June 28, 1955 K. W. J. HJELMBLAD 2,711,621

METHOD OF GRINDING CURVED SLOTS, AND A PRODUCT PRODUCED ACCORDING TO THIS METHOD

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Fig. 1.

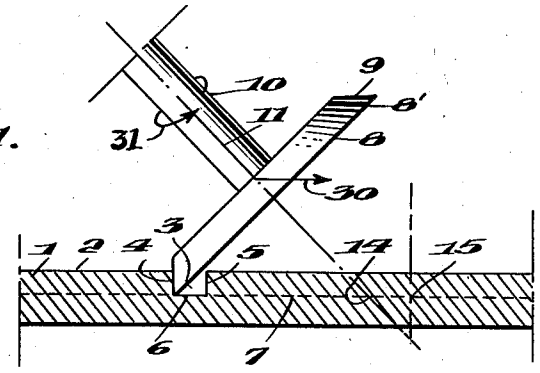


Fig. 2.

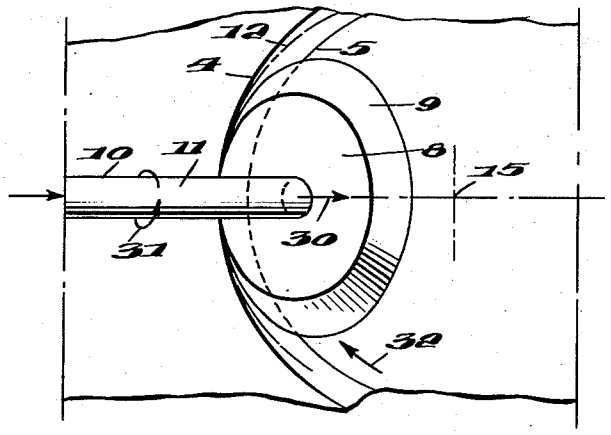
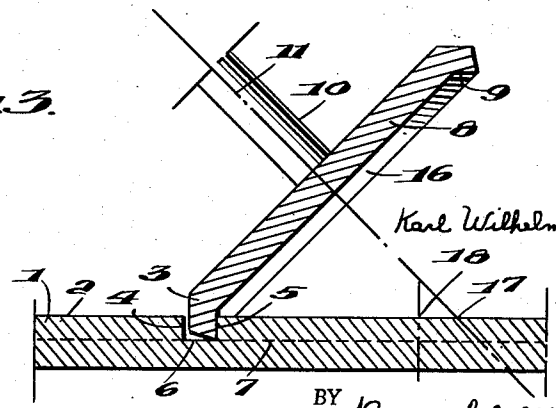


Fig. 3.



Karl Wilhelm Josef Hjelmblad
INVENTOR

BY Pierce, Scheffler & Parker
ATTORNEYS

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Fig. 4.

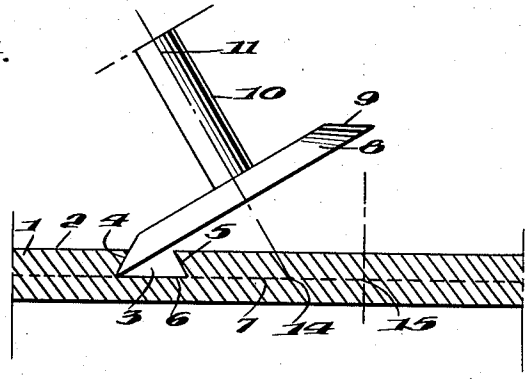


Fig. 5.

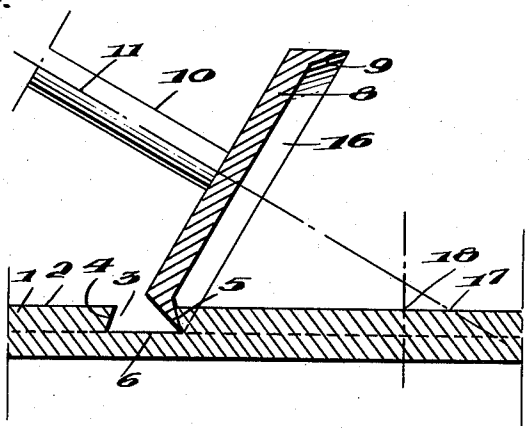
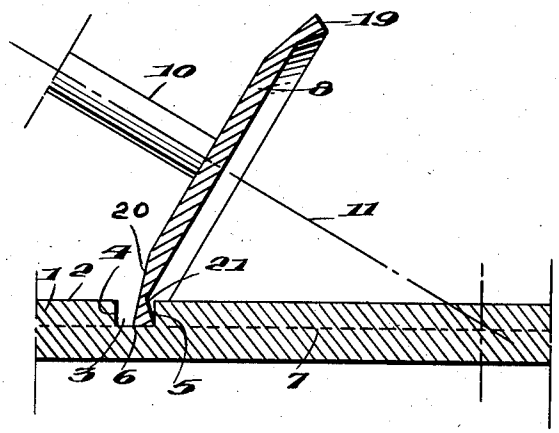


Fig. 6.



INVENTOR

Karl Wilhelm Josef Hjelmblad

BY

Pierce, Scheffler & Parker

ATTORNEYS

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METHOD OF GRINDING CURVED SLOTS, AND A PRODUCT PRODUCED ACCORDING TO THIS METHOD

Karl Wilhelm Josef Hjelmblad, Bromma, Sweden

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7 Claims. (Cl. 51—287)

In the grinding of the lateral borders and the bottom of curved slots, general practice is to make use of a grinding pin. This pin, however, has a very short life, inasmuch as its circumference is comparatively small, while the grinding depth must be very small at the same time. Furthermore, said pin calls for frequent adjustment on account of the wear thereof. Besides, a narrow grinding pin is apt to be broken very easily. The present invention provides the advantage that in the grinding of curved slots it will be possible to make use of a grinding disk of a large diameter, said disk being consequently worn very much less than a grinding pin, for which reason the grinding operation becomes more accurate, while the working time is reduced considerably at the same time.

The method may be applied to grooves having a convex lateral border and a concave lateral border, or a single convex lateral border. According to the invention, the method in consideration is principally distinguished by the feature that the grinding of one or both of the lateral borders is effected by means of a rotating grinding tool having a conical working surface. In the grinding of grooves, which in addition to the lateral borders have a plane bottom or a bottom with a rectilinear generatrix, the bottom may also be ground by means of a grinding tool provided with a conical working surface. The radius of curvature of the conical working surface in an arbitray plane at right angles to the axis of rotation of the grinding tool is here selected with respect to the surface to be ground, the grinding surface, in a manner such that the working surface of the grinding tool contacts the grinding surface on a line or at a point only. In case there is only a point contact the tool is fed during the grinding operation back and forth between the bottom and the edge of the mouth of the groove, so that the lateral border of the groove will successively contact with the grinding tool for the whole of its height. At the same time the grinding tool is obviously fed in the longitudinal direction of the groove. Instead of providing for the feeding of the grinding tool, a corresponding feed may be imparted to the work-piece.

In order that the grinding shall permit of being effected in the best possible manner, a few further conditions should preferably be fulfilled, particularly with respect to the relation between the radius of curvature of the intersecting line of the conical working surface with certain conceived planes extending through the bottom of the groove and the mouth edge of the groove, on the one hand, and the radius of curvature of the intersecting line between the lateral border of the groove and said plane, on the other hand. These conditions and further distinguishing features of the invention will appear from the following description of a few forms of embodiment of the method according to the invention with reference to the annexed diagrammatic drawings. Fig. 1 is a section on a plane at right angles to the upper side of the work-piece having the groove provided therein, and shows how the grinding of the concave lateral border of the groove is effected. Fig. 2 is a plan view corresponding to Fig. 1.

Fig. 3 illustrates, in the same manner as Fig. 1, the grinding of the convex side of the groove. In Figs. 1 to 3, the generatrix of the lateral borders are taken to form a right angle with the surface having the groove provided therein. Figs. 4 and 5 show the grinding of the concave and the convex side of a groove, respectively, where the lateral borders have a generatrix forming an acute angle with the surface in which the groove is provided, the groove in consideration being wider at the bottom than at said surface, that is to say at the edge of the mouth (undercut groove). Fig. 6 illustrates in the same manner as Figs. 1, 3, 4 and 5 the grinding of the bottom of the groove.

In Fig. 1, 1 designates a work-piece, in the surface 2 of which is provided a groove 3. The groove is curved and may, for instance, be spiral-shaped, the same then extending especially on a circular involute, formed by motion of the tool along a straight line 30, Figs. 1 and 2 parallel to the plane surface of the work while the work is rotating at a constant speed, as indicated by the arrow 32 in Fig. 2. The one lateral border of the groove, here the concave border, is designated by 4, while its other convex lateral border is denoted by 5 and its bottom by 6. A plane through the bottom may be conceived of as extending on the dashed line denoted by 7 in Fig. 1.

The grinding of the concave lateral border 4 of the groove is illustrated in the example shown in Figs. 1 and 2. As in the grinding of the remainder of the groove, a grinding tool is used here in the form of a grinding disk 8 having a conical working surface 9. The axis of the grinding disk is designated by 10 and the axis of rotation or the geometrical axis thereof is indicated by the chain-dotted line 11. In the example shown, the lateral borders 4, 5 as well as the bottom border 6 of the groove have a rectilinear generatrix, the working surface 9 having then also a rectilinear generatrix. In the grinding operation the tool is adjusted relatively to the surface to be ground in a manner such that the working surface 9 of the grinding tool is caused to contact the grinding surface on a line or a point only. In the examples shown, the grinding disk and the surface to be ground are taken to contact each other on a line extending in Figs. 1–3 at right angles to the bottom plane 7. The grinding disk is thus adjusted with the axis of rotation extending obliquely to the bottom plane of the groove. Its base surface 8' faces the work-piece.

In order that the grinding shall permit of being carried out properly, the grinding tool should be adjusted during grinding and the working surface 9 of the grinding tool selected in grinding, in a manner such that the radius of curvature of the line of intersection 12 (Fig. 2) between the conical working surface 9 and the plane 7 through the bottom of the groove is smaller than the radius of curvature of the intersecting line (the bottom corner line of the groove) between the concave lateral border 4 of the groove and said plane in the grinding of said lateral border. Furthermore, if the groove has a varying radius of curvature, the first-mentioned radius of curvature should be smaller than the smallest radius of curvature which the intersecting line between the concave lateral border of the groove and the bottom plane 7 has in any portion of the groove along the length thereof, if the same grinding disk shall permit of being used for the grinding of the whole groove.

After the grinding tool has been adjusted in the proper way relatively to the surface to be ground, the grinding operation may be effected in the usual way, that is to say, the grinding tool, on having had the requisite rotational speed imparted thereto as indicated by arrow 31, is moved along the surface to be ground, until the latter has been ground to the requisite extent. Such motion may be obtained by rotation of the work and the straight line mo-

tion of the tool as indicated above and with arrows 32 and 30, respectively. If the grinding tool is so adjusted such as by tilting as to touch the surface to be ground at a point only (that is to say at the contact point between the base circle of the conical grinding disk and the surface to be ground), the tool is moved up and down along the lateral border of the groove while being fed in the longitudinal direction thereof.

For the grinding of the concave lateral border 4, the further condition applies that the grinding tool should be preferably adjusted so that its axis of rotation 11 intersects the plane 7 through the bottom of the groove at a point, the point 14 in Fig. 1, situated between the groove and the center of curvature 15 of the intersecting line between said lateral border and the plane 7 of the bottom of the groove.

In the grinding of the convex lateral border 5 of the groove, conditions will be analogous to those applicable in the grinding of the concave lateral border, but here certain other conditions are brought into consideration for the adjustment and the configuration of the grinding disk. As shown in Fig. 3, the conical working surface 9 of the grinding disk 8 is formed by the circumferentially extending conical edge of a recess 16 in the side of the grinding disk facing the work-piece 1. In the grinding of the convex lateral border 5, the grinding disk is so adjusted during the grinding operation that the radius of curvature of the intersecting line between the conical working surface 9 and the surface 2 having the groove provided therein is greater than the radius of curvature of the intersecting line between the convex lateral border 5 of the groove and said surface 2.

In the grinding of grooves with undercut lateral borders, the grinding operation is effected entirely analogously to the above description relatively to grooves with lateral borders extending at right angles to the plane of the groove bottom and the plane of the surface having the groove provided therein, respectively. In Fig. 4, which shows the grinding of the concave lateral border 4 of the groove 3, and in Fig. 5, which shows the grinding of the convex lateral border 5, the same designations have thus been selected as in Figs. 1 and 3 respectively. A detail description of Figs. 4 and 5 is thus believed to be superfluous, it being sufficient to mention that the axis of rotation 11 of the grinding tool in Fig. 4 intersects the groove bottom plane 7 in the range between the center of curvature 15 and the groove, i. e. in a point 14, and in Fig. 5 intersects the surface 2 in a point, namely, the point 17 in Fig. 5, outside the range between the groove 3 and the center of curvature 18.

In the grinding of the convex side of groove, the grinding disk may obviously be arranged and constructed as in Figs. 1 and 4 instead of as in Figs. 3 and 5. In that case the condition set forth in the foregoing to the effect that the axis of rotation of the grinding disk must intersect the plane through the upper edge of the groove outside the range between the groove and the center of curvature of the line of intersection between the convex groove surface and said plane is always answered.

In the example of grinding the bottom 6 of a groove 3 having the lateral borders 4 and 5, as shown in Fig. 6, a grinding tool is used in the form of a grinding disk having a conical working surface 19, which is limited in the axial diretction by two conical surfaces 20, 21 having an axis 11 which is also the axis of the working surface 19. The nature of these conical surfaces is such and the grinding tool is so adjusted during the working operation that in the grinding of the bottom 6 of the groove adjacent to the concave lateral border 4 the radius of curvature of the line of intersection between the conical limiting surface 20 situated adjacent to this lateral border and the plane 7 through the bottom of the groove is smaller than the radius of curvature (the smallest radius of curvature in grooves having a varying radius of curvature) of the line of intersection between the concave lateral border 4 and said plane 7, and that in the grinding of the bottom of the groove adjacent to the convex lateral border 5 the radius of curvature of the line of intersection between the conical limiting surface 21 situated adjacent to this lateral border and the same plane is greater than the radius of curvature (the greatest radius of curvature in grooves having a varying radius of curvature) of the line of intersection between the convex lateral border 5 of the groove and said plane.

A condition for correct grinding of the bottom of the groove may also be expressed so that the axis of the grinding tool or the axis of rotation 11 thereof shall intersect the plane through the bottom of the groove between the groove and the center of curvature of the intersecting line between the concave lateral border 4 of the groove and said plane 7 in the grinding of the bottom 6 of the groove adjacent to the concave lateral border 4, and outside the range between the groove and the center of curvature of the intersecting line between the convex lateral border 5 of the groove and said plane in the grinding of the bottom of the groove adjacent to the convex lateral border 5 of the groove. When the grinding disk, the working edge 19 of which is narrower than the groove, is moved along the bottom of the groove from one lateral border to the other, the point of intersection between the axis of rotation 11 and the bottom plane 7 is consequently caused to move so as to pass the center of curvature of the line of intersection between the lateral border of the groove and the bottom plane, in order that the grinding disk shall not ruin the outside of the groove.

In the method above described for the grinding of the bottom of the groove, the same grinding disk is taken to be used for the grinding of the bottom of the groove adjacent to the concave lateral border and the convex lateral border of the groove. However, it is also possible to make use of two different grinding tools for the grinding of the groove bottom, that is to say, of one tool for grinding adjacent to the concave lateral border and of another tool for grinding adjacent to the convex lateral border. Here, the conditions defined above for the grinding of the bottom of the groove by means of a single grinding disk apply relative to the grinding adjacent to the concave lateral border and adjacent to the convex lateral border of the groove, respectively.

In addition to the above-named precautionary measures it is also necessary to observe that the grinding disk must not touch other sides of the groove than that to be operated upon.

Here, the grinding has been taken to be for a groove in the ordinary sense of the work, i. e. for a recess of uniform width. The method is obviously also applicable for the grinding of elongated recesses of a varying width and with straight or curved sides. Furthermore, the same method can be applied in the grinding of recesses with a sloping bottom.

The invention comprises not only a method of grinding as set forth hereinbefore but objects produced according to this method as well. In particular, the invention relates to the grinding of spiral-shaped grooves in disks for the adjustment of chuck jaws.

What I claim is:

1. A method of grinding a pre-cut spiral groove in a plane surface of a work, comprising the steps of applying a conical working surface of a tool to one border of the groove, rotating said tool about its axis disposed at an oblique angle to the plane defined by the surface of said work, rotating said work at constant speed on an axis coincident with the axis of said spiral groove and simultaneously therewith feeding said tool and work rectilinearly relative to each other and at constant speed along a line extending through the axis of the spiral groove in the plane thereof to maintain the working surface of said tool in contact with successively different portions of the border of the spiral groove being ground.

2. A method of grinding as defined in claim 1 wherein

the bottom border of said groove is a plane surface parallel with the surface of said work and the border of the spiral groove to be ground is a concave lateral border, and wherein the radius of curvature of the line of intersection between the conical working surface of said tool and a plane containing the bottom border of the groove is smaller than the radius of curvature of the line of intersection between the concave lateral border of the groove and said plane.

3. A method of grinding as defined in claim 2 wherein the axis of rotation of said tool intersects a plane containing the bottom border of the groove at a point in the range between the working surface of said tool and the axis of said spiral groove.

4. A method of grinding as defined in claim 1 wherein the bottom border of said groove is a plane surface parallel with the surface of said work and the border of the spiral groove to be ground is a convex lateral border, and wherein the radius of curvature of the line of intersection between the conical working surface of said tool and the surface of the work is greater than the line of intersection between the convex lateral border of the groove and the surface of the work.

5. A method of grinding as defined in claim 4 wherein the axis of rotation of said tool intersects a plane containing the bottom border of the groove at a point outside the range between the working surface of said tool and the axis of said spiral groove.

6. A method of grinding as defined in claim 1 wherein the border of the spiral groove to be ground is the bottom of the groove and which is constituted by a plane surface parallel with the surface of said work, wherein said conical working surface of said tool is limited in the axial direction by two other conical surfaces having an axis coincident with the axis of rotation of said tool facing respectively the concave and convex lateral borders of the groove, the radius of curvature of the line of intersection between that other conical surface of said tool facing said concave lateral border and a plane containing the bottom of the groove being smaller than the radius of curvature of the line of intersection between said concave lateral border and said plane when grinding the bottom of said groove adjacent said concave lateral border, and the radius of curvature of the line of intersection between that other conical surface of said tool facing said convex lateral border and said plane being greater than the radius of curvature of the line of intersection between said convex lateral border and said plane when grinding the bottom of said groove adjacent said convex lateral border.

7. A method of grinding as defined in claim 6 wherein the axis of rotation of said tool intersects the plane containing the bottom surface of said groove at a point in the range between said conical working surface of said tool and the axis of said spiral groove when grinding the bottom of said groove adjacent the concave lateral border of said groove, and wherein the axis of rotation of said tool intersects said plane at a point outside the range between said conical working surface of said tool and the axis of said spiral groove when grinding the bottom of said groove adjacent the convex lateral border of said groove.

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