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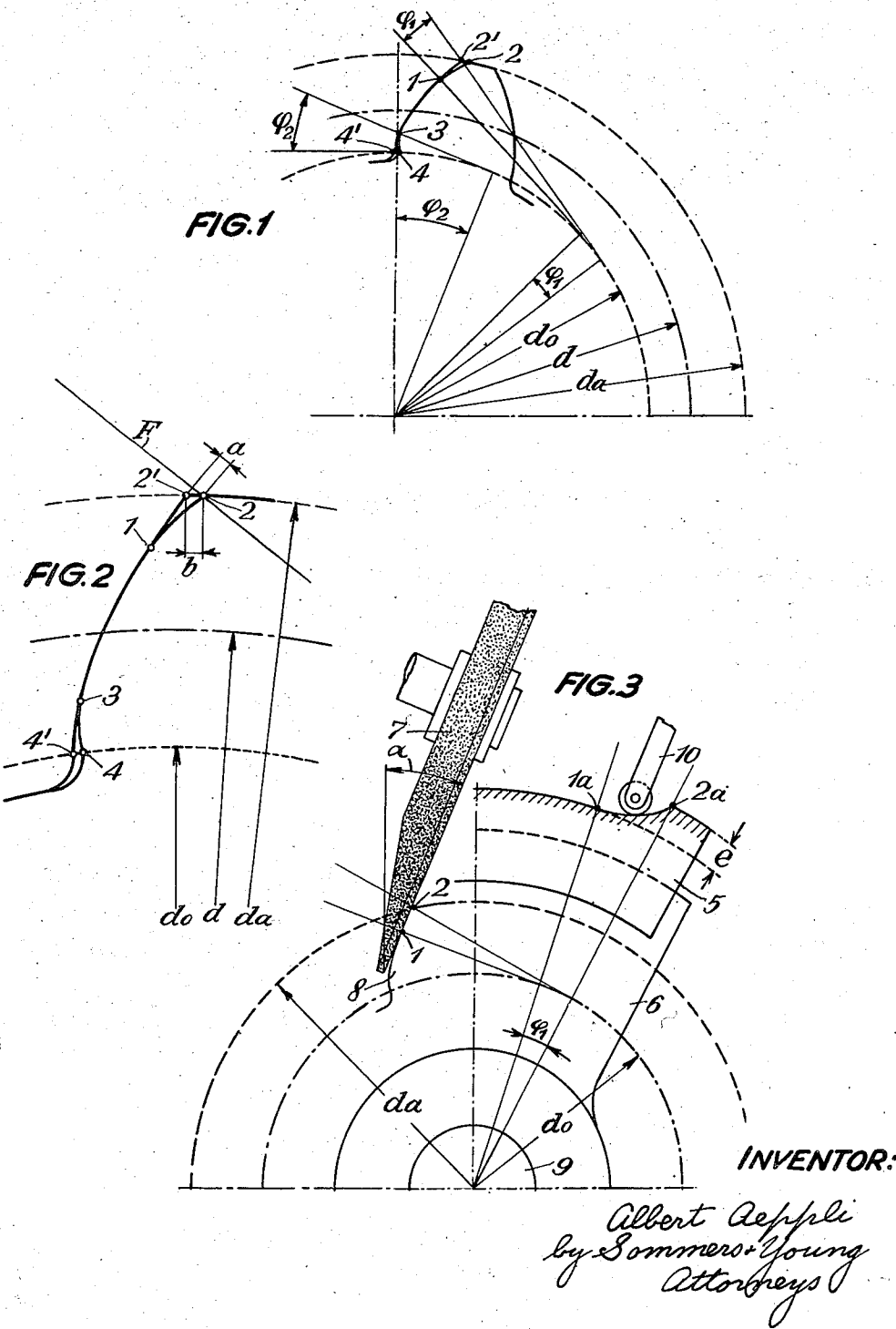
A. AEPPLI

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MACHINE FOR GRINDING GEAR WHEELS

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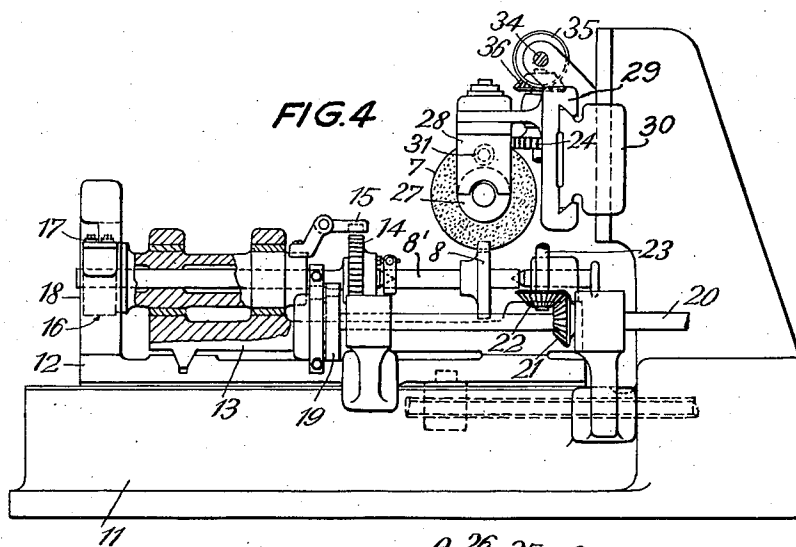
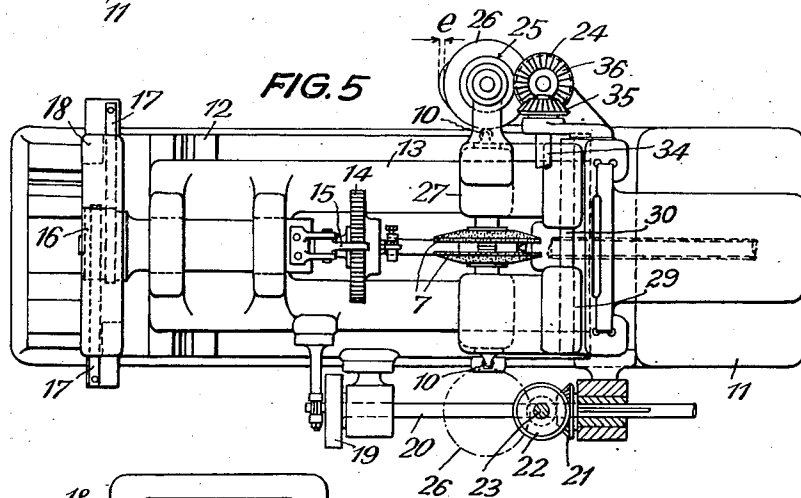
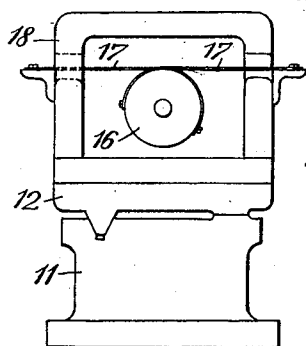
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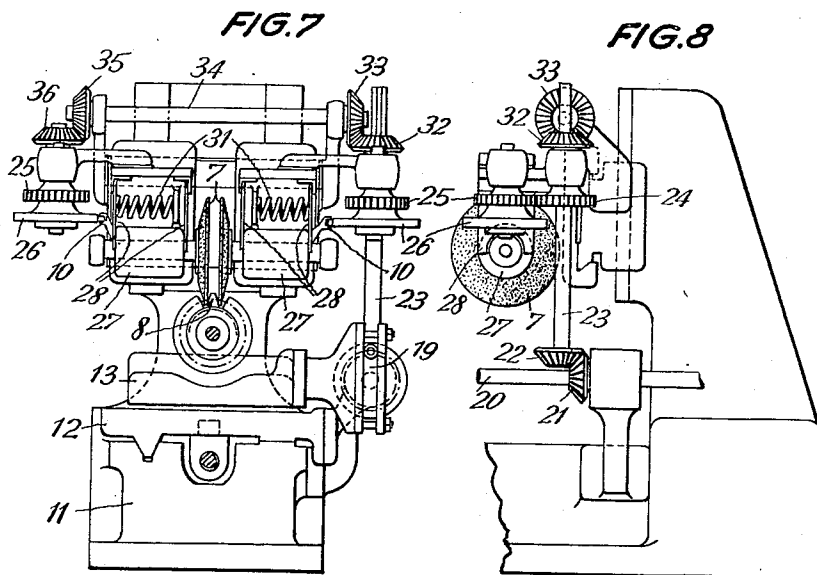
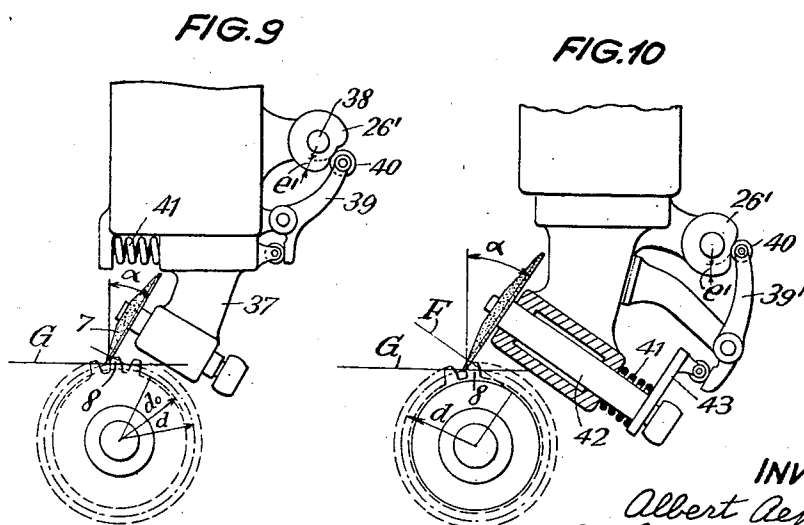
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

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MACHINE FOR GRINDING GEAR WHEELS

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5 Claims. (Cl. 51-123)

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My present invention relates to a method of and machine for grinding gear wheels in accord with the generating process, for the purpose of producing tooth profiles which partially deviate from the involute form.

As is known in the art, the teeth meshing at any one time in highly loaded or stressed gears are deflected by virtue of the high tooth pressure, which deflections are a maximum at the tooth-face. Each freshly intermeshing pair of teeth, now, causes a slight impact, since the tooth of the driving wheel—owing to the deflection of the preceding tooth—slightly leads with respect to the appurtenant tooth of the driven wheel and abuts against the face of such latter tooth. In order to eliminate such disadvantage, the teeth are given a profile which partially deviates from the true involute form, i. e. the tooth faces or roots are suitably rounded off.

Methods and machines serving such purpose are known in the art. In gear wheel grinding machines operating with form discs, the latter are so profiled as to impart the desired rounding to the teeth to be ground. Further, in machines grinding in accord with the generating method, the rolling cylinder of the generating means suitably is adapted noncircular, or the work is additionally moved when grinding the tooth faces or roots. Since, however, such latter machines usually work different tooth sides simultaneously, by means of two grinding wheels, there is the disadvantage that one cannot perform profile changes of any form and size desired, since, perhaps, one at the same time has to grind the tooth root on the left flank and the tooth face on the right flank. In such case, one is forced to work each tooth side per se, thus doubling the time of grinding.

Such disadvantage is eliminated, by the method disclosed in my present invention, in that the two grinding wheels, instead of the work piece, intermittently are subject to an additional movement, thus also producing tooth profiles which partially deviate from the involute form. In this manner, it is possible to displace each grinding wheel per se, at a predetermined time, by an amount corresponding to the amount of rounding or transition at the tooth face or root. It, therefore, is possible to simultaneously grind two different tooth sides by means of two grinding wheels. Such displacement of the latter may be brought about by any suitable means which are known per se.

In the machine for carrying out the method of my present invention, the grinding wheels are displaced through cams which act onto deflectors, a relative movement being set up be-

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tween the cam and deflector, which movement is linked with that of the generating means.

The method and various embodiments of the machine according to my present invention are illustrated in the accompanying drawings in which:

Fig. 1 schematically shows an involute tooth profile partially deviating from the involute form;

Fig. 2 the same profile enlarged;

Fig. 3 a schematic representation of the tooth profile, including the grinding wheel, cam and deflecting roller for the intermittent displacement of the grinding wheel,

Figs. 4 and 5 show a gear grinding machine working by means of two grinding wheels according to the such method, in elevation and plan respectively,

Fig. 6 shows a partial view of the said machine, including the generating means,

Fig. 7 a side view of Figs. 4 and 5,

Fig. 8 one form of the means for displacing the grinding wheels,

Fig. 9 another form for displacing the grinding wheel carrier in direction of the generating plane,

Fig. 10 the same means, but for displacing the grinding wheel in direction of its axis of rotation and parallel to the line of engagement, and

Figs. 11 and 12 show an elevation, partly in section, and a plan view of a gear grinding machine in which the two grinding wheels perform the generating movements, while the gear wheel only performs a feed motion relative to the grinding wheels.

Fig. 1 shows a general involute tooth profile 2'-4', including the base circle d_0 , the pitch circle d and the addendum circle d_a . On the tooth face, a deviation from the involute may be seen, beginning at point 1 and extending to the addendum circle at 2. Such deviation involves the angle φ_1 on the base circle. Similarly, a deviation or transition is provided on the tooth root, extending between the points 3 and 4 and subtending the angle φ_2 . Fig. 2 shows the same profile enlarged, the deviation on the tooth face or addendum in direction of the addendum circle and in direction of the line of engagement F being designated by b and a respectively. The said two deviations are so adapted as to smoothly pass into the involute curve at the points 1 and 3.

The said profile changes or deviations are brought about by a corresponding displacement of the grinding wheel.

One form of such means is schematically shown in Fig. 3, operating through a cam 5 secured to a carrier 6 which follows the rota-

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tion of the shaft 9 of the gear 8 to be ground, relative to the stationary grinding wheel 7, for the purpose of producing the generating motion. By virtue of such rotation, the cam 5 on passing through the angle ϕ_1 from point 1a to 2a, displaces a deflector 10 by the amount e which, reduced accordingly, is transmitted onto the grinding wheel 7. The latter successively approaches the tooth profile, from point 1 to 2 thereof, in direction of the grinding wheel axis, i. e. parallel to the line of engagement F, by the amount a (Fig. 2), whereby the tooth face is rounded as desired.

In Figs. 4-8 there is shown a gear grinding machine operating in accord with the method set forth above. A carriage 12 is mounted displaceable on the bed 11 and carries a further slide 13. On the latter is mounted a shaft 8' supporting the gear wheel 8 to be ground, which shaft is connected through the indexing means 14, 15 to the hobbing elements. The latter comprise the rolling cylinder 16 (Fig. 6) to which steel tapes 17 are secured. The ends of the latter are secured to the stirrup 18 which is attached to the carriage 12. When the slide 13 is moved transversely of the carriage 12, the cylinder 16 rolls off on the stretched tapes 17 and thus imparts the necessary generating movement to the gear wheel 8 relative to the grinding wheels 7.

A crank gear 19 serves for producing the transverse movement of the slide 13, and is actuated by a shaft 20. A bevel gear wheel 21 is keyed to the latter and drives a further shaft 23 through a bevel gear wheel 22. A gear wheel 24 is keyed to the shaft 23 and meshes with a gear wheel 25 which is connected to a cam 26 (Figs. 7, 8). The latter is contacted by a deflecting roller 10 of which the holder is secured to the casing 27 in which the shaft of one of the grinding wheels 7 is mounted. The said casing 27 is oscillatably suspended from a horizontally displaceable slide 29 by means of two resilient hangers 28. The said slide 29 in its turn rests on the slide 30 which is vertically adjustable on the upper portion of the bed 11. A spring 31 so abuts against one of the hangers 28 as to force the deflecting roller 10 against the cam 26.

A similar driving arrangement also is associated with the other grinding wheel 7. The drive is derived from the shaft 23 through a pair of bevel gear wheels 32, 33 and the shaft 34 onto a further pair of bevel gear wheels 35, 36. The latter drive the cam 26 through the left-side pair of gear wheels 24, 25.

The machine operates as follows: The gear ratio of the wheels 21, 22 and 24, 25 is so chosen that the cams 26 perform a revolution in the same time as the crank 19. It is required to round off the tooth faces of the wheel 8. In the form of machine described, grinding wheels 7 are used, of which the plane grinding faces are put opposite each other and at right angles to the hobbing tapes 17. The machine, therefore, grinds with a pressure angle of 0° relative to the vertical. A rounding of the tooth profile is produced on feeding the grinding wheels toward the centre of the machine. It is from this reason that each cam 26 (Fig. 5) is given a rise e of which the magnitude and run correspond with the desired degree of rounding off. As each revolution of the cam corresponds to a double generating movement of the gear wheel 8, the position of the rise e on the cam periphery may be accurately ascertained. Further, also the tooth face

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and root on one and the same tooth flank may be rounded off by providing two rises e on the cam periphery.

In the form of invention described above, the deviation of the tooth profile from the involute or, respectively, the grinding wheel feed is equal to the rise e . Since the values involved are very small, in the order of a few hundredths of a millimetre, it would be more advantageous to make the curve e to a larger scale, as shown in Figs. 9 and 10. In this case, the plane working faces of the grinding wheels 7 are facing outwardly and form the pressure angle α with the vertical. For the purpose of rounding the tooth profile, the grinding wheels, therefore, have to be outwardly displaced. Such displacement is brought about, according to Fig. 9, by adjusting the slide 31. The cam disc 26' is pinned to a shaft 38 which in its turn is so rotated through the crank-gear shaft 20 (Fig. 5) as to perform a revolution therewith. A transfer lever 39 comprises an idling roller 40 at one end, while the shorter arm contacts a stop of the grinding-wheel slide 37 which is forced against the lever 39 through a spring 41. The said roller 40, therefore, continuously contacts the said cam disc 26'. The curve of the latter, in the present case a depression e' , is derived as to form and position from the desired profile rounding. Since the slide is displaced parallel to the straight generating line G on the pitch circle d , the magnitude of such displacement on the addendum circle da (Fig. 2) is b , the ratio e'/b defining the length of the lever arms.

The arrangement shown in Fig. 10 is similar to that shown in Fig. 9, but in this case the grinding wheel is displaced in direction of the line of engagement or contact F by the amount a (Fig. 2). To such end, the grinding-spindle sleeve 42 is displaced in direction of its axis, in that a spring 41 presses an abutment 43 which is rigidly secured to the said sleeve 42, against the shorter arm of the lever 39. The idling roller 40 of the latter is deflected through the cam disc 26'.

While, heretofore, the work has been subject to the generating movement and the feeding movement relative to the grinding wheels, Figs. 11 and 12 show a machine in which the gear wheel to be ground solely performs the feeding movement, and the grinding wheels perform the entire generating movement and, further, an intermittent displacement for rounding off the tooth profile. The grinding-wheel carrier 44 is secured to a slide 45 resting on ball races 46 of a segment-like saddle 47 which is rotatable about the wheel axis C. The stationary rolling cylinder 16 secured to the standard 11 and provided with the steel tapes 17, also is arranged centrically to the said axis C. The free ends of the said tapes are screw-connected to two tensing levers 48, 48' which are so interconnected through a tie-rod 49 as to subject the tapes 17 to a tensile stress. The said lever 48' is provided with a third lever arm having an idling roller 50 which rolls off a guide plate 51 under the action of a spring 53. The said plate 51 comprises a plane face and a curved portion 52.

A rack 55 driven by means of the piston of a pressure-oil cylinder 54, causes the saddles 47 to swing or swivel. Gears 56 mesh with the rack 55 and are operatively connected to gears 57 which actuate toothed segments 58 secured to the saddles 47. The shaft 8', on which the gear 8 is mounted, is mounted on a saddle 59. The gear 8 does not participate in the hobbing movement, but is axially fed, in that the saddle 59 is displaced on the standard 11 through the rigging 60

which is actuated through a crank-gear 61 driven by the motor 62.

By virtue of the swiveling or swinging movement of the two saddles 47 about the axis C, the tensed steel bands 17 are caused to roll off the stationary rolling cylinder 16, and the plane outwardly directed working faces of the grinding wheels 7 move tangentially with respect to the involute-shaped tooth profile. Here also the tooth face or addendum shall be rounded off. During the generating movement, the idling roller 50 (Fig. 12) rolls along the guide 51 and arrives, at one end of the latter, on the curved portion 52. The roller 50, thus, is displaced somewhat, upon which the lever 48' is rotated clockwise through a small angle. Since the lever 48' is connected to the steel tapes 17 secured to the stationary rolling cylinder 16, its rotation causes a displacement of the slide 45 and, therefore, of the grinding wheel 7, which displacement corresponds to the desired rounding of the tooth face as to magnitude and run. A similar arrangement for displacement also is associated with the other grinding wheel so that the profiles of both tooth flanks may be simultaneously provided with any desired deviations from the true form of involute.

Although as exemplification of the invention the grinding of spur gear wheels of the ordinary type has been chosen it is obvious that the method is not limited to that particular type of wheel alone, but may be applied to other known types. Consequently, the claims are not intended to be limited to the grinding of any specific type of gear, except where the prior art requires it.

What I claim as new and desire to secure by Letters Patent is:

1. In a gear grinding machine for producing the tooth-profile on the work by means of relative rolling motion between the work and the grinding tool, two grinding wheels, a work carrier, work carrier drive elements, means for generating a normal involute motion relative to the grinding wheels and applying said motion to said work carrier drive elements, deflector means operatively connected to the grinding wheels for intermittently displacing the grinding wheels in the direction of the straight rolling off line, and cam discs acting on the deflector means and performing one revolution for each double passage of the rolling distance of the generating means so as to produce tooth profiles partially deviating from the involute shape.

2. In a gear grinding machine for producing the tooth-profile on the work by means of relative rolling motion between the work and the grinding tool, two grinding wheels, a work carrier, work carrier drive elements, means for generating a normal involute motion relative to the grinding wheels and applying said motion to said work carrier drive elements, slides carrying the grinding wheels, for intermittently displacing these wheels, and cam discs acting on the slides for displacing these slides in direction of the straight rolling off line and performing one revolution for each double passage of the rolling distance of the generating means so as to produce tooth profiles partially deviating from the involute shape.

3. In a gear grinding machine for producing the tooth-profile on the work by means of relative rolling motion between the work and the

grinding tool, two grinding wheels, a work carrier, work carrier drive elements, means for generating a normal involute motion relative to the grinding wheels and applying said motion to said work carrier drive elements, grinding wheel carriers for intermittently displacing the grinding wheels, and cam discs acting on the grinding wheel carriers for displacing these carriers in the direction of the spindle axis and parallel to the line of engagement and performing one revolution for each double passage of the rolling distance of the generating means so as to produce tooth profiles partially deviating from the involute shape.

4. In a gear grinding machine for producing the tooth-profile on the work by means of relative rolling motion between the work and the grinding tool, two grinding wheels, a work carrier, work carrier drive elements, means for generating a normal involute motion relative to the grinding wheels and applying said motion to said work carrier drive elements, cam discs performing one revolution for each double passage of the rolling distance of the generating means, cams on the cam discs of a rise greater than the grinding-wheel displacement, and transmitting means intermediate of cam and grinding wheel, and adapted to reduce the deflection originating from the cam to the magnitude of the actual displacement and carry same forward onto the grinding wheel so as to produce tooth profiles partially deviating from the involute shape.

5. In a gear grinding machine for producing the tooth-profile on the work by means of relative rolling motion between the work and the grinding tool, two grinding wheels, a work carrier, work carrier drive elements, means for generating a normal involute motion relative to the grinding wheels and applying said motion to the grinding wheels, said generating means including a stationary rolling cylinder and steel tapes secured to this cylinder, slides for carrying the grinding wheels, two tensing levers mounted on each slide and connected to the steel tapes and to each other, a deflector correlated to one of the said tensing levers, and a cam for acting on the deflector for displacing it, which displacement of the said deflector gives rise to a partial rotation of the said tensing levers, whereby the slide including the grinding wheel undergoes a displacement in direction of the steel tapes by an amount defined by the rise of the cam, such rise corresponding to the desired profile rounding or profile transition.

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