Feb. 18, 1958 W. KRUMME 2,823,448

GEAR GENERATING APPARATUS

Filed March 27, 1951

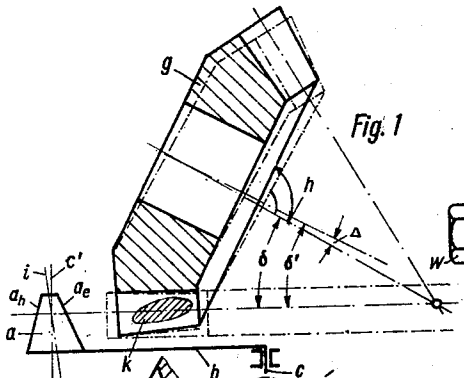


Fig. 1

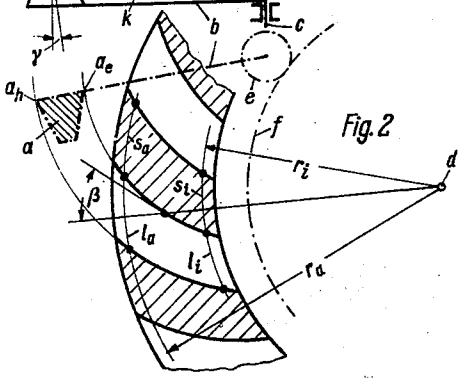


Fig. 2

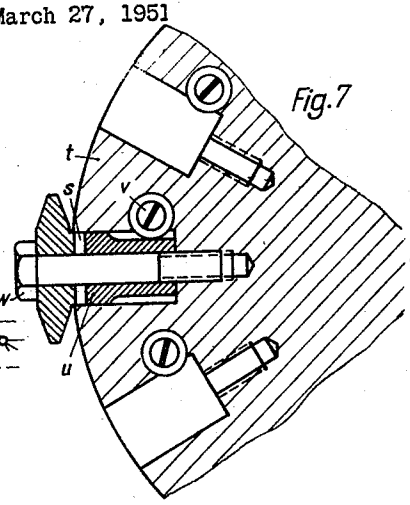


Fig. 7

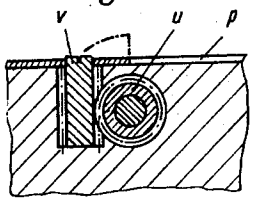


Fig. 8

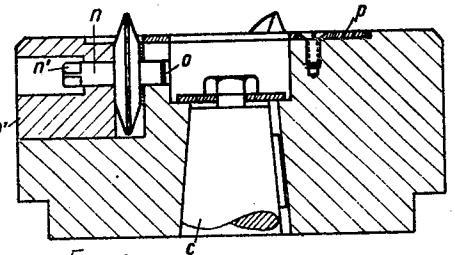


Fig. 3

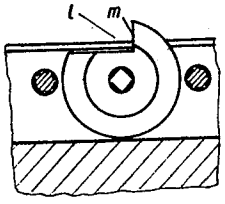


Fig. 5

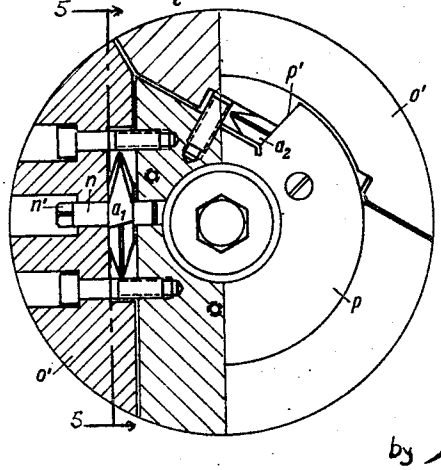


Fig. 4

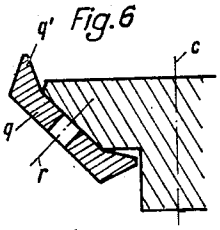


Fig. 6

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GEAR GENERATING APPARATUS

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2 Claims. (Cl. 29—105)

This invention refers to a gear generating apparatus. More particularly it relates to a gear hobbing tool for cutting bevel gears with curved teeth, in which both the concave and the convex tooth faces are cut in one operation, the cutting edges of the tool moving in cycloidal paths in the plane of the tool cross feed gear.

In the manufacture of bevel gears by prior art methods it is known to employ a rolling generating process in which a conical hob serves as the cutting member. Such a process results in wear of the hob, and resharpening the same is a difficult and painstaking operation. It is difficult to preserve the geometrical configuration of a re-sharpened hob and, at best the re-sharpening can only be performed a very limited number of times.

The present invention aims to provide a simplified method, and simplified apparatus for performing it, so that dull parts may be easily replaced an unlimited number of times with little expense and without affecting the accuracy of the cutting operation. Instead of employing a one-piece hob it is possible to use a tool comprising a knife head having a plurality of inexpensive replaceable knives, and to so arrange these knives that they can be removed or inserted in a few moments without in any way affecting the accuracy of the work performed.

The invention is characterized in that during the generating operation the axis of the work is arranged at an angle relative to the imaginary generating crown gear, in such a manner that the gash cut in the work, as measured in its circumferential direction, decreases over the distance from the large diameter of the wheel to its small diameter, and in proportion to these diameters. In carrying out the process the knives employed are characterized in that a symmetry line relative to the cutting edges for the concave and convex tooth faces, runs in an inclined position with respect to the axis of the tool (knife head), the angle of inclination being defined hereinafter.

It is possible within the scope of the invention, to fit the knives in their knife heads, and to make them adjustable in such a manner that any slight angular variation that may be encountered when renewing knives, and that affect the inclination of their symmetry line, can be compensated for. Another possibility of counteracting such variations of inclination between worn and replacement knives, as may have an adverse bearing on the accuracy and uniformity of the product, is the provision of knives of an especially long operative life, or in other words, the number of knife replacements is reduced to a minimum. Furthermore, this problem is solved in that the knives, following the pattern of chasing tools, are disc-shaped. These knives have a materially longer life than the conventional bar-shaped knives hitherto in general use.

The new process, and the apparatus for performing it are characterized by utmost simplicity. Due to this simplicity of design and method, the invention is particularly

well suited for the economical production of fine toothed bevel gears of a high degree of precision.

The objects of the invention are, therefore, to provide a simplified apparatus for performing the process; to reduce the cost of cutting tools and avoid inaccuracies attendant upon the resharpening of worn tools; to provide a novel type of cutting tool, and to generally make unnecessary the highly skilled operations hitherto required.

Numerous other objects and advantages of the invention will appear from the following description when it is read in conjunction with the accompanying drawings in which:

Fig. 1 is a combined sectional and diagrammatic view of a bevel gear to be cut, the gear being shown in engagement with the imaginary generating crown gear.

Fig. 2 is a plan view of Fig. 1.

Fig. 3 is a vertical cross section through one form of tool embodying the invention.

Fig. 4 is a plan view of the tool shown in Fig. 3, with some parts shown in plan and others in section.

Fig. 5 is a partial sectional view of one of the knives, the section being taken along the line 5—5 of Fig. 4.

Fig. 6 is a sectional view of a modified form of knife and its mounting.

Fig. 7 is a horizontal section of a still further modified form of knife head and knife.

Fig. 8 is a vertical section of the adjusting means shown in Fig. 7.

The production of spiral bevel gears in such a way that the cutting edges of the tool move on cycloidal paths in the plane of the imaginary generating crown gear is in line with the general practice of mechanical engineering and need not, therefore, be described in detail herein.

According to the present invention, referring particularly to Figs. 1 and 2, the known process is modified by swinging the axis of the work blank, during the cutting process, relative to the imaginary generating crown gear through the angle designated Δ in Fig. 1. In other words, the axis h of the blank is moved so that pitch cone angle δ becomes δ'. Consequently when the gear teeth are formed by cutting gashes in the blank, the teeth and the gashes appear as in Fig. 2. It will be seen that la exceeds li, in the same proportion that ra exceeds ri. In the same way tooth width Sa exceeds Si. A spiral bevel gear having tooth spaces which decrease in width from the outer diameter to the inner diameter of the gear is known in the art as a "palloid" spiral bevel gear.

The above structure can be produced readily by a tool comprising a knife head carrying one or more knives a, as shown diagrammatically in Fig. 1.

The knives, the cutting edges of which serve according to this process for the recessing of the gashes, are usually carried in a knife head that rotates about its axis, and simultaneously performs a planetary movement around the centre of the imaginary generating crown gear.

Fig. 1, in order to afford a clearer view, shows only a single knife a of the knife head. The knife head itself is not shown but is indicated schematically as a lever arm appearing as line b. c is the axis of the knife head, while e and f indicate schematically the gears which impart to the head its planetary motion around the centre of the imaginary generating crown gear.

The object of this invention is to cut tooth gashes in the work piece. The width of these gashes measured along the circumference of the work piece, decreases over the distance from the large diameter of the blank to its small diameter, and in direct proportion to these diameters. In the calculation the wheel diameters can be replaced by the radii r_a and r_i of the imaginary generat-

ing crown gear (see Fig. 2). Hence, l_a must vary in relation to l_1 as r_a varies in relation to r_1. If this condition is satisfied, then the tooth thickness is reduced over the distance from s_a to s_1 according to the same law.

If the blank g to be gear cut is so adjusted in relation to the imaginary generating crown gear that its axis h forms an angle δ with the latter, and this corresponds to the pitch cone of the gear, then the gashes are usually too wide at the inside diameter. When cutting gears according to this invention, this angle is made smaller by an amount such that the teeth of the imaginary generating crown gear, measured towards the centre of the imaginary generating crown gear, penetrate less deeply into the blank to be gear cut, in such a way that the ratio of gash widths at the outside and inside corresponds to the aforementioned rule. The angle δ' can be easily computed or ascertained by trial. With respect to Fig. 1, this rule can also be expressed in this way; viz, the axis of the work piece h is swung out of its usual angular position δ about an angle Δ in the corrected angular position δ'.

Preferably the reduction of gash width from the outside to the inside should largely approximate the optimum proportions even in the imaginary generating crown gear. This is the case if the cycloidal distances, according to which the teeth are curved in their longitudinal direction, are as similar as possible to spiral teeth curved to involutes, for it is characteristic of the involute spiral teeth that their gash width, while remaining uniform over the whole distance from the large diameter to the small diameter of the wheel when measured at right angles to the gash, decreases in the circumferential direction in the proportion called for in this invention.

The central spiral angle β can be regarded as an indication of this similarity. So the rule may be laid down that the central spiral angle of the gears cut according to this process should correspond to the central spiral angle that would be obtained when cutting involute teeth in the same gears.

The correction of the pitch cone angle to obtain angle δ' as indicated herein would in many cases bring about oblique meshing conditions. In order to counteract this effect, it is necessary that the symmetry line i (Fig. 1) be so arranged that it runs at a certain angle to the cutting edges a_h and a_e for the concave and convex tooth faces, with an inclination in relation to the axis c of the knife head. In Fig. 1 this angle is indicated by λ and formed by a line c' parallel to c. The angle of inclination is such as to insure that the area of contact in the centre of the teeth of a set of meshing gears generated according to this process, remains at approximately the same distance from addendum and root edges of the teeth, as shown in Fig. 1, contact diagram k. The angular difference can be calculated or ascertained easily by trial.

The foregoing description of the process, in order to make the matter more lucid, represents only a single knife a, cutting both concave and convex tooth faces in Figs. 1 and 2.

The gear cutting expert is familiar with the practice of employing a plurality of knives, say 2, in order to use one of them to cut the concave, and the other to cut the convex faces. The knife head shown in Figs. 3 to 5 is designed for two knives a_1 and a_2, which have the shape of a double cone disc. The circumference of this disc is interrupted at one point by an angular recess l forming a true rake m.

The disc-shaped knives a_1 and a_2 are rigidly fitted on shafts n with squares n' serving for centering the knives in holes o drilled into the knife head and its chucking covers o'.

As a consideration of Figs. 3 to 5 reveals, the position of the knives and their cutting edges in relation to the knife-head axis is fixed by the shape of the knives without any manipulation on the part of the operator. It is generally known, and therefore is mentioned only for the sake of completeness, that the knives must lie on an archimedic spiral. The knives are also fixed with respect to height by their shafts n. The only thing the operator has to do is to find the proper position of the true rake m before chucking the knife. For this purpose, there is provided a template-like plate p with two teeth p', which is attached to the knife head, and which serves to indicate the theoretically proper position of the true rakes. The squares n' enable the knives to be rotated by a wrench in such a way that their true rakes bear against the teeth of the plate. If that condition is met, the proper position is obtained and the knives can be chucked.

Fig. 6 shows a modified form of the new knife. In this case the circular knife is of dished shape having a plane bottom q and a tapered rim q'. The knife axis r intersects axis c of the knife head, not at right angles, but at an oblique angle. This design affords an improved correspondence between knife teeth and the curved face lines of the gear teeth.

In the case of this knife head, the knives are frictionally prevented from turning in consequence of the thrust caused by the cutting operation. Figures 7 and 8 show a knife head design in which turning is positively prevented. The knives in this case are also of dished shape, similar to those just described in Fig. 6. In contrast to the design illustrated above, they are, however, connected with a hub u fitted in a hole drilled radially in the knife head t by means of a spur-gear coupling s. This hub is toothed at the circumference. It acts conjointly with a small worm v which is mounted in a recess formed in the knife head at right angles to the hub. Knife and hub are held by a shoulder stud w. For finding the proper position of the true rake, a template-like plate p as already described in the first example is used.

The manipulation of this knife head is simple. The spur-gear coupling enables the knife to be dismounted from the hub, thus facilitating the knife replacement procedure. Worm v serves to advance the true rake of the knife against the tooth of the template-like plate p.

This invention is, of course, not limited to the examples presented herein. It is also possible, for instance, to use grinding tools in place of the cutter tools represented.

Having thus described my invention, what is claimed is:

1. A tool for cutting in a single operation both the concave and the convex faces of curved teeth bevel gears, comprising a circular knife head having a body and two abutting removable arcuate segments, a pair of disc-shaped cutting tools rotatably mounted in said head, one behind each of said segments and disposed in planes forming an acute angle with each other, with template means carried by said knife head for adjusting said cutting tools in proper cutting relation, said cutting tools being rotatable into engagement with said template.

2. A tool for cutting flanks of curved teeth on bevel gears, said tool comprising a circular knife head having a flat end face perpendicular to the axis of said knife head and a plurality of flat side faces each disposed at a right angle to said end face; a plurality of disc-shaped cutters each having opposed flat side faces, there being a cutter associated with each knife head side face; each cutter including a flat rake face, a curved top face and opposed conical surface flank faces, said top and flank faces extending from said rake face to form top and flank cutting edges with said rake face, said cutting edges extending axially beyond the flat end face of said knife head; and clamping means securing each cutter to its associated knife head side face, said clamping means including a removable knife head segment engaging one flat side face of each cutter to clamp the opposite cutter side face against its associated knife head side face, each cutter being rotatable about an axis perpendicular to its side faces to vary the extent to which said cutting edges project axially beyond the flat end face of said knife head.

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