No. 676,226. Patented June 11, 1901.

E. R. FELLOWS.

GEAR GENERATING CUTTER.

(Application filed June 24, 1899.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.

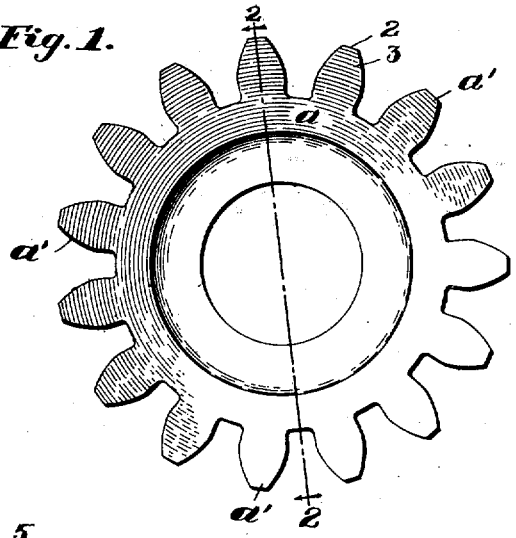


Fig. 2.

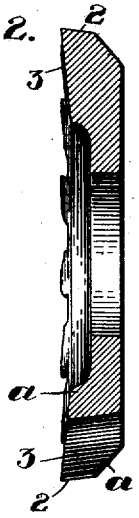


Fig. 3.

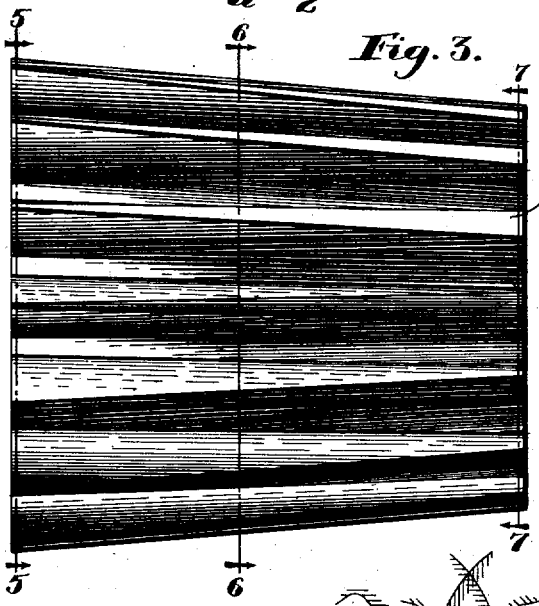


Fig. 17.

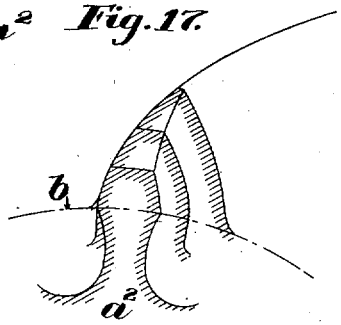
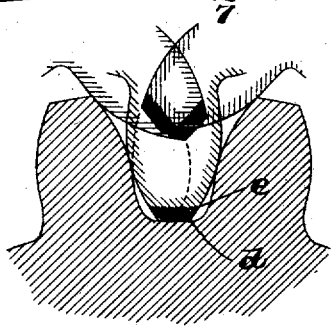


Fig. 19.



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(No Model.) 3 Sheets—Sheet 2.

Fig. 4.

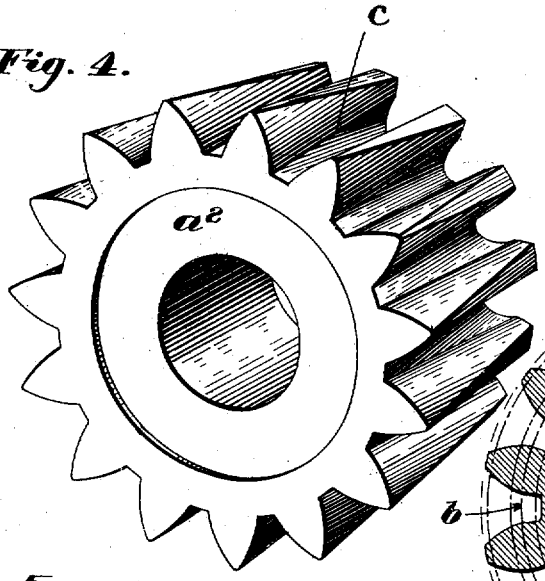


Fig. 6.

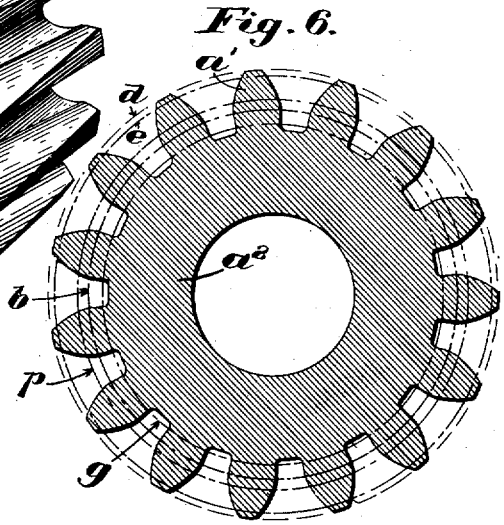


Fig. 5.

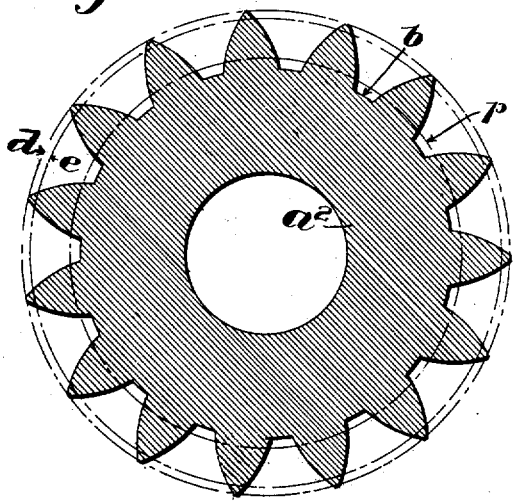
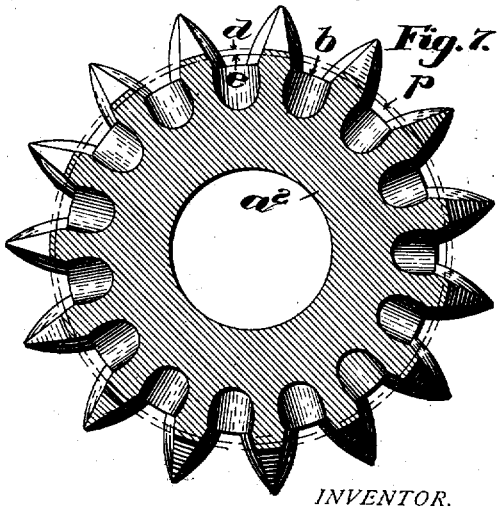


Fig. 7.



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(No Model.) (Application filed June 24, 1899.) 3 Sheets—Sheet 3.

Fig. 8.

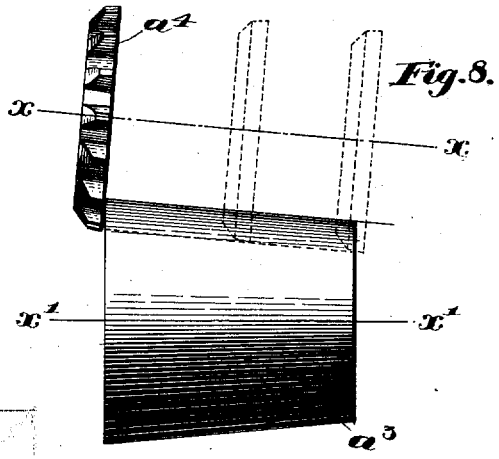

Fig. 9.

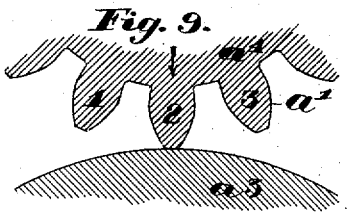

Fig. 10.

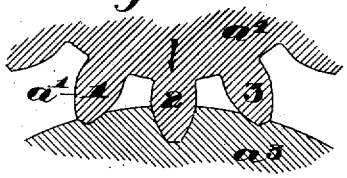

Fig. 11.

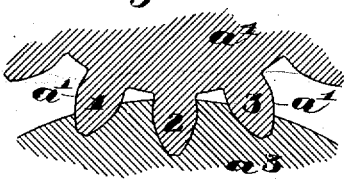

Fig. 12.

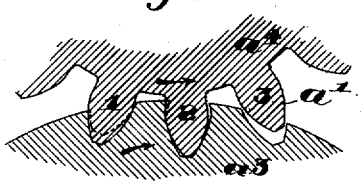

Fig. 18.

Fig. 13.

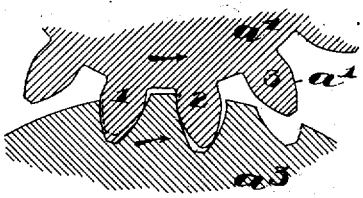

Fig. 14.

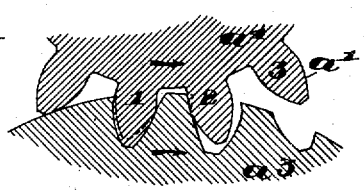

Fig. 15.

Fig. 16.

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UNITED STATES PATENT OFFICE.

EDWIN R. FELLOWS, OF SPRINGFIELD, VERMONT.

GEAR-GENERATING CUTTER.

SPECIFICATION forming part of Letters Patent No. 676,226, dated June 11, 1901.

Application filed June 24, 1899. Serial No. 721,712. (No model.)

To all whom it may concern:

Be it known that I, EDWIN R. FELLOWS, of Springfield, in the county of Windsor and State of Vermont, have invented certain new and useful Improvements in Gear-Generating Cutters, of which the following is a specification.

This invention relates to gear-generating cutters of the general form illustrated in United States Letters Patent No. 579,570, granted to me March 30, 1897, said cutters being adapted for employment in generating gears by the means described in United States Letters Patent No. 579,708, granted to me March 30, 1897. The first said patent describes a metal-planing cutter formed as a bevel-gear having a continuous circular series of radiating or outwardly-projecting metal-planing teeth, the backs of which are formed at a slight clearance angle with the axis of the cutter, the said cutter having cutting edges on its face at the ends of the teeth. A cutter of the character described will generate the curves of gear-teeth when reciprocated to cause its teeth to plane the gear-blank across the edge of the latter, the cutter and blank being given a relative rotary feed motion equivalent to the motion of intermeshing gears as provided for in the gear-generating machine described in the second said patent.

The present invention has for its object to improve the construction of the cutter shown in the first said patent; and it consists in the improved cutter substantially as hereinafter set forth.

Of the accompanying drawings, Figure 1 represents a face view of a cutter embodying my present invention. Fig. 2 represents an axial section thereof on the line 2 2 of Fig. 1. Fig. 3 represents a side elevation of a cutter, greatly elongated, so as to clearly illustrate its construction. Fig. 4 represents a perspective view of said elongated cutter. Fig. 5 represents a section at its large end on the line 5 5 of Fig. 3. Fig. 6 represents a median transverse section on the line 6 6 of Fig. 3. Fig. 7 represents a section at its small end on the line 7 7 of Fig. 3. Fig. 8 represents a side elevation of the conical blank for the elongated cutter, this view showing also the cutter-producing cutter in the relation which it has to the blank in planing the same. Figs. 9 to 16 represent detail sectional views showing steps in the evolution of the cutter-teeth. Fig. 17 represents a perspective view of one of the teeth of the elongated cutter, enlarged, with the lines of curvature, &c., marked thereon. Fig. 18 represents a side elevation of a modified form of cutter for generating spiral gears. Fig. 19 represents a diagrammatic view illustrating the generating action of a cutter-tooth having a clearance-producing extension.

The same reference characters indicate the same parts in all the figures.

In its front aspect, as seen in Fig. 1, the cutter has a circular body a and an endless circular series of outwardly-projecting or radiating gear-shaped teeth a' a', the backs or outer edges 2 of which have a slight inclination to the axis of the cutter to give the teeth the clearance of ordinary metal-planing tools. The cutting edges of the teeth are at their ends 3 on the face of the cutter, and said face of the cutter is preferably slightly dished or beveled, as shown, to give the cutting ends of the teeth the rake of ordinary metal-planing tools. The sides of the teeth converge sufficiently in receding from the cutting ends 3 to give the teeth the necessary side clearance. The operation of cutting gears by means of cutters of this character is explained in my Patent No. 579,708, hereinbefore referred to, and may also be understood by reference to Figs. 9 to 16 of the drawings accompanying this specification. The cutter is reciprocated longitudinally of the axis of the blank and its teeth plane the blank across its edge, the blank and cutter being separated on the return or non-cutting stroke and brought together again in a new relative position before each planing stroke. The cutter is at first fed radially toward the axis of the blank, before each planing stroke, until the proper depth of tooth has been cut, and after that the cutter and blank are given a relative rotary feed movement equivalent to that of intermeshing gears, so that the teeth of the cutter generate the teeth on the blank by a process of evolution. The resulting teeth on the blank will be similar to those on the cutter, and a single cutter is enabled to generate the gear-teeth on blanks of different sizes.

Cutters of the character described may be variously constructed as to the shape and convergence of the sides of their teeth. My Patent No. 579,570 describes a cutter shaped as a bevel-gear. The teeth of a correct bevel-gear, as is well known, vary constantly in curvature as they approach the apex of the gear, since the base-circles to which the curves of the teeth conform decrease in diameter and form a conical surface in approaching this apex. A cutter having the form of a correct bevel-gear will work satisfactorily in generating gears by the process herein alluded to, but as the cutter is sharpened by grinding away its face the cutting ends of its teeth will obviously be of slightly different curvature after each grinding. A cutter can be constructed, however, whose teeth as they are ground away in sharpening will always present cutting edges having the same curvature. Such a cutter is the subject of my present invention. Its characteristics will be best understood by reference to Figs. 4 to 8, showing the exaggerated form with greatly-elongated teeth. It may be assumed for illustration that the teeth of the normal and of the elongated cutter are involute teeth. The involutes are drawn to a base-circle which at the large end of the elongated cutter a^2 (seen in Fig. 5) coincides with the roots of the teeth and is lettered b. The pitch-circle is represented at p, just outside of base-circle b. At the median section of the cutter a^2 (seen in Fig. 6) the roots of the teeth have receded considerably within the base-circle, and at the small end of the cutter (seen in Fig. 7) there is but a small portion of the tooth outside of the base-circle. The heights of the teeth have remained the same, however, and the face portion of each tooth or that portion of its side outside of the pitch-circle has decreased, while its flank portion or that portion inside of the pitch-circle has increased in passing from the large end to the small end of the cutter. The curvature of each tooth, however, is the same from end to end, as may be seen in Fig. 17, which compares the sections taken at the middle and two ends of a tooth of the elongated cutter a^2. That portion of the side outline of each of the three sections which is outside of the base-circle b is an involute drawn to said base-circle, though there is less of the involute at the small end of the tooth than at the large end. That portion of the side outline of the tooth which is inside of the base-circle increases in passing from the large to the small end of the cutter. The line c drawn in Fig. 4 follows the base-cylinder of the cutter. It is also to be noted that the teeth at the small end of the cutter are narrower on the base-line than are those at the large end. This convergence gives the teeth their side-cutting clearance.

The method by which the cutter is formed will now be described.

To construct the elongated cutter a^2, a conical blank a^3 of the form represented in Fig. 8 is placed in an appropriate machine, such as a machine constructed on the principles of the one shown in my Patent No. 579,708, and a cutter a^4 similar to the cutter a (shown in Figs. 1 and 2) is given a back-and-forth endwise movement in the direction of its axis x x across the conical edge of the blank a^3 by the cutter-holder of said machine, so that the cutter planes out teeth on the blank and at the same time the cutter and blank are given a relative rotary feed movement, (illustrated in Figs. 12 to 16,) the same as when gears are generated as described in my Patent No. 579,708. During the reciprocating movement of the cutter across the blank, however, the axes $x\,x$ and $x'\,x'$ of the cutter and blank are held at an angle to one another, as represented in Fig. 8. Since the cutter a^4 planes toward the apex of a cone, the teeth generated on the blank will obviously narrow toward the small end of the blank and the result produced will be the elongated cutter a^2, having involute teeth curved at all points along their length to base-circles of equal diameter. The cutter or gear a^2 when meshed at any point in its length with a spur-gear of any diameter cut by the same cutter which produced it will have a theoretically-correct action and any part of it may be used as a cutter to generate correct involute gears. In practice the part of the elongated cutter which is used is taken from about its middle and is represented by the cutter in Figs. 1 and 2, which practically would be produced by acting on a blank of approximately its own length in the manner described.

It is of course necessary to harden the cutter a or the cutter a^2 after producing it by the method described in order to complete it as a working tool. This may be done by taking the cutter and subjecting it to any of the ordinary and well-known methods of hardening, after which it will be a complete working tool. It is well known, however, that tools in being hardened undergo more or less of a distortion, and therefore, chiefly because of this difficulty, I prefer instead of reducing the cutter, by the method described, to its final proportions and then hardening it to rough out a cutter by the method stated—in other words, produce a blank having the true form of the cutter, but with an excess of metal on its teeth, this being permissible by producing the said roughed-out blank with a cutter having smaller teeth than the standard gear-teeth—then to harden the roughed-out blank, and finally to grind the sides of its teeth to their final dimensions, thus avoiding the errors due to distortion. In an application for Letters Patent, Serial No. 721,711, filed by me June 24, 1899, I describe a cutter-grinding machine in which the roughed-out cutter herein alluded to can be ground to its true size and shape. A cutter having the novel characteristics herein described can also be produced by grinding in the machine de-

scribed in my said application from a roughed-out blank produced in any convenient manner other than by the novel method herein set forth, as by fluting a conical blank with an ordinary milling gear-cutter, although the metal to be removed by grinding after so roughing the blank will in general be greater in amount and less conveniently distributed than when the blank is roughed by the method herein set forth.

I do not confine myself in respect to my present invention to a cutter having involute teeth, as cutters having teeth of epicycloidal or other shape may be constructed in conformity with the invention.

The hereinbefore-described method of making cutters may be employed in producing the cutter illustrated in Fig. 18, which has skewed teeth, giving it somewhat the form of a skew bevel-gear. Cutters of this character are adapted for use in machines such as that described in an application, Serial No. 721,832, filed by me June 26, 1899, relating in part to a machine for generating spiral gears. The cutter a^5 in Fig. 18 may be produced by reciprocating a cutter such as the one shown in Figs. 1 and 2 in the direction of its axis across the edge of a conical blank, giving the two a relative rotary feed motion in the manner before described, the axes of the cutter and blank being set at an angle and also in different planes. The cutter a^5 can then be reproduced from itself by setting its axis at an angle to the axis of the blank, but in the same plane therewith, and twisting it or giving it a spiral motion on its axis as it is reciprocated across the blank in the direction of said axis.

Another feature of my invention consists in forming the teeth of gear-shaping cutters of the general character under consideration with extensions of their crests to give clearance in the gears which they cut. This extension is the portion d e on the end of the tooth and is equivalent to an addition on the end of the tooth of a standard gear of the same pitch as the cutter, equal to the depth of the space at the root of the tooth left for clearance. In the drawings, Fig. 6, that part of the tooth of the cutter inside of the line e may be taken as a representation of one tooth of a gear generated by said cutter. Said gear-tooth has on its side face the portion between its crest at the line e and the pitch-line p, known as the "addendum," the portion between said pitch-line and the line g, known as the "dedendum," and the portion inside of the line g, known as the "clearance." The clearance is necessary in order that the crests of the mating gear-teeth may not make contact at the roots of the teeth of the gear, and to cut this clearance the extension d e is added to the cutter-tooth, making the teeth of the cutter longer by an amount equal to said clearance than the teeth of a gear of the same pitch-diameter as the cutter produced by said cutter. Without this extension on its teeth the cutter would not produce an interchangeable set of gears all running correctly with each other, as those gears larger than the cutter would have insufficient clearance at the roots of their teeth to enable them to run correctly with each other.

I claim—

1. A gear-generating cutter having a series of metal-planing teeth whose sides converge in the direction of their length and are of equal curvature throughout their length.

2. A gear-generating cutter having an endless circular series of radiating or outwardly-projecting metal-planing teeth whose backs are inclined to the axis of the cutter to give the teeth the clearance of ordinary metal-planing tools, and whose sides are convergent in the direction of their length to give the teeth side clearance and are of equal curvature throughout their length.

3. A cutter of the kind which generates a gear by a planing motion across the face of a blank and a relative rotary feed motion of the cutter and blank equivalent to the motion of intermeshing gears, said cutter having an endless circular series of radiating or outwardly-projecting metal-planing teeth with cutting edges at the ends of the teeth, and extensions d e on the crests of said teeth equal in length to the clearance of gears of the same pitch-diameter as said cutter generated by said cutter.

In testimony whereof I have affixed my signature in presence of two witnesses.

EDWIN R. FELLOWS.

Witnesses:
WILBUR A. LEONARD,
E. J. FULLAM.