

Sept. 1, 1959

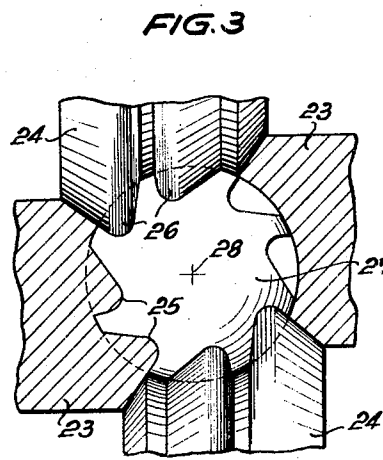
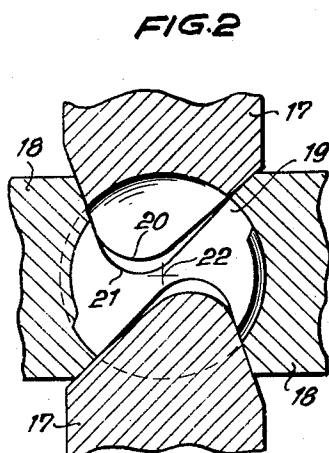
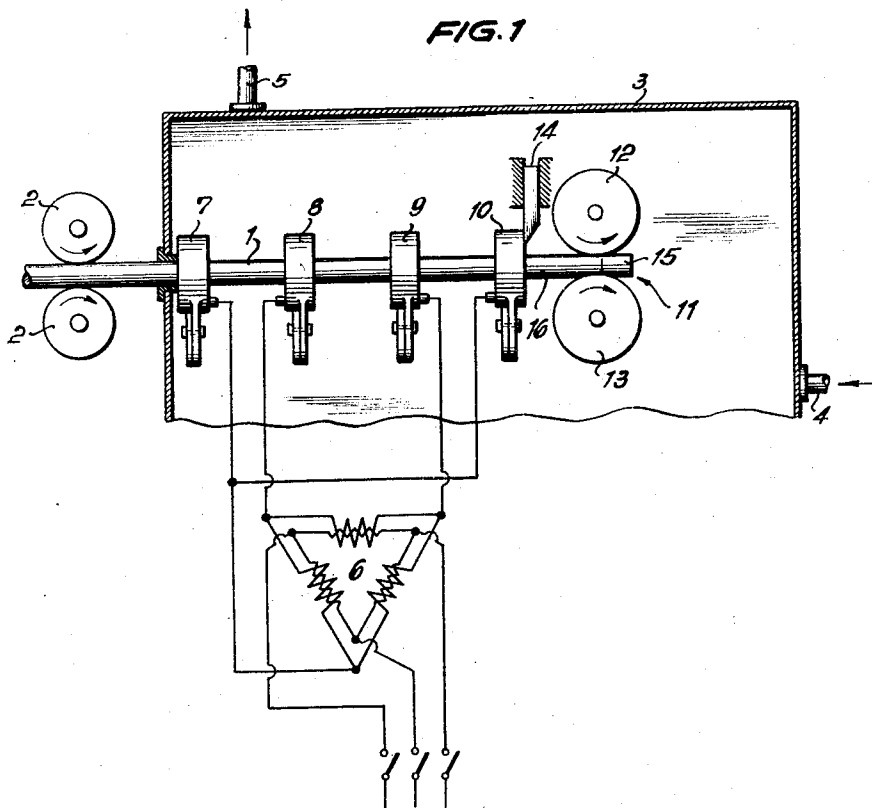
F. ERDÉLYI

2,901,932

METHOD AND APPARATUS FOR MANUFACTURING TOOLS WITH
A ROTATIONAL OPERATING MOVEMENT BY ROLLING

Filed April 9, 1954

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FIG. 4

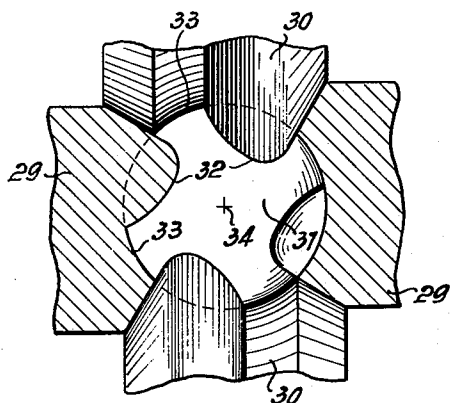


FIG. 5

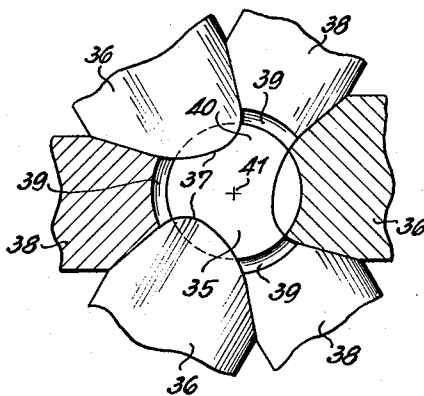
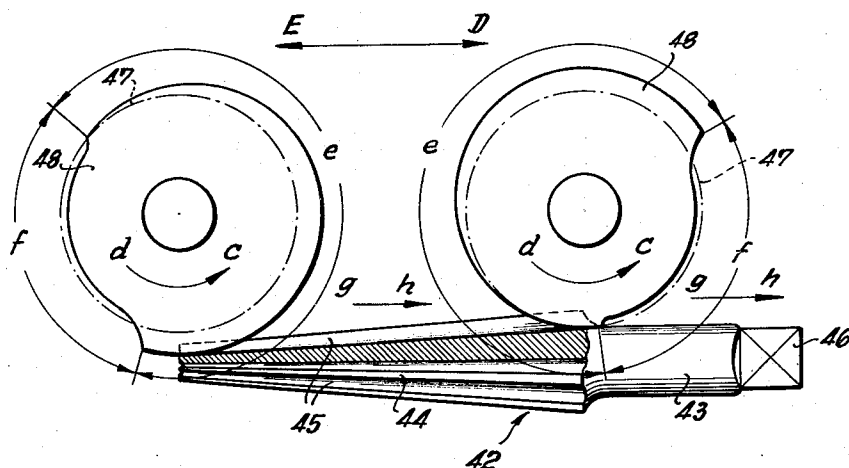


FIG. 6



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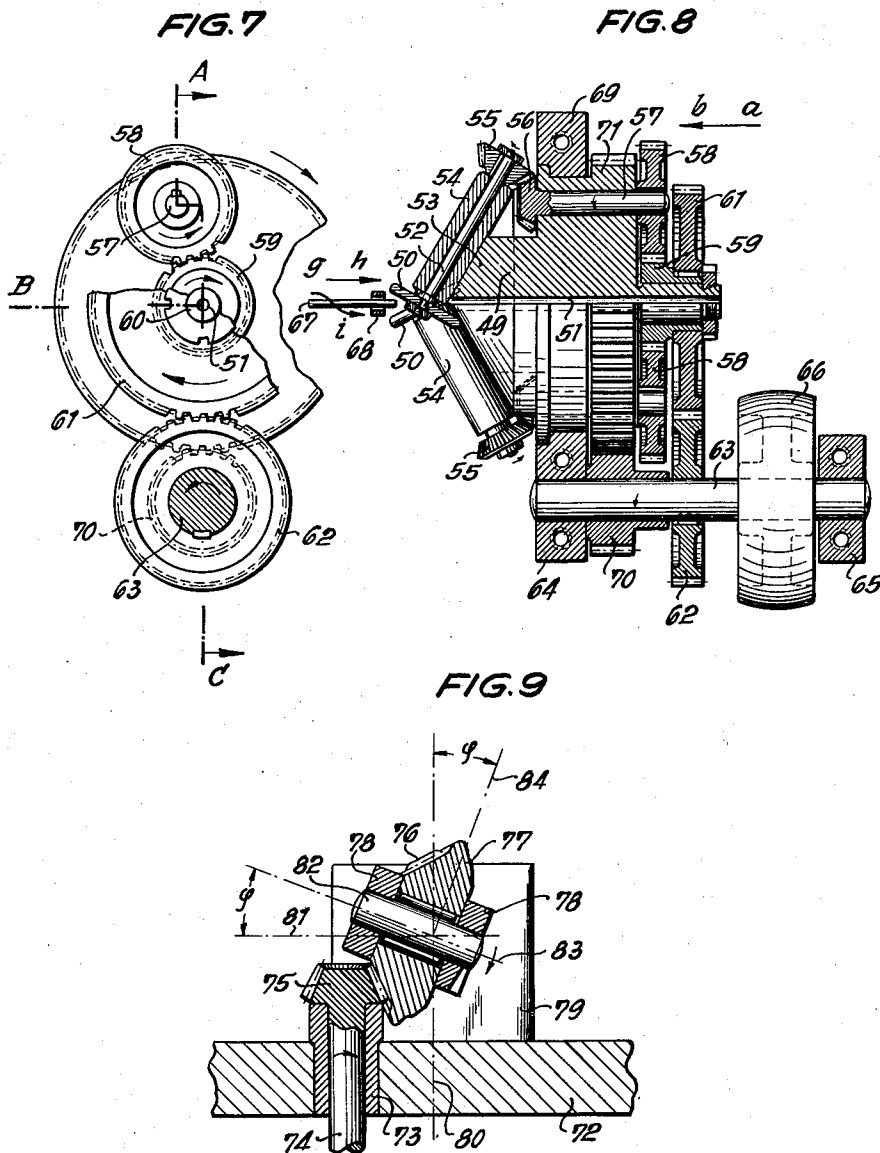
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4 Sheets-Sheet 3



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FIG. 10

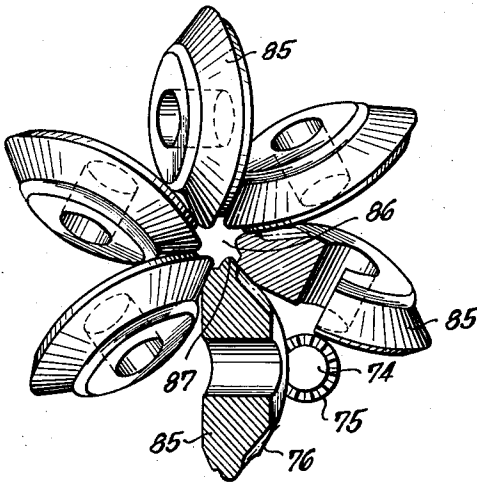
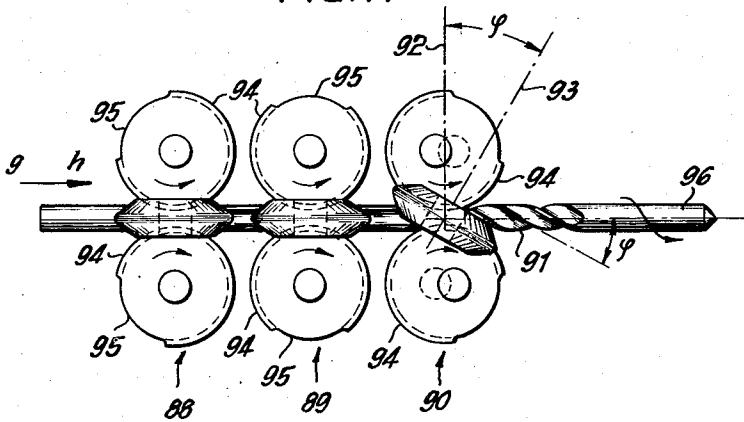


FIG. 11



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2,901,932

METHOD AND APPARATUS FOR MANUFACTURING TOOLS WITH A ROTATIONAL OPERATING MOVEMENT BY ROLLING

Ferenc Erdélyi, Cleveland, Ohio

Application April 9, 1954, Serial No. 422,163

Claims priority, application Germany April 10, 1953

3 Claims. (Cl. 80—61)

The invention relates to a method of manufacturing tools with a rotational operating movement by a rolling action from a preferably round bar, said tools having different profiles which extend in the direction of their axes of rotation.

Numerous methods and devices are known for the manufacture of such tools having a rotational operating movement by rolling them from a preferably round bar, without the results hitherto being able to meet requirements.

The main object of the invention is to improve manufacturing tools having a rotational operating movement by a rolling process.

A further object of the invention is to manufacture continuously tools having a rotational operating movement by heating the workpiece only one time and by rolling it thereafter without newly resetting it.

A further object of the invention is to manufacture tools having a rotational operating movement by rolling a bar up to the final shape of the tool to be manufactured.

Another object of the invention is to manufacture tools having a rotational operating movement from a bar by a rolling process taking place directly after having heated said bar and adapted to complete the final shape of said tool.

Yet another object of the invention is to manufacture tools having a rotational operating movement by heating and thereafter rolling a bar up to the final shape of the tool to be manufactured by means of at the least one set of rolls encircling completely the circumference of one cross section of said bar.

A further object is to improve the devices for rolling tools having a rotational operating movement.

According to the invention, the problem is solved by the fact that the round bar is heated to hot-shaping temperature (forging temperature) and immediately thereafter is finally rolled without resetting by means of a plurality of driven rolls, to which the bar is supplied directly from the heating position and which are arranged in a plane at right-angles to the axis of the bar and around the latter in such manner that the rolling profiles thereof actually engaging the round bar surround the circumference of its cross-section in this plane, the axes of rotation of the rolls are crossing this plane or are lying therein, i.e. the plane at right-angles to the axis of the bar. A further development and improvement of the process consists in that, for the purpose of producing twisted tool profiles extending axially of the tool, the axes of rotation of the individual rolls are swivelled to a maximum of an angle of 45° from the plane at right-angles to the axis of the bar to correspond to the required pitch angle of the tool profile.

The method permits the manufacture of such tools having a rotating operating movement in a single working operation and in one hot condition, it not being necessary for the round bar, or the tool to be made therefrom, to be clamped in any way during the rolling

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operation. This represents quite a decisive advance as compared with the known arrangement, and it has been shown that usually, even with a very considerable reduction in cross-section, it is sufficient to carry out the rolling with one set of rolls mounted as described with respect to one plane, the transport of the bar or the workpiece through the apparatus being effected exclusively by the rolls themselves. Combined to a large extent with the fact that the bar heated to the hot shaping or forging temperature is supplied immediately and directly to the rolling system is the decisive feature that the final rolling of the tool can be carried out in one working step and in the hot state. Another feature of decisive importance is that the rolls, during the rolling operation, completely surround the cross-section of the round bar, or the tool to be manufactured from the latter, and thus it is scarcely possible for any burrs to be formed.

The type of heating is in principle immaterial as regards the carrying out of the method. The bar may in particular be heated by electric resistance heating, by electric high-frequency heating or even by gas. With high-frequency heating, for example, the individual, preferably round bars may be cut beforehand to the length necessary for the production of the workpiece and then fed individually into magazines of the roll system. In one preferred embodiment of the invention, the heating position has fed to it a continuous rod, from which the round bar intended for the manufacture of the workpiece is cut off after the heating at an instant in time when the profiled rollers have already started to grip. If then that end of the round bar intended for the production of the workpiece is cut off at this instant, the continued feeding may be taken over by the roll system. As already mentioned above, one set of rolls arranged in one plane is usually sufficient. However, in certain circumstances, it is also possible and advantageous, for the final rolling of the tool profiles, to employ a plurality of roll sets arranged directly one after the other in space and time and operating in the same hot state. In such a case, it may be advisable only to swivel the rolls of the last set away from the plane at right-angles to the axis of the round bar in order in this manner to obtain as final product a tool with twisted tool profiles, for example, a drill. In this case also the tool is produced in one working step and in the same hot state, only the last roll set causing a twisting of the round bar in the manner required.

A further improvement of the invention is obtained, more especially in connection with the production of reamers, by the fact that one roll rolls a plurality of longitudinal profiles in the workpiece. Such a procedure is particularly important when there is a large number of longitudinal profiles on the workpiece, in order that the number of necessary rolls may be limited as far as possible.

If screw taps are to be rolled, the thread portions are rolled according to the invention by means of rolls which are mounted with their axis of rotation in a plane at right-angles to the axis of the round bar and the periphery of which comprises a corrugated profile with corrugations extending at an inclination to the axis of rotation of the roll to correspond to the required cutting thread. The effect achieved in this manner is that the axes of rotation of all rolls may lie in one plane at right-angles to the axis of the round bar. The round bar is therefore conveyed axially through the roll system without any turning movement, but the cutting threads of the cutting projections are provided with a certain taper to correspond to the required pitch of the thread.

If twisted longitudinal profiles according to the invention are to be rolled by means of rolls, the axes of rota-

tion of which are pivoted somewhat from the plane at right-angles to the axis of the round bar, a turning movement of the said bar or workpiece about its axis is produced in addition to the conveying movement thereof, if no particular provisions are made. The limitation of the pivoting angle to 45° is necessary in practice, since otherwise too powerful a correction of the rolls is necessary. In certain cases, this turning movement of the round bar, or of the workpiece being made therefrom, may be a disadvantage. In order to prevent this turning movement, the rolls according to the invention carry out a turning movement about the axis of the round bar in addition to the turning movement about their own axes, this movement being opposite to the direction of the rotation which is imparted to the round bar, by the fact that the true axis of the rolls about which they are rotated being inclined with respect to the plane at right-angles to the axis of the round bar. In this manner, the result can be obtained that the round bar is moved without any turning movement through the roll system. This idea is also adapted to be used with advantage in the cases where the rod or bar to be rolled is not heated before the rolling operation. This particular embodiment of the method may, for example, be considered as expedient for the manufacture of twisted reinforcing wires or rods for reinforced concrete. These reinforcing wires or rods are several metres long, so that a rotation of this wire or rod would take effect in a disadvantageous manner. Of particularly unfavourable effect in this respect is the fact that such wires or rods are only inadequately straightened. In accordance with this particular form of the method, it is true that the wire or rod is twisted without a special clamping arrangement, however, a rotation of the wire or rod about its own axis is dispensed with.

For carrying the method according to the invention into effect, it is usual to start with a round bar of truly circular cross-section, the reason for this being that the final profile can be rolled in one working operation and under the same heat. In certain cases, it is readily possible to carry the method into effect also with bars which are not strictly circular in their initial cross-section.

According to the invention, for carrying the method into effect, those rolls of a set which are situated in a vertical plane are driven by a common drive means and mounted in a common housing which comprises a central bore for the passage of the round bar or workpiece. If the round bar or workpiece is to be given a twisted profile, but no rotation is to take place, the arrangement according to the invention is that the common housing is rotatably mounted and adapted to be driven by a drive means which is preferably the same drive means as that also serving to drive the rolls of this roll set.

If the roll set consists of up to four rolls, the mounting thereof in a common housing and the mutual drive by means of a common drive means present no difficulties. If more than four rolls belong to one set, it is preferred according to the invention for one flank of each profiled roll to be fashioned as a gear wheel or be coupled with a gear wheel which meshes with a driving gear rotatably mounted in the housing. It is advisable in this case for the roll to be rotatably mounted, if possible on rollers, in a bearing block which is fixed to a projection of the housing, which engages from outside over the roll in relation to the axis of the round bar or workpiece. Even if this construction is particularly recommended in cases in which one roll set consists of more than four rolls, it may also be used with advantage in connection with those roll sets which comprise up to four rolls. It is possible by means of this construction to arrange six rolls without difficulty in a single plane, it being possible for the axes of rotation of said rolls also to be suitably swivelled for the production of twisted longitudinal profiles of the workpiece without the size of the rolls being increased to an impermissible degree. In this

connection, it is to be borne in mind that a larger number of rolls can be more easily mounted on a housing in proportion as the diameters of said rolls are larger.

Further improvements and expedient forms of the subject of the invention are explained with reference to the accompanying drawing, which shows a number of embodiments of the invention in simplified form and in which:

Figure 1 is a diagrammatic section through an arrangement for carrying out the process according to the invention,

Figure 2 is a section through a drill manufactured according to the invention and showing a section through the peripheral profile of the four rollers provided for this purpose,

Figure 3 is a section similar to Figure 2, in which however, a reaming bit is manufactured instead of a drill, Figure 4 is a section similar to those of Figures 2 and 3, but illustrating the production of a screw tap blank,

Figure 5 is a section similar to Figures 2 and 3, illustrating the manufacture of a screw tap with a threaded portion rolled thereon,

Figure 6 is a side elevation of a tapered reamer for explaining the method of its manufacture,

Figure 7 is an elevation of an apparatus constructed in accordance with the invention for carrying the method into effect, this view being in the direction of the arrow *a-b* of Figure 8,

Figure 8 shows, in the upper half, a section on the line A—O—B of Figure 7 and, in the lower half, a section on the line O—C of the same figure,

Figure 9 is a fragmentary section to illustrate one particular form of a roller and its drive means, as it may be employed, for example, in apparatus according to Figures 7 and 8,

Figure 10 is an elevation of a set of rollers which are constructed in accordance with the invention, and which may, for example, co-operate with an apparatus as illustrated in Figures 7 and 8,

Figure 11 is a diagrammatic view of another constructional form for manufacturing, for example, a drill.

In the constructional form according to Figure 1, the bar material 1 is introduced by means of feed rollers 2 into a housing 3 which is closed in gas-tight manner and to which a gas for preventing oxidation is supplied by way of the pipe 4, said gas being adapted to be discharged by way of the pipe 5.

The bar material 1 is heated by electric resistance heating, in that for this purpose there is provided a transformer which is connected in star-delta form and which transforms the 220/380 volt three-phase current to, for example, 1–2 volts. The converted current is fed to four contact jaws 7, 8, 9, 10, which surround the bar material 1 and which can be hinged upwardly in a manner not shown in detail. The four contact jaws 7, 8, 9, 10 are additionally cooled in order to prevent as far as possible heating of the bar material at those points, which finally are intended to form the stem of the tools to be manufactured. Any number of contact jaws may be provided and the number has no bearing on the essence of the invention.

By means of the arrangement of contact jaws 7, 8, 9, 10 as illustrated, the bar material is heated in stages to the temperature for hot deformation or forging. It is then fed to a rolling device 11, of which only the oppositely disposed rolls 12 and 13 are shown for the purpose of simplicity. In the actual constructional form, however, as will hereinafter be more fully explained, such a number of rolls are arranged around the periphery of the round bar that the periphery is completely covered.

Arranged immediately after the contact jaw 10 is a cutting device 14 which may be constructed in any suitable manner. By means of this cutting mechanism, the bar material is cut into separate round bars, the length

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of each round bar being composed of the end which is situated between the individual contact jaws and is thus heated and a further end which is situated within the range of the contact jaws, the bars being served in such manner that each round bar is transported out of the heating arrangement with the cold end first, which end was situated inside the contact jaws. The rolling mechanism 11 is arranged directly after the last contact jaw 10 in such manner that the stem end 15 of the round bar has already travelled between the rolls and the latter have already come into contact with that heated portion 16 of the round bar which is to be rolled, before the shears or the blade 14 has separated the said bar from the bar material.

The stem end 15 of each round bar therefore usually remains unrolled. The nature of the working of the end 16 of the round bar will now be more fully explained in the following figures.

According to Figure 2, two pairs of rolls, i.e. four rolls altogether, are provided for rolling the said part, the rolls of the first pair being indicated by the reference numeral 17 and the rolls of the second pair with the reference numeral 18. The roll pair 17 produces the grooves, while the roll pair 18 produces the cutting edges of the drill 19. The circumference of the rolls of the roll pair 17 is fashioned in such manner that the radius of the profile 20 increases gradually up to the radius of the profile 21, so that therefore the grooves rolled in by the peripheries of this pair of rollers 17, seen in the longitudinal direction and from the stem of the drill 19, become gradually deeper, which corresponds to the requirements concerning the formation of the drill and contributes to the fact that the drill has less tendency to break off.

The two pairs of rolls 17 and 18 are arranged in such manner that their pivot axes are disposed in a plane extending perpendicular to the axis 22 of the drill. In such a case, the grooves of the drill are finally rolled, but the drill itself still has no twist. In order to produce this, the pairs of rolls 17 and 18 must be additionally swung out of the aforesaid vertical plane, in a manner later to be described, corresponding to the required pitch of the twisted profiles.

According to Figure 3, two pairs of rolls 23 and 24 are again provided, but here they serve for the manufacture of a reamer. The rolls of each pair comprise two protuberances in order in suitable manner to roll two grooves 25 and 26, respectively, into the round bar. These protuberances are so arranged on the roll pairs 23 and 24 that they result in a cross-section of the reamer 27 in which eight longitudinal profiles are provided, which are distributed uniformly over the periphery. If this reamer is to be provided with a twist, the pivot shafts of the rolls of the separate pairs 23 and 24 are again to be swung out of the plane at right-angles to the axis 28 of the reamer in the manner above described.

Figure 4 illustrates the manner in which the blank for a screw tap is to be rolled in accordance with the invention. According to this figure, two pairs of rolls 29 and 30 are again arranged around the periphery of the screw tap blank 31 which is to be manufactured. Each roll of each pair is formed on the outside periphery with a protuberance 32 which is provided for rolling a continuous swarf channel. In addition, the outside periphery of the rolls of the pairs 29 and 30 are so profiled, as indicated at 33, that projections remain which are intended to receive the cutting thread. It is usually not necessary to provide a twist about the axis 34 of the blank, so that the axes of rotation of all four rolls of the pairs 29 and 30 lie in a plane which is perpendicular to the axis 34. Figure 5 illustrates how the method according to the invention is carried into effect for manufacturing a finally rolled screw tap. According to this figure, six rolls are arranged in two groups around the cross-section of the screw tap 35 which is to be manufactured, three

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identical rolls belonging to each group. The first group, the rolls of which are given the reference numeral 36, is provided on the outside periphery with projections 37 of such a nature that suitable longitudinal grooves are rolled into the tool. The rolls of the other group are indicated at 38 and are arranged in such manner that always one roll 38 is situated between two rolls 36, and here also the arrangement is such that the entire periphery of the cross-section of the screw tap 35 is covered by the profiles of the rolls 36 and 38. The rolls 38 are formed at 39 with a corrugated profile which is suitable for rolling the cutting thread into the projections 40 of the screw tap 35. The individual corrugations are inclined somewhat in relation to the plane of the drawing to correspond to the required thread pitch. The axes of rotation of all six rolls 36 and 38 are, however, situated in a plane at right-angles to the axis 41 of the screw tap, so that the separate longitudinal profiles of the tap do not have any twist.

The manufacture of a tapered reamer 42 consists essentially of a stem portion 43 and a conical reamer portion 44. The round bar necessary for this purpose is again fed, as explained with reference to Figure 1, with the stem portion 43 in front to the rolling mechanism consisting of a set of rolls, substantially as explained with reference to Figure 3. For the purpose of simplicity, only one such roll is shown in Figure 6, and the periphery of this roll is also only fashioned with the profile for making a longitudinal groove. However, these simplifications are only assumed for the purpose of clarity in conjunction with Figure 6.

In Figure 6, the initial condition is indicated at D, while the final condition is indicated by E. Concerned in each case, therefore, is the same roll which is positively driven in the direction of the arrow *c-d*. The roll periphery consists essentially of two segments, viz. the segment *e* and the segment *f*. The segment *e* is provided for the shaping of the conical grooves 45 of the reamer 42, while the segment *f* is to serve for guiding the stem section 43 of the reamer, the square end of which is indicated at 46. A concentric circle 47 is drawn in chain-dotted lines in the roll 48 and this circle corresponds substantially to the maximum groove depth of the reamer 42. It is to be clearly seen from Figure 6 that the shaping or profiling in the region of the segment *e* of the roll 48 increases gradually, whereby there is produced the gradually decreasing conicity of the part 44 of the reamer. In the position D, the beginning of the segment *e* with the smallest radius has just commenced to squeeze the part 44 of the reamer. In position E, the rolling of the reamer is completed, which now leaves the rolling mechanism in the direction of the arrow *g-h*. A fresh round bar is then gripped by the segment section *f*.

According to Figures 7 and 8, all the rolls 50 of one roll set are mounted in a common housing 49 which is provided with a central bore 51 for the passage of the finally rolled product. Two such rolls are shown in Figure 8, whereas Figure 7 shows only the drive means for one roll. The limitation of the number of rolls, however, is only made in both cases for clarity of illustration. Altogether, there are provided more particularly four, six or eight rolls (and even more with the manufacture of end-milling cutters). In the constructional example, each roll is provided with a shaft 52 which is mounted at the front end 53 of the housing 49 in bearings 54. The manner in which these bearings 54 are connected to the end 53 of the housing 49 is not shown in detail, since this is not essential to the invention. One end of the shaft 52 serves for the fixing of the bevel gear 55, which is so arranged that its larger diameter is directed upwardly. Its teeth mesh with a bevel gear 56 which is fixed to a shaft 57 mounted in the housing 49 parallel to the axis of the bore 51. Serving to drive this shaft 57 is a spur gear 58 meshing with a pinion 59 which is

mounted to rotate freely on an extension 60 of the housing 49. This extension 60 is arranged at the rear end of the housing, i.e. on the end facing away from the front end 53.

This pinion 59 therefore meshes with as many gears 58 as correspond to the number of rolls 50 which are provided. Only two such gears 58 are shown in Figure 8, this being in conformity with the fact that also only two rolls 50 are shown in this figure.

Connected fast to the pinion 59 is a toothed wheel 61 which is therefore also mounted to rotate freely on the extension 60. Meshing with the teeth of this gear wheel 61 is a gear wheel 62 keyed to a shaft 63 which is mounted to rotate in two fixed bearings 64, 65. These fixed bearings 64, 65 therefore form a part of the support or stand for the rolling mechanism or are rigidly connected to the said support or stand. The shaft 63 also has arranged thereon a belt pulley 66 co-operating with a belt (not shown) which is driven from any suitable prime mover, for example, an electric motor. A round bar 67 is supplied to the rolls 50 in the manner described above. The shaft 63 and thus the gear wheel 62 are driven by way of the belt pulley 66 in a direction which is indicated by arrows in the two Figures 7 and 8. The directions of rotation being produced at the other shafts and gear wheels are then also indicated by means of arrows in the two figures. The two rolls 50 are therefore driven in a counter-clockwise direction, when looking at their surface from their free side. They roll the required helical profile in the round bar 67, this profile being helical as a consequence of the fact that the shafts 52 of the rolls are swung out of the plane at right-angles to the axis of the bore 51 and of the round bar 67. Due to the engagement of the two rolls, the round bar is not only advanced through the bore 51 towards the right in Figure 8 (in the direction of the arrow *g—h*), but a turning movement is also imparted to the round bar, which movement is indicated by the twisted arrow *i* and which extends in a clockwise direction when the round bar is viewed from the rear, i.e. from its rear end in Figure 8.

Indicated at 68 is a cutter device which corresponds to the cutter device 14 in Figure 1. In order to prevent or to reduce the rotation of the round bar 67 in the direction of the arrow *i*, the housing 49 may in addition be arranged to be rotatable about the axis of the bore 51, and not fixed. For this purpose, the housing is mounted in a bearing block 69 which may be in one piece with the bearing block 64 for the support of the driving shaft 63. This driving shaft 63 is in addition rigidly connected to a pinion 70, the teeth of which mesh with the teeth of a gear wheel 71 which is provided on the housing 49 or forms a part of said housing. The drive of the shaft 57 and thus of the rolls 50 is therefore not impeded by the fact that in addition the housing 49 is rotated about the axis of the bore 51. The housing is rotated in a direction which is indicated by the arrows drawn in Figures 7 and 8 and which is opposite to the direction of rotation *i* of the round bar 67. Therefore, if the direction *i* is in the clockwise direction (seen in the direction of the end 57 of the housing 49), the revolution of the housing 49 about the axis of the bore 51 is then in a counter-clockwise direction.

The construction in which the housing 49 is rotatably driven about the axis of the bore 71 is particularly recommended in the cases in which a particularly long bar or rod is to be provided with grooves which extend helically. This applies more especially with helically coiled reinforcing wires or rods for the production of reinforced concrete.

Figure 9 shows a housing 72 which is again somewhat modified and which, by means of a bushing 73, serves for the mounting of a shaft 74, the end of which has fixed thereto a bevel pinion 75 meshing with the teeth of a bevel gear 76 which is fashioned as a part of a

roll 77 by one flank of this roll being formed with the teeth of the bevel gear 76. This roll 77 is mounted with the aid of a bearing block by means of two arms 78 on a projection 79 which is fixed in a manner not shown in detail to the housing 72 and engages from outside over the roll 77. The longitudinal axis of the tool to be manufactured from a round bar is indicated at 80, whereas a plane at right-angles to this axis is given the reference numeral 81. For mounting the roller 77 a pin 82 is provided, the axis 83 of which is rotated through an angle α out of the plane 81. The plane 84 of the roll 77 is also swivelled by the same angle α in relation to the axis 80 of the tool to be manufactured. This construction is particularly recommended when more than four rolls arranged in one plane belong to one set.

Figure 10 illustrates the manner in which altogether six rolls 85 are arranged around one workpiece 86 with the mountings according to Figure 9. In the constructional example, this workpiece consists of the blank for a reamer with six twisted or helical longitudinal grooves 87, a suitable protuberance on the external periphery of the rolls 85 being provided for the manufacture of each longitudinal groove. The rolls again enclose the cross-section of the workpiece 86 in a completely closed formation. Its outside periphery may also be provided with different segments, as described with reference to Figure 6.

In the constructional example according to Figure 11, three sets of rolls 88, 89, 90 are provided in series in order to roll a comparatively long drill 91 in the hot state. Each roll set in the present embodiment consists of four rolls which enclose the cross-section of the round bar or workpiece 91 and which may be constructed similarly to those indicated in Figure 2. In the embodiment according to Figure 11, however, the twisting and the final rolling is only effected with the aid of the rolls of the roll set 90, in that for this purpose, the axes 93 of all rolls of this set are pivoted through the angle γ in relation to the plane 92 at right-angles to the longitudinal axis of the workpiece 91. All rolls of the sets 88, 89 and 90 consist of a shaping segment 94 and a stem segment 95 by which the stem section 96 of the workpiece 91 is formed.

In a manner not shown in greater detail, the four rolls of the sets 88, 89, 90 are always assembled in pairs in conformity with Figure 2, so that two oppositely disposed rolls form the longitudinal grooves and the two rolls which are disposed substantially at right-angles thereto form the cutting edges.

The rolls of the sets 88 and 89 only initially form the profiles for which they are designed, since these two rolls also do not impart any twist to the longitudinal grooves of the workpiece. The axes of rotation of their rolls are therefore not pivoted in relation to the planes 92 at right-angles to the axis of the workpiece 91. The workpiece travels in the direction of the arrow *g—h* without twist through the driven rolls of the roll sets 88 and 89, the twist first being imparted to the longitudinal grooves by the rolls of the roll set 90.

I claim:

1. A method of rolling elongated flutes in rotary cutting tools in a single heat and with one pass through the rollers comprising providing a tool blank, heating the section of the blank to be fluted to hot rolling temperature while maintaining the shank of the tool at a cold temperature, feeding the blank into the grip of a closed rolling pass embracing the entire circumference of the blank, gripping the cold shank by the pass rollers and thereby feeding the blank into the fluting section of the rollers and rolling the flutes to finished depth, said heating, gripping and rolling being completed prior to any substantial transmission of the heat of the hot section into the cold shank.

2. A method of rolling elongated flutes in rotary cutting tools as defined in claim 1 in which the heating of the

section of the blank to be fluted is performed by electrical high frequency heating.

3. A method of rolling elongated flutes in rotary cutting tools as defined in claim 1 in which the heating of the section of the blank to be fluted is performed in an inert gas atmosphere. 5

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