United States Patent

Schmidt

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[54] **METHOD AND APPARATUS FOR ROLLING GEAR TEETH OR THE LIKE**

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[30] **Foreign Application Priority Data**

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[52] U.S. Cl. **72/78,** 72/95, 72/108, 29/159.2

[51] Int. Cl. **B21h 5/02**

[58] **Field of Search** 72/78, 95, 100, 107, 108, 110, 72/118, 119; 29/159.2

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[57] **ABSTRACT**

Cylindrical metallic blanks are provided with rolled gear teeth or splines by passing lengthwise between equidistant bevel gear shaped masters whose axes are inclined with reference to the axes of the blanks and which are mounted in a support arranged to orbit the masters about the axes of the blanks. The front end face of an advancing blank engages the teeth of the masters in the region of the larger-diameter ends of cones formed by the crowns of teeth on the masters and the outer diameters of annuli of teeth or splines formed by the masters exceed the diameters of the blanks. The masters are adjustable radially and/or angularly with reference to the axes of the blanks.

11 Claims, 3 Drawing Figures

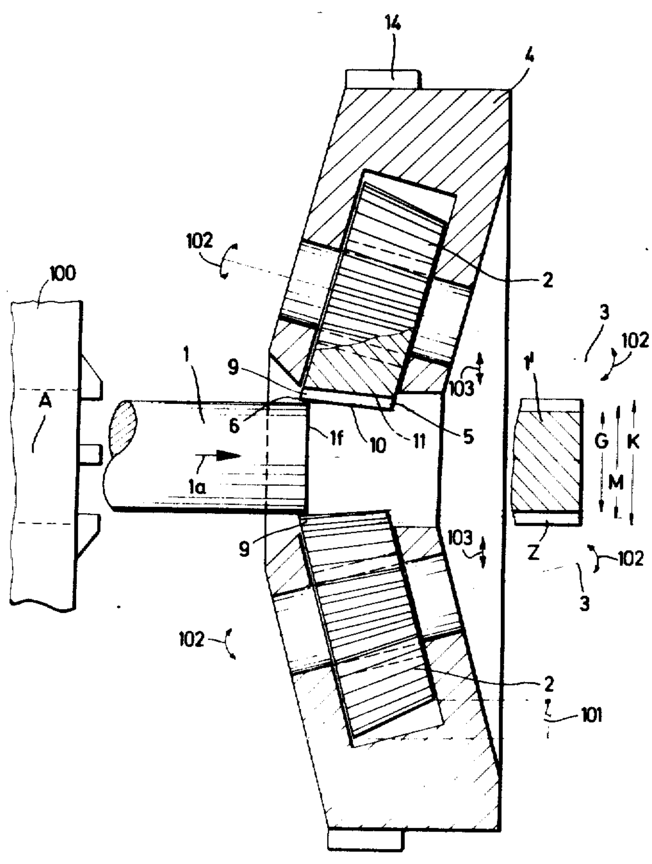

FIG. 1

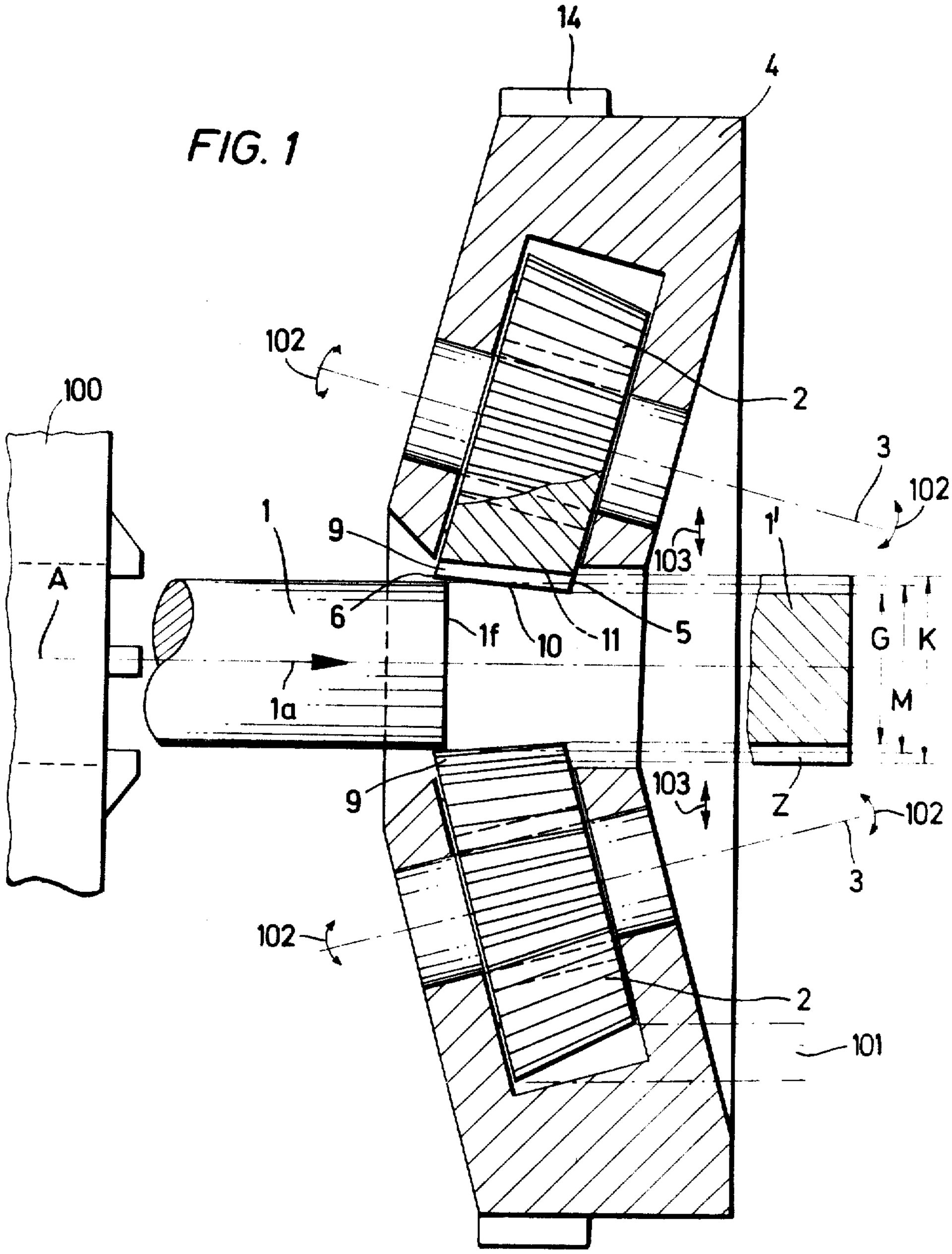

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FIG. 2

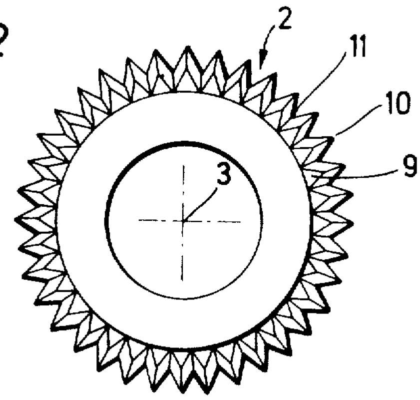
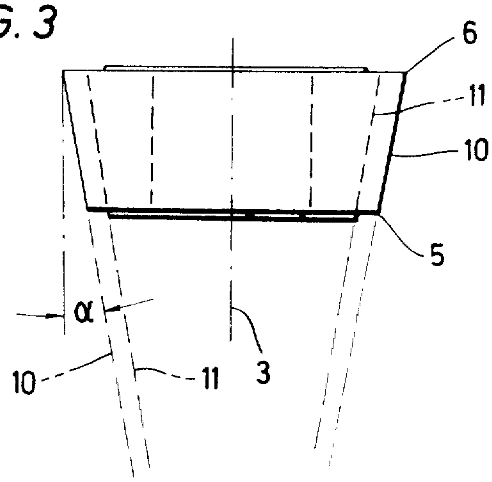


FIG. 3



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METHOD AND APPARATUS FOR ROLLING GEAR TEETH OR THE LIKE

BACKGROUND OF THE INVENTION

The present invention relates to a method and apparatus for rolling gear teeth, splines or the like into metallic blanks.

It is already known to employ gear-shaped masters for final treatment of rough-finished gear blanks. The master is driven and meshes with the blank while simultaneously moving axially to thus displace the surplus of metallic material from the flanks of gear teeth on the workpiece. Such displacement is effected by the flanks and edges of teeth on the revolving master.

A drawback of the conventional method is that the workpiece must be prepared in a preceding operation. Furthermore, axial movement of the revolving master causes the edges of the master to remove shavings from the adjacent surfaces of the workpiece.

Attempts to form gear teeth by rolling, i.e., without removal of material from the blank, have met with little success. Such method is employed for the formation of milled or knurled surfaces and/or relatively shallow splines and utilizes a large-diameter master which is fed radially toward the axis of the blank. Once the height of the gear teeth or splines on the blank exceeds a rather small value, such teeth or splines undergo deformation under the action of teeth on the master because the pitch diameter of the blank varies continuously in response to radial feed movement of the master. The extent to which the pitch diameter varies equals times the radial displacement of the master.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel and improved method of rolling gear teeth, splines or like projections on metallic blanks.

Another object of the invention is to provide a method according to which relatively deep tooth spaces or grooves can be formed in metallic blanks without any removal of material and in a time-saving operation.

A further object of the invention is to provide a novel apparatus for the practice of the above-outlined method and to construct and assemble the apparatus in such a way that it can be rapidly and conveniently converted for rolling of different types and/or sizes of gear teeth, splines or the like.

An additional object of the invention is to provide novel and improved masters for use in such apparatus.

An ancillary object of the invention is to provide a method of mass-producing disk-shaped gears by rolling of gear teeth into metallic blanks without removal of metallic material.

The method of my invention is employed for rolling into the external surface of a cylindrical blank an annulus of gear teeth (this term is intended to embrace gear teeth and splines) wherein the mean between the outer diameter and the root diameter of such annulus at least approximates the diameter of the external surface on the blank. The method comprises the steps of

1. moving the blank axially toward and through a rolling station,

1. moving the blank axially toward and through a rolling station,

2. installing at the rolling station two, three or more equidistant bevel gear shaped masters in such positions that
   a. the larger-diameter ends of the crown cones (namely, the cones formed by the top lands of teeth on the masters) are located ahead of the smaller-diameter ends, as considered in the direction of travel of the blank, that
   b. the distance between the axis of the blank and the larger-diameter ends of the crown cones slightly exceeds the radius of the blank, that
   c. the distance between the smaller-diameter ends of the crown cones and the axis of the blank at least approximates half the root diameter of the annulus of gear teeth to be formed on the blank, and that
   d. the distance between the axis of the blank and the smaller-diameter ends of the root cones of the masters (namely, cones formed by the roots of teeth on the masters) slightly exceeds half the outer diameter of the annulus of gear teeth to be formed on the blank, and
3. orbiting the masters about the axis of the blank and/or rotating the blank about its axis whereby the teeth of the masters shift the material of the blank into the spaces between such teeth.

When the rolling of gear teeth on a cylindrical blank is to be started, i.e., when the front end face of the blank approaches the rolling station, such front end face engages the teeth of the masters in the region of the larger-diameter ends of the crown cones.

The blank may constitute a cylindrical bar and the method may comprise the additional step of subdividing the thus rolled bar into discrete gears, e.g., into substantially disk-shaped gears.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved apparatus 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 schematic partly elevational and partly sectional view of an apparatus which embodies one form of the invention;

FIG. 2 is a front elevational view of a master; and

FIG. 3 is a side elevational view of the master shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, there is shown an apparatus which is employed for rolling an annulus 7 of gear teeth, splines or like projections into the external surface of a cylindrical rod-shaped blank 1. The latter is advanced axially in the direction indicated by arrow 1a by means of a mechanism 100 of any known design; such mechanism may include, for example, several sets of driven rolls of the type often employed in shaving machines for tubes or the like. The apparatus further comprises a ring-shaped support 4 which is rotatable about the axis A of the advancing blank 1 and is located at a rolling station. The support 4 serves as a carrier for at least two equidistant bevel gear shaped masters 2 whose axes 3 are coplanar and made an acute angle with the axis A of the blank 1. The teeth 9 of the masters 2 have top lands or crowns which define a so-called crown cone 10 and the roots of such teeth define a so-called root cone 11. It will be noted that the larger-diameter ends of the cones 10, 11 are located ahead of the respective smaller-diameter ends, as considered in the direction of travel of the blank 1 (arrow 1*a*). Thus, when the front end face 1a of the blank 1 approaches the rolling station, it enters the space between the masters 2 in the region of the larger-diameter ends 6 of the crown cones 10. When the apparatus is in use, the mechanism 100 feeds the blank 1 lengthwise and the support 4 causes the masters 2 to orbit about the axis A. At the same time, the masters 2 rotate about their own axes 3. The means for rotating the support 4 may comprise a ring gear 14 which is provided on the periphery of the support and meshes with a motor-driven pinion, not shown.

The annulus 7 of teeth or splines which are formed in the blank 1 by the teeth 9 of the masters 2 is shown in the right-hand portion of FIG. 1. This annulus has an outer diameter K, a root diameter G and a mean diameter M which equals or approximates the diameter of the blank 1. The finished portion of the blank 1 is denoted by the reference character 1'. The profile of the finished portion 1' equals or resembles the profile of the smaller-diameter ends of masters 2.

The masters 2 are disposed diametrically opposite each other (because the support 4 is provided with only two masters). Their positioning in the support 4 is such that the distance between the axis A and the larger-diameter ends 6 of the crown cones 10 slightly exceeds the radius of the blank 1 and that the distance between the axis A and the smaller-diameter ends 5 of the crown cones 10 equals half the root diameter G. The distance between the axis A and the smaller-diameter ends of the root cones 11 slightly exceeds half the outer diameter K. In view of the just described mounting of the masters 2, the front end face 1f of a freshly introduced blank 1 meets the teeth 9 of the masters in the region of the larger-diameter ends 6 of the crown cones 10.

The support 4 resembles a disk and is designed to take up most of the stresses transmitted by the masters 2. Such stresses are balanced because the two masters are mounted diametrically opposite each other. As stated before, the apparatus may comprise more than two (for example, three or four) masters which are preferably equidistant from each other. The rotary movements of masters 2 are synchronized in such a way that the teeth 9 of the lower master 2 shown in FIG. 1 enter the depressions formed in the external surface of the blank 1 by the teeth 9 of the lower upper master 2, and vice versa. The synchronizing means may include bevel gears one of which is indicated in the lower part of FIG. 1, as at 101. The mechanism 100 may be stationary or it may be designed to move with the blank 1 toward the rolling station.

The apparatus preferably further comprises means (indicated by arrows 102) for changing the inclination of the axes 3 of the masters 2 with reference to the axis A of the blank 1, and means (indicated by arrows 103) for moving the masters radially toward and away from the axis A. Such adjustability of the masters enables the operators to convert the apparatus for the formation of differently configurated and/or dimensioned gear teeth or the like.

The finished workpiece 1' of FIG. 1 can be severed at right angles to its axis to yield a series of discrete gears, e.g., substantially disk-shaped gears whose axial length is a small fraction of the outer diameter K.

It will be noted that the diameter K exceeds the diameter (M) of the blank 1. Thus, the material which is displaced by the teeth 9 of the masters 2 is not lost but is used to form a finished portion 1' whose maximum transverse dimension (K) is greater than the diameter of external surface on the blank. Another advantage of the improved method and apparatus is that the flow lines in the material of the product 1' are uninterrupted and that the teeth 9 insure a highly satisfactory surface finish on the finished product. Despite the fact that the extent to which the front and rear portions of teeth 9 on the masters 2 penetrate into the material of the blank 1 varies in the direction of the arrow 1*a*, the peripheral speed of the material-engaging portions of all masters always corresponds to circumferential speed of the deformed regions of the workpiece. The aforedescribed mounting of masters 2 in the support 4 insures that, during the formation of teeth on the blank 1, the pitch diameter of such teeth decreases at the same rate as the diameters of cones 10, 11 on the masters 2. The manner in which the support 4 can rotate with the masters 2 is similar to that in which the tools are mounted in a milling or knurling head.

FIGS. 2 and 3 illustrate in greater detail a bevel gear shaped master 2 which can be utilized in the apparatus of the present invention. This master is provided with pointed teeth 9 which can be used to roll in a cylindrical rod-shaped workpiece splines separated by grooves of tri-angular cross-sectional outline. The angle alpha between the axis 3 and the top lands or ridges of teeth 9 (crown cone 10) is preferably between 5 and 25 degrees, most preferably less than 20 degrees.

It is clear that the improved apparatus is susceptible of many further modifications without departing from the spirit of the invention. For example, the support 4 may remain stationary if the blank 1 is caused to rotate about the axis A while it moves lengthwise (arrow 1a). It is also possible to rotate the blank 1 about the axis A while the support 4 rotates about the same axis. Instead of rotating the support 4, the apparatus may comprise means for positively driving one or more masters whereby the support automatically compels all of the masters to orbit about the axis A.

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 into the external surface of a cylindrical blank an annulus of teeth wherein the mean between the outer and root diameters of such annulus at least approximates the diameter of the external surface on the blank, comprising the steps of

I. moving the blank axially toward and through a rolling station;

II. installing at said station a plurality of equidistant bevel gear shaped masters in such positions that
   a. the larger-diameter ends of the crown cones formed by the top lands of teeth on the masters are located ahead of the smaller-diameter ends of such crown cones, as considered in the direction of travel of the blank, that
   b. the distance between the axis of the blank and the larger-diameter ends of the crown cones slightly exceeds the radius of the blank, that
   c. the distance between the smaller-diameter ends of the crown cones and the axis of the blank at least approximates half the root diameter of said annulus, and that
   d. the distance between the axis of the blank the the smaller-diameter ends of the root cones formed by the roots of teeth on the masters slightly exceeds half the outer diameter of said annulus; and

III. effecting relative angular movement between the blank and the masters about the axis of the blank whereby the teeth of the masters shift the material of the blank into the spaces between the teeth of the masters.

2. A method as defined in claim 1, wherein the blank has a front end face which is normal to the axis of the blank and engages the teeth of the masters in the region of the larger-diameter ends of said crown cones when such front end face enters said rolling station.

3. A method as defined in claim 1, wherein the blank is a cylindrical bar.

4. A method as defined in claim 3, further comprising the step of subdividing the thus rolled bar into discrete gears.

5. A method as defined in claim 4, wherein said discrete gears are disks.

6. Apparatus for rolling into the external surfaces of cylindrical blanks an annulus of teeth, comprising means for advancing the blanks lengthwise so that the axes of the blanks move along a predetermined path; a support adjacent to a portion of said path; at least two bevel gear shaped masters mounted on said support for rotation about axes which are inclined with reference to said path, each of said masters having teeth whose roots form a first cone and whose crowns form a second cone, each of said cones having a smaller-diameter end and a larger-diameter end and the distance between the larger-diameter ends of said second cones and said path slightly exceeding the radius of a blank, the distance between the smaller-diameter ends of said second cones and said path at least approximating one-half the mean between the outer and root diameters of said annulus and the distance between the smaller-diameter ends of said first cones and said path being at least equal to half the outer diameter of said annulus, said larger-diameter ends being located ahead of the respec-

tive smaller-diameter ends, as considered in the direction of movement of the blanks; and means for effecting relative angular movement between the blanks and said support about said path.

7. Apparatus as defined in claim 6, wherein the circular pitch of teeth on each of said masters is the same.

8. Apparatus as defined in claim 6, further comprising means for synchronizing the rotary movements of said masters so that the teeth of any one of said masters enter depressions formed in the external surfaces of the blanks by the teeth of each other master.

9. Apparatus as defined in claim 6, wherein said masters are adjustable with reference to said support so as to change the inclination of their axes with reference to said path.

10. Apparatus as defined in claim 6, wherein said masters are adjustable with reference to said support radially of said path.

11. Apparatus as defined in claim 6, wherein the axes of said masters are located in a common plane.

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