Aug. 1, 1961 H. PELPHREY 2,994,237

TOOTH FORMING TOOL

Original Filed Aug. 9, 1957 2 Sheets-Sheet 1

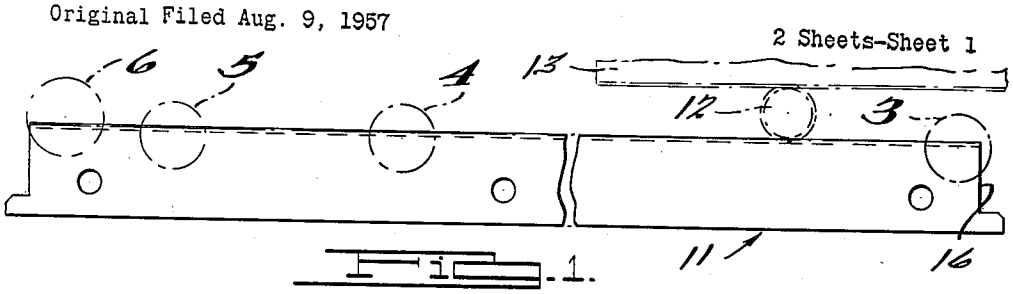


Fig. 1.

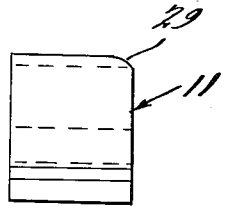


Fig. 2.

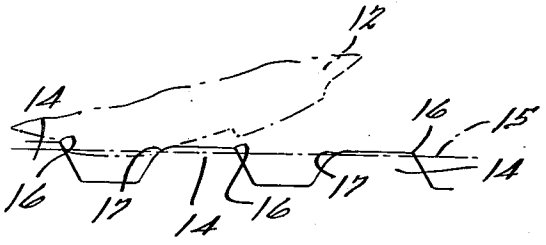


Fig. 3.

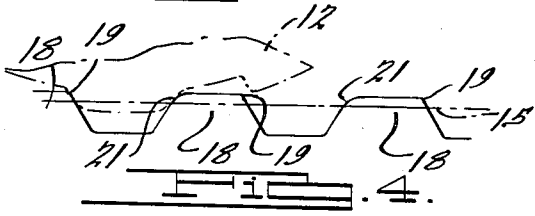


Fig. 4.

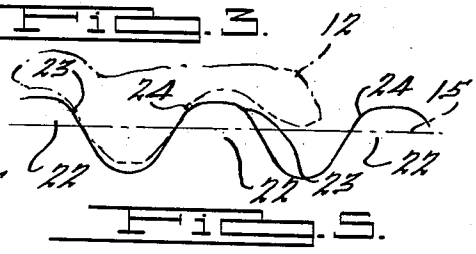


Fig. 5.

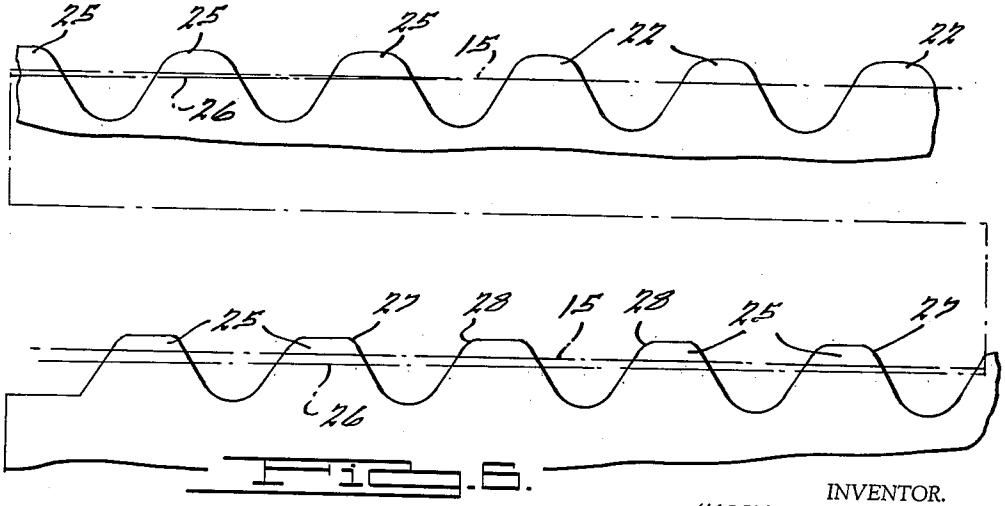


Fig. 6.

INVENTOR.
HARRY PELPHREY, DECEASED
BY LILLIAN PELPHREY,
ADMINISTRATRIX

By Harness, Dickey & Pierce.
ATTORNEYS.

Aug. 1, 1961 H. PELPHREY 2,994,237

TOOTH FORMING TOOL

Original Filed Aug. 9, 1957

2 Sheets-Sheet 2

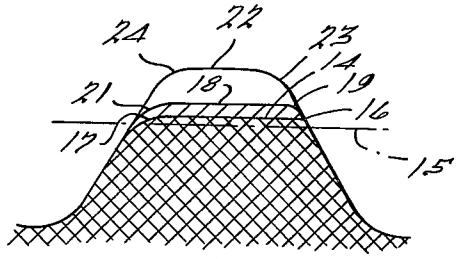


FIG. 7.

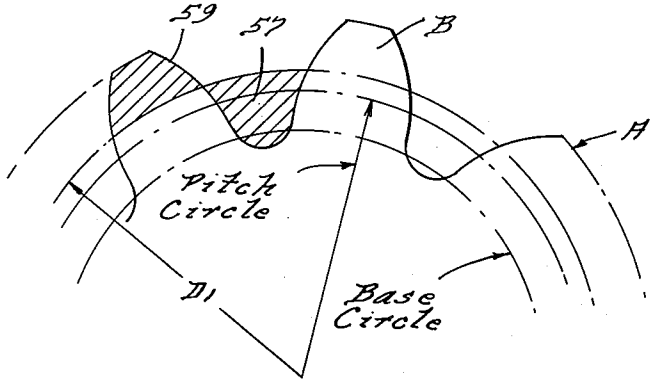


FIG. 8.

INVENTOR.
HARRY PELPHREY, DECEASED
BY LILLIAN PELPHREY,
ADMINISTRATRIX

By Harness, Dickey & Pierce,
ATTORNEYS.

United States Patent Office 2,994,237 Patented Aug. 1, 1961

2,994,237

TOOTH FORMING TOOL

Harry Pelphrey, deceased, late of Detroit, Mich., by Lillian Pelphrey, administratrix, Detroit, Mich., assignor to Michigan Tool Company, Detroit, Mich., a corporation of Delaware

Continuation of application Serial No. 677,254, Aug. 9, 1957. This application Oct. 4, 1960, Ser. No. 60,509
3 Claims. (Cl. 80—20)

This invention relates to tooth forming tools, and more particularly to the construction of tools used for the formation of splines, serrations and similar forms in a cold-forming process by means of which the part is formed by metal displacement without removal of material from the workpiece. This application is a continuation of application Serial No. 677,254, filed August 9, 1957, now abandoned.

In copending application Serial No. 461,178, filed October 8, 1954, by Joseph C. Drader and assigned to the assignee of the present application, a process is described in which splines or similar tooth forms are produced by rolling workpieces between tools moving in opposite directions, the tools being provided with teeth which are forced into the work-piece material to form conjugate teeth thereon by metal displacement. In this type of process, it is of extreme importance that slippage between the forming tools and part rolling therebetween be avoided, especially at the beginning of the operation when there is relatively little contact between the part and forming tools.

It is an object of the present invention to provide an improved tool construction which will eliminate the possibility of slippage during this initial phase of the operation without interfering with the normal operation of the tools in forming the workpiece.

It is another object to provide an improved tooth forming tool of this character in which the possibility of failure due to fatigue stresses is greatly reduced with the tool being capable of producing parts at a relatively high production rate.

Other objects, features and advantages of the present invention will become apparent from the subsequent description, taken in conjunction with the accompanying drawings.

In the drawings:

FIGURE 1 is a side elevational view of a tool comprising a tooth forming rack which incorporates the features of the present invention, the figure showing portions of a mating rack and a workpiece disposed between the racks;

FIGURE 2 is an end elevational view of the rack shown in FIGURE 1;

FIGURE 3 is a fragmentary elevational view showing a group of teeth in the circle marked 3 of FIGURE 1 at the leading end of the rack, together with a portion of a workpiece being formed thereby;

FIGURE 4 is a similar fragmentary elevational view of several teeth in the circle marked 4 of FIGURE 1;

FIGURE 5 is a view similar to FIGURES 3 and 4 taken in the circle marked 5 of FIGURE 1;

FIGURE 6 is a fragmentary elevational view of a group of teeth in a circle marked 6 of FIGURE 1, this view being broken for purposes of the drawing.

FIGURE 7 is a diagrammatic view showing superimposed outlines of teeth taken from circles 3, 4 and 5 of FIGURE 1; and

FIGURE 8 is a fragmentary view of a typical involute spline that may be formed by means of the invention.

The illustrated embodiment of the invention comprises a specific tooth construction for a rack generally indicated at 11 which is one of a pair of identical racks used to cold-form a gear, spline or similar set of teeth

on a circular part. The manner in which a pair of racks or similar toothed tools are used to form a workpiece by metal displacement is described in detail in the aforesaid copending application. In general terms, the process involves the rolling of the workpiece on at least one toothed tool which moves tangentially relative to the workpiece. The teeth on the tool or tools are of progressively increasing effective depth and displace metal on the peripheral portion of the circular workpiece in a progressive manner, creating the desired shape on the rolled piece by conjugate action. FIGURE 1 shows in dot-dash lines a workpiece 12 and a portion of a rack 13 which is identical with rack 11, the workpiece being in the process of being rolled between the racks. The dot-dash portion of FIGURE 1 illustrate in a general way the nature of the tooth forming method with which the present invention is associated.

To illustrate by consideration of a common but very important shape that may be rolled by means of the invention there is shown in FIGURE 8 a portion of a cross section of part A in finished form in which the part has involute teeth or splines B. Since no metal is removed in the cold rolling operation, the diameter of the part prior to rolling cannot be either the final O.D. or the root diameter and it is only by chance that it can properly be the pitch diameter. The rolling diameter D_1 of the part A is selected so that the area 57 of removed tooth material below the D_1 periphery is equal to the area 59 of tooth material on a greater diameter than D_1. The diameter D_1, or substantially this diameter, is taken as the tool pitch diameter in the case of gear-like tools and defines the pitch line for rack type tools such as tools 11 and 13. The pressure angle of the teeth of gear type tools at diameter D_1 and the pressure angle or obliquity of the teeth of rack type tools in the angle whose cosine is D/D_1 times the cosine of the pressure angle at pitch diameter of teeth B where D is the pitch diameter of part A. The base pitch of the tools and the part are identical. With such a construction, the circular pitch of the teeth on the tool, as measured on the pitch line thereof, corresponds with the circular pitch of the teeth on the workpiece, as measured on the diameter D_1 of the workpiece. The whole depth of at least some of the last teeth in the tool which engage the part A is preferably the same as that of the part, i.e., these tool teeth are fully conjugate to the part.

In a preferred manner of carrying out this tooth forming method, racks 11 and 13 are driven in opposite directions while workpiece 12 is supported on a stationary pivot and is rotated by the moving racks. The teeth on those portions of the racks which initially engage workpiece 12 have addenda which are reduced from full addenda in order that the racks may properly engage the workpiece. In order to have satisfactory tooth formation, it is extremely important that no slippage occur between the workpiece and either of the racks during the rolling operation. If such slippage occurs, workpiece teeth which have been partially formed by engagement with one of the racks will be misaligned with the teeth on the other rack, and a defective workpiece is likely to be produced.

As each tooth on each rack approaches workpiece 12, it will engage the workpiece at its forward portion and will be forced into the material of the workpiece, displacing the material while at the same time causing rotation of the workpiece. The teeth at the forward end of each rack have a novel formation seen best in FIGURE 3, which facilitates proper rotation of the workpiece as the teeth are initially forced into the workpiece material. The teeth in his portion are indicated at 14, and it will be noted that these teeth are not of full height

with respect to pitch line 15. More particularly, the addendum of the first tooth 14 at the leading end of the rack (this end being indicated at 16 in FIGURE 1) is relatively short, and the addenda of the succeeding teeth 14 are progressively higher. It should be understood that the effective depth of the rack teeth could be varied in other ways within the principles of the invention, as described more fully in the aforementioned copending application.

In order to permit teeth 14 to cause proper rotation of the initially engaged workpiece, the forward edges 16 of these teeth are relatively sharp, as seen in FIGURE 3. Due to the fact that at the beginning of the operation there is relatively little contact between the racks and workpiece, sharp edges 16 of teeth 14 will insure proper rotation of workpiece 12 and will prevent slippage. The rear edges 17 of teeth 14 are rounded as seen in FIGURE 3 to produce the proper conjugate action.

As soon as the teeth on workpiece 12 are formed deeply enough to provide a more positive drive, the leading edges of the rack teeth are provided with a relatively small radius, as seen in FIGURE 4 which shows teeth 18 at an intermediate portion of the rack. It should be noted that the addenda of teeth 18 are progressively increasing but are still not full, and the radii 19 on the leading edges of these teeth do not extend below pitch line 15. The radii 21 on the rear edges of teeth 18 are of full radii to facilitate flow of metal, similar to radii 17 of teeth 14.

FIGURE 5 shows a group of teeth 22 of constant height which have full addenda with respect to pitch line 15. The forward edges 23 of these teeth have full radii similar to the rear edge radii 24, and proper metal flow will thus be facilitated as these teeth engage the workpiece.

FIGURE 6 shows a group of teeth at the trailing end of rack 11 in order to illustrate the manner in which the trailing rack ends are relieved in order to properly disengage themselves from the workpiece. These teeth, indicated at 25, are on a pitch line 26 which tapers downwardly with respect to pitch line 15. Radii 27 and 28 of teeth 25 are full, and the stresses in the workpiece will be gradually relieved by the tapering nature of these teeth as the racks leave the workpiece.

As seen in FIGURE 2, one upper edge of rack 11 is rounded as indicated at 29, and rack 13 is similarly formed. This is in order to create a fillet at one end of the spline or other tooth formation on workpiece 12, as seen in FIGURE 2.

As an illustrative example, a pair of racks constructed in accordance with the foregoing principles was as follows:

The part to be produced was a splined shaft having a pitch diameter of 1.208 inches, a major diameter of 1.25 inches, a minor diameter of 1.127 inches, and 29 teeth with a diametral pitch of 24/48 and a pressure angle of 30°.

Each rack of the pair was 2.187 inches high, 1.875 inches wide, and had an effective length of 36 inches. There were 277 teeth on each rack, of which the tops of the first 242 teeth tapered at 0°4′ angle from the pitch line at the leading end to full depth, the next 29 teeth were of full depth, and the last six teeth were progressively relieved to 0.005 inch below normal height. Of these teeth, the leading edges of the first 99 teeth have no radii, and the leading edges of the next 58 teeth had radii of 0.010 inch. Full radii of 0.016 inch were formed on the leading edges of the remaining 120 teeth of each rack. The trailing edges of all rack teeth had full radii of 0.016 inch.

FIGURE 7 superimposes these teeth 14, 18 and 22 to show how the flanks of teeth 14 and 18 follow the contour of conjugate teeth 22, with the tops of teeth 14 and 18 being lower than those of teeth 22. This figure also shows the fact that forward edges 16 of teeth 14 are sharp, forward edges 19 of teeth 18 have small radii, and forward edges 23 of teeth 22 have full radii. The radii 17, 21 and 24 of teeth 14, 18 and 22 are all full.

In operation, racks 11 and 13 will approach workpiece 12 from opposite directions, and teeth 14 thereof will initially engage the workpiece as seen in FIGURE 3. The sharp edges 16 of teeth 14 will engage workpiece 12 and will insure proper rotation thereof as the rack teeth are impressed into the workpiece material. The rounded rear edges 17 of these teeth will insure proper flow of metal as the teeth on the workpiece are formed. After the teeth on workpiece 12 have been partially formed, teeth 18 on the racks will engage the workpiece, these teeth having relatively small radii 19 at their forward edges which will facilitate metal flow along with rear edges 21. When the fully conjugate teeth 22 of the racks engage workpiece 12, radii 23 and 24 on the edges of these teeth will create proper metal flow as the rack teeth engage the workpiece. As the trailing ends of the racks pass the workpiece, the relieved teeth 25 thereof will permit the workpiece to expand slightly to relieve the stresses therein.

As a result of this novel rack tooth construction, it has been found that high production of toothed cylindrical workpieces may be achieved by rapid reciprocation of the racks with a greatly reduced likelihood of defective workpieces being produced due to improper rotation of the workpiece with respect to the racks. Since radii are provided on both the leading and trailing edges of teeth 18, 22 and 25, proper metal flow will be obtained on the workpiece as the teeth are formed thereon, and true involute action will take place between the racks and workpiece.

While it will be apparent that the preferred embodiment of the invention disclosed is well calculated to fulfill the objects above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. In a tool for pressure forming teeth on the periphery of a cylindrical workpiece, a body provided with a working face having a series of teeth thereon, a first group of teeth in said series, the configuration of the flanks and top of each of said first group of teeth being fully conjugate to the teeth to be formed on said workpiece, the juncture of the leading and trailing flanks of each of said first group of teeth with its top having a predetermined radius, a second group of teeth in said series spaced from said first group, corresponding portions of the flanks of said first and second groups of teeth having identical configurations, the tops of second group of teeth being of less height than the tops of said first group, the junctures of the leading flanks and tops of said second group of teeth being without a radius, the junctures of the trailing flanks and tops of said second group of teeth having said predetermined radius, and a third group of teeth disposed between said first and second groups corresponding portions of the flanks of said first and third groups of teeth having identical configurations, the heights of the tops of said third group of teeth being intermediate the heights of said first and second groups, the junctures of the leading flanks and tops of said second group of teeth having a radius smaller than said predetermined radius, the junctures of the trailing flanks and tops of said third group of teeth having said predetermined radius.

2. A tool for pressure forming teeth on the periphery of a cylindrical workpiece, said tool including a body provided with a working face having teeth thereon conjugate to the teeth to be formed on said workpiece and including a leading tooth and a trailing tooth, the leading edge of the tip of said leading tooth being without a radius, the trailing edge of said leading tooth having a predetermined radius, both the leading edge and the trailing edge of the tip of said trailing tooth having said pre-

determined radius, a first multiplicity of teeth between said leading tooth and said trailing tooth being fully conjugate to the teeth to be formed on said workpiece, the leading and trailing edges of the tips of said first multiplicity of teeth having said predetermined radius, a second multiplicity of teeth between said first multiplicity of teeth and said leading tooth formed so that the leading edges of the tips thereof have a radius less than said predetermined radius and the trailing edges of the tips thereof have said predetermined radius, and a third multiplicity of teeth between said second multiplicity of teeth and said leading teeth formed so that the leading edges of the tips thereof are without a radius and the trailing edges of the tips thereof have said predetermined radius, the flank profiles of corresponding portions of all said teeth being identical, the tops of said second and

third multiplicity of teeth being progressively lower than said first multiplicity of teeth.

3. A tool for pressure forming teeth on the periphery of a cylindrical workpiece, said tool being provided with a plurality of teeth having a pitch line, a first multiplicity of said teeth formed so that the leading edges of the tips thereof are sharp and the trailing edges thereof have a predetermined radius, a second multiplicity of said teeth formed so that the leading edges of the tips thereof have a radius less than said predetermined radius and the trailing edges of the tips thereof have a radius substantially the same as said predetermined radius, and a third multiplicity of teeth formed so that both the leading edges and trailing edges of the tips thereof have said predetermined radius, the leading edges and the trailing edges of all of said teeth being disposed on one side of said pitch line.

No references cited.