Nov. 8, 1938. E. REINECKER 2,136,266

TEETH GENERATING MACHINE

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Fig. 1

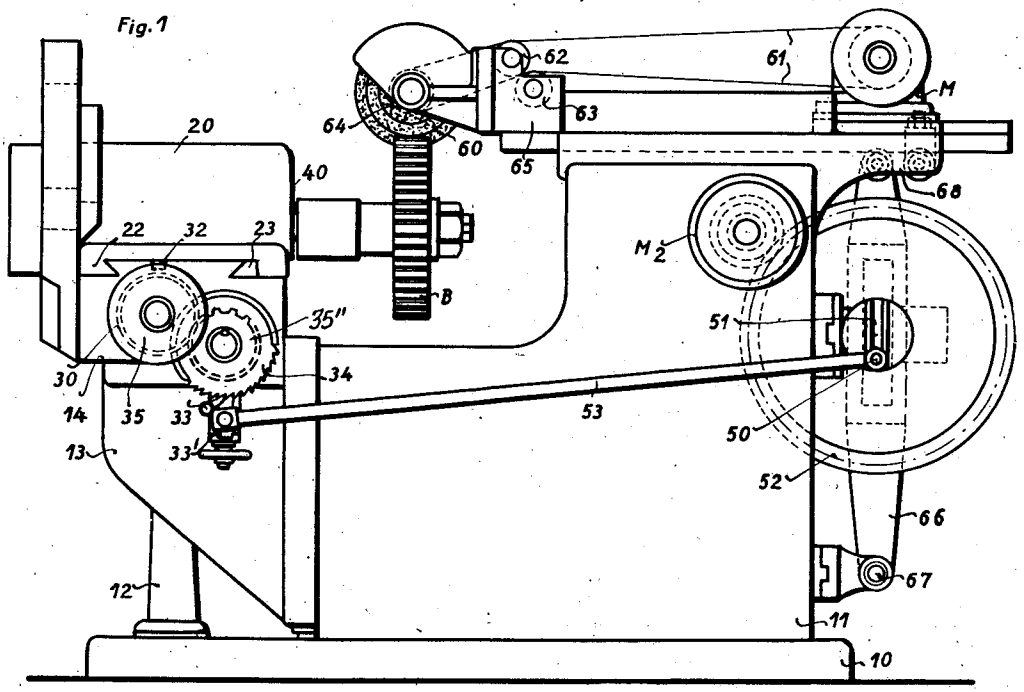

Fig. 2

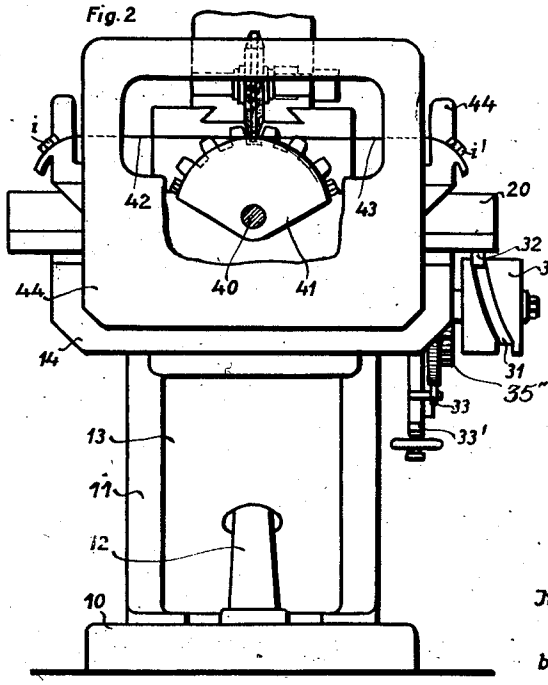

Fig. 3

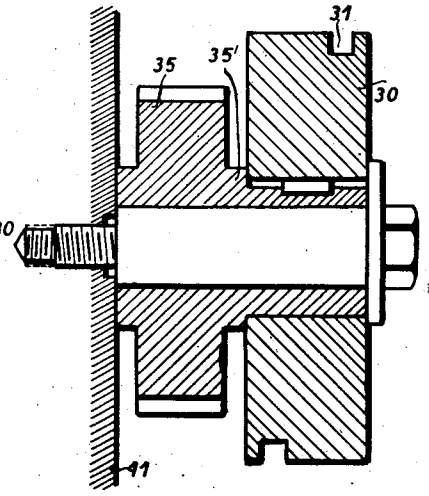

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Fig. 4

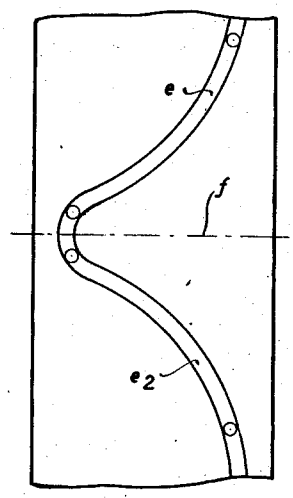


Fig. 5

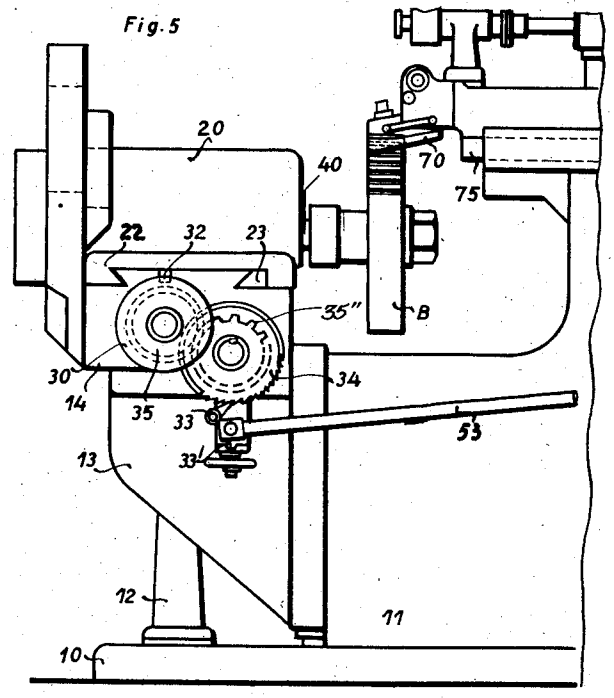


Fig. 6

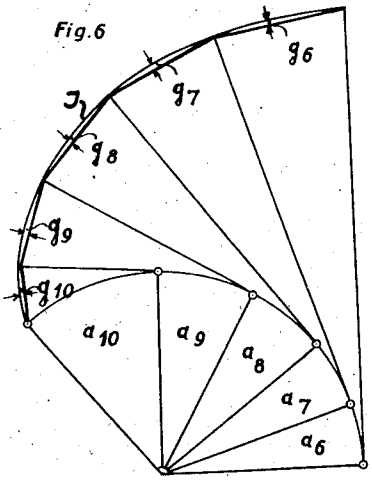
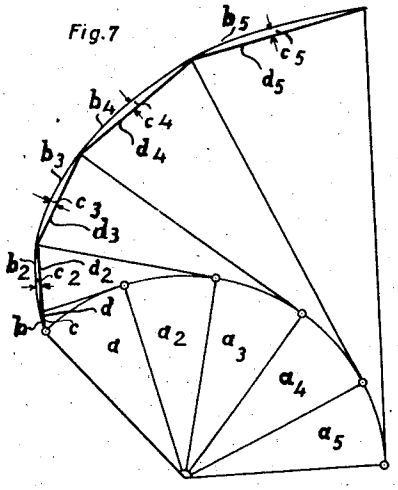


Fig. 7



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2,136,266

TEETH GENERATING MACHINE

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Application December 23, 1937, Serial No. 181,348
In Germany June 18, 1936

4 Claims. (Cl. 51—56)

My invention relates to the problem of producing spur and bevel gear wheels having teeth of the involute type, which must be highly accurate as to the correct shape of their curved profiles as required, wherever smooth running under load and at high working speeds, the absence of vibrations and grating noises, truly correct intermeshing of the teeth with a minimum of friction and wear and consequent longevity of the gears are considerations of paramount importance.

Gear wheels of the involute type, which must fulfill the severe requirements stipulated above, are generally made from blanks the teeth of which are roughened out first, are thereafter hardened, and finally correctly shaped by cutting or grinding tools according to the so-called "generating" method, wherein the tool, usually a straight edged cutter or a grinding wheel presenting a straight line of working contact with the tooth under treatment, is reciprocated across the face of the blank, while the latter is intermittently given a rolling motion as though rolling along a rack of which one tooth flank is represented by the shaping tool.

Machine tools for making gear wheels according to the generating method are usually provided with a mechanism for producing the said rolling motion of the blank, which is cooperatively so associated with a feeding mechanism of conventional design—for instance a screw and nut gear having a pawl and ratchet wheel attached—that the blank is periodically revolved through angles of equal size during its rolling motion, which however are very small ranging in practice say from 1/6 to 1/4 of one degree.

The results of this manner of feeding, namely, periodically revolving the blank through equal angles of rotation, while its teeth are generated, are diagrammatically shown in Fig. 7 of the accompanying drawings but—for elucidating better the objects of this invention—with angles of rotation which are many times larger than they are in practice.

It will be noted in Fig. 7 that on generating from a circular sector, as shown and subdivided into a number of sections a, $a2$, $a3$, $a4$, $a5$ of equal size, step by step the respective involute curve the latter will present arcs b, $b2$, $b3$, $b4$, $b5$ of unequal length which are progressively longer, and of which the distances c, $c2$, $c3$, $c4$, $c5$ from the chords d, $d2$, $d3$, $d4$, $d5$ coordinated thereto are likewise progressively larger.

By realizing that in Fig. 7 the arcs b, $b2$, $b3$, $b4$, $b5$ represent the ideal and truly correct profile, which the finished teeth of the gear wheel should have, while the chords d, $d2$, $d3$, $d4$, $d5$ represent the flat faces in fact produced by the straight edged shaping tools concerned upon the roughened out teeth under treatment, it will be understood why it is disadvantageous to roll the blank step by step through angles of equal size because the teeth obtained are misproportioned in a progressive degree more especially at their upper faces outside the pitch circle.

As a rule gear wheels having teeth misproportioned at their upper faces and generated in the manner described by machine tools used heretofore are not classifiable among those high duty gear wheels, for which very narrow tolerances—generally not exceeding one ten-thousandth of an inch—are nowadays prescribed.

It has been attempted to reduce the said differences in measurement and to comply with the emergencies in shaping the teeth of gear wheels, by reducing the width of the individual flat faces produced by the straight edged cutting or grinding tools concerned, namely, by adopting a smaller angle through which the blank is periodically revolved in its rolling motion; however this procedure obviously entails a correspondingly larger number of working strokes of the shaping tool across the blank and in turn longer working time and higher costs for finishing the blank.

The principal object of this invention is to overcome the said drawbacks, namely, to provide a structurally improved machine tool on which gear wheels highly accurate in the shape, measurement and proportions of their teeth and fulfilling the severe requirements of modern high quality standard gear wheels can be made under conditions of greater economy than before.

In connection therewith the invention aims at so re-designing the machine tool concerned, that gear wheels having teeth which come within the narrow tolerances prescribed can be obtained by a relatively small number of working strokes of the shaping tool, smaller than with machines known and used heretofore.

Other objects of the invention will become incidentally apparent to practitioners in this field as the description proceeds.

The nature and scope of this invention are briefly outlined in the appended claims and will be more fully understood from the following specification taken together with the accompanying drawings, in which—

Fig. 1 is a side elevation of the gear grinding machine re-designed according to this invention and shown by way of an example;

Fig. 2 is a front elevation of the machine shown in Fig. 1,

Fig. 3 is a cross section taken vertically through a grooved crown cam used in connection with gear shaping machines according to this invention,

Fig. 4 is a layout drawn in a smaller scale, wherein the grooved crown cam shown in Fig. 3 is wound off,

Fig. 5 is a fragmentary side elevation of a gear cutting machine designed according to this invention,

Fig. 6 is a diagram elucidating by the trick of exaggeration a most salient feature of this invention which consists in differently proportioning the individual angles of rotation through which the blank under treatment is successively revolved in its rolling motion,

Fig. 7 is a diagram likewise showing by way of comparison and by the trick of exaggeration one of the drawbacks inherent to known machines for shaping the teeth of gear wheels and described in detail in the preamble to the specification.

Briefly stated the invention consists in providing machine tools for generating teeth of the involute type on spur and bevel gear wheels—wherein a straight edged tool is reciprocated across the face of the blank, and wherein the latter is periodically rolled as though engaging the tooth of a fixed rack represented by the shaping tool—with means for so enlarging step by step the individual angles of rotation *a6*, *a7*, *a8*, *a9*, *a10*, through which the blank is revolved in its rolling motion that, while the shaping tool descends on the tooth under treatment, flat faces *g6*, *g7*, *g8*, *g9*, *g10* forming the tooth profile are generated, which are substantially equidistant from the correct involute curve J enveloping said flat faces.

The grinding machine shown in Figs. 1 to 4 and designed to generate the teeth of gear wheels according to this invention comprises:

(1) A machine frame having a bed plate **10**, an upright box frame **11** and a column **12**, the latter carrying a support **13**, formed with a saddle **14** at its upper end and being slidably attached at the front end of the box frame **11**; means are provided for raising and lowering said support which comprise a nut and screw gear (not shown) enclosed in said column **12**;

(2) A setting table **20** for carrying the blank B and imparting a rolling motion to the latter; said setting table is slidably mounted at **22**, **23** on guide ways formed on the saddle **14** and capable of being displaced step by step by

(3) Feeding means re-designed according to this invention and comprising:

A rotary cam **30** formed with a groove **31** running therearound and having two branches or sections *e*, e2, which are progressively more steeply inclined relatively to the median line of symmetry indicated at *f* in Fig. 4, a pin **32** fixed in the setting table **20** and engaging said grooved cam, and means for intermittently revolving said crown cam **30** which comprise a pawl and ratchet gear **33**, **34** cooperatively associated by means of a gear wheel **35''** with another gear wheel **35** on the hub **35'** of which the said crown cam **30** is splined (Fig. 3) so as to be exchangable; the means for actuating the pawl and ratchet gear and in turn the crown cam **30** comprise a crank pin **50** adjustably mounted as to its eccentric position in the guide way **51** of a rotary block attached to the shaft of a driving wheel **52**, and a connecting rod **53** cooperatively interengaging said crank pin **50** and a swing arm **33'** carrying said pawl **33**;

(4) Means for imparting a rolling motion to the blank B which comprise:

A rotary shaft **40** carrying the blank B and being journalled in the setting table **20**, a sector shaped arch **41** keyed to said shaft **40**, two flexible steel tapes **42**, **43** the inner ends of which are fixed to the said arch **41** in staggered position to each other so as to be in close engagement therewith, while their outer portions tangentially projecting from the arch are fixed by clamping screws *i*, *i'* to an auxiliary frame **44** attached to the saddle **14**.

On displacing step by step the setting table **20** to the right or left the arch **41** is intermittently revolved by the tapes **42**, **43** and in turn the shaft **40** which is keyed to the arch and carries the blank B, is given a rolling motion; the latter will—by virtue of the specific shape of the grooved crown cam **30** described—be revolved through different angles which progressively grow larger or smaller and are so proportioned that, while the straight edged shaping tool descends relatively to the tooth under treatment flat faces forming the tooth profile are generated, which are substantially equidistant from the correct involute curve enveloping said flat faces;

(5) A rotary grinding wheel **60** having conical working faces, which represent the straight flanks of a tooth of a stationary rack with which the teeth generated on the blank B are supposed to mesh; said grinding wheel **60** is reciprocated across the face of the blank B; the means for rotating the grinding wheel **60** comprise an electric motor M and a belt drive **61** including pulleys **62**, **63**, **64**, over which the belt runs.

The means for reciprocating the grinding wheel **60** comprise:

A ram **65** slidably mounted on top of the box-frame **11** and carrying the grinding wheel **60** and its rotating means, a slotted swing-arm **66** fulcrumed at **67** on the box-frame **11** and linked at **68** to said ram **65**; said arm **66** is cooperatively associated on the order of conventional crank motions with the driving wheel **52** by means of a crank pin (not shown) which is slidable in the slot of said arm **66** and eccentrically attached to the driving wheel **52**, and another electric motor M2 for driving the latter.

Instead of a covered crown cam **30**, presenting an oblique groove **31** of specific design as the feeding element, variable feed mechanism of different design may be conveniently employed, including slotted cam and crank motions.

In the structural modified machine shown by way of another example in Fig. 5 the ram **75** is provided with a straight edged cutting tool **70** instead of a grinding wheel; in all other details of construction the machine shown in Fig. 5 is identical to that described above with reference to Figs. 1–4.

Various other modifications and changes may be conveniently made in the structural details of machine tools of the improved design described for generating teeth of involute shape on gear wheels, without substantially departing from the spirit and the salient ideas of this invention.

What I claim is:

1. In a machine for generating involute teeth of gear wheels a machine frame, a setting table slidably mounted thereon, and carrying the blank under treatment, means for feeding said setting

table and concurrently imparting an intermittent rolling motion to said blank, a straight edged shaping tool adapted to be reciprocated across the face of the blank relatively to the latter, and means for reciprocating said shaping tool, said feeding means being adapted to revolve the blank step by step, as the shaping tool descends relatively thereto, through progressively larger angles of rotation.

2. In a machine for generating involute teeth of gear wheels a machine frame, a setting table slidably mounted thereon, and carrying the blank under treatment, means for feeding said setting table and concurrently imparting an intermittent rolling motion to said blank, a straight edged shaping tool adapted to be reciprocated across the face of the blank relatively to the latter, and means for reciprocating said shaping tool, said feeding means being adapted to revolve the blank step by step, as the shaping tool descends relatively thereto, through progressively larger angles of rotation, so proportioned, that the flat faces generated by the shaping tool are substantially equidistant from the correct involute curve enveloping said flat faces.

3. In a machine for generating involute teeth of gear wheels a machine frame, a setting table slidably mounted thereon, and carrying the blank under treatment, means for feeding said setting table and concurrently imparting an intermittent rolling motion to said blank, a straight edged shaping tool adapted to be reciprocated across the face of the blank relatively to the latter, and means for reciprocating said shaping tool, said feeding means being adapted to revolve the blank step by step, as the shaping tool descends relatively thereto, through progressively larger angles of rotation, so proportioned, that the flat faces generated by the shaping tool are substantially equidistant from the correct involute curve enveloping said flat faces, said feeding means comprising a grooved crown cam rotatably fixed at the machine frame, a pin attached to the setting table and engaging said crown cam, and means for intermittently revolving the latter.

4. In a machine for generating involute teeth of gear wheels a machine frame, a setting table slidably mounted thereon, and carrying the blank under treatment, means for feeding said setting table and concurrently imparting an intermittent rolling motion to said blank, a straight edged shaping tool adapted to be reciprocated across the face of the blank relatively to the latter, and means for reciprocating said shaping tool, said feeding means being adapted to revolve the blank step by step, as the shaping tool descends relatively thereto, through progressively larger angles of rotation, so proportioned, that the flat faces generated by the shaping tool are substantially equidistant from the correct involute curve enveloping said flat faces, said feeding means comprising a grooved crown cam, rotatably and exchangeably fixed at the machine frame, a pin attached to the setting table and engaging said crown cam, and means for intermittently revolving the latter.

ERNST REINECKER.