Feb. 25, 1958 W. H. BATEMAN 2,824,556

METHOD AND MEANS FOR SHAPING AND TRIMMING HELICALLY FORMED GRINDING WHEELS

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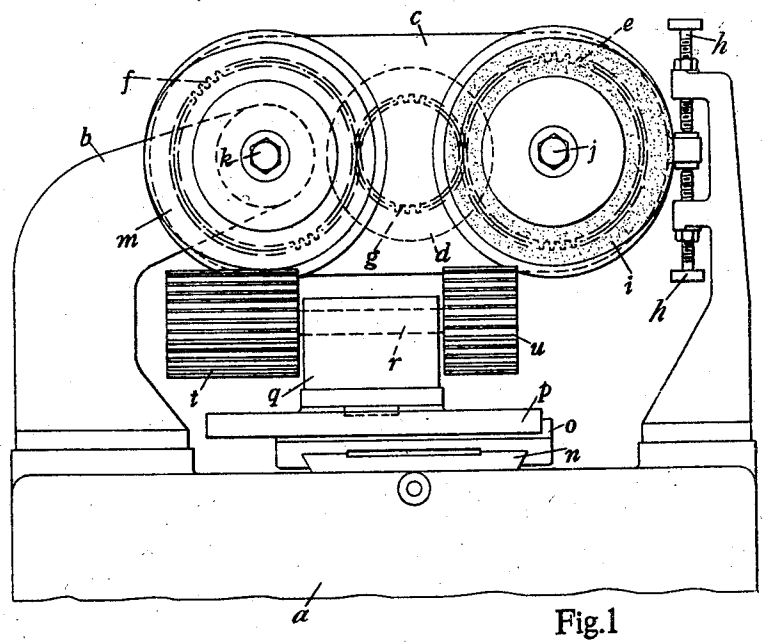

Fig.1

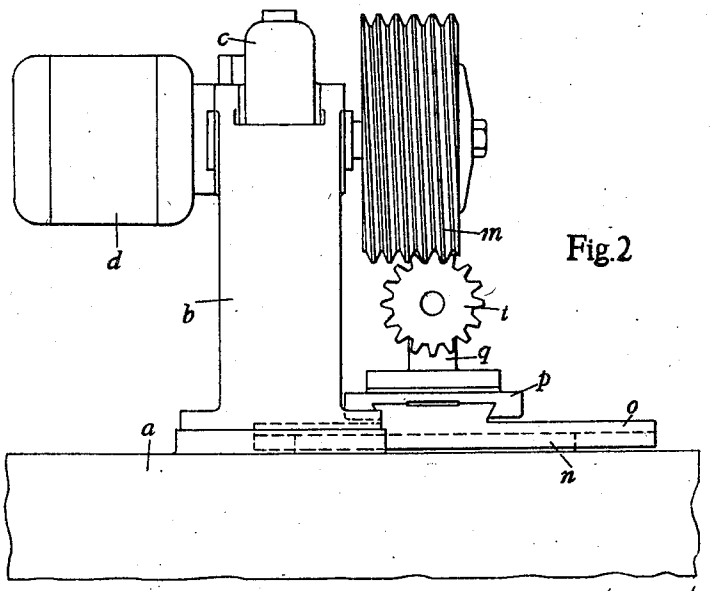

Fig.2

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Fig. 3

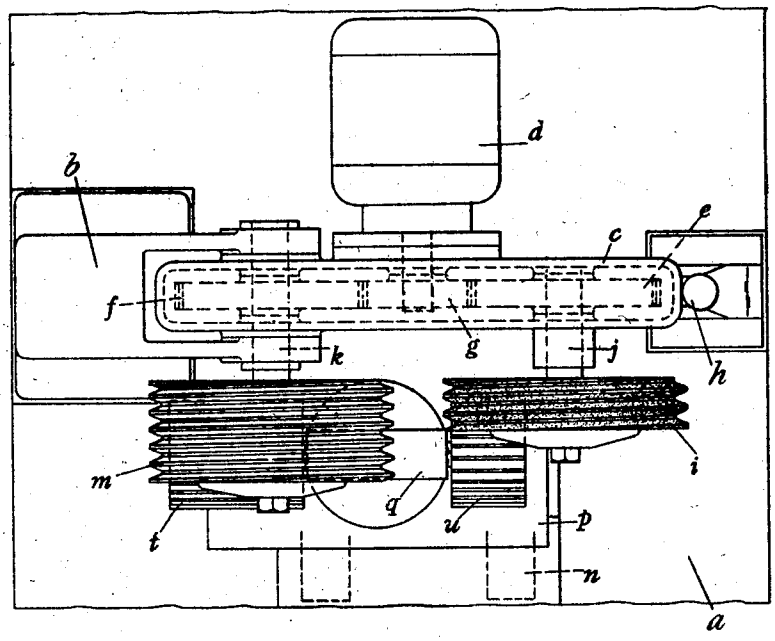


Fig. 4

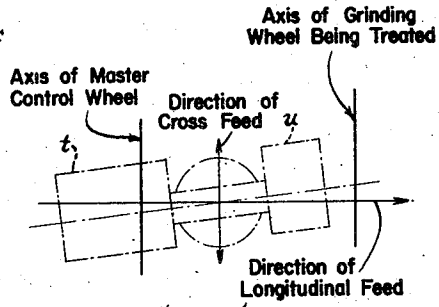
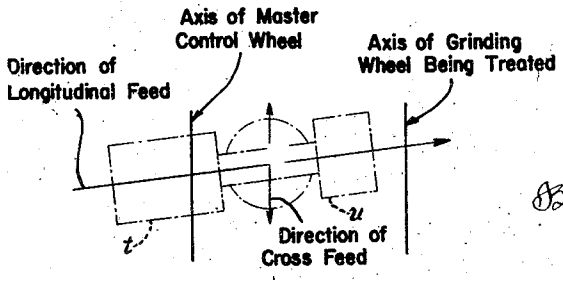


Fig. 5



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METHOD AND MEANS FOR SHAPING AND TRIMMING HELICALLY FORMED GRINDING WHEELS

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15 Claims. (Cl. 125—11)

This invention relates to a method and means for shaping the peripheral surface of a grinding wheel to a helical form, such wheels being required for use in the grinding of gear wheel teeth, shaft splines or like parts of other analogous workpieces.

For grinding gear wheel teeth of involute form, the grinding wheel is required to have upon its periphery a helix of pitch and form corresponding substantially to that of a worm wheel which would mesh in rotary engagement with the gear wheel to be ground. The cross section of the helix would be of rack form.

Hitherto the forming of the helix on such a grinding wheel has been effected by means analogous to those used in the cutting of screw threads, or by the crushing action of hard rollers.

According to the invention the desired helix on the periphery of a grinding wheel is generated by means of a rotary tool resembling a toothed wheel the contour of the teeth of which is conjugate to that of the form to be imparted to the grinding wheel.

In one example, the invention consists of a method wherein there is presented to the periphery of a rotating grinding wheel, an end face of a rotary cutting tool as above defined, mounted with its rotation axis parallel with a tangent to the grinding wheel, and wherein the tool is traversed in a direction parallel with the axis of the grinding wheel and concurrently rotated at the rate it would derive from engagement with a rotating helical gear wheel of the same pitch as that of the helix to be formed on the grinding wheel.

The invention also comprises means as hereinafter described for performing the operations defined in the preceding paragraph.

In the accompanying drawings, Figure 1 is a side elevation, Figure 2 an end view, Figure 3 a plan of a machine for shaping a grinding wheel in accordance with the invention, and Figures 4 and 5 are schematic diagrams illustrating different possible orientations of the main elements of such a machine.

Referring to the drawings, the machine there shown comprises a base *a* on which is formed or secured a bracket *b*. To the bracket there is pivotally attached one end of a hollow arm *c* on which is mounted an electric motor *d*. Within the arm are contained two gear wheels *e*, *f* of equal size, and an intermediate and smaller driving wheel *g*, the latter being driven by the motor *d*. Angular movement of the arm about the axis of the pivot is controlled by adjustable stops *h*.

The grinding wheel *i* to be treated, is mounted on the spindle *j* of the wheel *e*, and on the spindle *k* of the wheel *f* (which also serves to provide the pivotal connection between the arm and bracket) is mounted a master control wheel *m* having on its periphery a helix of pitch corresponding to the helix to be formed on the grinding wheel. The wheel *m* is preferably (though not essentially) of about the same diameter as the grinding wheel, but its helical pitch is identical with that of the grinding wheel.

On the base *a* of the machine and beneath the arm *c* is formed or secured a guide *n* for a slide *o*, the direction of movement of the slide being parallel with the axes of the wheels *e*, *f* and on the slide *o* is mounted a slide *p* which is movable on the slide *o* in a direction at right angles to the movement of the slide *o*.

On the slide *p* is provided a bearing *q* for a spindle *r*, which bearing may be angularly adjustable in a horizontal plane. At its opposite ends the spindle *r* carries a toothed wheel *t* for engagement with the control wheel *m*, and the cutting tool *u* for effecting the shaping operation on the grinding wheel *i*.

Alternatively the axis of the tool may be inclined so as to be substantially parallel with the helix to be formed on the grinding wheel. Also the slide *p* may be mounted on the slide *o* for movements substantially parallel with the helix to be formed on the grinding wheel.

Examples of such alternative orientations are illustrated in the schematic diagrams, Figures 4 and 5; Figure 4 illustrating an arrangement of the main members of the machine wherein the axis of the toothed wheel *t* is inclined to the helix angle or thereabouts of the grinding wheel *i*, but is fed in a direction at right angles to the axes of the grinding wheel *i* and master wheel *m*. In the arrangement Figure 5, the axis of the toothed wheel *t* is similarly inclined, but in this case is fed in a direction parallel with the axis of the said toothed wheel *t*.

Any convenient means (not shown) such as nut and screw mechanisms are provided for imparting the required movements to the slides *o*, *p*.

For forming a grinding wheel for the grinding of gears of involute tooth form the teeth on the cutting wheel *u* are of involute form and the cross-sectional shape of the helix to be formed on the grinding wheel is the conjugate rack. The operative end of the cutting tool is the right-hand end as viewed in Figure 1, and this end is conveniently made from a hard metal composition such as tungsten carbide, or of abrasive diamond grains embedded in a suitable metal.

The required operation on the grinding wheel is performed as follows:

The slide *p* is first moved to the left of the position shown in Figure 1, in which the tool *u* is then in an inoperative position. The arm *c* is then adjusted vertically by means of the stops *h* so as to bring the grinding wheel *i* into the position in which the tool by movement to the right can form to the full depth the helix upon the grinding wheel. After the motor *d* has been set in motion, the slide *p* is given feed-movements to the right until the right-hand end face of the cutting tool *u* occupies the vertical plane containing the axis of the grinding wheel. During these feed-movements of the tool the slide *o* is moved in the direction parallel with the spindles *j*, *k* causing the tool to travel across the periphery of the grinding wheel. Concurrently the cutting tool is also rotated by the interaction of the control wheel *m* and wheel *t*.

It will be apparent that all of the rotary elements being synchronised, feed-movements both longitudinal and across applied to the tool slides may be effected independently and either intermittently or continuously.

Alternatively the cutting tool is moved to an initial position in which its right-hand end-face occupies the vertical plane containing the axis of the grinding wheel and thereafter the grinding wheel is fed downwards to the full depth of the helix to be formed during the rotational and traversing movements described in the first example.

The method above described may be employed for generating the desired form on a grinding wheel having initially a plain cylindrical surface, or for restoring the surface to the desired form after use.

Either single and multi-start helices may be formed in the manner above described.

Having thus described my invention what I claim as new desire to secure by Letters Patent is:

1. A method of generating a peripheral helix on a grinding wheel of abrasive composition, including the steps of bringing a toothed cutting surface of a tooth contour which is conjugate to that of the form to be imparted to said grinding wheel by a relatively slow unidirectional movement into tangential cutting contact with the outer periphery of the grinding wheel, while rotating both said toothed surface and said grinding wheel at predetermined, relative speeds, and maintaining said tangential cutting contact while moving said toothed surface unidirectionally across the outer peripheral surface of the grinding wheel in a fixed linear path.

2. A method of generating a peripheral helix on a grinding wheel of abrasive composition, including the steps of bringing the end of a toothed cutting tool of a tooth contour which is conjugate to that of the form to be imparted to said grinding wheel by a relatively slow unidirectional movement into tangential cutting contact with the outer periphery of the grinding wheel, while rotating both said toothed cutting tool and said grinding wheel at such predetermined relative speeds that the cutting tool is rotated at the rate it would normally derive from engagement with a rotating helical gear wheel of the same pitch as that of the helix to be formed on the grinding wheel, and maintaining said tangential cutting contact while moving said toothed cutting tool unidirectionally across the outer peripheral surface of the grinding wheel in a fixed linear path.

3. A method of generating a peripheral helix on a grinding wheel of abrasive composition, including the steps of bringing the end of a toothed cutting tool of a tooth contour which is conjugate to that of the form to be imparted to said grinding wheel by a relatively slow unidirectional movement transversely of the axis of rotation of said grinding wheel into tangential cutting contact with the outer periphery of said grinding wheel, while rotating both said toothed surface and said grinding wheel at predetermined relative speeds, and maintaining said tangential cutting contact while moving said toothed cutting tool unidirectionally across the outer peripheral surface of the grinding wheel in a fixed linear path which is parallel to the axis of rotation of said grinding wheel.

4. A method of generating a peripheral helix on a grinding wheel of abrasive composition, including the steps of bringing the end of a toothed cutting tool of a tooth contour which is conjugate to that of the form to be imparted to said grinding wheel in a relatively slow unidirectional movement into tangential cutting contact with the outer periphery of the grinding wheel, while rotating said grinding wheel and an accurately formed master control wheel at the same speed, driving said tool by said master control wheel to impart the desired speed relative to that of said grinding wheel, and maintaining said tangential cutting contact while moving said toothed surface unidirectionally across the outer peripheral surface of said grinding wheel in a fixed linear path.

5. A machine for generating an accurate peripheral helical rack on a grinding wheel of abrasive material, including a rotary spindle for mounting the grinding wheel, a second spindle having a rotary toothed cutting tool mounted thereon, a third spindle having mounted thereon an accurately formed master control wheel the helical pitch of which is identical to that which is to be formed on said grinding wheel, means for rotating said grinding wheel spindle and said master wheel spindle at equal speeds, means connecting said master wheel with said cutting tool in driving relationship whereby said cutting tool will be rotated at that speed relative to the speed of rotation of said grinding wheel that a correct helical pitch will be obtained on said grinding wheel, means for guiding said rotating cutting tool in a fixed linear path across the surface of said grinding wheel, and means for adjusting said cutting tool in a direction transversely of the axis of rotation of said grinding wheel.

6. A machine for generating an accurate peripheral helical rack on a grinding wheel of abrasive material, including a rotary spindle for mounting the grinding wheel, a second spindle having a rotary toothed cutting tool mounted thereon, a third spindle having mounted thereon an accurately formed master control wheel the helical pitch of which is identical to that which is desired for said grinding wheel, means for rotating said grinding wheel spindle and said master wheel spindle at equal speeds, a drive gear fixed to said second spindle and meshed in driving relationship with said master wheel, means for guiding said rotating cutting tool in a fixed linear path across the surface of said grinding wheel, and means for adjusting said cutting tool in a direction transversely of the axis of rotation of said grinding wheel.

7. A machine for generating an accurate peripheral helical rack on a grinding wheel of abrasive material, including a base, a bracket extending upwardly from said base, an arm pivotally attached at one end to said bracket, a pair of spaced spindles extending transversely of said bracket arm and journalled for rotation thereon, the first of said spindles serving as the pivot for said arm on said bracket, drive means for rotating the spindles at equal speeds, an accurately formed master control wheel fixed to said pivot spindle, a grinding wheel of abrasive material fixed to said second spindle, a third spindle, positioned below and extending transversely of said spaced spindles, a toothed cutting tool on said third spindle beneath said grinding wheel, a drive gear on said spindle meshing in driving relationship with said master helical wheel, a support on said base for said third spindle, means for guiding said support in movement across said base in a direction transversely of said grinding wheel, and means for guiding said support for adjustment along said base in a direction transversely of the axis of said spaced first and second spindles.

8. A structure as set forth in claim 7 having adjustable stop means for said arm whereby the relative positions of said grinding wheel and said cutting tool may be adjusted.

9. A structure as set forth in claim 7 wherein said adjustable stop means comprises a pair of opposed stop screws mounted on said base and having a portion of said arm extending between said screws.

10. A structure as set forth in claim 7 wherein said spindle drive means includes a drive gear on each spindle, said drive gears being of equal size, an intermediate gear between and in driving engagement with said drive gears, and motor means for driving said intermediate gear.

11. A structure as set forth in claim 7 wherein said drive gear on said third spindle is of the same diameter and tooth structure as said cutting tool and is elongated to permit maximum adjustment of said cutting tool and its support in a direction transversely of the axis of the spaced first and second spindles.

12. A method of generating a peripheral helix on a grinding wheel of abrasive composition, including the steps of bringing the peripheral edge of a toothed cutting tool of a tooth contour which is conjugate to that of the form to be imparted to said grinding wheel into tangential contact with the outer periphery of the grinding wheel with the end face of said cutting tool being so positioned relative to the axis of rotation of said grinding wheel that a plane through said end face will intersect said axis of rotation, and then while rotating both said toothed tool and said grinding wheel at predetermined, relative speeds, slowly moving said grinding wheel against said cutting tool and toward the axis of rotation thereof, while moving said cutting tool across the outer peripheral surface of the grinding wheel in a fixed linear path.

13. A method of generating a peripheral helix on a grinding wheel of abrasive composition, including the steps of bringing the peripheral edge of a toothed cutting tool of a tooth contour which is conjugate to that of the form to be imparted to said grinding wheel into tangential contact with the outer periphery of the grinding wheel with the end face of said cutting tool being so positioned relative to the axis of rotation of said grinding wheel that a plane through said end face will intersect said axis of rotation, and then while rotating both said toothed tool and said grinding wheel at such predetermined relative speeds that the cutting tool is rotated at the rate it would normally derive from engagement with a rotating helical gear wheel of the same pitch as that of the helix to be formed on the grinding wheel, slowly moving said grinding wheel against said cutting tool and toward the axis of rotation thereof, while moving said cutting tool across the outer peripheral surface of the grinding wheel in a fixed linear path.

14. A machine for generating an accurate peripheral helical rack on a grinding wheel of abrasive material, including a rotary spindle for mounting the grinding wheel, a second spindle having a rotary toothed cutting tool mounted thereon, a third spindle having mounted thereon an accurately formed master control wheel the helical pitch of which is identical to that which is to be formed on said grinding wheel, means for rotating said grinding wheel spindle and said master wheel spindle at equal speeds, means connecting said master wheel with said cutting tool in driving relationship whereby said cutting tool will be rotated at that speed relative to the speed of rotation of said grinding wheel that a correct helical pitch will be obtained on said grinding wheel, means for guiding said rotating cutting tool in a fixed linear path across the surface of said grinding wheel, means for adjusting said cutting tool in a direction transversely of the axis of rotation of said grinding wheel, and means for inclining the axis of said cutting wheel into substantial parallelism with the helix to be formed on the grinding wheel.

15. A machine for generating an accurate peripheral helical rack on a grinding wheel of abrasive material, including a base, a bracket extending upwardly from said base, an arm pivotally attached at one end to said bracket, a pair of spaced spindles extending transversely of said bracket arm and journaled for rotation thereon, the first of said spindles serving as the pivot for said arm on said bracket, drive means for rotating the spindles at equal speeds, an accurately formed master control wheel fixed to said pivot spindle, a grinding wheel of abrasive material fixed to said second spindle, a third spindle positioned below and extending transversely of said spaced spindles, a toothed cutting tool on said third spindle beneath said grinding wheel, a drive gear on said spindle meshing in driving relationship with said master helical wheel, a support on said base for said third spindle, means for guiding said support in movement across said base in a direction transversely of said grinding wheel, means for guiding said support for adjustment along said base in a direction transversely of the axis of said spaced first and second spindles, and means for inclining the axis of said cutting tool into substantial parallelism with the helix to be formed on the grinding wheel.

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