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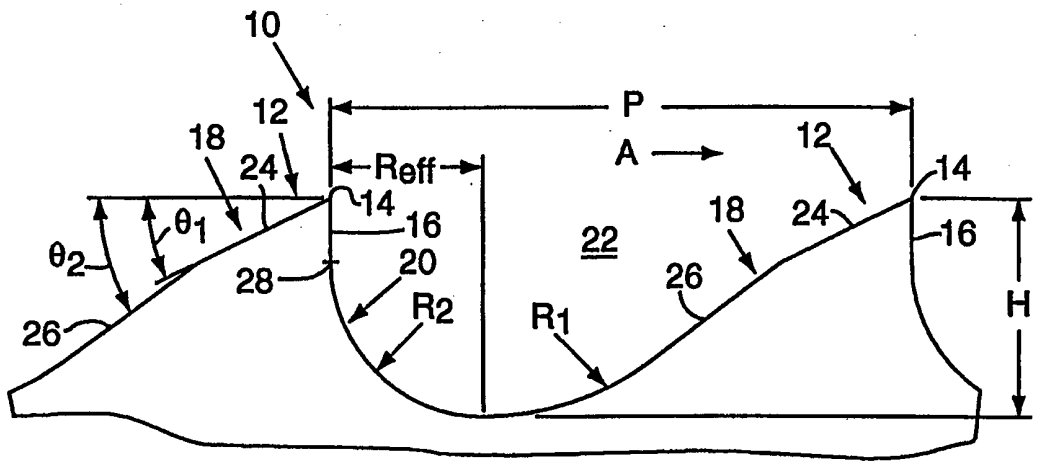
(54) Title: IMPROVED TOOTH FORM FOR A SAW BLADE



(57) Abstract

In a saw blade (10) having a cutting edge defined by a plurality of teeth (12) disposed along the blade, each tooth includes a tip (14), a rake face (16), and a curvilinear base surface (20). The tip of each tooth and the tip of the next consecutively disposed tooth cooperate to define a pitch distance (P) therebetween, with the curvilinear base surface and the tip of each tooth cooperating to define a maximum gullet depth (H). In addition, the rake face and the curvilinear base surface of each tooth define an effective gullet radius (Reff) greater than about 25 % of the pitch distance, and also greater than about 55 % of the maximum gullet depth.

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Improved Tooth Form For A Saw Blade

Cross Reference To Related Applications

This patent application is a continuation-in-part of U.S. patent application Ser. No. 08/967,279 entitled "SYNCHRONIZED VARIABLE TOOTH ARRANGEMENTS FOR SAWS," filed on November 7, 1997, which is a continuation of Ser. No. 08/577,930, also entitled "SYNCHRONIZED VARIABLE TOOTH ARRANGEMENTS FOR SAWS," filed on December 22, 1995, which in turn is a continuation-in-part of Ser. No. 08/408,847 filed on March 23, 1995.

Field Of The Invention

The present invention relates generally to saw blades, and deals more particularly with an improved tooth form for providing enhanced discharge of chips from the gullet area of each tooth and improved tooth strength.

Background Of The Invention

The terms used herein to describe the profile of a saw blade tooth are to be construed in accordance with the definitions found in International Standard Number ISO 4875/1-1978. In addition, the phrase "effective gullet radius" as used herein should be construed to mean the horizontal distance from the leftmost point of the gullet area, when the saw blade is viewed with the teeth pointing upward, to the point where the gullet depth reaches its maximum value.

In many instances, particularly in production settings, it is desirable to cut materials such as wood, plastic, and metal at the highest feed rates achievable. However, the rate at which a particular material can be presented to the saw blade is governed in large part by the stresses induced in the teeth of the blade, as well as by the rate at which particles or chips generated by the cutting action of the blade are discharged from the gullet area between consecutively spaced teeth.

In prior art tooth forms, the effective gullet radius is relatively small, typically less than approximately 25% of the tooth pitch. In addition, the gullet depth or gullet depth is typically between about 40% and about 50% of the tooth pitch with the length of the rake

face accounting for approximately half of the height. As a result of this relatively small effective gullet radius and the relatively long rake face, shear stresses are concentrated at the base of each tooth on the saw blade which often are of sufficient magnitude to tear or shear a tooth from the saw blade during a cutting operation.

Another problem associated with known tooth forms having a profile similar to that described above is that during a cutting operation, the long rake face combined with a small gullet radius inhibits the flow of chips out of the gullet area by acting as a barrier. This creates the potential for the chips generated during a cutting operation to become lodged in the gullet area, which in turn diminishes the cutting efficiency of the saw blade. To minimize this problem, the feed rate of the material through the saw, or the cutting speed of the blade, must be reduced, resulting in a concomitant reduction in production.

Based on the foregoing, it is the general object of the present invention to provide a saw blade employing a tooth profile that overcomes the above-described drawbacks of prior art saw blade teeth.

It is a more specific object of the present invention to provide a saw tooth profile having enhanced chip discharge characteristics.

Summary Of The Invention

The present invention is directed to a saw blade having a cutting edge defined by a plurality of teeth disposed along the blade. Each of the teeth includes a tip, a rake face, a relief surface, and a curvilinear base surface, with the tip of one tooth and the tip of the next consecutive tooth defining a pitch distance therebetween. The tip of each tooth and the curvilinear base surface disposed between consecutively spaced teeth cooperate to define a maximum gullet depth. In addition, the rake face of each tooth and the curvilinear base surface cooperate to define the effective gullet radius.

To provide enhanced chip discharge capabilities over prior art saw blades, the saw tooth profile of the present invention includes an effective gullet radius that is greater than approximately 25% of the pitch distance, and 55% of the maximum gullet depth. This larger radius extends upwardly toward the tip of the tooth leaving only a small vertical rake face, thereby minimizing any barriers that would inhibit the flow of chips from between the teeth of the blade. To further improve the chip discharge characteristics, the tooth profile can also be formed such that the relationship between the pitch distance and the height of the tooth is optimized. Preferably, the gullet depth of the saw blade of the present invention is greater than approximately 40% of the pitch distance.

In addition to the foregoing, each saw tooth may include a primary relief surface defined by a first relief angle extending from the tip of the tooth in a direction opposite to the cutting direction of the saw blade, and a secondary relief surface extending from the first relief surface and defined by a second relief angle different from, and larger than, the first relief angle. Preferably, the first relief angle is approximately 35° and the second relief angle is between about 45° and about 55°, with both the first and second relief angles being measured from a plane approximately perpendicular to the cutting direction of the blade. The presence of the secondary relief surface, coupled with the fact that the second relief angle is larger than the first relief angle, increases the gullet area between consecutive teeth over that which would be achieved if only the first relief angle were present. This increased gullet area reduces the likelihood of chips lodging between consecutively disposed teeth by providing a larger gullet area for chips to collect. The increased gullet area also allows the rate of chip ingress to, and egress from, the gullet area to equilibrate during a cutting operation.

In addition to providing enhanced chip discharge capabilities over that of known saw blades, it is also desirable to maximize the stress-bearing capabilities of the saw teeth. Accordingly, the teeth of the saw blade of the present invention employ a relatively short rake face, preferably less than 25% of the gullet depth, and a large radius tangent to the rake face which is defined by the curvilinear base surface. The combination of the short rake face and large radius increases the stress-bearing characteristics of the saw teeth by providing greater tooth width at the base of each tooth where stresses are greatest, without increasing the gullet depth. This reduces the likelihood of the teeth shearing or tearing during a cutting operation.

Brief Description Of The Drawings

FIG. 1 is an enlarged partial side elevational view of the saw blade of the present invention;

FIG. 2 is an enlarged partial side elevational view of an alternate embodiment of the saw blade of FIG. 1;

FIG. 3 is an enlarged partial side elevational view of an alternate embodiment of the saw blade of FIG. 1; and

FIG. 4 is an enlarged partial side elevational view of an alternate embodiment of the saw blade of FIG. 1.

Detailed Description Of The Preferred Embodiments

Detailed Description Of The Preferred Embodiments

FIG. 1 illustrates a saw blade embodying the invention. The saw blade, generally designated by the reference numeral 10, includes a cutting edge defined by a plurality of saw teeth 12, each tooth having a tip 14, a rake face 16, and a relief surface 18 extending from the tip in a direction opposite to the saw blade's cutting direction designated in FIG. 1 by arrow A. The teeth 12 are spaced along the cutting edge with the tip of one tooth and the tip of the next consecutively disposed tooth cooperating to define a pitch distance P. A curvilinear base surface 20 extends between the rake face 16 of one tooth 12 and the relief surface 18 of the next consecutive tooth. As shown in FIG. 1, the base surface 20 is tangent to the rake face 16. The rake face 16, the curvilinear base surface 20, and the relief surface 18 cooperate to define a gullet area 22. In addition, an effective gullet radius R_{eff} is defined by the rake face 16 and the curvilinear base surface 20. R_{eff} is equal to the horizontal distance from the leftmost point of the gullet area 22, when the saw blade 10 is viewed in the orientation shown in FIG. 1, to the point where the gullet depth or gullet depth H reaches its maximum value.

Still referring to FIG. 1, the relief surface 18 includes a primary relief surface 24 extending from the tip 14 of the tooth 12 and a secondary relief surface 26 extending from the primary relief surface tangent to a radius R_1 defined by the curvilinear base surface 20. The primary and secondary relief surfaces, 24 and 26, respectively, are further defined by first and second relief angles, θ_1 and θ_2, respectively, measured from a plane extending parallel to the cutting direction A of the saw blade 10. Preferably, the second relief angle θ_2 is larger that the first relief angle θ_1, thereby increasing the size of the gullet area 22 over that which would be possible if only the first relief surface were present.

In the embodiment of the present invention illustrated in FIG. 1, the effective gullet radius R_{eff} is greater than approximately 25%, and preferably equal to about 30% of the pitch distance P. In addition, the effective gullet radius R_{eff} is greater than approximately 55% of the gullet depth H, and is preferably between about 65% and 85% of the gullet depth, and most preferably equal to about 81% of the gullet depth. Moreover, the length of the rake face 16 between the tip 14 of the tooth 12 and the point where the rake face is tangent to a radius R_2 defined by the curvilinear base surface 20, is preferably less than 25% of the gullet depth. This relatively short rake face length allows the radius R_2 to be maximized, thereby minimizing stress at the base of the tooth.

Still referring to FIG. 1, during a cutting operation, chips generated by the saw blade 10 flow into the gullet areas 22 between consecutively disposed teeth 12. As the cutting operation continues, the chips must be discharged from the gullet areas 22 so that

newly generated chips can be accommodated. The large effective gullet radius R_{eff}, the relatively short rake face 16, the primary and secondary relief surfaces, 24 and 26, respectively, and the curvilinear base surface 20 all cooperate to define a gullet area 22 that provides for the smooth ingress and egress of chips to and from the gullet area.

A second embodiment of the saw blade of the present invention, shown in FIG. 2, is generally designated by the reference numeral 110. The saw blade 110 is similar in many respects to the saw blade 10 described above, and therefore like reference numerals preceded by the number 1 are used to indicate like elements. The saw blade 110 differs from the saw blade 10 in that the effective gullet radius R_{eff} is approximately 36% of the pitch distance P and approximately 77% of the gullet depth H. In addition, the gullet depth is approximately 46% of the pitch distance P.

Still referring to FIG. 2, the relief surface 118 includes a primary relief surface 124 extending from the tip 114 of the tooth 112, and a secondary relief surface 126 extending from the primary relief surface tangent to the radius R_{101} defined by the curvilinear base surface 120. The primary and secondary relief surfaces, 124 and 126, are further defined by first and second relief angles, θ_{101} and θ_{102}, respectively, measured from a plane extending parallel to the cutting direction of the saw blade 110. Preferably, the second relief angle θ_{102} is larger than the first relief angle θ_{101}. In the illustrated embodiment θ_{101} is approximately 35°, and θ_{102} is approximately 45°.

A third embodiment of the saw blade of the present invention is shown in FIG. 3 and is generally designated by the reference number 210. The saw blade 210 is similar in many respects to the saw blade 10 described above, and therefore like reference numerals preceded by the number 2 are used to indicate like elements. The saw blade 210 differs from the saw blade 10 in that the effective gullet radius R_{eff} is approximately 41% of the pitch distance P and approximately 79% of the gullet depth H. In addition, the gullet depth is approximately 46% of the pitch distance.

The relief surface 218 includes a primary relief surface 224 extending from the tip 214 of the tooth 212, and a secondary relief surface 226 extending from the primary relief surface tangent to the radius R_{201} defined by the curvilinear base surface 220. The primary and secondary relief surfaces, 224 and 226, are further defined by first and second relief angles, θ_{201} and θ_{202}, respectively, measured from a plane extending parallel to the cutting direction of the saw blade 210. Preferably, the second relief angle θ_{202} is larger than the first relief angle θ_{201}. In the illustrated embodiment θ_{201} is approximately 35°, and θ_{202} is approximately 55°.

A fourth embodiment of the saw blade of the present invention is shown in FIG. 4 and is generally designated by the reference numeral 310. The saw blade 310 is similar in many respects to the saw blade 10 described above, and therefore like reference numerals preceded by the number 3 are used to indicate like elements. The saw blade 310 differs from the saw blade 10 in that the rake face 316 defines a positive rake angle θ_{rake} measured from a plane extending approximately perpendicular to the cutting direction A of the saw blade 310. While the angle θ_{rake} is positive in the illustrated embodiment, the present invention is not limited in this regard as θ_{rake} can also be zero or negative without departing from the broader aspects of the invention.

The embodiment illustrated in FIG. 4 also differs from the other embodiments described above in that the curvilinear base surface 320 is defined by a combination of radii, R_{301} and R_{302}, with rectilinear portion L_{301} interposed therebetween. In addition, the relief surface 318 includes a primary relief surface 324 defined by relief angle θ_{301}, and a secondary relief surface 326 defined by radius R_{303}. In the illustrated embodiment, the radius R_{303} is tangent to the primary relief surface 324 and the radius R_{301} defined by the curvilinear base surface 320. In addition, the radius R_{303} is convex relative to the radius R_{301} defined by the curvilinear base surface 320. However, the invention is not limited in this regard as the radius R_{303} can be either convex or concave and does not have to be tangent to the primary relief surface 324 or the curvilinear base surface 320. In addition, while the curvilinear base surface 320 has been shown and described as being defined by a combination of radii, R_{301} and R_{302}, with rectilinear portion L_{301} interposed therebetween, the present invention is not limited in this regard. The curvilinear base surface 320 can be defined by any combination of radii and rectilinear sections without departing from the broader aspects of the present invention. Moreover, the relief surface 318, while shown and described in the illustrated embodiment as including a rectilinear primary relief surface 324 and a radial secondary relief surface 326, is not limited in this regard as any combination of radial and rectilinear surfaces can be employed without departing from the broader aspects of the present invention.

Referring to FIGS. 2-4, during a cutting operation, chips are generated by the saw blades, 110, 210, or 310, which flow into the respective gullet areas. As the cutting operation continues, the chips must be discharged from the gullet areas so that newly generated chips can be accommodated. The larger effective gullet radii R_{eff}, the relatively short rake faces, the larger angles or radii of the secondary relief surfaces 126, 226, and 326, as well as the curvilinear base surfaces 120, 220, or 320 of each of these blades, all cooperate to define gullet areas larger than those of known saw blades. The larger gullet areas provide the saw blades with the capability to handle larger volumes of chips, thereby enabling the

blades to operate at higher speeds. In addition, the large radii which define the curvilinear base surfaces provide the teeth of these blades with enhanced stress-bearing capabilities by minimizing any stress concentrations at the base of the teeth. This in turn reduces the likelihood of the teeth shearing or tearing from the blades, thereby enabling them to cut materials at higher speeds which would normally impose large amounts of stress on the teeth.

While preferred embodiments have been shown and described, various modifications and substitutions may be made without departing from the spirit and scope of the present invention. Accordingly, it is to be understood that the present invention has been described by way of example, and not by limitation.

What is claimed is:

1. A saw blade having a cutting edge defined by a plurality of teeth disposed along the blade, each of said teeth having a tip, a rake face, a relief surface and a curvilinear base surface, the tip of each tooth and the tip of the next consecutively disposed tooth defining a pitch distance, the curvilinear base surface and the tip of each tooth cooperating to define a maximum gullet depth, and the rake face and the curvilinear base surface of each tooth cooperating to define an effective gullet radius greater than about 25% of the pitch distance and greater than about 55% of the maximum gullet depth.

2. The saw blade of claim 1 wherein the rake face and the curvilinear base surface of each tooth cooperate to define an effective gullet radius greater than about 30% of pitch distance.

3. The saw blade of claim 1 wherein the rake face of each tooth defines a positive rake angle.

4. The saw blade of claim 1 wherein the rake face of each tooth defines a negative rake angle.

5. The saw blade of claim 1 wherein the relief surface of each tooth includes a primary relief surface defined by a first relief angle and a secondary relief surface defined by a second relief angle, the first and second relief angles being measured relative to a plane substantially parallel to the cutting direction of the saw blade.

6. The saw blade of claim 5 wherein the first relief angle is approximately 35°.

7. The saw blade of claim 5 wherein the second relief angle is approximately 45°.

8. A saw blade having a cutting edge defined by a plurality of teeth disposed along the blade, each of said teeth having a tip, a rake face, a relief surface and a curvilinear base surface, each tooth and the next consecutively disposed tooth defining a pitch distance extending between the tips thereof, the curvilinear base surface and the tip of each tooth cooperating to define a gullet depth greater than about 40% of the pitch distance, and

the rake face and the curvilinear base surface of each tooth cooperating to define an effective gullet radius greater than about 25% of the pitch distance.

9. The saw blade of claim 8 wherein the effective gullet radius is greater than about 30% of the pitch distance.

10. The saw blade of claim 8 wherein the rake face defines a positive rake angle as measured relative to a plane approximately perpendicular to the cutting direction of the saw blade.

11. The saw blade of claim 8 wherein the rake face defines a negative rake angle as measured relative to a plane approximately perpendicular to the cutting direction of the saw blade.

12. The saw blade of claim 8 wherein the relief surface of each tooth includes a primary relief surface defined by a first relief angle extending from the tip of the tooth, and a secondary relief surface defining a second relief angle extending from the primary relief surface, the first and second relief angles being measured relative to a plane substantially parallel to the cutting direction of the saw blade.

13. The saw blade of claim 12 wherein the first relief angle is approximately 35°.

14. The saw blade of claim 12 wherein the second relief angle is between approximately 45° and approximately 55°.

15. The saw blade of claim 8 wherein:

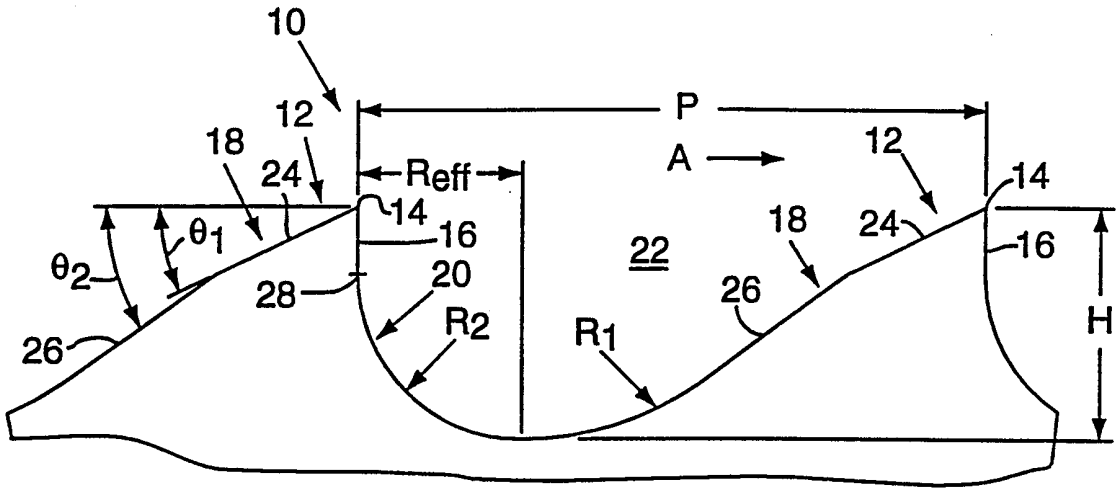
16. the relief surface of each tooth is defined by a primary relief surface extending from the tip of the tooth, and a secondary relief surface extending from the primary relief surface; and wherein

a respective one of the primary and secondary relief surfaces is defined by a relief angle measured from a plane approximately parallel with the direction of cut of the saw blade, and the other of the primary and secondary relief surfaces is defined by a radius.

17. The saw blade of claim 8 wherein the curvilinear base surface is defined by a first radius tangent to the rake face and at least a second radius tangent at one end to the first radius and at another end to the relief surface.

18. The saw blade of claim 8 wherein:
the curvilinear base section of each tooth is defined by at least one radius; and
the rake face is between about 10% and about 25% of the gullet depth.

19. The saw blade of claim 1 wherein the curvilinear base surface is defined by a combination of radial and rectilinear sections.


10
12
P
18
24
Reff
A
12
14
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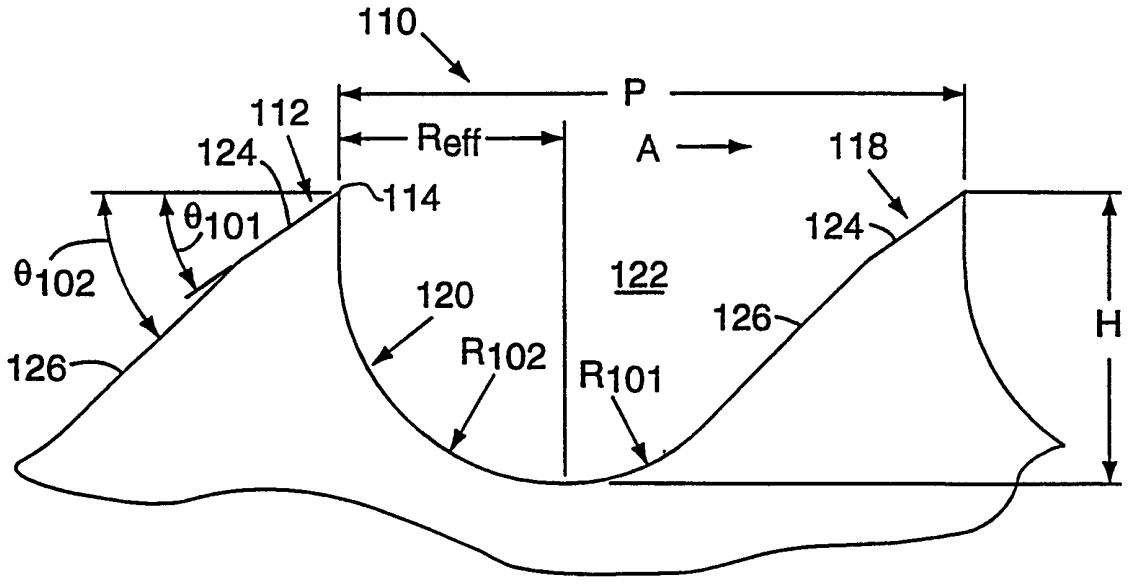
16
θ1
θ2
28
20
22
18
24
16
26
R2
R1
26
H

FIG. 1


110
P
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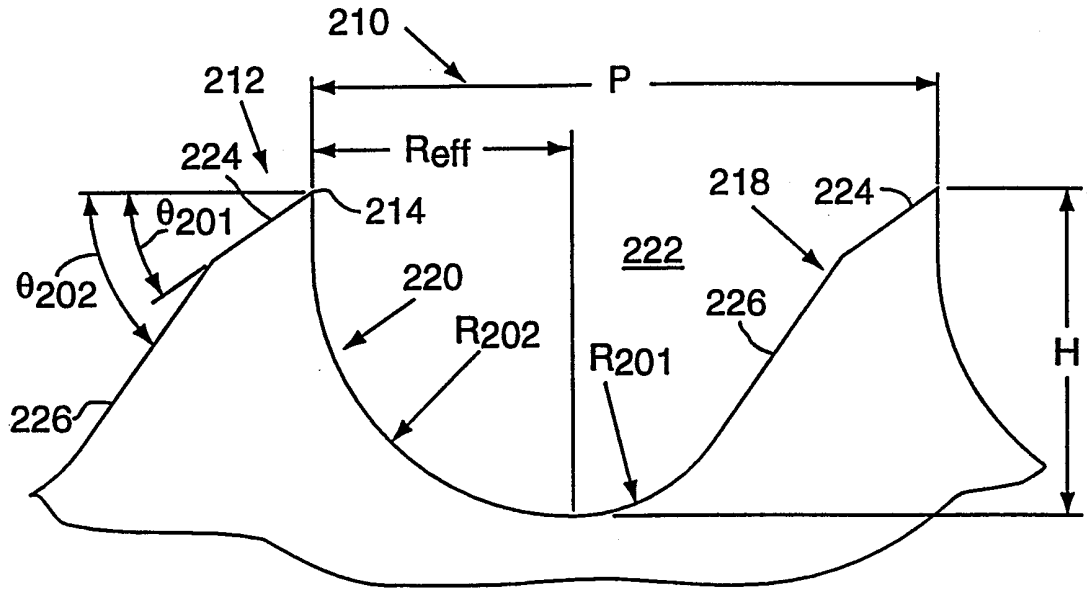
θ101
θ102
120
122
124
126
R102
R101
126
H

FIG. 2


210
212
P
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Reff
218
224
θ201
214
222
θ202
220
226
R202
R201
H
226

FIG. 3

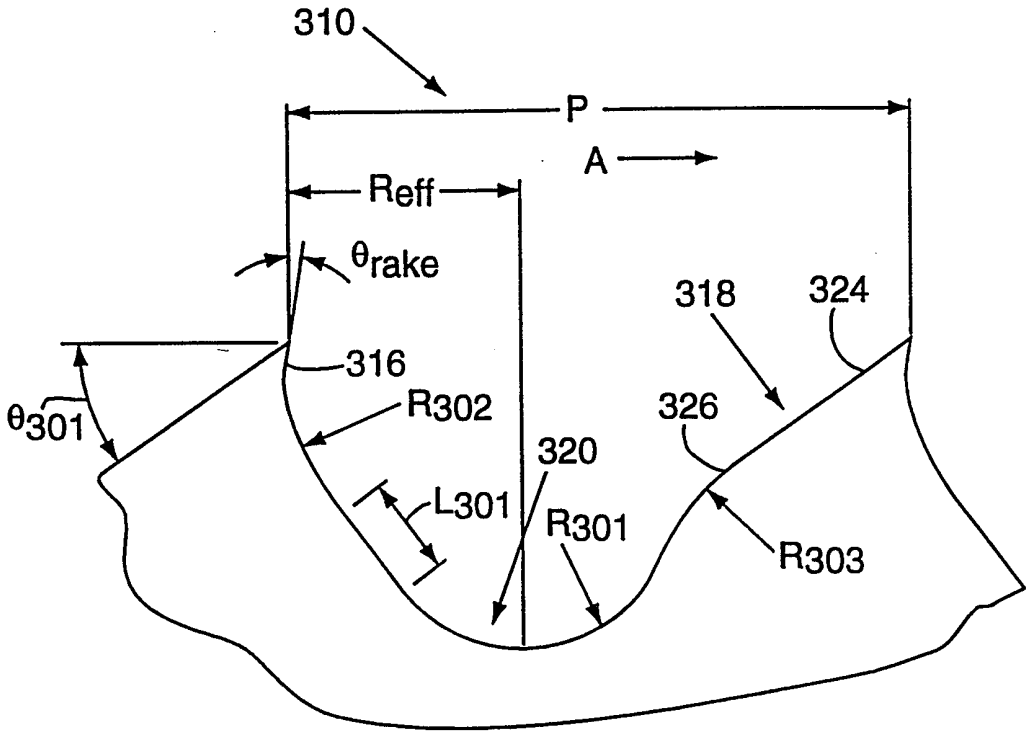
310
P
A
Reff
θrake
318
324
316
θ301
R302
326
320
L301
R301
R303

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02113

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B27B 33/02
US CL :83/835, 855

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 83/661, 663, 835, 854, 855; 76/112

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 4,292,871 A (NEUMEYER et al.) 06 October 1981, col. 4, line 40 - col. 6, line 44.	8,10,12,14,15, 17,18 --- 1-7,9,11,13,19
X --- Y	US 3,072,164 A (RAMIREZ et al.) 08 January 1963, col. 6, lines 5-40.	1-3,19 --- 4,8-11,17,18
Y	US 4,587,876 A (ERHARDT) 13 May 1986, Figs. 1, 2, 5 and 6.	1-15,17-19
Y	US 5,018,421 A (LUCKI et al) 28 May 1991, Fig. 2.	1-15,17-19

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
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"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
26 MARCH 1999	14 APR 1999

Name and mailing address of the ISA/US	Authorized officer
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Paralegal Specialist
Technology Center 3700

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,249,485 A (HAYDEN, SR.) 05 October 1993, Fig. 1.	1-15,17-19

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02113

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 16
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

Numeral 16 is included as part of claim 15 and thus does not represent a separate claim.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/02113

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains claims directed to more than one species of the generic invention. These species are deemed to lack Unity of Invention because they are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for more than one species to be searched, the appropriate additional search fees must be paid. The species are as follows:

Species I - Figure 1-3;
Species II - Figure 4.

The claims are deemed to correspond to the species listed above in the following manner:

Species I - claims 1, 2, 5-9 and 12-17
Species II - claims 1, 3, 4, 8, 10, 11 and 18.

The following claims are generic: 1 and 8

The species listed above do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, the species lack the same or corresponding special technical features for the following reasons: for example, species I lacks the rack face having a positive or negative rake angle which is a special technical feature of species II; species II lacks a relief surface which includes primary and secondary relief surfaces which is a special technical feature of species I.