substance of the broad invention, the scope of which is commensurate with the appended claims.

What I claim is:

1. In the rolling of threads on a substantially cylindrical workpiece between substantially flat dies having operating surfaces grooved in sectionally complementary relation to the threads desired to be formed on the workpiece, the steps of locating said dies laterally from one another by a distance greater than that required to form the completed thread on the workpiece but less than the diameter of the blank, moving said dies longitudinally with respect to each other and introducing said workpiece therebetween while in said laterally located condition, continuing said longitudinal movement of said dies with respect to each other while they are in said laterally located condition until a continuous but incompletely formed thread has been formed on said workpiece, and then moving one die toward the other thereof to reduce the lateral spacing of said dies with respect to each other and continuing said longitudinal movement between said dies.

2. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the steps of locating the operative faces of said dies laterally with respect to each other by an amount less than the diameter of the workpiece and greater than the lateral spacing between said dies required to form the completed threads upon said workpiece, moving said dies longitudinally with respect to each other and introducing said workpiece therebetween without substantially varying the lateral spacing of said dies, and then laterally advancing said dies relatively toward one another during continued relative longitudinal movement between them.

3. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the steps of locating the operative faces of said dies laterally with respect to each other by an amount less than the diameter of the workpiece and greater than the lateral spacing between said dies required to form the completed threads upon said workpiece, moving said dies longitudinally with respect to each other and introducing said workpiece therebetween, then laterally advancing said dies relatively toward one another during continued relative longitudinal movement between them, and effecting a lateral separating movement between said dies prior to the time said workpiece is ejected therefrom.

4. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the steps of locating the operative faces of said dies laterally with respect to each other by an amount less than the diameter of the workpiece and greater than the lateral spacing between said dies required to form the completed threads upon said workpiece, moving said dies longitudinally with respect to each other and introducing said workpiece therebetween without substantially varying the lateral spacing of said
dies, and then gradually laterally advancing said dies relatively toward one another during continued relative longitudinal movement between them.

5. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the steps of locating the operative faces of said dies laterally with respect to each other by an amount less than the diameter of the workpiece and greater than the lateral spacing between said dies required to form the completed threads upon said workpiece, moving said dies longitudinally with respect to each other and introducing said workpiece therebetween without substantially varying the lateral spacing of said dies, then advancing said dies relatively toward one another in a lateral direction until the spacing therebetween is that required to form complete full depth threads in said workpiece during an interval of time required for the workpiece to rotate in excess of one revolution between said dies.

6. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the steps of locating the operative faces of said dies laterally with respect to each other by an amount less than the diameter of the workpiece and greater than the lateral spacing between said dies required to form the completed threads upon said workpiece, moving said dies longitudinally with respect to each other and introducing said workpiece therebetween without substantially varying the lateral spacing of said dies, then advancing said dies relatively toward one another in a lateral direction until the spacing therebetween is that required to form complete full depth threads in said workpiece during an interval of time required for the workpiece to rotate in excess of one revolution between said dies, and continuing said longitudinal movement between said dies while in said last-mentioned laterally spaced condition until said workpiece has been rotated through at least 180° of rotation, then advancing said dies relatively toward one another in a lateral direction during continued longitudinal movement between said dies and over a period of time required to effect in excess of one complete revolution of said workpiece between said dies until said dies are laterally spaced from one another by a distance required to form complete threads on said workpiece, continuing said longitudinal movement between said dies while in said last-mentioned laterally spaced condition until said workpiece has been rotated through at least three additional turns, and continuing said die movement toward one another without substantially varying the lateral spacing of said dies while in said lateral advanced relation with respect to each other until said workpiece has rotated through at least three additional turns.

7. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the steps of locating said dies in laterally separated relation with respect to each other by a distance equal to or less than said diameter of said workpiece, effecting relative longitudinal movement of said dies and introducing said workpiece therebetween without substantially varying the lateral spacing of said dies, continuing said longitudinal movement of said dies after said introduction of said workpiece therebetween until said workpiece has rotated through at least 180° of rotation, then advancing said dies relatively toward one another in a lateral direction during continued longitudinal movement between said dies and over a period of time required to effect in excess of one complete revolution of said workpiece between said dies until said dies are laterally spaced from one another by a distance required to form complete threads on said workpiece, continuing said longitudinal movement of said dies while in said last-mentioned laterally spaced condition until said workpiece has been rotated through at least three additional turns, and continuing said die movement toward one another in a lateral direction during continued relative movement thereof longitudinally with respect to each other until said dies are in bedded in said work an amount required to form completed threads on said work, and continuing said longitudinal movement of said dies while spaced the last-mentioned distance until said work has been caused to rotate for at least three additional revolutions between said dies.

8. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the steps of locating the operative faces of said dies laterally with respect to each other by a distance equal to from 0.010" to 0.030" less than the diameter of said workpiece, effecting relative longitudinal movement of said dies and introducing said workpiece therebetween without substantially varying the lateral spacing of said dies, continuing said longitudinal movement of said dies after said introduction of said workpiece therebetween until said workpiece has rotated through at least 180° of rotation, then advancing said dies relatively toward one another in a lateral direction during continued longitudinal movement between said dies and over a period of time required to effect in excess of one complete revolution of said workpiece between said dies until said dies are laterally spaced from one another by a distance required to form complete threads on said workpiece, and continuing said relative longitudinal movement between said dies while in said last-mentioned laterally spaced condition until said workpiece has been rotated through at least three additional turns.
arated from each other by a distance greater than that required to form completed threads on the workpiece, effecting relative longitudinal movement of said dies and simultaneously advancing said dies relatively toward one another under a pressure capable of being exerted while, and of an extent insufficient to effect imbedding of the dies to their full extent in the workpiece while, both the dies and the workpiece are stationary, but of sufficient extent to effect said imbedding during continued rolling movement of said work relative to said dies.

11. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the steps of introducing said workpiece between said dies while said dies are laterally separated from each other by a distance greater than that required to form completed threads on the workpiece, effecting relative longitudinal movement of said dies and then urging one of said dies laterally into closer spaced relation with respect to the other thereof during continued longitudinal movement of said dies relative to one another under the influence of fluid pressure of insufficient force to effect complete imbedding of said dies in said work when said dies and work are stationary but sufficient to effect such complete imbedding during continued relative rotation of said workpiece with respect to said dies.

12. In the rolling of threads on a substantially cylindrical workpiece by means of dies having substantially flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the step of rigidly holding said dies against lateral separating movement while said dies are laterally spaced from one another by a distance less than the outside diameter of said workpiece but greater than the lateral spacing required thereof to form complete threads upon said workpiece, introducing said workpiece between said dies while so spaced and while said dies are moving relative to one another longitudinally thereof, and then laterally advancing said dies relatively toward one another under the influence of fluid pressure of insufficient extent to completely imbed the grooved faces of said dies into said workpiece when said dies and workpiece are stationary but of sufficient intensity to effect said complete imbedding during continued relative rotation of said workpiece with respect to said dies.

13. In the rolling of threads on a substantially cylindrical workpiece by means of dies having flat operating faces grooved in complementary sectional relationship with respect to the desired threads to be formed on the workpiece, the method of checking the dies for synchronism with each other comprising the steps of locating the operative faces of said dies laterally with respect to each other by an amount less than the diameter of the workpiece and greater than the lateral spacing between said dies required to form completed threads upon the workpiece, rolling said workpiece between said dies to form partial threads in the workpiece by each of the dies over substantially no more than half of the circumference of said workpiece, inserting said workpiece in an optical projector, lining up the partial threads formed by one of the dies with a line of the projector perpendicular to the axis of the workpiece, then visually determining the accuracy of location of the partially formed thread on said workpiece produced by the remaining die thereon with respect to said line, and then adjusting at least one of said dies to correct any error thus determined.

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