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Kruse

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[54] **METHOD AND MACHINE FOR ROLLING THREADS OR THE LIKE**

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[52] **U.S. Cl.** **72/104;** 72/108; 72/121

[51] **Int. Cl.²** **B21H 3/04**

[58] **Field of Search** 72/104, 107, 108, 112, 72/126, 121

[56] **References Cited**

UNITED STATES PATENTS

412,626	10/1889	Jones	72/107
964,272	7/1910	Kaiserman	72/107
2,686,442	8/1954	Wilson	72/107
2,886,990	5/1959	Bregi	72/105

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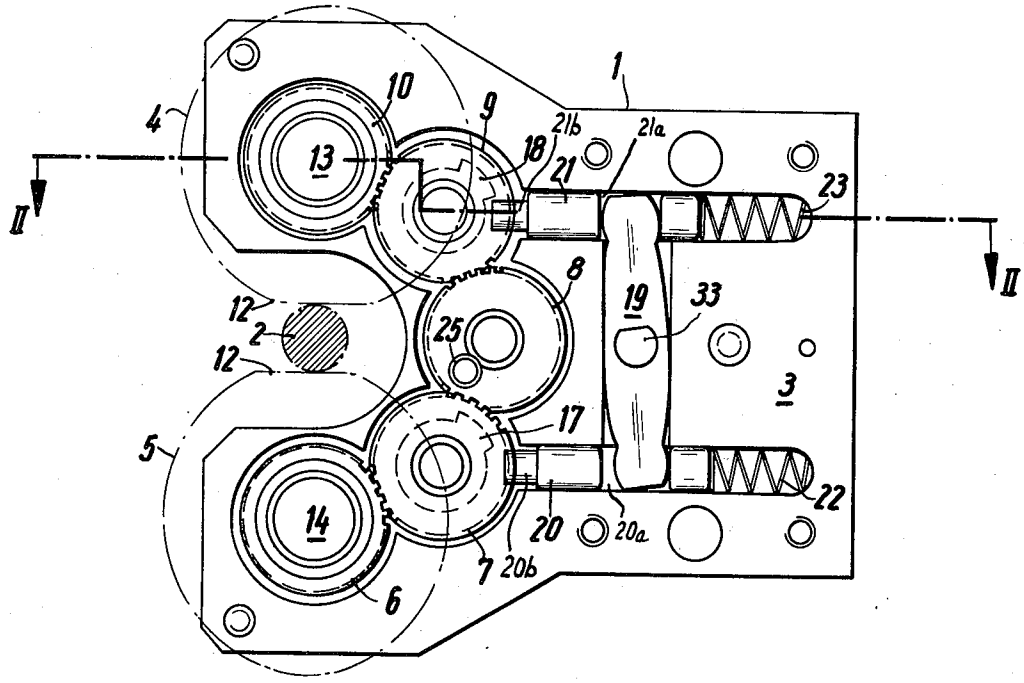
[57] **ABSTRACT**

Round blanks consisting of ductile metallic material are formed with threads, knurled or otherwise profiled in a rolling machine wherein a head supports two or more cylindrical dies each having a flat and a profile including a first section of gradually increasing radius, a second section of constant radius and a third section of gradually decreasing radius. The head may rotate about a non-rotating blank so that the dies orbit about the blank, or the blank may rotate about its axis with respect to a stationary head. The flats of the dies face the periphery of the blank when the head is moved to operative position by the slide of a machine tool, and the dies are thereupon caused to turn so as to move the first sections of their profiles into frictional engagement with the blank. The rolling operation is completed when each of the dies completes a single revolution. The rotary movements of dies are synchronized by a gear train whose gears can lock the dies in selected angular positions so that the flats face a blank during movement of the head to or from the operative position. The gears can be unlocked in automatic response to movement of the head to operative position and are relocked as soon as the dies complete a single revolution.

31 Claims, 10 Drawing Figures



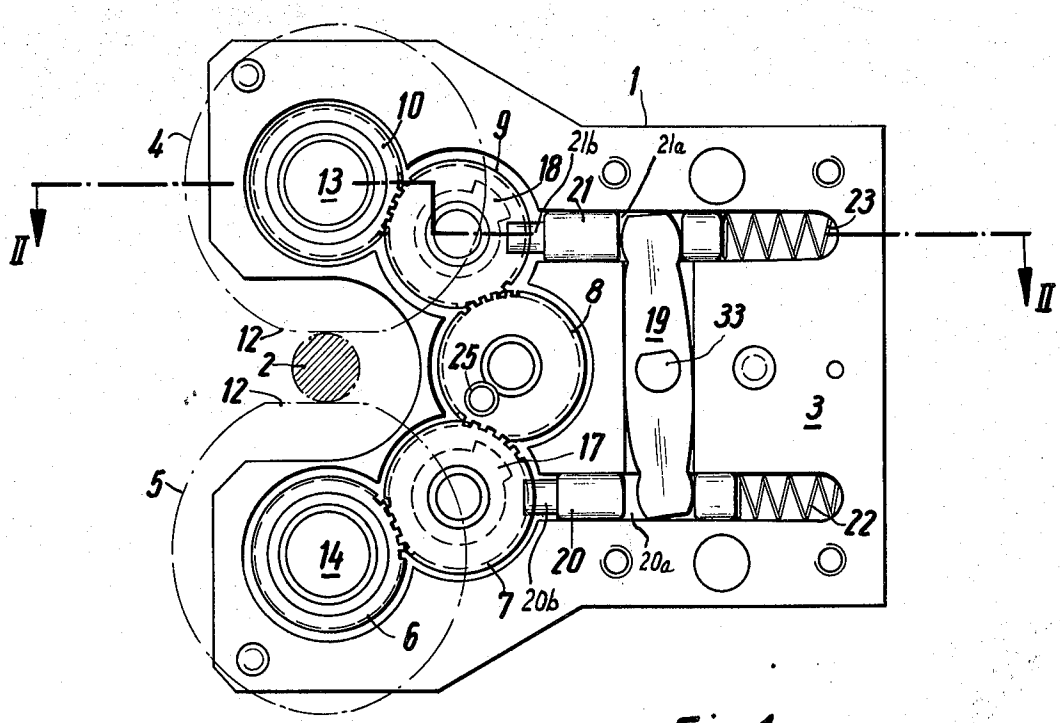

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Fig. 1

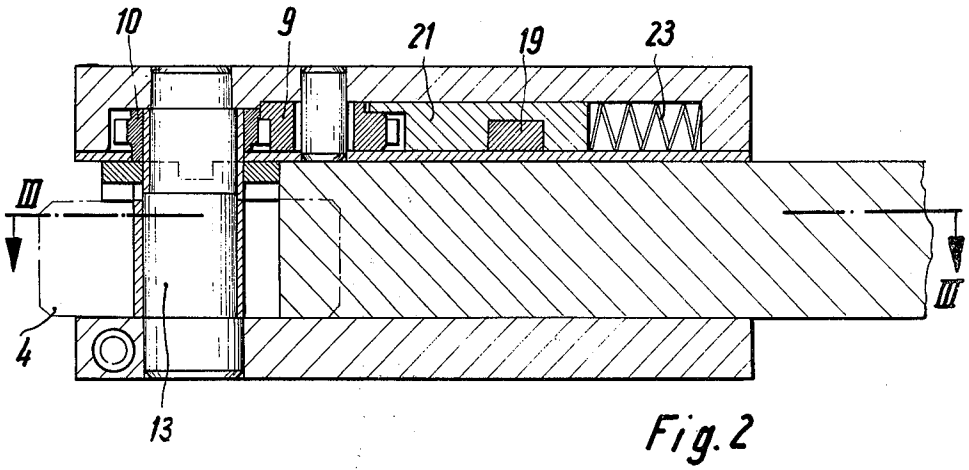


Fig. 2

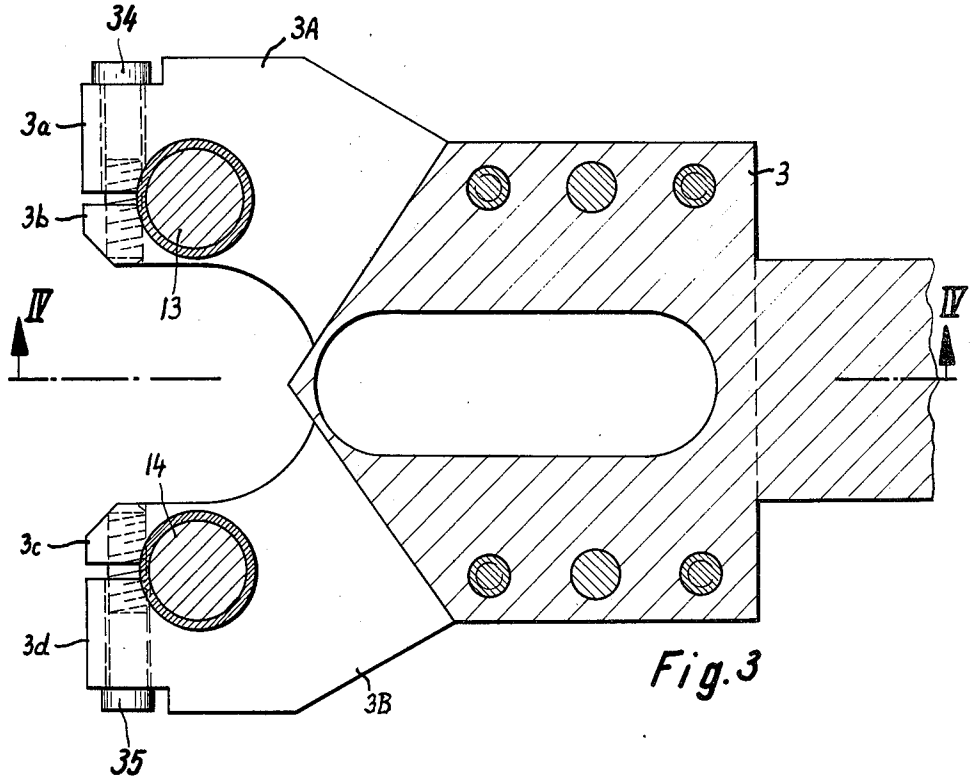


Fig. 3

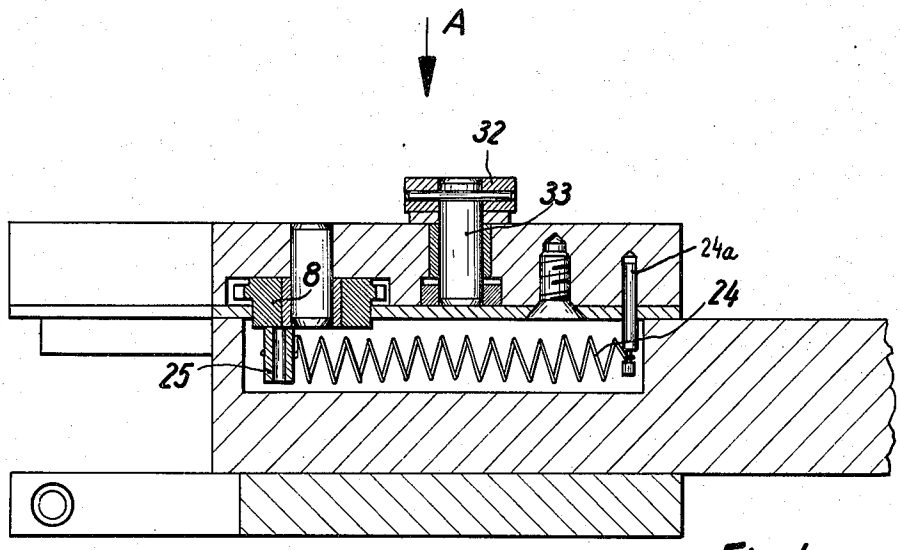


Fig. 4

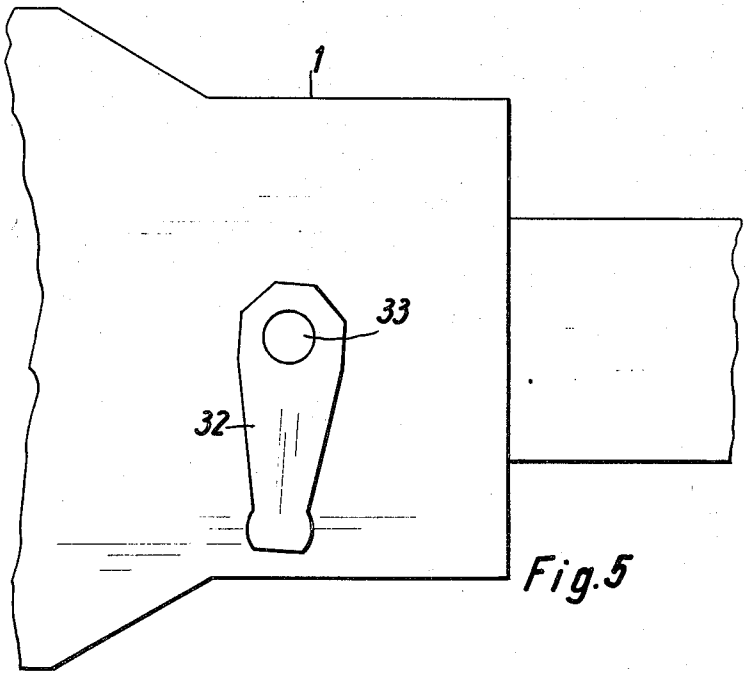


Fig. 5

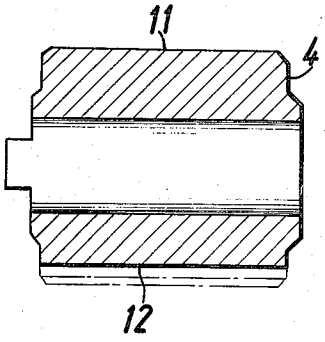


Fig. 7

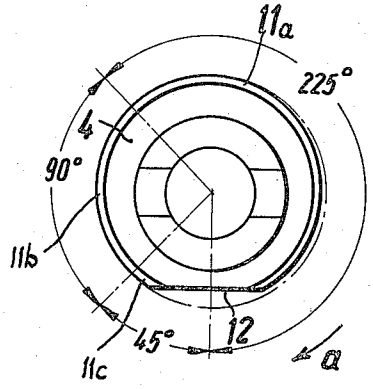


Fig. 6

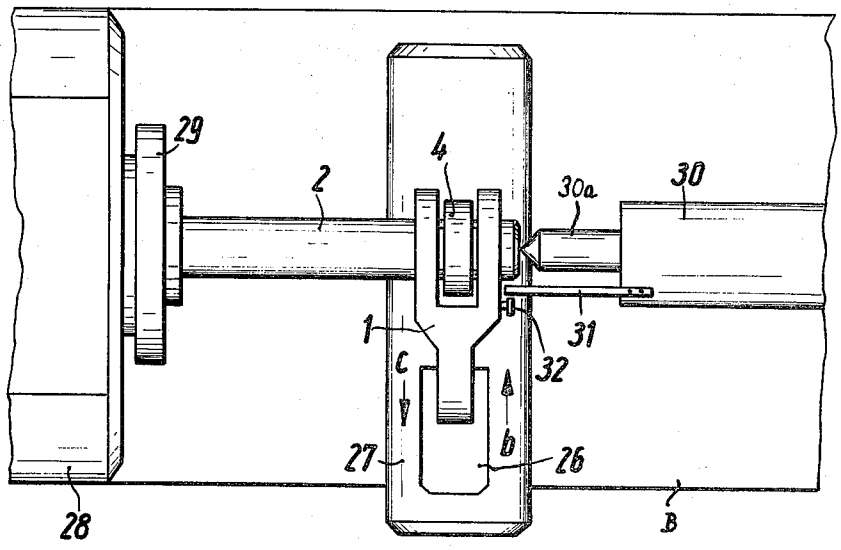
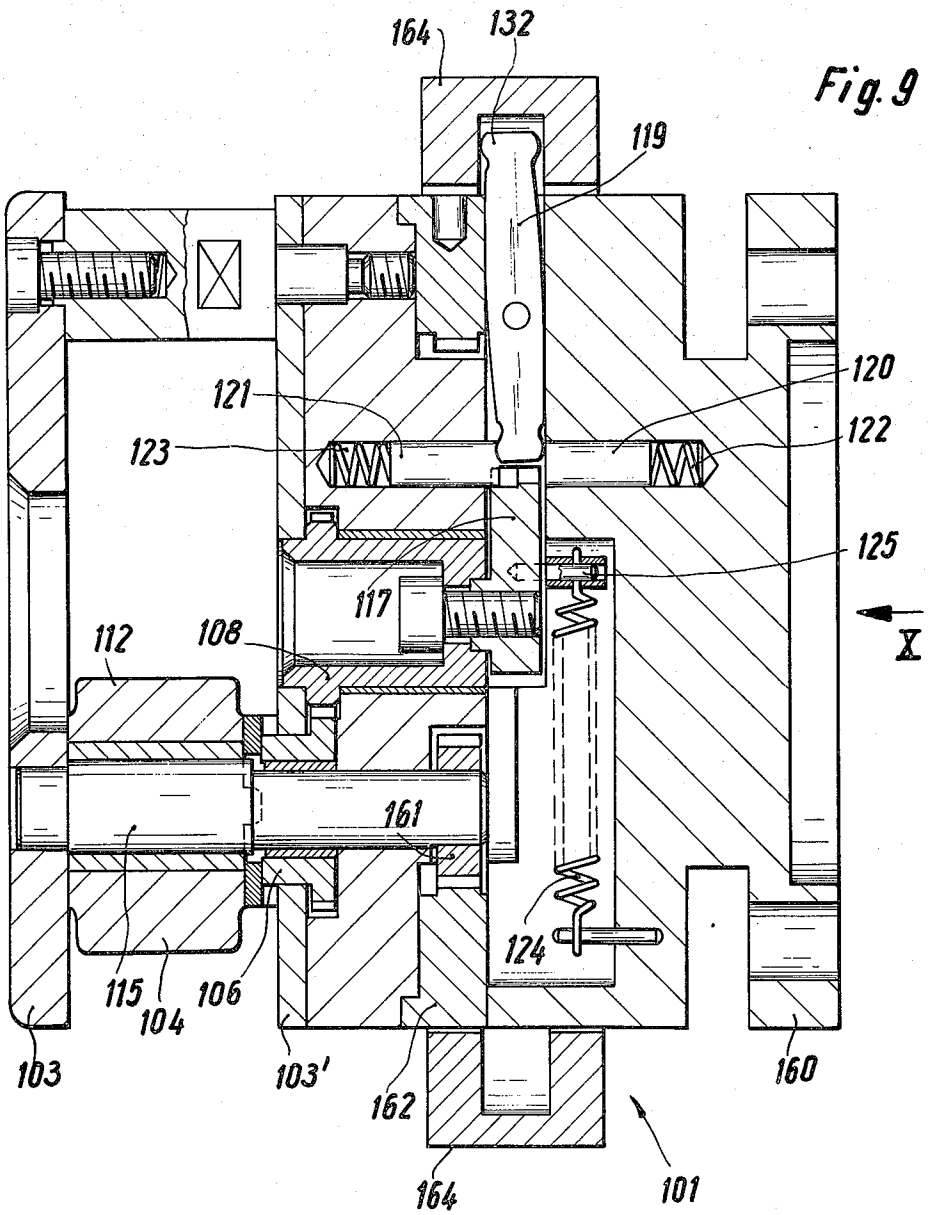


Fig. 8

Fig. 9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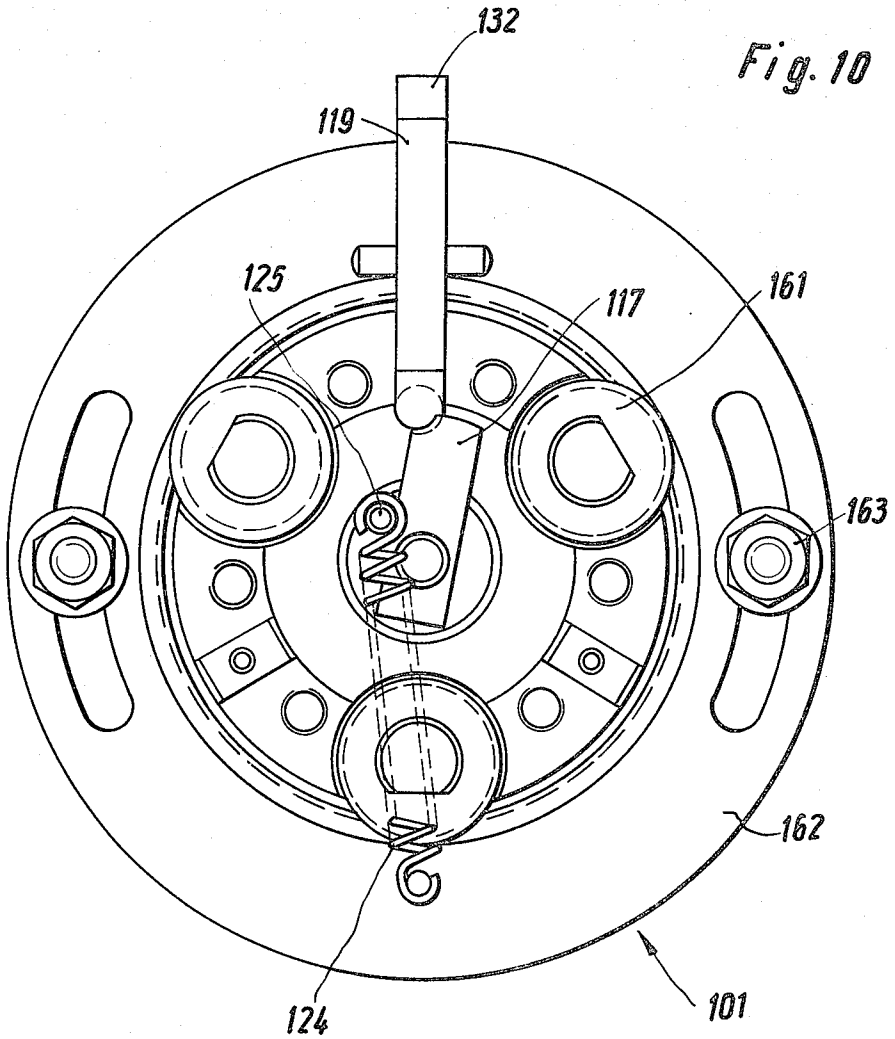

Fig. 10

METHOD AND MACHINE FOR ROLLING THREADS OR THE LIKE

BACKGROUND OF THE INVENTION

The present invention relates to improvements in methods and machines for cold forming round workpieces, and more particularly to an improved method and machine for rolling (e.g., threading, knurling, ridging, grooving or burnishing) profiles into peripheral surfaces of round workpieces, especially workpieces which consist of ductile metallic material. Still more particularly, the invention relates to improvements in a method and machine for rolling threads or analogous profiles into round workpieces by resorting to a plurality of substantially cylindrical dies whose profiles are complementary to the desired profile of a round workpiece.

It is already known to roll threads by resorting to machines which employ two or more cylindrical dies and utilize a gear train which insures that all of the dies rotate in synchronism with each other. The dies are mounted in a head which is movable tangentially of a blank and maintains the dies in spaced-apart positions so that the distances between neighboring dies equal the root diameter of threads on a finished workpiece. In order to move the dies into proper engagement with a blank, the head must be moved in a first direction at right angles to the axis of the blank and is thereupon retracted, again at right angles to the axis of the blank but in the opposite direction, when the thread rolling operation is completed.

THe versatility of thread rolling machines which utilize the just described heat is rather limited, especially because the length of intervals which are required for the profiling of a blank is excessive, at least for the purpose of mass production. As a rule, the blank must complete 15–20 revolutions during profiling, and the disengagement of dies from the finished workpiece requires an interval corresponding to that which elapses while the workpiece completes about five additional revolutions. Moreover, the just discussed head can be mounted only in specially designed thread rolling machines, i.e., the head cannot be used in conventional turning lathes, chucking automatics, bar machines or analogous machine tools. This is due to the fact that such machine tools are incapable of invariably feeding and withdrawing the head while the respective blanks complete between 15 and 25 revolutions. The number of revolutions of a workpiece during engagement with thread rolling dies cannot be selected at will because the number of revolutions determines the quality of the thread or another profile which is produced in the peripheral surface of a blank during engagement with cylindrical dies. Moreover, the just discussed head must move the dies into and from engagement with a blank by exertion of a considerable force which, depending on the dimensions of the head and the nature of threads, often approaches and even exceeds 1,000 kp.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved method of providing round blanks which consist of a ductile metallic material with threads or analogous profiles with a high degree of reproducibility, within intervals of time which are shorter than those required in accordance with heretofore known

methods, and by resorting to relatively simple rolling dies.

Another object of the invention is to provide a method according to which the movements of dies into engagement with round blanks or vice versa necessitate the exertion of relatively small forces.

A further object of the invention is to provide a novel and improved rolling machine wherein the head for two or more cylindrical rolling dies is constructed, assembled and movable in a novel and improved way.

An additional object of the invention is to provide a machine wherein a single revolution of each of two or more substantially cylindrical dies suffices to complete the formation of threads or analogous profiles on round metallic blanks.

A further object of the invention is to provide the machine with novel and improved means for moving the dies into a requisite position with respect to a blank and/or vice versa.

Another object of the invention is to provide a novel and improved head for two or more cylindrical rolling dies which can be installed in conventional machine tools, such as turning lathes, chucking automatics, bar machines or the like.

Still another object of the invention is to provide novel dies for use in the improved machine.

A further object of the invention is to provide a machine which is capable of properly profiling relatively soft as well as relatively hard blanks and wherein the conversion from treatment of softer blanks to treatment of harder blanks or vice versa takes up a minimum of time.

The method of the present invention can be practiced to roll threads or analogous profiles into the peripheral surfaces of round blanks which consist of a ductile material and which are treated by two or more cylindrical dies having profiles which are complementary to the desired profile of a blank. The method comprises the steps of positioning the dies into frictional contact with a selected portion of the peripheral surface of a round blank while maintaining the axes of the dies at identical distances from the axis of the blank, and rotating the blank about its axis or orbiting the dies about the axis of the blank so that the dies rotate about their respective axes due to frictional engagement with the blank and complete the rolling of a profile into the peripheral surface of the blank in response to completion of one revolution about their respective axes.

The method preferably further comprises the steps of locking the dies against rotation about their respective axes prior to the positioning step and locking the dies against rotation about their respetive axes upon completion of the one revolution, i.e., immediately following the completed profiling of a blank.

Still further, the method may comprise the step of biasing the dies to predetermined angular positions which the dies assume upon disengagement of their profiles from a profiled blank.

The method may also comprise the steps of moving a blank to a predetermined position relative to the dies or vice versa, and terminating the first locking step in the course of the moving step. For example, the dies can be moved relative to a rotating blank and are unlocked during such movement so that they can begin to turn under the action of one or more springs in order to frictionally engage a blank whereby the dies begin to rotate about their axes due to rotation of the blank or

because a holder for the dies orbits about the axis of the blank. The second locking step is preferably carried out in automatic response to completion of one revolution, i.e., in response to completed profiling of a blank.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved machine itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a diagrammatic plan view of a head which can be used in a two-die cylindrical die rolling machine;

FIG. 2 is a sectional view as seen in the direction of arrows from the line II—II of FIG. 1;

FIG. 3 is a sectional view as seen in the direction of arrows from the line III—III of FIG. 2;

FIG. 4 is a sectional view as seen in the direction of arrows from the line IV—IV of FIG. 3;

FIG. 5 is an enlarged fragmentary plan view as seen in the direction of arrow A in FIG. 4;

FIG. 6 is an end elevational view of a die;

FIG. 7 is an axial sectional view of a die;

FIG. 8 is a fragmentary plan view of a machine which can utilize the head of FIG. 1;

FIG. 9 is a sectional view of a head which can be utilized in a three-die cylindrical die rolling machine; and

FIG. 10 is an end elevational view of a portion of the head as seen in the direction of arrow X in FIG. 9.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 to 8 show certain details of a two-die cylindrical die rolling machine having a rolling head 1 including two substantially cylindrical dies 4 and 5. The head 1 is movable radially of a rotating round blank 2 which is to be formed with threads, knurled, grooved, burnished and/or similarly profiled. The head 1 includes a bifurcated holder 3 wherein the dies 4, 5 are rotatably mounted on eccentric portions of studs 13, 14. The dies 4, 5 can rotate in unison due to the provision of a gear train having gears 10, 6 which are respectively coaxial and rigid with the dies 4, 5 gears 9, 7 which respectively mesh with the gears 10, 6, and a fifth gear 8 which meshes with the gears 7, 9. As shown in FIGS. 1, 6 and 7, each of the dies 4, 5 has a flat 12 and a profile 11 which includes a first section 11a extending along an arc of approximately 225°, a second section 11*b* extending along an arc of approximately 90°, and a third section 11*c* extending along an arc of approximately 45°. The radius of the section 11*a* increases gradually contrary to the direction in which the die 4 or 5 rotates (see the arrow *a*); the radius of the section 11*b* is constant; and the radius of the section 11*c* decreases contrary to the direction of rotation. The flat 12 extends in part into the section 11*a* and in part into the section 11*c*.

The flats 12 of the dies 4, 5 are parallel to and face each other in the starting angular positions of the dies. The distance between these flats in the starting positions of the dies is slightly greater than the maximum diameter of a finished workpiece. As known, the diameter of the workpiece 2 increases during rolling because some material of the workpiece penetrates into the grooves of the threaded portions 11. Since the distance between the flats 12 (when the flats assume the positions shown in FIG. 1) is greater than the diameters of the crests of threads which are rolled into the workpiece 2, the head 1 can be readily withdrawn from the operative position shown in FIG. 1 by moving in a direction to the right. The movement of the head 1 back to the position shown in FIG. 1 presents no problems since the diameter of an untreated workpiece 2 is evidently less than the distance between the flats 12 when the flats are maintained in parallelism with and face each other.

The gears 7 and 9 which respectively mesh with the gears 6 and 10 of the dies 5 and 4 have radial projections or lobes 17, 18 which constitute component parts of two detent devices. The detect device which includes the lobe 17 further includes a reciprocable locking bolt 20 and a spring 22 which biases the bolt 20 in a direction to the left, as viewed in FIG. 1. The detent device including the lobe 18 further comprises a reciprocable locking bolt 21 and a helical spring 23 which is stronger than the spring 22 and urges the bolt 21 in a direction to the left, as viewed in FIG. 1. The locking bolts 20, 21 are articulately connected with the respective arms of a two-armed actuating lever 19 which is pivotable on a pin 33 mounted in the holder 3. The recess or notch 20*a* which receives the rounded end portion of the lower arm of the actuating lever 19, as viewed in FIG. 1, is longer than the notch 21*a*, i.e., the locking bolt 20 has a certain amount of freedom of lengthwise movement relative to the actuating lever 19 and locking bolt 21. The front end portion 21*b* of the locking bolt 21 is narrower than the front end portion 20*b* of the locking bolt 20.

The median gear 8 of the gear train 6–10 has an eccentric post 25 which is connected with one end of a helical resetting spring 24 (see particlarly FIG. 4). The other end of the spring 25 is attached to a post 24*a* in the holder 3. The purpose of the spring 24 is to permanently bias the gears 7, 9 in directions to move the lobe 17 against the end portion 20*b* of the locking bolt 20 and/or to move the lobe 18 of the gear 9 into abutment with the end portion 21*b* of the locking bolt 21. When the lobe 18 abuts against the end portion 21*b* of the locking bolt 21, the dies 4 and 5 assume the starting positions shown in FIG. 1, i.e., the flats 12 are then parallel to and face each other.

FIG. 8 shows a portion of a turning machine 28 having a rotary holder or chuck 29 for a cylindrical workpiece 2. The head 1 (i.e., the holder 3) is mounted on a cross slide 26 which is movable on a main slide 27 in directions indicated by arrows *b* and *c*. The main slide 27 is movable in the bed B of the machine tool 28 in the axial direction of the workpiece 2. The front end face of the workpiece abuts against a center 30*a* which is mounted in a tailstock 30. The tailstock 30 further carries a trip 31 which extends into the path of movement of a handle 32 rigid with and turnable with the pin 33 for the actuating lever 19 (see also FIGS. 4 and 5). When the cross slide 26 is shifted in the direction indicated by arrow *b* (FIG. 8), the handle 32 is engaged and pivoted by the trip 31 so that the actuating lever 19 pivots clockwise, as viewed in FIG. 1, and retracts the end portion 21*b* of the locking bolt 21 from engagement with the lobe 18 of the gear 9. The spring 24 then turns the gear 8 which rotates the gears 7, 9 and hence the gears 6, 10 whereby the sections 11*a* of the dies 4, 5 en-

gage the rotating workpiece **2** and the dies **4, 5** are rotated due to frictional engagement with the work. The thread rolling operation is completed when each of the dies **4, 5** completes a single revolution. The dies are then automatically locked in their starting positions so that the head **1** can be withdrawn (arrow *c* in FIG. **8**), the finished workpiece removed, and a fresh blank **2** inserted into the holder or chuck **29** before the cross slide **26** is again caused to move in the direction indicated by arrow *b*.

The handle **32** is automatically disengaged from the trip **31** when the cross slide **26** is retracted (arrow *c*) whereby the spring **23** (which is stronger than the spring **22**) expands and pushes the locking bolt **21** into the path of the lobe **18** on the gear **9.**

The operation is as follows:

When the cross slide **26** is retracted, the dies **4** and **5** assume the starting angular positions shown in FIG. **1.** The end portion **21***b* of the locking bolt **21** engages the lobe **18** of the gear **9** to insure that the flats **12** are maintained in parallelism with and face each other. The spring **24** is stressed (see the angular position of the post **25** in FIG. 1) and tends to rotate the gear **8** in a counterclockwise direction, as viewed in FIG. **1.**

The slide **26** is thereupon moved in the direction of arrow *b* (FIG. **8**) whereby the handle **32** strikes against the trip **31** on the tailstock **30** and pivots the actuating lever **19** clockwise, as viewed in FIG. **1.** Thus, the spring **24** is free to rotate the gear **8** counterclockwise at a time when the flats **12** of the dies **4, 5** are located at the opposite sides of the rotating blank **2.** The gear **8** rotates the gears **7, 9** clockwise and the gears **7, 9** rotate the gears **6, 10** and dies **5, 4** counterclockwise. Consequently, the sections **11***a* of the profiles **11** on the dies **4, 5** come into engagement with the peripheral surface of the blank **2** and the dies **4, 5** begin to rotate due to frictional engagement with the blank which is driven by the chuck **29.** The angular position of the actuating lever **19** due to engagement between the trip **31** and handle **32** is such that the locking bolts **20, 21** cannot interfere with rotary movements of the respective gears **7** and **9.** The rolling operation is completed in response to rotation of the dies **4, 5** through 360°, i.e., at a time when the flats **12** are again parallel to and face each other.

As mentioned above, the width of the end portion **21***a* of the locking bolt **21** is somewhat less than the width of the end portion **20***b* of the locking bolt **20.** When the locking bolt **21** is withdrawn by the actuating lever **19** due to engagement between the trip **31** and handle **32,** the end portion **20***b* of the locking bolt **20** is free to move under the action of the relatively weak spring **22** and engages the end face of the lobe **17** on the rotating gear **7.** Thus, the locking bolt **20** does not prevent rotation of the gear **7.** Once the lobe **17** moves beyond the end portion **20***b*, the spring **22** expands further and moves the end portion **20***b* behind the lobe **17.** Consequently, the end portion **20***b* automatically arrests the gear **7** (and hence the gears **4, 8, 9, 10** and dies **4, 5**) when the gear **7** practically completes a full revolution, i.e., when the rolling operation is completed. The end portion **21***b* of the locking bolt **21** remains in retracted or inoperative position because the handle **32** is still in engagement with the trip **31.**

While the gear **8** rotates due to frictional engagement between the rotating blank **2** and the dies **4, 5,** the spring **24** dissipates energy during the first stage of rotation and thereupon again stores energy as the lobe **17** approaches the end portion **20***b* of the locking bolt **20** which is held in the extended or operative position. When the cross slide **26** is thereupon retracted (arrow *c* in FIG. **8**) and the handle **32** is disengaged from the trip **31,** the relatively strong spring **23** pushes the locking bolt **21** to its extended position and the spring **24** contracts to the extent which is necessary to move the lobe **18** of the gear **9** into engagement with the end portion **21***b*. The movement of locking bolt **21** to the extended position of FIG. **1** automatically entails a retraction of the locking bolt **20.** The extent of angular movement of the gear **8** under the action of spring **24** as a result of disengagement of handle **32** from the trip **31** corresponds to the difference between the widths of the end portions **20***b* and **21***b*. The finished workpiece is then accessible for removal from the machine and a new blank **2** is inserted into the chuck **29** before the cross slide **26** again moves in the direction of arrow *b* to start the next rolling operation.

The studs **13, 14** for the dies **4, 5** are held in selected angular positions by arresting screws **34, 35** (see FIG. **3**). When the screw **34** or **35** is loosened, the angular position of the respective stud can be changed and the screw **34, 35** is thereupon tightened to cause the respective prongs **3***a*, **3***b* or **3***c*, **3***d* of the holder **3** to frictionally engage and hold the respective stud in the selected angular position. The angular adjustment of studs **13, 14** results in movement of the axes of dies **4, 5** toward or away from each other. This is necessary when a batch of blanks **2** consisting of a relatively soft material is followed by a batch of harder blanks which cause a more pronounced spreading of the two legs **3A, 3B** of the holder **3** when the dies **4, 5** rotate with a relatively hard blank.

It is clear that the head **1** of FIGS. **1** to **8** can carry more than two (for example, three) substantially cylindrical dies.

An important advantage of automatic locking of the dies **4, 5** in their starting positions upon completion of a rolling operation is that the cross slide **26** can be fed forwardly (arrow *b*) as well as retracted (arrow *c*) by a programming system because the length of the interval which is needed for the rolling of threads or the like on a blank **2** is always the same. Thus, the operator need not observe the angular positions of the uies **4, 5** before the cross slide **26** is retracted in order to move the dies **4, 5** away from the finished workpiece. A rolling operation can be completed with a small fraction of a second.

The configuration of the sections **11***a* of the profile **11** on a die **4** or **5** can be selected as follows:

The radii of roots and crests and the inclination of flanks or threads on the section **11***a* can increase gradually contrary to the direction indicated by arrow *a* (FIG. **6**).

The radii of roots and the inclination of flanks are constant, the same as in the section **11***b*, but the radii of crests increase gradually from the flat **12** toward the section **11***b*. Thus, the height of the profile of threads on the section **11***a* increases gradually toward the height of profile on the section **11***b*.

The increase in the radii of roots and the increase in inclination of flanks are less pronounced than the increase in the radii of crests. This, too, insures that the depth of grooves increases gradually toward the full depth of grooves in the section **11***b*.

FIGS. 9 and 10 illustrate a head 101 which forms part of a three-die cylindrical-die rolling machine. The head 101 includes three substantially cylindrical dies 104 each of which may be configurated in a manner as described in connection with the dies 4 and 5. The dies 104 are equally spaced from each other and are rotatable in a holder including two parallel plates 103, 103'. Each of the dies 104 is rotatable with a coaxial gear 106, and the three gears 106 mesh with a centrally located intermediate gear 108. The flats of the dies 104 are shown at 112. The first section of the profile on each die 104 (corresponding to the section 11*a* in FIG. 6) extends along an arc of 180° (as considered from the center of the respective flat 112); the second section extends along an arc of 90°, and the third or receding section also extends along an arc of 90°.

The gear 108 is a functional equivalent of the gear 8 and carries a projection or lobe 117 which can cooperate with two locking bolts 120, 121. The locking bolts 120, 121 are respectively biased by springs 122, 123 and can be moved lengthwise by one arm of a pivotable actuating lever 119 the other arm of which constitutes a handle 132. The spring 123 is stronger than the spring 122. The gear 108 has an eccentrically mounted post 125 which is connected to one end of a helical restoring spring 124. The latter serves to maintain the dies 104 in their starting positions in which the flats 112 face the adjacent portions of the peripheral surface of a rotary blank which extends into the space between the dies 104.

FIG. 9 shows that the portion of the lobe 117 which can be engaged by the locking bolt 122 extends beyond the portion which is to be engaged by the locking bolt 121. This insures that the locking of gear 108 by the bolt 120 is slightly delayed when the actuating lever 119 disengages the locking bolt 121.

The dies 104 are mounted on eccentric portions of studs 115 each of which is rigid with a discrete gear 161. The gears 161 mesh with a ring gear or internal gear 162 to thus insure that the angular adjustment of one stud 115 invariably entails an equal angular adjustment of the other two studs 115. All of the studs 115 can be adjusted simultaneously by changing the angular position of the internal gear 162 in the head 101. The gear 162 can be turned in the head 101 in response to loosening of two nuts 163 shown in FIG. 10. Adjustments of the angular positions of studs 115 via gears 162, 161 do not change the spacing between the dies 104, as considered in the circumferential direction of the gear 162 and the distance between the axis of the gear 162 and the axes of the dies 104 invariably changes to the same extent.

The operation of the machine which utilizes the head 101 of FIGS. 9 and 10 is as follows:

The head 101 has a flange 160 which can be mounted on the main slide of a turning machine. The axis of the gear 162 must coincide exactly with the axis of a rotating blank (not shown) which can be mounted in a rotary holder similar or analogous to the chuck 29 of FIG. 8. The head 101 is thereupon moved axially so that the flats 112 of the dies 104 are adjacent to a selected portion of the peripheral surface on the rotating blank, namely that portion which is to be knurled, threaded or otherwise profiled (depending on the configuration of the sections of the profiles of the dies 104). The main slide of the machine can be moved by a programming system and is arrested when a trip (similar to the trip 31 of FIG. 8) engages the handle 132 of the actuating lever 119. The latter disengages the locking bolt 121 from the lobe 117 of the gear 108 so that the spring 124 is free to dissipate energy and rotates the gears 106 and dies 104 clockwise, as viewed in FIG. 9 and 10. This moves the first sections of the dies 104 into engagement with the rotating blank. From there on, the dies 104 rotate due to frictional engagement with the driven blank and the latter is formed with a profile which is complementary to the profiles of the second sections of the dies 104.

The spring 124 dissipates energy during the first stage of counterclockwise rotation of the gear 108 and thereupon stores energy as the pin 125 moves counterclockwise beyond the six o'clock position, as viewed in FIG. 10. When the gear 108 completes a revolution, the lobe 117 strikes against the locking bolt 120 or 121 and arrests the dies 104 in such angular positions in which the flats 112 again face the adjacent portions of the peripheral surface of the finished workpiece. Thus, the head 101 can be withdrawn by moving axially of the workpiece, i.e., in a direction to the right, as viewed in FIG. 9.

It is equally within the purview of the invention to omit the aforementioned trip and to manually pivot the actuating lever 119 through the medium of the handle 132 when the dies 104 are disposed around a selected portion of the peripheral surface of a rotating blank. The rolling operation is the same as described above and the head 101 can be retracted axially of the finished workpiece by an automatic mechanism which is set in operation with a predetermined delay following manual actuation of the handle 132. The rolling operation is completed within a fraction of a second and normally requires only a few revolutions of the blank, i.e., a number of blank revolutions corresponding to a full revolution of each of the dies 104.

The machine which utilizes the head 101 of FIGS. 9 and 10 can be modified as follows:

The flange 160 can be secured to a rotary part (e.g., to the spindle) of a turning machine. The chuck or other holder means for the blank does not rotate and is held in such position that the axis of the blank coincides with the axis of the number (spindle) which rotates the head 101. The head 101 is preferably held against axial movement but the blank is movable axially so as to place a selected portion of its periphery into the space between the flats 112 of the dies 104 which orbit about the axis of the spindle. The actuating lever 119 is pivoted as soon as the blank reaches a desired axial position whereby the spring 124 causes the gear 108 to change the angular positions of the dies 104 in the holder 103, 103' so that the profiled first sections of the dies engage the blank and the dies rotate about their axes while orbiting about the non-rotating blank. The blank then acts not unlike a fixed sun gear in a planetary transmission and the dies 104 act not unlike planet pinion which are rotatable in their carrier (103, 103') which rotates about the sun gear. If the head 101 is to rotate with a spindle or the like, it may be provided with a ring-shaped trip 164 which can be braked relative to the rotating flange 160 to thereby pivot the actuating lever 119 so that the latter can disengage the locking bolt 121 from the lobe 117 of the gear 108 to thus initiate a rolling operation. Such operation is completed automatically when the lobe 117 is engaged by the locking bolt 120 whereby the flats 112 face the ad-

jacent portions of the finished workpiece which can be withdrawn by moving it axially and in a direction to the left, as viewed in FIG. **9**.

An important advantage of the improved method and apparatus is that the dies can be moved into an optimum position with respect to a blank (or vice versa) by exertion of a negligible force. This is attributable to the provision of flats **12, 112** which enable the dies to assume their operative positions without even touching a blank. Also, the head **1** or **101** can be mounted in a conventional machine tool (lathe, chucking automatic, bar machine or the like) without necessitating any or by requiring minimal alterations of such machine tools (see the trip **31** in FIG. **8**). Thus, when a head **1** of the type shown in FIGS. **1–7** is mounted in the machine tool **28** of FIG. **8**, the cross force which is needed to move the cross slide **26** into the illustrated position is an extremely small fraction of the force (up to 1,000 kp) which is needed to move a conventional head into proper engagement with a blank.

Another advantage of the improved method and machine is that, regardless of whether the blank rotates about its axis or the dies orbit about the axis of a non-rotating blank, the intervals which are required for profiling are always of identical length so that the finished workpiece can be replaced with fresh blanks at regular intervals. Moreover, and since the rolling operation is invariably completed in response to a single revolution of the dies **4, 5** or **104**, the finished workpiece can continue to rotate about its axis or the holder **103, 103'** can continue to orbit about the axis of a finished workpiece without damaging the profile of the finished product. This will be readily understood by considering that the dies have flats **12** or **112** and that the rotation of dies about their respective axes is automatically terminated as soon as each die in a head completes a single revolution. Such construction and mode of operation insure that the quality of profiles which are rolled into blanks is not dependent on the conscientiousness and/or skill of the attendants; in fact, if the machine tool wherein the head **1** or **101** is mounted is equipped or associated with automatic blank feeding and product removing devices, the operation may be automated to such an extent that a single attendant can supervise an entire battery of machine tools.

The head **1** or **101** can be used for rolling threads or analogous profiles into extremely short workpieces, for rolling threads all the way to the collar or flange of a round blank, for rolling threads with or without runout, and also for rolling extremely short threads, as considered in the axial direction of the blank.

The first sections of the profiles of dies **4, 5** or **104** (see the section **11***a* in FIG. **6**) have increasing radii in order to reduce wear on the dies, and the third sections (**11***c*) have decreasing radii in order to improve the quality of profiles on finished articles, for example, by preventing the formation of pronounced ridges or the like which develop in response to abrupt relaxation of pressure between a die and a blank. The length of sections **11***a*, 11*b*, 11*c*, as considered in the circumferential direction of the dies depends on the ratio of die diameter to blank diameter, on the type of profiles of dies and/or on the height of treads or other raised portions on the sections **11***a–11c*. As a rule, the section will extend along an arc of at least 180° and the section **11***c* along an arc of less than 100°. The section **11***b* may extend along an arc of approximately 90° or less.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by letters Patent is set forth in the appended claims.

1. A method of rolling threads or analogous profiles into the peripheral surfaces of ductile round blank means with die means including a plurality of substantially cylindrical dies having profiles which are complementary to the desired profiles of blanks, comprising the steps of positioning the dies into frictional contact with the peripheral surface of a blank means while maintaining the axes of the dies at identical distances from the axis of the blank means; rotating one of said means relative to the other about the axis of the blank means so that the dies rotate about their respective axes due to frictional engagement with the blank means and complete the rolling of a profile into the peripheral surface of the blank means in response to completion of one revolution about their respective axes; and biasing said dies to predetermined angular positions which said dies assume upon disengagement of their profiles from a profiled blank means.

2. A method of rolling threads or analogous profiles into the peripheral surfaces of ductile round blank means with die means including a plurality of substantially cylindrical dies having profiles which are complementary to the desired profiles of blanks, comprising the steps of positioning the dies into frictional contact with the peripheral surface of a blank means while maintaining the axis of the dies at identical distances from the axis of the blank means; rotating one of said means relative to the other about the axis of the blank means so that the dies rotate about their respective axes due to the frictional engagement with the blank means and complete the rolling of a profile into the peripheral surface of the blank means in response to completion of one revolution about their respective axes; locking the dies against rotation about their respective axes prior to said positioning step; and locking said dies against rotation about their respective axes upon completion of said one revolution.

3. A method as defined in claim **2**, further comprising the steps of moving a blank means into a predetermined position relative to the dies, or vice versa, and terminating the first locking step in the course of said moving step.

4. A method as defined in claim **2**, wherein said second locking step is effected in response to completion of said one revolution.

5. In a machine for rolling threads or analogous profiles into the peripheral surfaces of ductile round blanks, a combination comprising a first holder arranged to support a blank therein; a head including a second holder, a plurality of spaced-apart substantially cylindrical dies rotatably mounted in said second holder and having profiles complementary to the desired profile of a blank in said first holder, a gear train mounted in said second holder and connecting said dies for rotation in synchronism with each other, means for moving the axes of said dies nearer to or away from

each other and comprisng shafts turnably mounted in said second holder and having eccentric portions surrounded by the respective dies, one of said holders being movable relative to the other holder to a predetermined position in which said dies are adjacent to a selected portion of the peripheral surface of a blank in said first holder and the axes of said dies are disposed at identical distances from the axis of such blank; and means for rotating one of said holders about the axis of a blank in said first holder whereby the blank and said second holder move relative to each other about the axis of the blank in said first holder and the dies complete the profiling of the blank in response to completion of one revolution about their respective axes owing to frictional engagement with the blank.

6. A combination as defined in claim **5,** wherein the profile of each of said dies comprises a section whose radius increases contrary to the direction of rotation of the die about its axis during frictional engagement with a blank is said first holder.

7. A combination as defined in claim **6,** wherein said radius increases gradually.

8. A combintion as defined in claim **6,** wherein said section of the profile of each of said dies has raised portions of uniform height.

9. A combination as defined in claim **6,** wherein said section of the profile of each of said dies has raised portions whose height increases contrary to the direction of rotation of the respective die about its axis.

10. A combination as defined in claim **9,** wherein the profile of each of said dies has a second section which follows the respective first mentioned section, as considered contrary to the direction of rotation of the corresponding die about its axis, and has a constant radius.

11. A combination as defined in claim **6,** wherein the profile of each of said dies has a flat which precedes said section, as considered in the direction of rotation of the respective die about its axis, said flat being adjacent to and spaced from said selected portion of a blank in said predetermined position of said one holder and said head further comprising means for rotating said dies about their respective axes sufficiently to move said sections into frictional engagement with the blank in said first holder.

12. A combination as defined in claim **5,** wherein the profile of each of said dies has a first section whose radius increases contrary to the direction of rotation of the respective die about its axis, a second section following said first section and having a constant radius, and a third section which follows said second section and whose radius decreases in said direction.

13. A combination as defined in claim **12,** wherein each of said first sections extends along an arc of at least 180°, as considered in the circumferential direction of the respective die.

14. A combination as defined in claim **12,** wherein each of said second sections extends along an arc of approximately 90°, as considered in the circumferential direction of the respective die.

15. A combination as defined in claim **12,** wherein each of said third sections extends along an arc of less than 100°, as considered in the circumferential direction of the respective die.

16. In a machine for rolling threads or a nalogous profiles into the peripheral surfaces of ductile round blanks, a combination comprising a first holder arranged to support a blank rotatable about its axis; a head including a second holder, a plurality of spaced-apart substantially cylindrical dies rotatably mounted on said second holder and having profiles complementary to the desired profile of a blank in said first holder, and a gear train mounted in said second holder and connecting said dies for rotation in synchronism with each other, said head being movable relative to said first holder from a first to a second position in which said dies are adjacent to a selected portion of the peripheral surface of a blank in said first holder and the axes of said dies are disposed at identical distances from each other; releasable locking means for locking said dies, when said head is in said first position, in a predetermined angular relationship with respect to each other; means cooperating with said releasable locking means to automatically release the latter upon movement of said head from said first to said second position; means operatively connected to said dies for moving the same out of said predetermined angular position when said locking means are released so that the dies engage the peripheral surface of a blank in said first holder; and means for rotating said first holder about the axis of a blank in said first holder whereby said blank rotates with said first holder and the dies complete the profiling of the blank in response to completion of one revolution about their respective axes owing to frictional engagement with the blank.

17. A combination as defined in claim **16,** wherein each of the dies has a flat, and wherein said flats are adjacent to but spaced from the peripheral surface of the blank in said predetermined angular position of said dies.

18. In a machine for rolling threads or analogous profiles into the peripheral surfaces of ductile roung blanks, a combination comprising, a first holder arranged to support a blank therein; a head including a second holder, first and second spaced-apart substantially cylindrical dies rotatably mounted in said second holder and having profiles complementary to the desired profile of the blank in said first holder, and each of said dies having a flat, said head further comprising means for rotating said dies about their respective axes to move the profiles of said dies in frictional engagement with the blank in said first holder, a gear train mounted in said second holder and connecting said dies for rotation in synchronism with each other, said gear train including first and second gears coaxial and rigid with said first and second dies, third and fourth gears respectively mating with said first and second gears, and additional gear means mating with said third and fourth gears, and detent means for releasably holding said dies against rotation about their respective axes, said detent means comprising first and second projections respectively provided on said third and fourth gears, first and second locking bolts movable into and out of the path of movement of said first and second projections, and actuating means for moving said bolts, one of said holders being movable relative to said other holder to a predetermined position in which said flats are adjacent to a selected portion of the peripheral surface of the blank in said first holder and the axes of said dies are disposed at identical distances from the axis of such blank; and means for rotating one of said holders about the axis of a blank in said first holder whereby the blank and the second holder move relative to each other about the axis of the blank in said first holder and the dies complete the profiling of the blank in response

to completion of one revolution about their respective axes owing to frictional engagement with the blank.

19. A combination as defined in claim **18,** wherein said detent means further comprises discrete first and second resilient means for biasing said first and second locking bolts into the path of movement of the respective projections.

20. A combination as defined in claim **19,** wherein the bias of said first resilient means exceeds the bias of said second resilient means and said actuating means is arranged to disengage one of said bolts from the respective projection when the other of said bolts extends into the path of movement of the respective projection whereby said first resilient means automatically disengages said second bolt against the opposition of said second biasing means when said actuating means allows said first bolt to move into the path of movement of said first projection.

21. A combination as defined in claim **20,** wherein said second locking bolt is mounted in said second holder with limited freedom of movement relative to said actuating means.

22. A combination as defined in claim **18,** wherein said additional gear means comprises a fifth gear in mesh with said third and fourth gears and said means for rotating said dies comprises resilient means arranged to bias said fifth gear so that said fifth gear tends to rotate said dies by way of said first to fourth gears when said detent means permits rotation of said third and fourth gears, said resilient means being arranged to bias said projections against the respective locking bolts when said flats are adjacent to but spaced from a blank in said first holder.

23. A combination as defined in claim **22,** wherein said fifth gear comprises an eccentric post and said resilient means comprises a spring connected to said post and reacting against said second holder.

24. In a machine for rolling threads or analogous profiles into the peripheral surfaces of ductile round blanks, a combination comprising a first holder arranged to support a blank therein; a head including a second holder, a plurality of spaced-apart substantially cylindrical dies rotatably mounted in said second holder and having profiles complementary to the desired profile of a blank in said first holder, and a gear train mounted in said second holder and connecting said dies for rotation in synchronism with each other, one of said holders being movable relative to the other holder to a predetermined position in which said dies are adjacent to a selected portion of the peripheral surface of a blank in said first holder and the axes of said dies are disposed at identical distances from the axis of such blank; and a machine tool for rotating one of said holders about the axis of a blank in said first holder whereby the blank and the second holder move relative to each other about the axis of the blank in said first holder and the dies complete the profiling of the blank in response to completion of one revolution about their respective axes owing to frictional engagement with the blank, said dies having flats which are adjacent to but spaced from the blank in said first holder in said predetermined position of said one holder, and said head further comprising resilient means for rotating said dies about their respective axes sufficiently to move the profiles of said dies into frictional engagement with the blank in said first holder and means for releasably locking said dies against rotation under the action of said resilient means, said machine tool having a trip arranged to deactivate said locking means in response to movement of said one holder to said predetermined position.

25. In a machine for rolling threads or analogous profiles into the peripheral surfaces of ductile round blanks, a combination comprising a first holders arranged to support a blank therein; a head including a second holder, a plurality of spaced-apart substantially cylindrical dies rotatably mounted in said second holder and having profiles complementary to the desired profile of a blank in said first holder and flats which are adjacent to but spaced from a blank in said first holder, and a gear train mounted in said second holder and connectng said dies for rotation in synchronism with each other, said gear train including discrete first gears rigid with said dies and a second gear surrounded by and meshing with said first gears, said head further comprising resilient means for rotating said dies about their axes sufficiently to move the profiles of said dies into frictional engagement with the blank in said first holder, and means for releasably locking said dies against rotation under the action of said resilient means, said locking means comprising a projection on said second gear, first and second locking bolts movable into and from the path of movement of said projection, and actuating means for moving said bolts, one of said holders being movable relative to the other holder to a predetermined position in which said dies are adjacent to a selected portion of the peripheral surface of a blank in said first holder and the axes of said dies are disposed at identical distances from the axis of such blank; and means for rotating one of said holders about the axis of a blank in said first holder whereby the blank and the second holder move relative to each other about the axis of the blank in said first holder and the dies complete the profiling of the blank in response to completion of one revolution about their respective axes owing to frictional engagement with the blank.

26. A combination as defined in claim **25,** wherein said projection comprises a portion which is engaged by said first bolt before said projection is engaged by said second bolt, said locking means further comprising first and second springs for respectively biasing said first and second bolts with a weaker and greater force toward engagement with the projection of said second gear.

27. A combination as defined in claim **25,** wherein said resilient means engages and tends to rotate said second gear.

28. A combination as defined in claim **25,** further comprising means for moving said dies radially of a blank in said first holder.

29. A combination as defined in claim **28,** wherein said means for moving said dies radially comprises discrete stubs rotatably mounted in said second holder and each having an eccentric portion rotatably supporting a die, third gears rigid with said stubs, and means for simultaneously rotating said third gears through identical angles.

30. A combination as defined in claim **29,** wherein said means for rotating said third gears comprises a ring gear meshing with said third gears and being rotatable with respect to said second holder.

31. A combination as defined in claim **25,** further comprising an annular trip mounted on and rotatable with respect to said second holder to thereby disengage said bolts from said projection through the medium of said actuating means.

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