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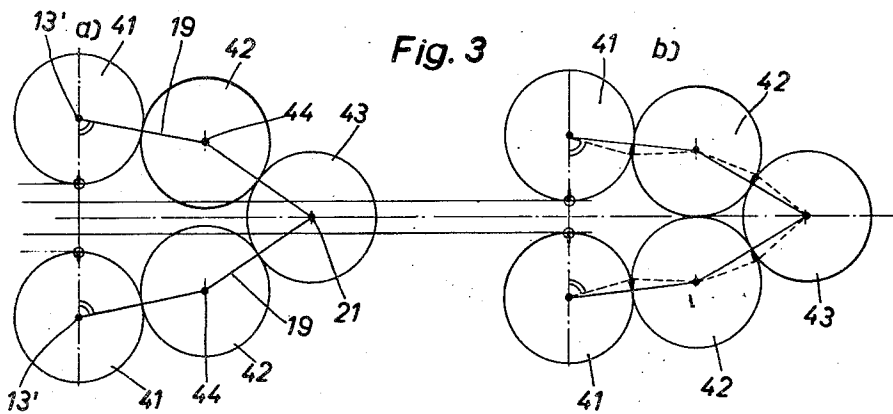
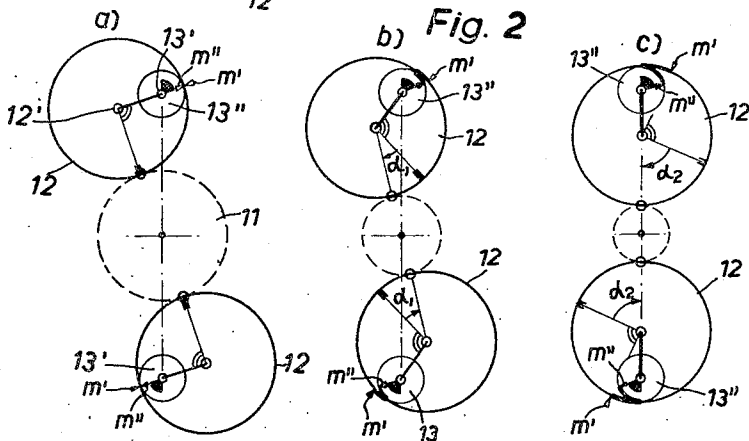
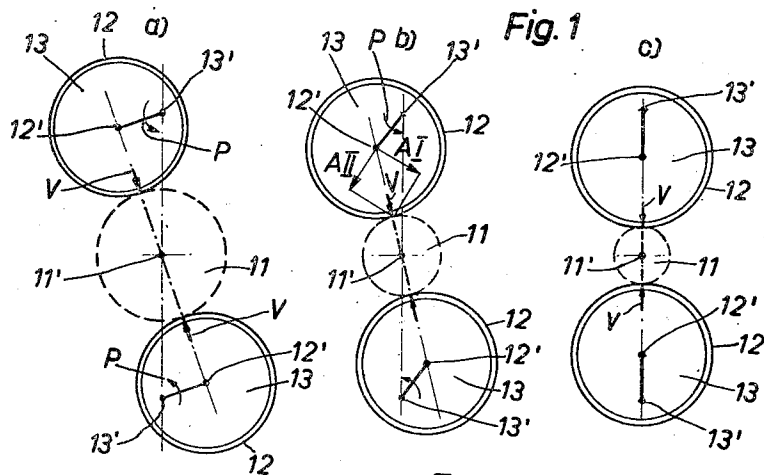
J. P. HOFER

3,048,064

THREAD ROLLING METHOD AND APPARATUS

Filed Dec. 11, 1959

5 Sheets-Sheet 1



JEAN PIERRE HOFER, INVENTOR
By Wendt, Lind & Coxack
ATTORNEYS

Aug. 7, 1962

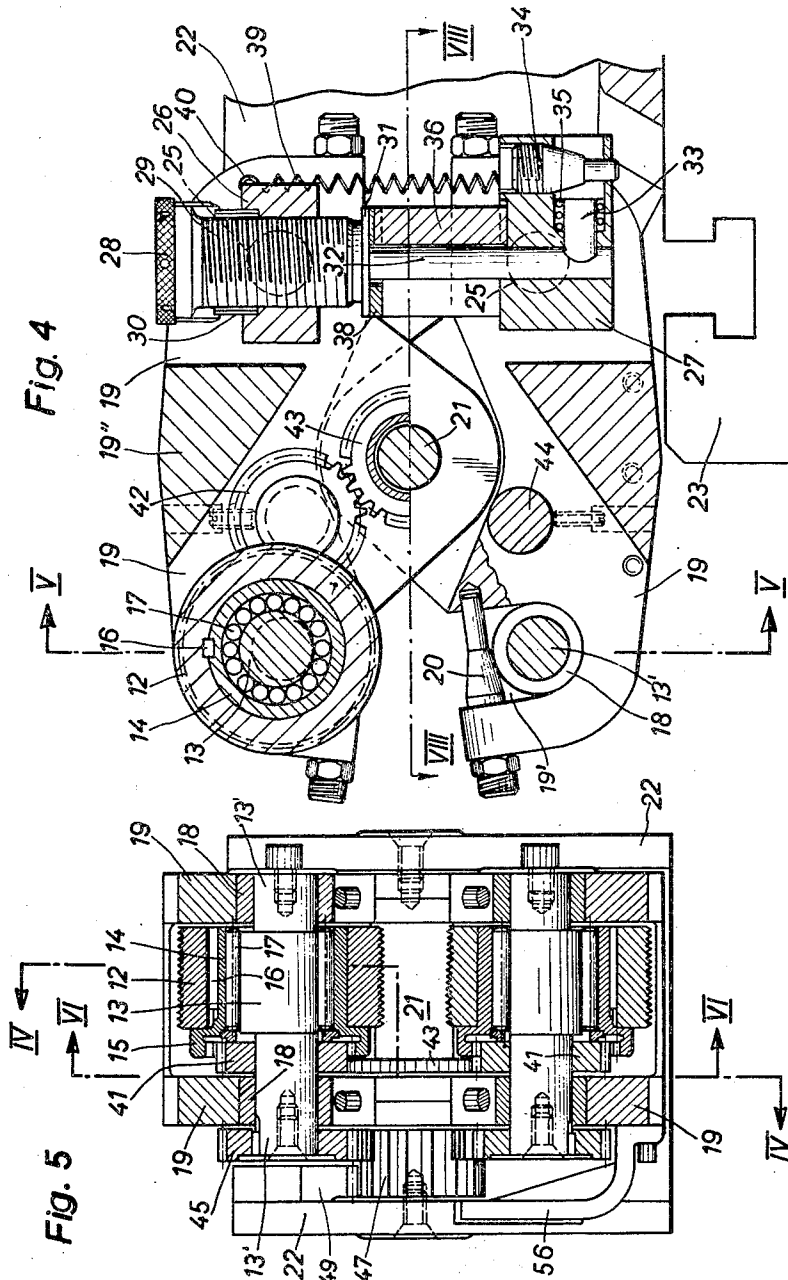
J. P. HOFER

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THREAD ROLLING METHOD AND APPARATUS

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5 Sheets-Sheet 2



JEAN PIERRE HOFER, INVENTOR
By Wunderath, Lind & Cousch
ATTORNEYS

Aug. 7, 1962

J. P. HOFER

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THREAD ROLLING METHOD AND APPARATUS

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Fig. 10

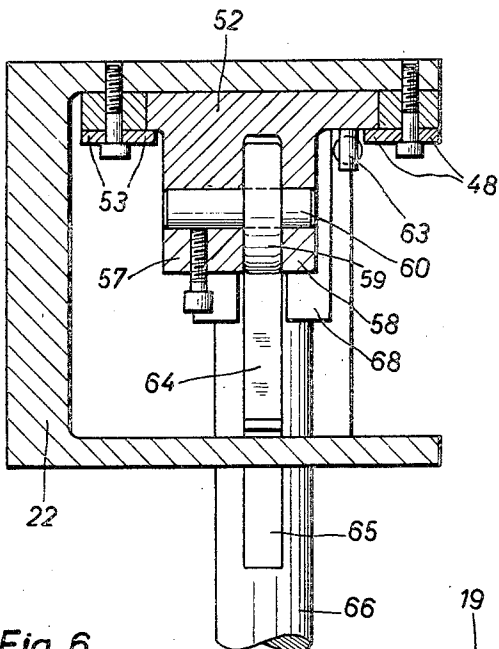


Fig. 6

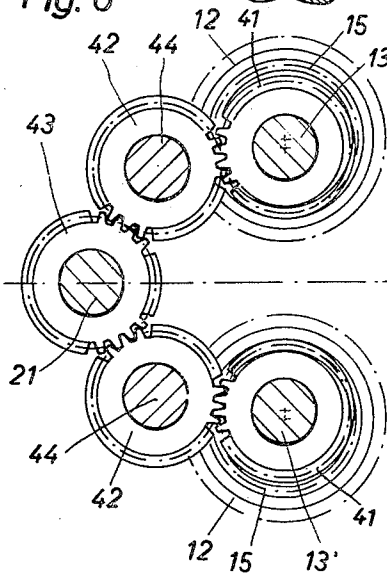
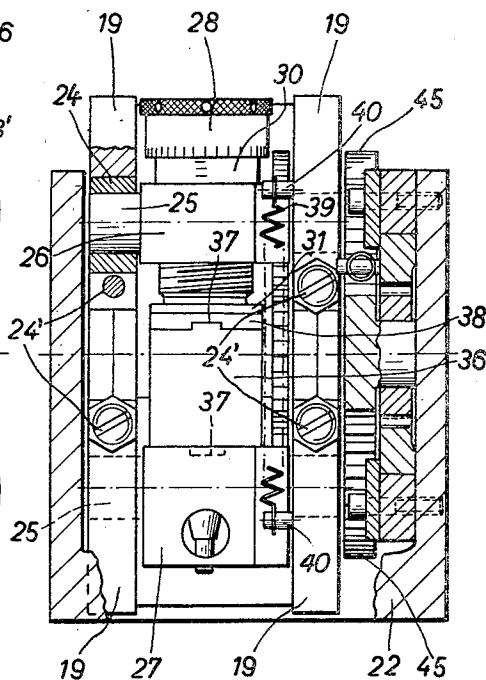


Fig. 9



JEAN PIERRE HOFER
INVENTOR

By Wendrich, Lind & Conach
ATTORNEYS

Aug. 7, 1962

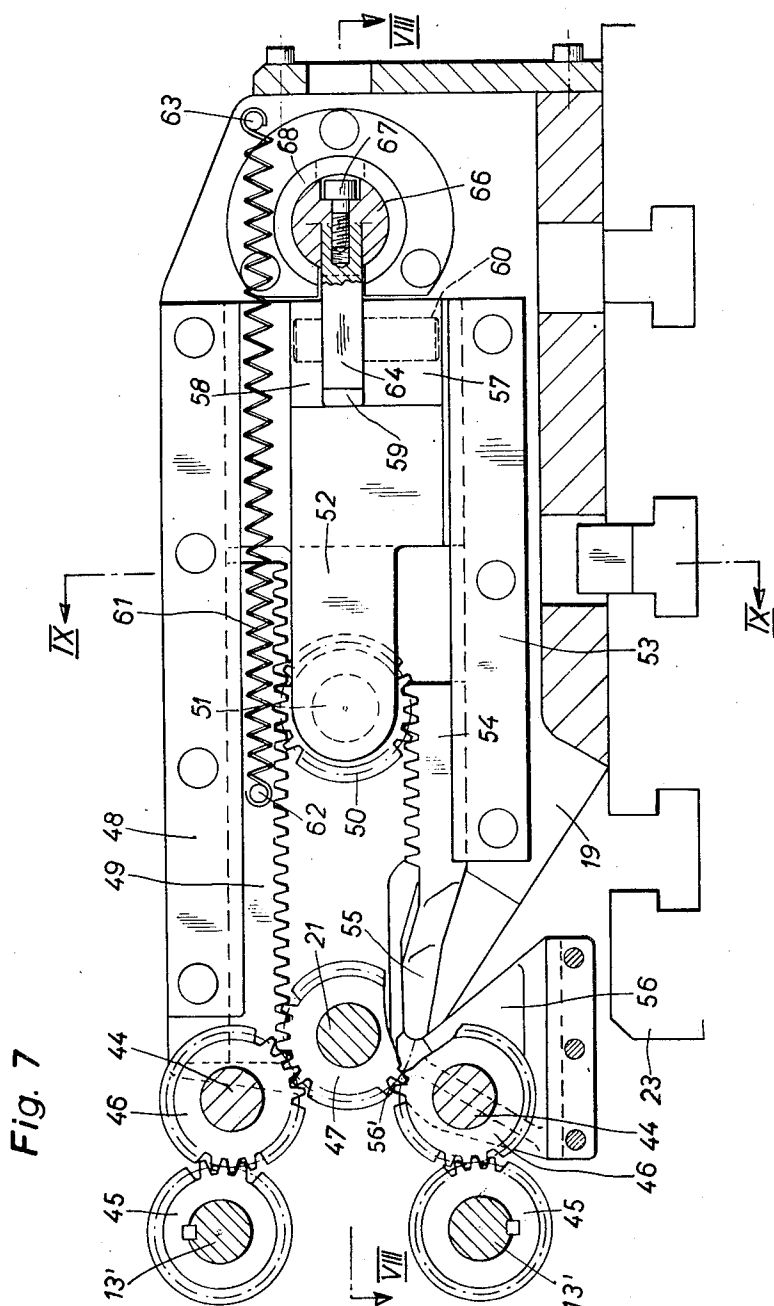
J. P. HOFER

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THREAD ROLLING METHOD AND APPARATUS

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5 Sheets-Sheet 4



JEAN PIERRE HOFER

INVENTOR

By Wandersath, Lind & Conner
ATTORNEYS

Aug. 7, 1962

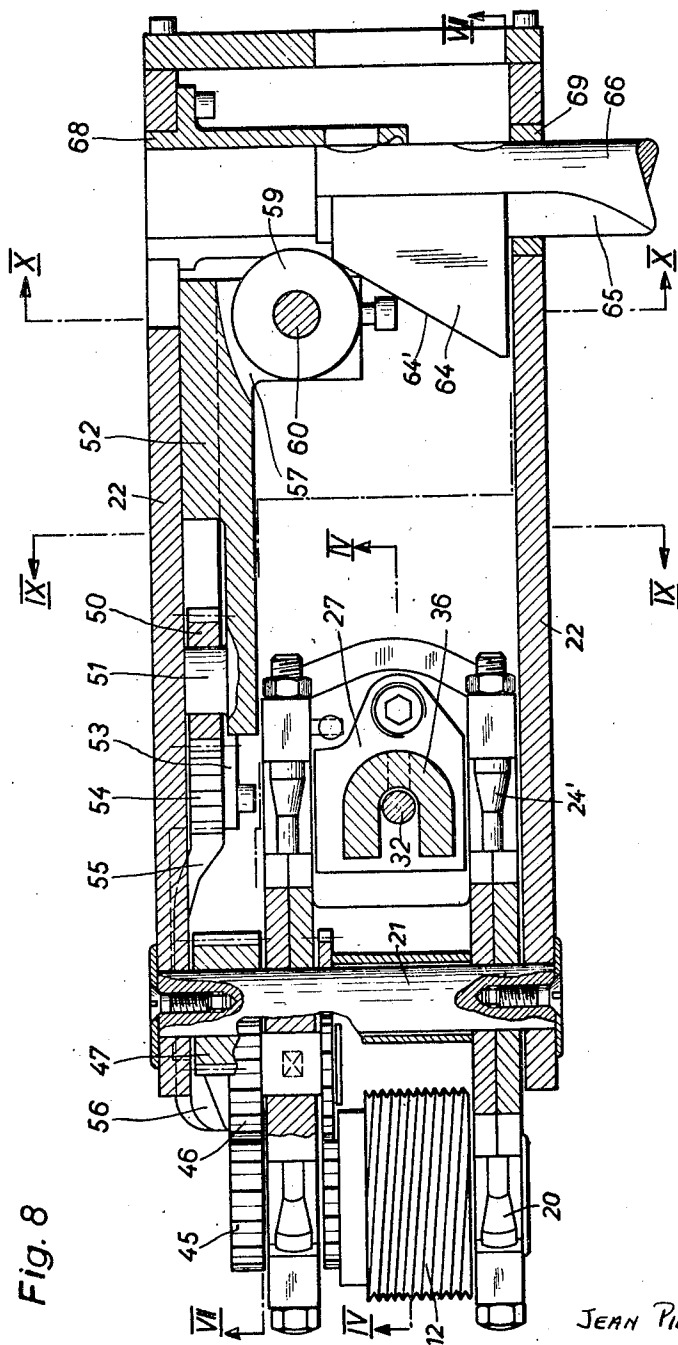
J. P. HOFER

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THREAD ROLLING METHOD AND APPARATUS

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JEAN PIERRE HOFER
INVENTOR

By Wendt, Lind & Pouch
ATTORNEYS

THREAD ROLLING METHOD AND APPARATUS

Jean Pierre Hofer, 11 Bedford Gardens,
Hornchurch, England

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2 Claims. (Cl. 80-6)

This invention relates to a method and apparatus for shaping workpieces which are rotatable about an axis, and particularly to a thread rolling method and apparatus.

According to the method of this invention, two shaping tools to which a feed motion is imparted are subjected to a primary and a secondary working force in such manner that two resulting shaping forces are applied to the workpiece, the two forces being directed toward each other in a line of application passing through said axis of rotation and extending at right angles thereto, the feed motion of the tools being effected by a movement of rotation of the working forces about their pivot point of application relatively to said common line of application of the shaping forces, and simultaneous rotation of said line of application about said axis of rotation.

The apparatus according to the invention comprises at least two shaping tools situated diametrically opposite each other relatively to the axis of rotation of the workpiece, the tools being movable in the same direction and positively guided each along a curved path around the axis of rotation of the workpiece, the two curved paths being symmetrical relatively to a point of said axis of rotation.

The invention consists of the novel method, construction and arrangement of parts as will be hereinafter more specifically described and illustrated in the accompanying drawings in which is shown an embodiment of the invention constituted by a thread rolling attachment.

In the drawings,

FIG. 1 represents diagrammatically the rolling tools and the shaping forces exerted by them in different positions of feed motion;

FIG. 2 shows the cinematics of the rolling tools during the feed motion;

FIG. 3 shows diagrammatically the rolling tools which are operatively interconnected by means of a gear train, and the cinematics during feeding of the tools;

FIG. 4 is a fragmentary longitudinal section through the thread rolling attachment along the line IV—IV of FIG. 5 or FIG. 8;

FIG. 5 is a transverse section along the line V—V of FIG. 4;

FIG. 6 is a transverse section along the line VI—VI of FIG. 5;

FIG. 7 is a longitudinal section along the line VII—VII of FIG. 8;

FIG. 8 is a longitudinal section along the line VIII—VIII of FIG. 7 or FIG. 4;

FIG. 9 is a transverse section along the line IX—IX of FIG. 7 or FIG. 8.

FIG. 10 is a transverse section along the line X—X of FIG. 8.

Referring to FIG. 1, the thread rolling attachment comprises two threading rolls 12 disposed diametrically opposite each other with respect to the axis 11' of a workpiece 11 which is rotatable about its axis. The roll axes 12' extend symmetrically with respect to the workpiece axis 11'.

In a conventional thread rolling attachment in which the rolls effect a feed motion, working forces which are identical with the shaping or forming forces and act in the common axial plane of the rolls and of the workpiece, become effective on the rolls 12. These forces result in a feed motion in which the axes of rotation 12'

of the rolls move in the mentioned common axial plane while remaining parallel.

In the thread rolling apparatus according to the invention the rolls 12 are formed as rings and each roll is mounted rotatably on an eccentric 13. The axes 13' about which the eccentrics 13 turn are symmetrical with respect to the axis 11' of the workpiece, and the distance between the axes 12', 13' always remains constant. The feed motion of the rolls 12 relatively to the workpiece is effected by a movement of rotation of the two eccentrics 13 by means of a working force applied in the direction of the arrows P, i.e. in counter clockwise direction for both eccentrics. FIGS. 1(a), (b) and (c) show different phases of the progressing feeding motion, the deformation of the workpiece 11 being indicated in dotted lines. It will be understood, as shown in this figure, that the shaping or forming forces V which arise upon feeding the rolls and are applied on the workpiece, are directed towards each other and are always situated on a common line passing through the axis of rotation of the workpiece. These forces V, during the feed motion of the rolls 12, rotate in clockwise direction about the axis 11' of the workpiece.

An analysis of the forces shows that each forming or shaping force V in fact is the resultant of a primary and a secondary working force designated by A_I and A_{II} in FIG. 1(b). The primary force A_I depends as to its direction on the instantaneous position of the eccentric 13, and extends always at right angles to the crank of the eccentric, while the secondary force A_{II} coincides with the direction of the crank. When feeding the rolls 12, the mentioned working forces turn about their point of application coinciding with the roll axis 12', relative to their resultant which, as mentioned already, turns about the axis 11' of the workpiece.

An analysis of the movement of the tools shows that the rolls 12 are guided to be radially movable relative to the workpiece axis 11', as required in a thread rolling device. Besides, the rolls 12 are each angularly movable about the workpiece axis 11' along a guide curve, namely a circular arc described by the end of the crank of the eccentric 13 about the axis 13' thereof. This movement is positively effected in the same direction for both rolls 12 since, as explained later, the two eccentrics are interconnected for rotation by a gear train.

The above considerations solely concern the feed motion of the rolls, while the actual rolling of the thread, requiring a rolling movement of the tools along the surface of the workpiece has not been considered. The workpiece 11 is rotated about its axis in any known manner and drives by contact friction the rolls 12 applied with the required shaping force against the surface of the workpiece, so that the rolls effect a movement of rotation about their axes on the eccentrics 13. It obviously is important that the two rolls 12 are positively coupled for rotation with one another so as to exclude a relative rotary movement between themselves. It is also important that the rolls 12 effect their rolling movement along the surface of the workpiece without any slip, so that their threads always correctly engage with the threads already rolled into the workpiece 11, since the shaping operation is effected during several revolutions of the workpiece. This means that the angular velocities of both rolls 12, corresponding to that of the workpiece, must be rigorously equal during the entire rolling operation.

FIGS. 2(a), (b) and (c) represent the conditions of movement of the rolls 12 relatively to each other and to the workpiece 11 during the feed motion. For the sake of clearness this has been illustrated in the following manner: fixed shafts 13'' extend through the annular threading rolls 12. The axes of the shafts 13'' coincide with the axes of the eccentrics shown in FIG. 1, and the diameter

of the shafts is so chosen that the roll axes 12' are displaced relatively to the eccentric axes 13' through an amount equal to the eccentricity of the eccentrics 13. It is supposed that the rolls 12 are provided with internal teeth and the shafts 13'' with external teeth meshing with the teeth of the rollers, so that a rotation of the rolls 12 about their axes is prevented and their only possibility of movement is a rolling movement of their internal teeth along the teeth of the shafts 13''. This movement corresponds, as illustrated by the three movement phases shown in FIGS. 2(a), (b) and (c), to the feed motion of the rolls 12 by means of the eccentrics 13 as explained before. The marks m' and m'' on the shafts 13' and the rolls 12, respectively, and the angular movement of the forming or shaping force relative to the rolls 12 show that the advance of the point of contact of the rolls 12 with the workpiece 11 or the shafts 13'' takes place in the same direction and through the same angle for both rolls. Thus, synchronism of the rolling tools and of the workpiece is not disturbed during the feed motion.

In a practical embodiment of the thread rolling attachment according to the invention, as illustrated in FIGS. 4 to 10, this attachment is suitable for use in combination with lathes, automatics or other machine tools, in which case the workpiece has to be chucked to the spindle of the machine. However, the thread rolling apparatus can also be combined with a special workpiece spindle and operated as an independent machine.

According to FIGS. 4 and 5, a sleeve 14 is inserted into the bore of the annular threading rolls 12. Each sleeve 14 carries at one end an internal gear crown 15 which is coaxial with the sleeve. The gear crown 15 and its sleeve 14 are connected for rotation with the roll 12 by means of a key 16. The sleeves 14 are rotatably mounted on eccentrics 13 by the intermediary of needles 17, and the eccentrics are fast on eccentric shafts 13'. Each shaft 13' is rotatably mounted on one end of a pair of tilting levers 19, there being an upper and a lower pair of levers. The shafts 13' are journaled in bearing sleeves 18 which are inserted in recesses 19' of the levers 19 and maintained therein by conical screw studs 20. The two lever arms 19 of each pair of levers are rigid with each other by means of a web portion 19'' (FIG. 4). The two threading rolls 12 are situated between the levers of the upper pair and the lower pair, respectively. Both lever pairs 19 are journaled on a pin 21 which is mounted in the two lateral walls of a U-shaped carrier member 22 (see also FIGS. 7, 8 and 10); the web portion of this carrier member bears upon the tool slide 23 of a machine tool (FIG. 4), for example on the cross slide of an automatic screw lathe, and is fixed thereto so that the free end portions of the levers 19 hold the rolls 12 in contact with the workpiece. By means of a tilting movement of the upper and lower levers 19 in opposite direction the rolls 12 together with the eccentrics 13 can approach or move away from each other. This arrangement permits threading of workpieces of different diameters.

Sleeves 24 for bearing pins 25 (FIGS. 9 and 4) are inserted in recesses of the opposite ends of the levers 19 and are maintained therein by means of conical screw studs 24'.

The upper and lower bearing pins 25 each support a rotatable block 26 and 27, respectively. The block 26 mounted in the upper lever 19 is provided with a threaded hole to receive an adjusting screw 29 provided with graduated drum 28. The graduation of the drum 28 coacts with graduation marks formed on a sleeve 30 which surrounds the screw 29 and is secured to the block 26. The end of the adjusting screw 29 bears against a flanged head 31 of a pin 32 extending with its opposite end into a bore of the block 27 where it is fixed by means of a transversally movable lock pin 33. A conical tensioning screw 34 coacts with the head of the lock pin 33 to move the pin 33 towards the pin 32 against the action of a spring 35. This arrangement permits an easy removal of the pin 32 and exchange of a U-shaped spacing member 36 (FIGS. 4 and 8) which

is clamped between the head 31 of the pin 32 and the block 27. The spacing member 36 is provided at the top and bottom sides with a protuberance 37 engaging in a recess of the block 27 and of a washer 38, respectively. In this manner the spacing member 36 is held in a fixed position, and the pin 32, upon an exchange of the spacing member, can be inserted in the block 27 and easily located and clamped without searching for the correct position. A spring 39 having its ends attached to the top and bottom levers 19, respectively, constantly applies the adjusting screw 29 against the head 31 of the pin 32. In this manner the distance between the axes of the two rolls 12 is exactly set and can be adjusted, coarse adjustment being made by insertion of a spacing member 36 of suitable length, and fine adjustment being effected by means of the screw 29. For exchanging a spacing member it is only necessary to release the pin 32 from engagement with the lock pin 33 and to press the ends of the levers 19 carrying the rolls 12 towards each other, so that the spacing member 36 can be removed and replaced by another one. It is further possible, when the spacing member has been removed, to tilt the roll carrying lever ends so far away from each other that the rolls 12 and their eccentrics 13 can be easily removed and replaced. In this manner, threading rolls of different diameter and different thread can be used, and workpieces of different diameters can be threaded, and it is an important feature of the invention that the finishing dimensions of the thread which is rolled can be adjusted with high precision and that threaded workpieces can be produced having the desired exact measurements.

As already mentioned, it is necessary to interconnect the threading rolls 12 for rotation. For this purpose gear wheels 41 (FIGS. 5 and 6) are loosely mounted on the eccentric shafts 13' and mesh with the gear crowns 15. Upon a movement of rotation of the eccentrics 13, the gear crowns 15 roll around the gears 41. Reference is made to the explanations in connection with FIG. 2 of the drawings which can be regarded as illustrating the operative connection of the gear crowns 15 with the gears 41. Each gear wheel 41 meshes with a wheel 42 mounted on a pin 44 carried by the levers 19, and the two wheels 42 in turn mesh with a gear wheel 43 on the journal pin 21 of the levers 19.

FIG. 3 illustrates diagrammatically this gear train. In FIG. 3(a) the roll carrying ends of the two levers 19 are supposed to be opened more than in FIG. 3(b). It will be understood from these figures that when opening or closing the roll carrying ends of the levers 19, i.e. when adjusting the device according to the diameter of the workpiece, the gear wheels 41 cannot effect any rotation relative to each other, and that synchronism between the two rolls 12 is maintained. The rolls 12 may be provided with marks to permit their insertion in correct relative position.

A gear wheel 45 is keyed to the end of each eccentric shaft 13' (FIG. 7). These gear wheels are connected by the intermediary of gear wheels 46 turning on pins 44 with a gear wheel 47 which is loose on the journal pin 21 of the levers 19. Thus the eccentric shafts 13' are interconnected for rotation in a manner similar to the connection of the rolls 12. This gear connection of the eccentric shafts prevents the eccentrics 13 from any relative rotation when the levers 19 effect a closing movement, and an angular movement of the gear wheel 47 permits an angular adjustment of the eccentrics in the same direction for effecting a feed movement of the rolls 12. It is evident that the eccentrics 13 are angularly displaced with respect to each other through an angle of 180°. The wheels 45, 46 and 47 can be marked to enable setting of the eccentrics in their correct relative position.

A sliding rack 49 is mounted for longitudinal movement in a rail 48 secured to one lateral wall of the carrier 22. The rack 49 meshes with the gear wheel 47 and with a further gear wheel 50 mounted at the rear of the wheel 47 on a pin 51 carried by a slide 52. The slide

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is guided in the guide rail 48 and in a further lower parallel guide rail 53 for movement in the same direction as the rack 49. A further rack 54, movable along the guide rail 53, also meshes with the gear wheel 50. Movement of the two racks 49 and 54 is obtained by displacing the slide 52, the gear wheel 50 having a compensating action. The front end of the rack 54 remote of the slide 52 carries a finger 55 extending laterally of the gear wheel 47. The rounded end of the finger 55 engages a recess 56' in a bracket 56 which is screwed to the lower lever 19 (FIG. 5). The line of contact of the finger 55 with the bracket 56 is at a distance from the centre line of the journal pin 21 which substantially corresponds to the active radius of the gear wheel 47. With this arrangement the lower lever 19 can be tilted about the journal pin 21 by a forward movement of the rack 54, the tilting movement being in clockwise direction as seen in FIG. 7, while a movement in opposite direction of the lever 19 will be transmitted to the rack 54. The purpose of this structure will be explained later.

The slide 52 is provided at its rear end remote of the gear wheel 50 with two parallel extensions 57 and 58 carrying a pin 60 extending at right angles to the direction of movement of the slide 52. A roll 59 is mounted on the pin 60 between the two extensions 57 and 58. A spring 61, attached at 62 to the rack 49 and at 63 to the carrier 22, acts to pull the rack rearwardly, and by the intermediary of the gear wheel 50 and slide 52 applies the roll 59 on the inclined face 64' of a cam 64 (FIGS. 7 and 8). The cam 64 is inserted into an axial groove 65 of a push rod 66 and secured therein by screws 67. The push rod 66 is axially movable and guided in a sleeve 68 fixed to one lateral wall of the carrier 22, and in a sleeve 69 inserted into the opposite wall of the carrier. The outer end of the push rod 66 is operatively connected with a reciprocating member, not shown, which member may be a slide of the machine tool equipped with the thread rolling attachment according to this invention, or a hydraulic cylinder and piston. By means of this reciprocating member the push rod can be axially moved to have the cam surface 64' acting on the roll 59.

The following explanations are based on the supposition that the described attachment is combined with the cross slide of a screw-cutting lathe and that the push rod 66 is operated by a separate hydraulic plunger. After the thread rolls 12 have been correctly positioned on their eccentric shafts the appropriate spacing member 36 is used for approximate adjustment of the levers 19. Fine adjustment is then effected by means of the screw 29. Then the cross slide of the lathe is so positioned that the axis of rotation of the eccentrics and the axis of rotation of the workpiece are situated in the same plane, as shown in FIG. 1. The eccentrics 13 must then have the "open" position shown in FIGS. 4 and 5, i.e. the major radii of both eccentrics are also situated in said common plane and directed away from each other. Now the push rod 66 is advanced to have the cam surface 64' acting against the roll 59 and to advance the slide 52 forwardly toward the workpiece. The movement of the slide 52 is transmitted to the racks 49 and 54 by the gear wheel 50, the rack 49 rotating the gear wheels 47, 46 and 45, and accordingly both eccentrics 13 in the same direction. This movement of the eccentrics produces the feed motion of the rolls towards the workpiece. During this feed motion the two rolls exert radially directed opposite forming or shaping forces on workpiece. The forming operation on the workpieces is terminated when the rolls have arrived in the position of feed motion as represented in FIG. 1(c), in which position the axes of the rolls are situated in the common plane of both eccentric axes. When reacting this position, the rolling of the screw thread into the workpiece is terminated.

Since the two rolls 12 are mounted in the tilting levers 19 and can swing about the axis 21, they can center

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themselves on the workpiece. This makes it possible that both rolls operate uniformly. However, the torque exerted on the gear wheel 47 for effecting the feed motion of the rolls 12 is also transmitted by the gear wheels 46 on the levers 19. Such a torque which would result in a greater contact pressure of the upper lever 19 on the workpiece than that exerted by the lower lever, is transmitted by the bracket 56 carried by the lower lever 19 to the finger 55 of the rack 54 and is eventually absorbed by the force exerted by the gear wheel 50 on the rack 54. It will be understood, that with this arrangement, no free unbalanced forces act upon the workpiece.

The characteristic of the roll feed motion is obviously dependent of the shape of the cam face 64'. By a corresponding shape of the cam face, it is possible, instead of a feed motion which is linearly proportional with respect to the push rod movement, to have a progressive or retrogressive feed motion characteristic. It would also be possible to have the mentioned reciprocating member directly acting on the slide 52.

The two eccentrics could be replaced by correspondingly mounted cranks of appropriate dimension, which could be rotated by rotation of the crank axle. The feeding force, however, could also be applied directly to the revolving crank arm. It would also be possible to guide both revolving crank arms in a double link which is symmetrical to and rotatable about the central axis of the workpiece. Feeding movement can then be effected by rotation of the link. The cranks could be operated in the manner of one or two-armed levers. The rolls could receive their feed motion also by a toggle lever mechanism, in which case the toggle joint and the fixed fulcrum may also be situated outside of the rolls 12.

The new thread rolling method and apparatus according to the invention offers certain particular advantages. The floating disposition of the threading tools and their balanced feed motion in combination with the radially applied shaping forces prevents the workpiece spindle from being subjected to any stress. The speed of the feed motion can be adapted to the particular conditions, e.g. to the shape or size of the workpiece or to the material thereof. This speed is independent of the number of revolutions of the workpiece. Any slip between the rolls or between the rolls and the workpiece is prevented, and the threading rolls are small and cheap. Both rolls used on the thread rolling attachment are identical.

The feeding and synchronising mechanisms are located on the same side of the attachment and therefore permit easy interchange of rolls when producing different types of screw threads. The particular mounting of the roll provides exceptional close-to-shoulder rolling, e.g. screws having the threaded portion extending up to the screw head can be rolled.

The apparatus may be easily adapted to different workpieces and a high accuracy in finishing the workpiece may be obtained.

All parts of the apparatus are of simple and robust design.

The described new method of shaping workpieces not only can be used for thread rolling, but also for other shaping operations, for example turning, profiling, slicing, pressing, etc. using tools which are adapted to the particular type of shaping operation.

I claim:

1. A thread rolling apparatus comprising a pair of threading rolls disposed diametrically opposite each other relatively to the axis of rotation of a workpiece placed therebetween, a pair of eccentrics each rotatably carrying one of said threading rolls, a pair of shafts extending parallel to said axis of rotation, each shaft carrying one of said eccentrics for rotation therewith, a pair of double-armed levers, a common journal pin carrying said levers and extending parallel with said axis of rotation, one end of each lever carrying one of said eccentric shafts, a gear wheel fixed to each of said eccentric shafts,

a gear wheel loose on said common journal pin and connected with both said gear wheels on the eccentric shafts to make said eccentric shafts rotate together in the same direction, means interconnecting said threading rolls for preventing relative movement of the rolls on their eccentrics, a longitudinally slidable gear rack meshing with said gear wheel on the common journal pin of said levers, a second longitudinally slidable gear rack extending parallel to said first mentioned gear rack and abutting against one of said levers, a gear wheel meshing with both racks, and a power operated slide rotatably carrying said gear wheel meshing with both racks.

2. A thread rolling apparatus as claimed in claim 1

and comprising a power operated push rod, a cam and a cam follower for transmitting the movement of the push rod to said slide.

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