

May 24, 1960

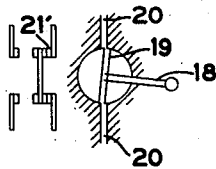
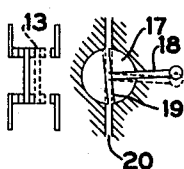
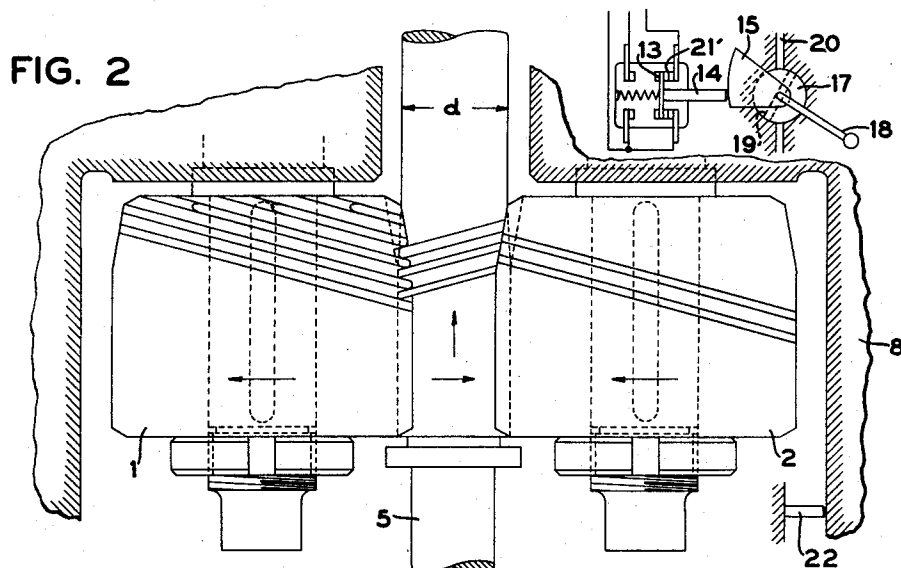
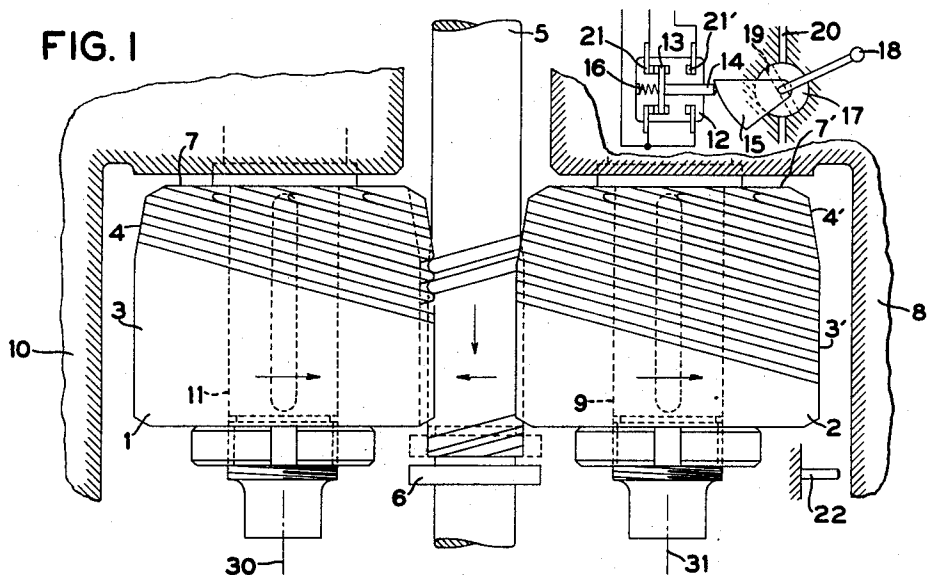
E. F. W. MOELTZNER

2,937,547

METHOD OF ROLLING WORKPIECES

Filed Aug. 4, 1953

4 Sheets-Sheet 1



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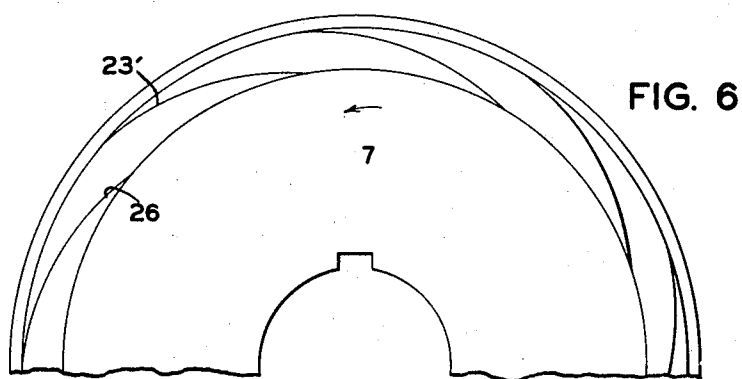
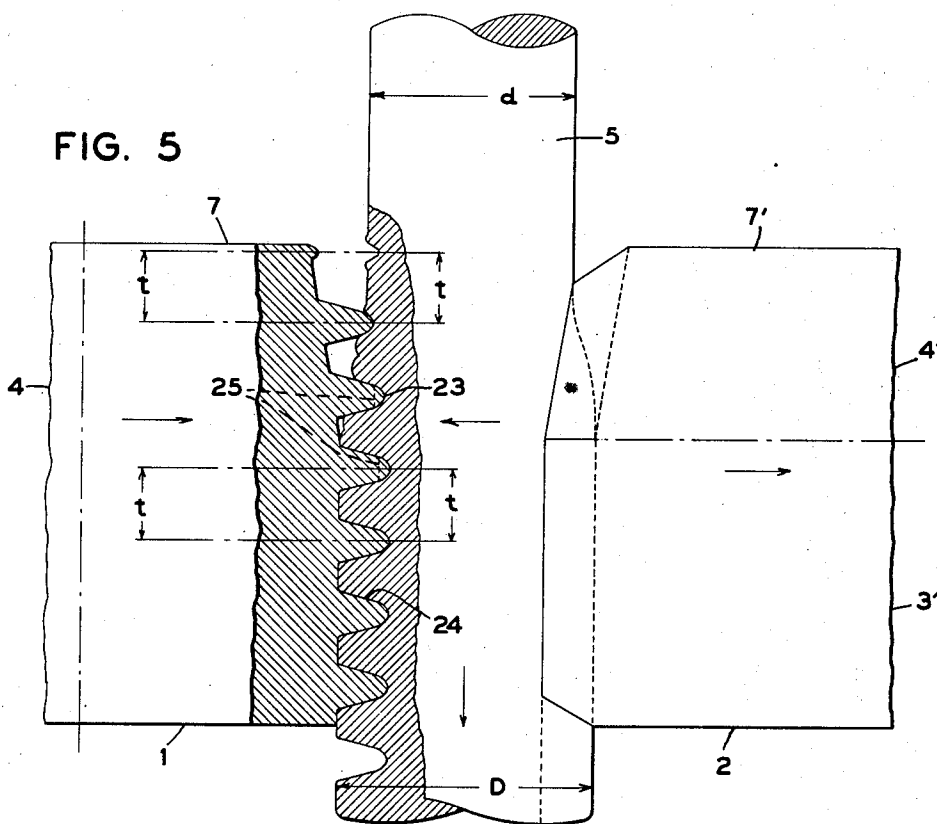
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4 Sheets-Sheet 2



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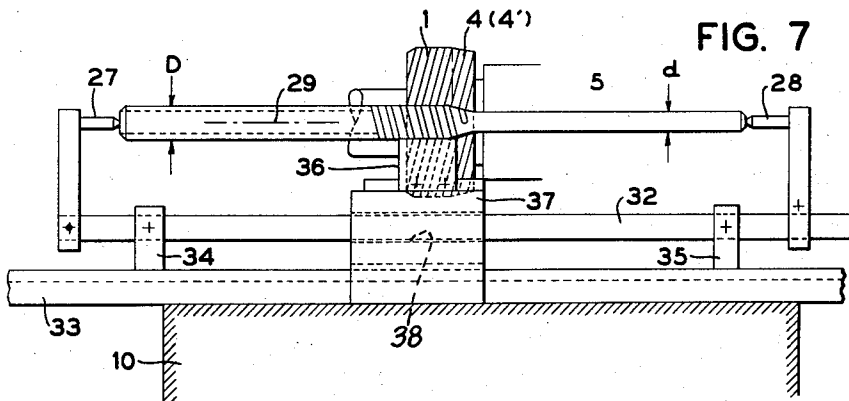


FIG. 7

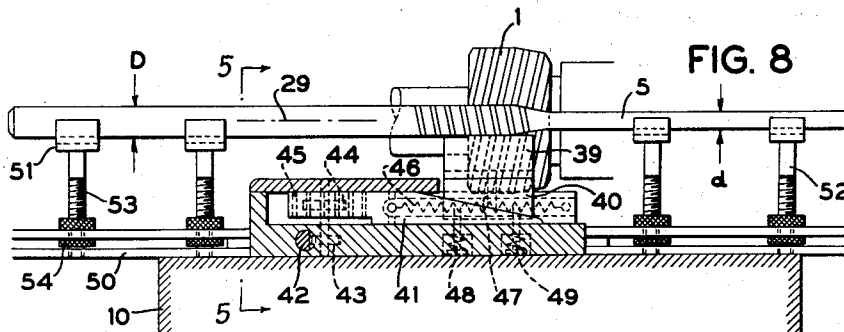


FIG. 8

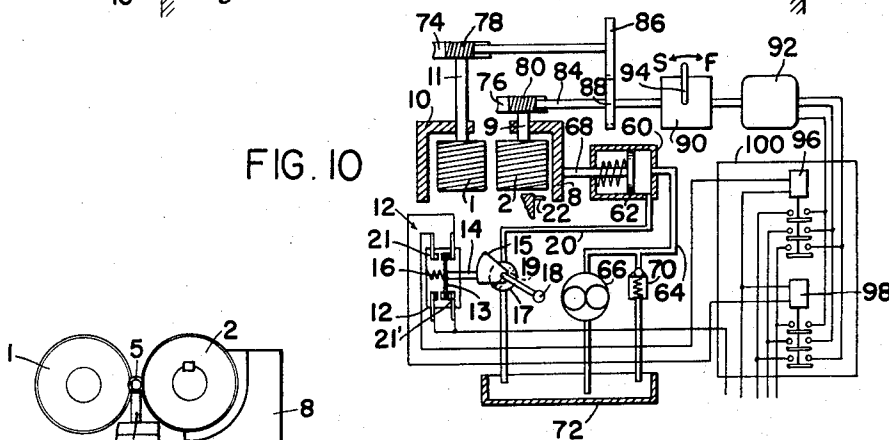


FIG. 10

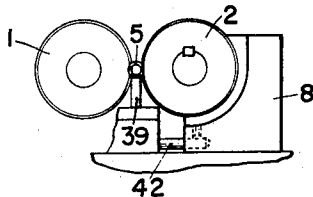


FIG. 9

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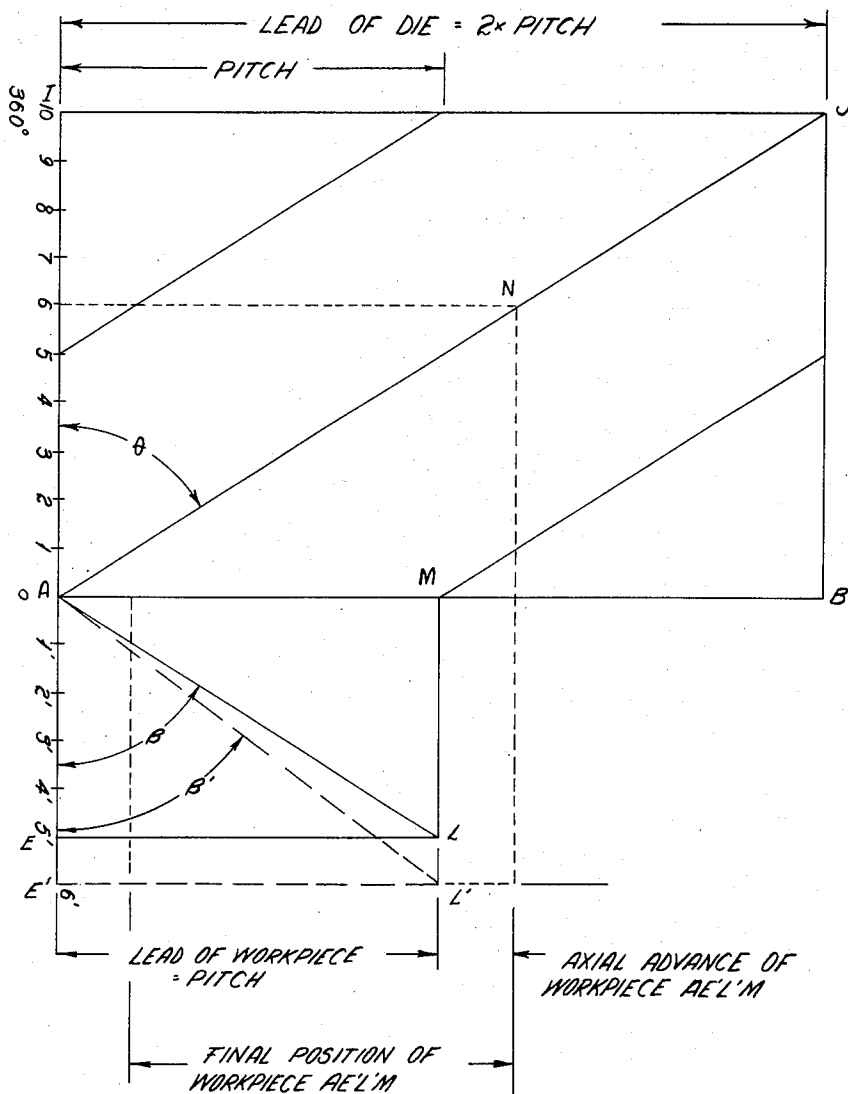


Fig. 11

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METHOD OF ROLLING WORKPIECES

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2 Claims. (Cl. 80-61)

The invention is concerned with the production of long shafts by rolling the threads on thread rolling machines employing the through-rolling process.

Work pieces, pre-machined to preliminary dimensions have previously been rolled by the through-rolling process by means of rotating threading rolls, the work piece screwing itself through between the rolls in the axial direction. The rolls were initially set to the finished size of the thread. Moreover, the work piece had to be gripped. It was not possible, however, to obtain an accurate thread and only small deformations of material were attempted such as are necessary for M10 threads, for example.

It has also been previously proposed to use three rolls for rolling external threads by the through-rolling method, one of the rolls being adjustable. These rolls had single start threads and the work was passed axially through the rolls, first with the adjustable roll set to a preliminary size and was thereby prerolled; then the work was passed through in the other direction with the adjustable roll set to the final size and with the rolls rotating in the opposite direction, and was finish-rolled. Thereafter the adjustable roll was again set to the preliminary size and the direction of rotation was reversed, so that the finish-rolled thread was passed through with the rolls relieved of pressure. During the rolling process proper, the threading rolls were at a fixed axial distance from each other, which, after the preliminary rolling operation, was set to the finished size of the thread being rolled. The work thus passed its entire thread length through the rolls three times and the rolls had to be reset after each pass. This procedure is bothersome and time-wasting. This process can be used for standard threads of small depth. However, large deformations of material cannot be accomplished in this manner, since the rolls must roll out the predetermined depth in two steps. This process cannot be considered for through-rolling long work pieces to produce threaded shafts.

These disadvantages are avoided by the process of this invention by reason of the fact that the thread at the beginning of that portion of the work piece which was pre-machined to preliminary dimensions, is rolled to full depth by means of rolls which are caused to approach each other in the axial plane and transversely to their axes, during the rolling process; and then the thread is rolled with the threading rolls under rolling pressure and fixed at full rolling depth by means of an adjustable end stop set at the corresponding separation, wherein the portion of the threading rolls, which produces the full depth of penetration, undertakes the guiding and feeding of the work piece in that portion of the work which is already threaded; and the portion at the entrance side of the threading rolls undertakes to roll the thread to the full depth of penetration.

In this manner, continuous threads on work pieces of any desired length may be rolled to full depth in one pass by the through-rolling process.

In order to preserve the threading rolls and to prevent the ends of the thread starts from breaking away, par-

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ticularly when deep threads are rolled, the ends of the thread starts at the entrance side of the rolls roll themselves out of the material of the work piece.

In accordance with the invention, rolling of the thread to full depth is effected under high pressure and with low rotational speed of the rolls, the direction of rotation of the rolls being reversed a number of times if necessary for a large amount of material deformation, and the subsequent through rolling operation is effected at low pressure and greater rotational speed of the threading rolls. In this way it is possible, after the first section of the thread, which is rolled to full depth, has been produced, to accomplish the subsequent through-rolling operation more quickly and to reduce the rolling time for the entire length of the work piece.

In most cases it will be possible to reach the full rolling depth in one pass, using the slow rotational speed of the threading rolls and the high rolling pressure, so that the through-rolling operation can begin immediately thereafter. In case very great deformations of material, such as in the production of trapezoidal threads of large depth, are to be rolled, the direction of axial travel of the work piece is, according to the invention, reversed a number of times by changing the direction of rotation of the threading rolls and the rolling pressure diminishes almost to zero before each change in the direction of roll rotation and, when the direction of rotation has been reversed, first the drive is re-started and then the pressure rises to full operating pressure. The deforming process is thereby favorably influenced. The material fibres rise radially along the shortest path; the material flows easily right from the start of the rolling process and no turbulence or excessive resistance occurs. Furthermore, out-of-roundness of the work piece is avoided because the rolling pressure is reduced at the instant the work piece stops.

The material can be made to roll more easily by the special construction of the threading rolls, especially when trapezoidal threads are to be produced as is normally the case with threaded shafts.

The cylindrical threading rolls for carrying out the invention are constructed in such fashion that they are conically reduced at the entrance side in such a way that the rolling space formed between the rolls corresponds, at the entrance side, when full-depth penetration is reached, to the work-blank diameter, wherein the thread teeth on the tapered portion of the threading rolls have the same pitch perpendicular to the axis of the roll, as on the cylindrical portion of the rolls.

In the through-rolling operation, this tapered portion of the threading rolls undertakes the actual work of rolling and the thread ridges on the cylindrical portion of the threading rolls serve to equalize, guide and feed the work piece in the axial direction. This subdivision of the threading rolls makes it possible to produce an acceptable, very accurate continuous thread on long work pieces such as shafts, by using comparatively low rolling pressures, so that the life of the threading rolls is vastly increased.

The special construction of the crest of the thread profile on the rolls also serves this purpose. According to the invention, the profile crests of the threads on the tapered and the cylindrical parts of the rolls have a parabolic or similar form for avoiding any turbulence in the material rolled and the standard profile is surmounted by the parabolic or similar portion of the profile crest. This addition to the crest has the effect on the work piece that the thread root is deeper by the amount of the addition. This has no adverse effect since the thread is supported by the flanks.

The advantage is thereby achieved that the profile crest of the thread of the work piece is formed in the work piece material without turbulence right from the start, so that the material is thereby made to roll more easily.

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The axial passage of the work piece is caused by the fact that the helix angle of the threading rolls differs from the helix angle of the finished work piece. The difference in helix angle may be obtained by either increasing or decreasing the diameter of the rolls from their normal diameter which is an integer multiple of the pitch diameter of the work piece. In most cases the desired change in the helix angle can be obtained by an increase or a decrease of about 10% in the roll diameter. Whether the threads of the work piece are to be right hand or left hand, the direction of feed may be determined by the direction of rotation of the rolls. Accordingly the direction of axial feed may be reversed by reversing the direction of rotation of the rolls.

The phenomenon of axial movement of the workpiece can be further explained by reference to a specific example in which it is desired to form a standard thread of 10 threads per inch on a .685 inch diameter blank (major diameter $\frac{3}{4}$ inch). The pitch circumference of such a workpiece is about 2.15 inches. A twelve start die with the same helix angle would have a circumference twelve times 2.15 or about 25.8 inches. The application of the above-mentioned correction factor produces a die having a pitch circumference of 24 inches retaining the same .1 inch thread pitch. In rolling contact with the workpiece, the die will rotate $2.15/24$ or .0895 revolution for every revolution of the workpiece. Since the axial advance of the thread on the die is .1 inch for $\frac{1}{12}$ or .0833 revolution of the die, then for .0895 revolution of the die the axial advance is $.0895/.0833$ times 0.1 inch or about 0.1077 inch. In the same time the workpiece makes one revolution and its thread advances one pitch or 0.1 inch. The difference of 0.0077 inch represents the relative axial movement between the die and the work for the thread on the latter to conform to that of the former which it must do. It is the natural tendency of the work to conform to the die and there is nothing to prevent it from doing so.

In thread rolling machines which serve to carry out the process, using the threading rolls of the invention, the work-receiving mechanism comprises a centering attachment mounted between the rolls and parallel to the direction of the roll axes, by means of which the work piece is mounted with its axis in the plane containing the threading roll axes. The receiving mechanism also comprises a work rest blade, independent of the centering attachment and set at the finished diameter of the threaded shaft, said work rest blade being mounted between the cylindrical portions of the rolls, leaving the space between the tapered portions of the rolls open. Through this combination of centering attachment and work rest the advantage is obtained that long work pieces can be positioned in the axial plane of the rolls, while the work rest blade guarantees to support the work piece directly beneath the rolling position, in any position of the work piece, so as to avoid thread errors due to sagging of the long work pieces. In this case, the work rest does not need to absorb rolling pressures, in contrast to its known manner of use, in which the work piece is positioned with its axis somewhat below the plane passing through the axes of both threading rolls, so that the disadvantages which were present formerly, such as the roughening of the outer surface of the finished work piece, do not occur.

A receiving mechanism serving the same purpose comprises a vertically adjustable work rest mounted between the cylindrical portions of the rolls and a plurality of supports arranged before and behind the work rest. The height of the supports on the entrance side is adjusted to the work blank diameter and the height of the supports on the discharge side is adjusted to the finished diameter of the work piece. In this receiving mechanism, the work rest, whose height is automatically adjustable and which is controlled by the feeding movement of the threading

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roll slide, is set so that the axis of the work piece lies substantially in the axial plane of the rolls so that the rolling pressure induced upon the work rest is small and the work piece is nevertheless securely conducted between the rolls because of its three point mounting. It is essential that the supports on both sides of the work rest be set to different heights, corresponding to the blank diameter and finished diameter of the work piece.

In order to reduce the rolling pressure almost to zero before each change in rotational direction of the rolls and, when the direction of rotation has been reversed, to be able first to start the drive and then to increase the pressure again to full operating pressure, the manually controlled stop cock, which is installed in the hydraulic fluid discharge line leading from the roll feeding cylinder, is connected in the machine to a plate cam which controls accordingly the reversing switch of the roll driving motor.

The invention is exemplified on a thread rolling machine in the accompanying drawings, in which

Figures 1 and 2 show the threading rolls with a work piece and with the control means for reversing the direction of rotation of the threading rolls, schematically represented in two different working positions,

Figures 3 and 4 show the reversing control means in intermediate positions.

Figure 5 shows the threading rolls and work piece at an enlarged scale,

Figure 6 is an elevation of the entrance side face of a threading roll,

Figure 7 shows a receiving mechanism with centers and work rest,

Figure 8 shows a receiving mechanism with work rest and supports, both adjustable for height,

Figure 9 is a fragmentary section taken along line 9—9 of Figure 8,

Figure 10 is a schematic illustration of the electrical and hydraulic circuits, and

Figure 11 is a graphical representation of the interaction between the die and the workpiece which causes axial travel of the workpiece during the thread rolling operation.

As shown in Figs. 1 through 4, the threading rolls 1 and 2 have the cylindrical portions 3, 3' and the tapered portions 4, 4'. The work piece 5, whose shoulder 6 is disposed toward the front of the machine, is located between the rolls 1 and 2. The end faces 7, 7' of both threading rolls are disposed toward the entrance side. In the position of Fig. 2, in which the threading rolls have reached their full depth of penetration in the work piece 5, the rolling space formed between the rolls corresponds, at the entrance side, with the blank diameter d of the work piece.

The roll 1 is mounted on the driving shaft 11 journaled in the machine frame 10. The roll 2 is mounted on driving shaft 9 journaled in the slide 8 and parallel with shaft 11. The slide 8 carrying the roll 2 is moved toward and away from the roll 1 by a hydraulic drive including cylinder 60 containing a piston 62 connected to the slide 8 and urged to the right as viewed in Figure 10 by a retracting spring 64. Fluid under pressure is supplied to cylinder 60 from a pump 66 through a pressure line 68 having the usual relief valve 70 leading to the sump 72.

The shafts 9 and 11 are driven at the same speed and in the same direction by worm wheels 74 and 76, worms 78 and 80, shafts 82 and 84, and gears 86 and 88, through a conventional speed control device 90 driven by a motor 92. The roll speed may be regulated as desired by positioning the operating handle 94 of the speed controller 90.

The reversing switch 12 is employed to control the reversal of the rotation direction of rotation of the driving motor 92 by selectively energizing the forward and

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reverse relays 96 and 98 respectively of a conventional reversing controller 100. The movable contact 13 of the switch is displaced against the force of the resetting spring 16 by the plate cam 15 and the push rod 14. The plate cam 15 is connected to the valve 17 which can be manually operated by the handle 18. The valve 17 has a bore 19 and is installed in the discharge line 20 which permits the hydraulic fluid to flow out of the feeding cylinder 60 when the valve is suitably positioned. The contacts 21, when closed, energize the relay 26 to cause the driving motor to rotate in the proper direction and cause the rolls to rotate clockwise as viewed in Figure 1. The contacts 21', when closed, energize the relay 98 to cause the driving motor to rotate in the reverse direction to cause the rolls to rotate counter-clockwise as shown in Figure 2.

The adjustable stop 22, which the slide 8 has moved against in the position of Fig. 2, when the rolls reach the full depth of penetration, is mounted on the machine frame. The slide 8 nevertheless remains under the preset rolling pressure.

In Fig. 5 the threading rolls 1 and 2 are shown at an enlarged scale and with the work being rolled through. The profile crest of all thread ridges 24 is formed parabolically and the standard profile 25, indicated by dotted lines, is surmounted by the parabolic or similar part of the profile crest. The thread ridges 24 have the same pitch, perpendicular to the axis of the thread roll, on the tapered portion 4 as on the cylindrical portion 3. The direction of rotation of both rolls is indicated by the arrows. The work piece 5 moves axially in the direction of the arrow. The blank diameter is indicated by d and the finished diameter by D .

Figure 6 shows an elevation of the threading rolls from the entrance side. The beginning of a thread start is designated 26. The profile crest 23' descends spirally in conformity with the conicity of the tapered portion 4.

In Figs. 7, 8 and 9 are shown two different receiving mechanisms for through-rolling long hafts. The finished diameter is designated D and the blank diameter d . The difference between the two is shown in exaggerated form. The work piece 5 is received between the centers 27 and 28, so that the axis 29 of the work piece lies in the plane passing through the axes 30 and 31 of the threading rolls. The distance between the centers 27 and 28 is adjustable. The centers 27 and 28 are secured on the cylindrical guide 32 which is movable, in a direction parallel to the axes of the two rolls, in the bearings 34, 35 in the slideway 33 which is mounted on the machine frame 10. The work rest blade 36 is also between the two rolls and supports the work piece 5 by its finish-rolled portion and permits the tapered portion 4, 4' of the threading rolls to operate freely. The work rest 36 is interchangeably mounted on the bracket 37 which is disposed between the two rolls and which has an opening 38 to permit the passage of the cylindrical guide 32.

The receiving mechanism shown in Figures 8 and 9 comprises the vertically adjustable work rest 39 which is adjusted vertically by the two wedges 40 and 41 by displacing the wedge 41 in accordance with the feeding movement of the slide 8. This adjustment is such that the axis 29 of the work piece 5 is always at the same height as, or slightly under, the plane passing through the axes 30 and 31 of the threading rolls. The displacement of this wedge 41 is effected by the engagement of the rack 42, which, through the pinions 43 and 44, displaces the wedge 41, which is provided with longitudinally arranged rack teeth 45, against the force of the spring 46. The wedge 40 has the vertical guide groove 47 and the retracting springs 48, 49.

The rail 50 is mounted on the machine frame between the threading rolls and serves to receive the supports 51 at the front and the supports 42 at the rear of the ma-

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chine. The height of the supports 51 and 52 is adjustable by the threads 53 and lock nuts 54. The supports 51 and 52 are set to the finished diameter D and the blank diameter d respectively.

The manner of operation is as follows:

The work piece, pre-machined to the blank dimensions is brought between the threading rolls 1 and 2 with the aid of the receiving mechanism shown in Figure 7 or 8. The work piece is positioned so that the shoulder, if any, lies closely adjacent to the end faces of the threading rolls at the front of the machine at the beginning of the threading operation, as shown in dotted lines in Fig. 1. The drive for the rolls is started and the slide 8 with the threading roll 2 is moved against the work piece. The rolling is effected with the pre-set high rolling pressure and with a low rotational speed of the rolls, so that the work piece is slowly screwed forwardly out of the rolls until the full depth of penetration is reached.

The factors which determine the axial travel of the workpiece are shown graphically in Figure 11. In this figure the circumference of one of the dies laid out flat is represented at ABJI. AELM and AE'L'M represent the laid out circumferences of workpieces of different diameter. In this illustrative example, the circumference of the die is arbitrarily chosen as being 10 units, the circumference of the smaller workpiece is 5 units and the circumference of the larger workpiece is 6 units. Since the circumference of the workpiece AELM is 5 units, which is half that of the die, the die must have two starts in order to roll a single start thread on the work. One of the starts or thread ridges is shown as AJ and its helix angle is ϕ . The corresponding indentation made on work piece AELM is AL and its helix angle is β which equals ϕ because of the whole number ratio between the diameter of the workpiece and the diameter of the die. The axial extent of the helix of the second workpiece AE'L'M is also equal to one pitch since it is a single thread and is the same as for workpiece AELM. Thus, E'L' must equal EL which establishes the helical trace AL' at the helix angle β which is not equal to the angle ϕ .

At the end of one revolution of the workpiece AELM, the point L' must coincide with the point N on AJ which is the same circumferential distance (6 units) from the starting point. Therefore, workpiece AE'L'M must advance in one revolution an amount equal to the axial distance between L' and N. Thus the ridge AJ can form an impression AL' coinciding with the latter at all points only when the workpiece as a whole is permitted to move axially.

In the case of very large deformation of the material, as in the production of trapezoidal threads, it may be necessary to reverse the direction of rotation a number of times until the full depth is reached, since the thread should be rolled to full depth close up to the shoulder. The work piece moves back again after reversal of the direction of rotation of the threading rolls, as is shown in Fig. 2, where the full depth of penetration is reached.

Reversal of the direction of rotation of the threading rolls is effected by operation of the hand lever 18. Upon the operation of this lever, the discharge of hydraulic fluid from the feeding cylinder is controlled by the stop cock 17 and, at the same time, reversal of the driving motor is controlled by the reversing switch 12. Rolling is effected in accordance with Figs. 1 and 2 under full rolling pressure while the discharge line 20 to the stop cock is closed. Upon reversal of the direction of rotation of the rolls, the stop cock is first brought to the position shown in full lines in Fig. 3, in which position the discharge line is already opened while the reversing switch still maintains its closed position. In the next instant, when the discharge line is fully open, the reversing switch is opened, as shown in dotted lines in Fig. 3. Upon further movement of the handle, the reversing

switch is closed to reverse the direction of rotation while the discharge line is still slightly open, as shown in Fig. 4, and then the parts occupy the position of Fig. 2, in which the full rolling pressure is reached.

For through-rolling, the direction of rotation of the threading rolls is again reversed. The rotational speed of the rolls is simultaneously increased. The work piece, in through-rolling, once more travels forwardly out of the machine, whereby the full depth, even with maximum material displacement, is produced in a single pass.

I claim:

1. In the method of rolling threads on a long substantially cylindrical workpiece between forming rolls having parallel axes and helical thread forming ridges, comprising providing an elongated workpiece with freedom of axial movement and of a diameter differing from a reciprocal of a multiple of the diameter of said rolls by a correction factor such that a helix angle on the workpiece is formed which is different from the helix angle of the forming rolls to the extent that the forming ridges in meshing with the thread groove previously formed creates a side force on the thread causing axial movement of the workpiece, subjecting one end only of said workpiece to an increment of shallow thread forming by said rolls in one direction of rotation, reversing the direction of rotation with greater increment of thread forming, continuing said rotation and reverse rotation to incrementally form said thread to full depth to thereby create a firm thread drive between said workpiece and said rolls to insure said axial movement, and then rotating said rolls continuously in the same direction to form threads on the remainder of said workpiece to full depth.

2. In the method of rolling threads on a long substantially cylindrical workpiece between forming rolls having parallel axes and helical thread forming ridges, comprising providing an elongated workpiece with freedom of axial movement and of a diameter differing from a reciprocal of a multiple of the diameter of said rolls by a correction factor such that a helix angle on the workpiece is formed which is different from the helix angle of the forming rolls to the extent that the forming ridges in meshing with the thread groove previously formed creates a side force on the thread causing axial movement of the workpiece, subjecting one end only of said workpiece to an increment of shallow thread forming by said rolls in one direction of rotation, reversing the direction of rotation with greater increment of thread forming, continuing said rotation and reverse rotation to incrementally form said thread to full depth to thereby create a firm thread drive between said workpiece and said rolls to insure said axial movement, and then rotating said rolls continuously in the same direction to form threads on the remainder of said workpiece to full depth.

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