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Tangential cutting insert and milling cutter

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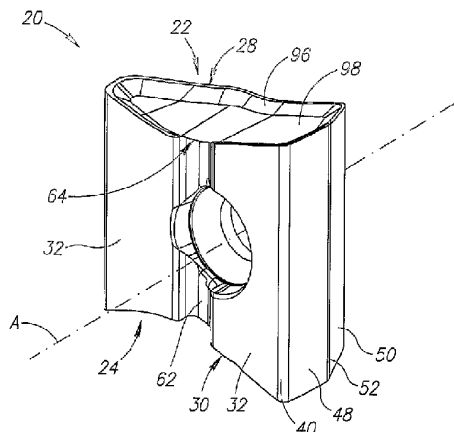
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(54) Title: TANGENTIAL CUTTING INSERT AND MILLING CUTTER



(57) Abstract: A tangential cutting insert (20) having first and second opposing end surfaces (22, 24) peripheral side (26) extending therebetween. First and second edges (28, 30) are formed at the intersection of the first and second end surfaces (22, 24) with the peripheral side surface (26). A groove (62) in the peripheral side surface (26) extends between and intersects the first and second end surfaces (22, 24) at first and second opposing side views of the cutting insert (20), at least the first edge (28) is generally concave.

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## TANGENTIAL CUTTING INSERT AND MILLING CUTTER

### FIELD OF THE INVENTION

The present invention relates in general to a tangential cutting insert and a milling cutter for metal cutting operations for milling complex profiles such as for milling crankshafts with an annular internal-milling cutter.

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### BACKGROUND OF THE INVENTION

Such milling cutters typically comprise an annular cutter body having a plurality of identical segments equally spaced about the inner circumference of the cutter body. Each segment having typically three or more cutting inserts secured to it, with each cutting insert intended to mill a particular feature of the complex profile. Inevitably, at least one of the cutting inserts of each segment has a different geometry from the other cutting inserts of that segment. consequently, a stock of at least two types of cutting inserts has to be kept and care has to be taken when

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replacing a worn cutting insert of a segment not to replace it by a cutting insert of a different geometry.

In many such milling cutters, tangential cutting inserts are used. Tangential cutting inserts, also known as on-edge, or lay down, cutting inserts, are oriented in an insert holder in such a manner that during a cutting operation on a workpiece the cutting forces are directed along a major (thicker) dimension of the cutting insert. An advantage of such an arrangement being that the cutting insert can withstand greater cutting forces than when oriented in such a manner that the cutting forces are directed along a minor (thinner) dimension of the cutting insert.

One advantage of the tangential cutting insert for use in a milling cutter of the present invention is that it is capable of milling features of a complex profile of a metal workpiece.

#### SUMMARY OF THE INVENTION

In accordance with the present invention there is provided a tangential cutting insert comprising:

first and second opposing end surfaces and a peripheral side surface extending therebetween;  
first and second peripheral edges, respectively, formed at the intersection of the first and second end surfaces with the peripheral side surface, at least a section of the first peripheral edge forming a major cutting edge;

at least one groove in the peripheral side surface extending between and intersecting the first and second end surfaces at secondary edges, respectively, the secondary edges forming minor cutting edges;

wherein, in first and second opposing side views of the cutting insert, at least the first peripheral edge is generally concave.

One advantage of the tangential cutting insert for use in a milling cutter of the present invention is that

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it is capable of milling features of a complex profile of a metal workpiece.

In accordance with the present invention, in the first and second opposing side views the at least the  
5 first edge extends between first and second end points

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thereof, the second end point being closer to a median plane of the cutting insert than the first end point.

Further in accordance with the present invention, in the first side view a minimum point exists on the at least the first peripheral edge, the minimum point  
5 being closer to the median plane of the cutting insert than any other point on the at least the first peripheral edge and also being closer to one end point than the other.

Preferably, the cutting insert is provided with a through bore passing through the peripheral side surface.

Further typically, the through bore has an axis contained in the median  
10 plane of the cutting insert.

There is also provided in accordance with the present invention, a milling cutter comprising an annular cutter body having a plurality of identical segments equally spaced about an inner circumference of the cutter body, each segment having seven cutting inserts in accordance with the present invention secured  
15 thereto.

Preferably, the seven cutting inserts on each segment are arranged three pairs and a single unpaired cutting insert.

Further preferably, in a first of the three pairs the cutting inserts are located on opposing side faces of the segment; in a second of the three pairs the cutting inserts  
20 are located on the inner face of the segment with one of the cutting inserts adjacent one side face of the segment and the other cutting insert adjacent the opposing side face of the segment; in a third of the three pairs, the cutting inserts are located adjacent a median plane of the segment on either side thereof; and the single unpaired cutting insert is located substantially midway between the two side faces of the  
25 segment.

In accordance with the present invention, the single unpaired cutting insert is secured to the segment with its groove facing away from the segment, whereas each of the cutting inserts of the three pairs of cutting inserts is secured to the segment with its groove facing towards the segment.

**BRIEF DESCRIPTION OF THE DRAWINGS**

- For a better understanding of the present invention and to show how the same may be carried out in practice, reference will now be made to the accompanying
- 5 drawings, in which:
- Fig. 1** is a perspective view of a cutting insert according to the present invention;
- Fig. 2** is another perspective view of the cutting insert shown in Fig. 1;
- Fig. 3** is an end view of the cutting insert shown in Fig. 1;
- Fig. 4** is a side view of the cutting insert shown in Fig. 1 taken in the direction IV
- 10 as shown in Fig. 3;
- Fig. 5** is a side view of the cutting insert shown in Fig. 1 taken in the direction V as shown in Fig. 3;
- Fig. 6** is a side view of the cutting insert shown in Fig. 1 taken in the direction VI as shown in Fig. 3;
- 15 **Fig. 7** is a side view of the cutting insert shown in Fig. 1 taken in the direction VII as shown in Fig. 3;
- Fig. 8** is a perspective view of a milling cutter in accordance with the present invention;
- Fig. 9** is a partial side view of a crankshaft milled with the milling cutter shown
- 20 in Fig. 8;
- Fig. 10** is a cross section of the crankshaft shown in Fig. 9, taken along the line XX;
- Fig. 11** is a cross section similar to that shown in Fig. 10 before the crankshaft is milled;
- 25 **Fig. 12** is a perspective view of a segment of the milling cutter shown in Fig. 8;
- Fig. 13** is an end on view of the segment shown in Fig. 8; and
- Fig. 14** is a side view of the segment shown in Fig. 8.

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**DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT**

Attention is drawn to Figs. 1 to 7 of the drawings showing a double-sided tangential cutting insert **20** in accordance with the present invention. The cutting insert **20** is typically made of extremely hard and wear-resistant material such as cemented carbide, either by form-pressing and sintering carbide powders in a binder or by powder injection molding methods. The cutting insert **20** comprises identical opposing end surfaces **22, 24** and a peripheral side surface **26** extending between the end surfaces **22, 24**. A median plane **M** divides the cutting insert **20** into two equal halves, with the two end surfaces **22, 24** located on opposite sides of the median plane **M**. The cutting insert **20** possesses mirror (or reflection) symmetry about the median plane **M**. During a cutting operation, only one of the end surfaces **22**, referred to as the operative end surface **22**, participates in the cutting operation. Since the two end surfaces **22, 24** are identical, only one of them, namely the operative end surface **22**, will be described in detail (the opposing end surface will be referred to as the non-operative end surface **24**).

The peripheral side surface **26** intersects the end surfaces **22, 24** at peripheral edges **28, 30**. The peripheral side surface **26** comprises first and second, generally planar and parallel, opposing major side surfaces **32, 34** and first and second opposing minor side surfaces **36, 38** extending between the major side surfaces **32, 34**. Adjacent major and minor side surfaces merge at common corner side surfaces. The first major side surface **32** merges with the first minor side surface **36** at a first corner side surface **40**. The first minor side surface **36** merges with the second major side surface **34** at a second corner side surface **42**. The second major side surface **34** merges with the second minor side surface **38** at a third corner side surface **44** and the second minor side surface **38** merges with the first major side surface **32** at a fourth corner side surface **46**. Each minor side surface is divided into two component minor side surfaces. The first minor side surface **36** comprises first and second component first minor side surfaces **48, 50** merging at a first component corner side surface **52**. The second minor side surface **38** comprises first and second component second

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minor side surfaces 54, 56 merging at a second component corner side surface 58. The first component first minor side surface 48 and the first component second minor side surface 54 are adjacent the first major side surface 32, whereas the second component first minor side surface 50 and the second component second minor side surface 56 are adjacent the second major side surface 34.

A through bore 60, having an axis A which lies in the median plane M, passes through the peripheral side surface 26, extending between the first and second major side surfaces 32, 34. A groove 62 in the peripheral side surface 26 extends between the opposing end surfaces 22, 24. The groove 62, which is intersected by the through bore 60, is straight and perpendicular to the median plane M of the cutting insert 20.

The peripheral edge 28 comprises two component edges, a secondary edge 64 and a primary edge 66. The secondary edge 64 is formed at the intersection of the groove 62 and the operative end surface 22, and the primary edge 66 is the whole of the peripheral edge 28 apart from the secondary edge 64. The primary edge 66 comprises first and second major edges 68, 70, formed at the intersection of the first and second major side surfaces 32, 34 with the operative end surface 22, respectively; first and second minor edges 72, 74, formed at the intersection of the first and second minor side surfaces 36, 38 with the operative end surface 22, respectively; and first, second, third and fourth corner edges 76, 78, 80, 82, formed at the intersection of the first, second, third and fourth corner side surfaces 40, 42, 44, 46 with the operative end surface 22, respectively. The first minor edge 72 comprises a first component first minor edge 84, a second component first minor edge 86 and a first component corner edge 88, formed at the intersection of the first component first minor side surface 48, the second component first minor side surface 50 and the first component corner side surface 52 with the operative end surface 22, respectively. Similarly, the second minor edge 74 comprises a first component second minor edge 90, a second component second minor edge 92 and a second component corner edge 94, formed at the intersection of the first component second minor side surface 54, the second

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component second minor side surface **56** and the second component corner side surface **58** with the operative end surface **22**, respectively.

The operative end surface **22** comprises a peripheral surface portion **96** sloping inwardly from the peripheral edge **28** towards the median plane **M** and  
5 merging with a central surface portion **98** of the operative end surface **22**. The peripheral edge **28** forms a cutting edge and the peripheral surface portion **96** forms an associated chip rake surface. Consequently, any section of the peripheral edge **28** forms a cutting edge and therefore any such section will be referred to herein either as an edge or a cutting edge.

10 With reference to Fig. 6, it is noted that in a side view of the cutting insert **20** taken perpendicular to the second major side surface **34**, also referred to herein as a first side view of the cutting insert **20**, the second component first minor cutting **86**, the second corner edge **78**, the second major edge **70**, the third corner edge **80**, the second component second minor edge **92** and the second component corner edge **94**  
15 form a generally concave edge portion **C** of the peripheral edge **28**. In other words, in the first side view the peripheral edge **28** is generally concave. The structure of this generally concave edge portion **C** is as follows. The second component first minor cutting **86** extends from the first component corner edge **88** sloping towards the median plane **M** and merges with the second corner edge **78**. The second corner edge **78**  
20 extends from the second component first minor cutting **86** sloping towards the median plane and merges with the second major edge **70**. The second major edge **70** extends from the second corner edge **78** sloping towards the median plane **M** and merges with the third corner edge **80** at a region of join **100**. The region of join **100** contains a point **Q** which is the point on the concave edge portion **C** closest to the  
25 median plane **M**, also referred to as the minimum point **Q**, with respect to the median plane **M**. Around the region of join **100**, the peripheral edge **28** is parallel to the median plane **M**. The third corner edge **80** extends from the region of join **100** sloping away from the median plane **M** and merges with the second component second minor edge **92**. The second component second minor edge **92** extends from

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the third corner edge **80** sloping away from the median plane **M** and merges with the second component corner edge **94**. In the first view, the first and second component corner edges **88, 94** form first and second end points **X1, X2** of the generally concave edge portion **C**, with the second end point **X2** being closer to the median plane **M** than  
5 the first end point **X1**.

In the first side view, the cutting insert **20** is bounded by the first component corner side surface **52** on one side and the second component corner side surface **58** on the other side, the first and second component corner side surfaces **52, 58** thereby defining first and second bounding lines **H1, H2** of the cutting insert **20**.  
10 The minimum point **Q** on the generally concave edge portion **C** of the peripheral edge **28** is closer to the second bounding line **H2** than to the first bounding line **H1**. Therefore, in the first side view, the generally concave edge portion **C** is non-symmetric about the minimum point **Q**. It is also seen that in the side view of the cutting insert **20** taken perpendicular to the second major side surface **34**, the cutting  
15 insert **20** has three characteristic lengths measured between the peripheral edges **28** of the opposing end surfaces **22**. A maximum length **L1**, measured between the first component corner edges **33** (therefore **L1** defines a maximum length of the first minor side surface **36**), an intermediate length **L2** measured between the second component corner edges **94** (therefore **L2** defines a maximum length of the second minor side  
20 surface **38**) and a minimum length **L3**, measured between the minimum points **Q** on the peripheral edges **28**. Clearly, the maximum length **L1** is greater than the intermediate length **L2** which in turn is greater than the minimum length **L3**. The difference in lengths between the first and second minor side surface **36, 38**, can also be clearly seen in Fig. 5 where, due to the fact that the maximum length of the second  
25 minor side surface **38** is smaller than the maximum length of the first minor side surface **36**, portions of both the operative end surface **22** and the opposing non-operative end surface **24** can be seen.

With reference to Fig. 7, it is noted that in a side view of the cutting insert **20** taken perpendicular to the first major side surface **32**, also referred to herein as a

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second side view of the cutting insert 20, the fourth corner edge 82, the first major edge 68, the secondary edge 64 and the first corner edge 76 form a generally concave edge portion S of the peripheral edge 28. In other words, in the second side view the peripheral edge 28 is generally concave. When comparing the generally concave edge portion S of the peripheral edge 28 in the second side view with the generally concave edge portion C of the peripheral edge 28 in the first side view it is noted that the later is slightly recessed at a central region thereof, the recess being formed by the secondary edge 64.

With reference to Fig. 3, it can be seen that in an end view of the cutting insert 20, the second component first minor edge 86 makes a first angle  $\alpha 1$  with the second major edge 70 and the second component second minor edge 92 makes a second angle  $\alpha 2$  with the second major edge 70. The first component second minor edge 90 makes a third angle  $\alpha 3$  with a line N normal to a continuation line of the second major edge 70 and the first component first minor edge 84 is perpendicular to the continuation line of the second major edge 70. The secondary edge 64 comprises three component edges, an inner secondary edge 64' and two outer secondary edges 64'' extending from either end of the inner secondary edge 64' to the first major edge 68, with each outer secondary edge 64'' making an obtuse angle with the inner secondary edge 64'. The first major edge 68, comprises two straight line portions, interrupted by the groove 62, parallel to the second major edge 70, in the end view.

With reference to Fig. 4, it is noted that in a third side view of the cutting insert 20, the second component first minor edge 86 extends from the second corner edge 78 to the first component corner edge 88 sloping away from the median plane M. Similarly, with reference to Fig. 5, it is noted that in a fourth side view of the cutting insert 20, the second component second minor edge 92 extends from the third corner edge 80 to the second component corner edge 94 sloping away from the median plane M. As can be seen in the figures, the through bore 60 can be seen in the first and second side views but not in the third and fourth side views.

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As will be described herein below with reference to Figs. 8 to 14, the above described geometrical properties of the cutting insert 20 enable it to mill all the features of a complex profile for which it is designed. Fig. 8 shows an annular internal milling cutter 102 comprising nine segments 104, each segment 104 having seven cutting inserts 20 secured thereto. Fig. 9 shows a section of a crankshaft 106 after being milled by the milling cutter 102 and Fig. 10 shows in cross section the features milled. These features are the cheeks 108, mini-cheek 110 midway between the cheeks 108, two 90° sections 112 (that is, at 90° to the cheeks 108) between the mini-cheek 110 and the cheeks 108 and two 45° sections 114 adjacent the cheeks 108 and the 90° sections 112. The mini-cheek 108 comprises an upper straight section 116 that merges with two corner sections 118 and two 30° sections 120 (that is, at 30° to the cheeks 108) extending from the corner sections to the 90° section 112.

Fig. 11 shows a cross section of the crankshaft 106 similar to that shown in Fig. 10, but before the crankshaft 106 is milled. The continuous line represents the above-mentioned features before the crankshaft 106 is milled and the dashed line adjacent the continuous line shows the milled surface as in Fig. 10. The pre-milled features being, pre-milled cheeks 108', pre-milled mini-cheek 110 (pre-milled upper section 116', pre-milled corner sections 118, pre-milled 30° sections 120') pre-milled 90° sections 112' and pre-milled two 45° sections 114'. It will be appreciated by those skilled in the art that the crankshaft 106, as well as crankshafts in general, are milled in a number of stages. The milling process as described herein and as illustrated in Fig. 11, represents only one intermediate stage of a number of stages required in order to fully mill the crankshaft 106.

Attention is now drawn to Figs. 12 to 14 showing one segment 104. The segment 104 has seven cutting inserts 20 secured to it by means of clamping screws 122 and arranged in three pairs of cutting inserts and a single unpaired cutting insert. A first pair comprises two extreme outer cutting inserts 20a located on opposing side faces 124 of the segment 104. A second pair comprises two outer cutting inserts 20b located on the inner face 126 of the segment 104 with one of the outer cutting inserts

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20b adjacent one side face 124 and the other outer cutting insert 20b adjacent the opposing side face 124. A third pair comprises two inner cutting inserts 20c located adjacent a median plane P of the segment 104 on either side thereof. The single unpaired cutting insert is a central cutting insert 20d located substantially midway  
5 between the two side faces 124. The central cutting insert 20d is secured to the segment 104 with its groove 36 facing away from the segment 104, whereas each of the extreme outer cutting inserts 20a, the outer cutting inserts 20b and the inner cutting inserts 20c is secured to the segment 104 with its groove 36 facing towards the segment 104.

10 When milling the crankshaft 106, the cutting inserts 20a, 20b, 20c, 20d of each segment 104 operate on given sections of the crankshaft 106. The two extreme outer cutting inserts 20a mill the cheeks 108', the 45° sections 114' and a portion of the 90° section 112' adjacent the 45° section 112'. The two outer cutting inserts 20b mill the 45° sections and a portion of the 90° section 112' adjacent the 45° section  
15 114' extending to approximately half way along the 90° section. The two inner cutting inserts 20c mill the 30° sections 120' and a portion of the 90° section 112' adjacent the 30° section 120' extending to approximately half way along the 90° section, and the central cutting insert 20d mills the upper section 116 and the corner sections 118 of the mini-check 110. It will be appreciated that the way in which the cutting edges  
20 slope relative to the median plane M provides them with an inherent positive axial rake, thereby making the cutting process more efficient.

Although the present invention has been described to a certain degree of particularity, it should be understood that various alterations and modifications could be made without departing from the spirit or scope of the invention as  
25 hereinafter claimed.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprise" or variations such as "comprises" or "comprising" is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the  
5 presence or addition of further features in various embodiments of the invention.

## THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A tangential cutting insert comprising:  
first and second opposing end surfaces and a peripheral side surface extending  
5 therebetween;  
first and second peripheral edges, respectively, formed at the intersection of the  
first and second end surfaces with the peripheral side surface, at least a section of the  
first peripheral edge forming a major cutting edge;  
at least one groove in the peripheral side surface extending between and  
10 intersecting the first and second end surfaces at secondary edges, said second edges  
forming minor cutting edges;  
wherein, in first and second opposing side views of the cutting insert, at least the  
first peripheral edge is generally concave;  
characterized in that in an end view of the cutting insert the major cutting edge  
15 comprises two straight line portions interrupted by the at least one groove.
2. The tangential cutting insert according to claim 1, wherein in the first and  
second opposing side views the at least the first peripheral edge extends between first  
and second end points thereof, the second end point being closer to a median plane of  
20 the cutting insert than the first end point.
3. The tangential cutting insert according to claim 2, wherein in the first side view  
a minimum point exists on the at least the first peripheral edge, the minimum point  
being closer to the median plane of the cutting insert than any other point on the at least  
25 the first peripheral edge and also being closer to one end point than the other.
4. The tangential cutting insert according to claim 3, wherein the cutting insert is  
provided with a through bore passing through the peripheral side surface.
- 30 5. The tangential cutting insert according to claim 4, wherein the through bore has  
an axis contained in the median plane of the cutting insert.
6. A milling cutter comprising an annular cutter body having a plurality of  
identical segments equally spaced about an inner circumference of the cutter body, each  
35 segment having seven cutting inserts in accordance with claim 5 secured thereto.
7. The milling cutter according to claim 6, wherein the seven cutting inserts on

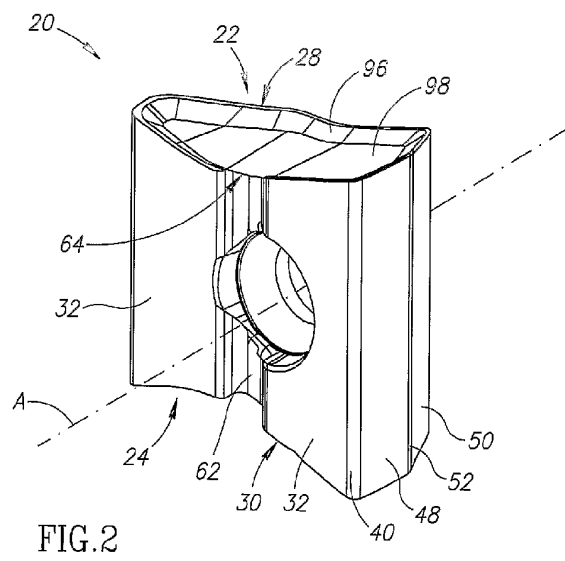
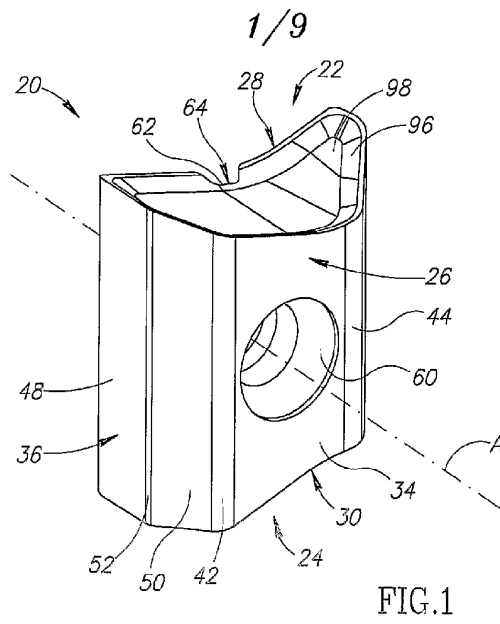
each segment are arranged three pairs and a single unpaired cutting insert.

8. The milling cutter according to claim 7, wherein in a first of the three pairs the cutting inserts are located on opposing side faces of the segment; in a second of the  
5 three pairs the cutting inserts are located on the inner face of the segment with one of the cutting inserts adjacent one side face of the segment and the other cutting insert adjacent the opposing side face of the segment; in a third of the three pairs, the cutting inserts are located adjacent a median plane of the segment on either side thereof; and the single unpaired cutting insert is located substantially midway between the two side  
10 faces of the segment.

9. The milling cutter according to claim 8, wherein the single unpaired cutting insert is secured to the segment with its groove facing away from the segment, whereas each of the cutting inserts of the three pairs of cutting inserts is secured to the segment  
15 with its groove facing towards the segment.

10. A tangential cutting insert substantially as herein described with reference to the accompanying drawings.

20 11. A milling cutter substantially as herein described with reference to the accompanying drawings.



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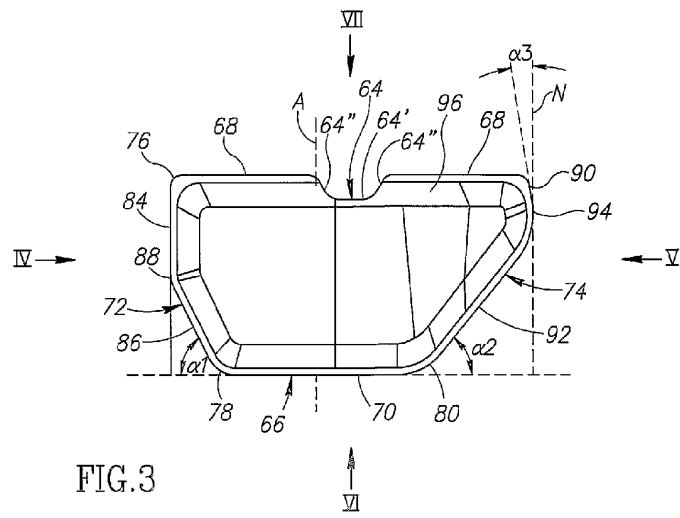


FIG.3

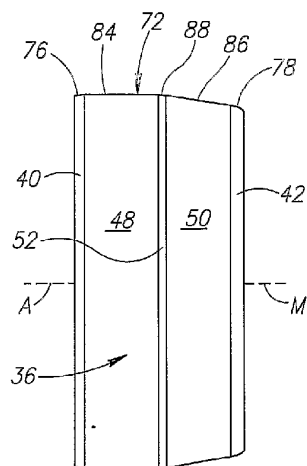


FIG.4

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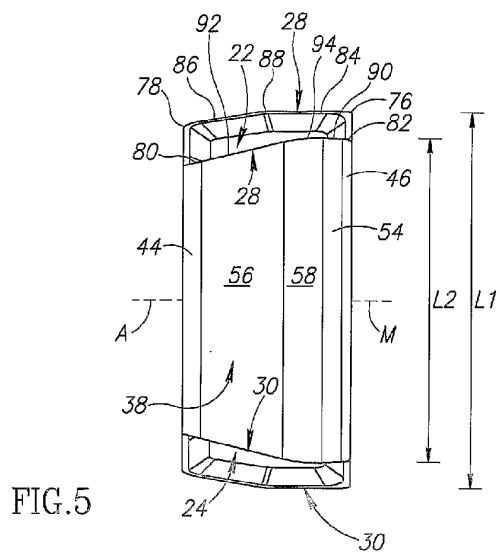


FIG. 5

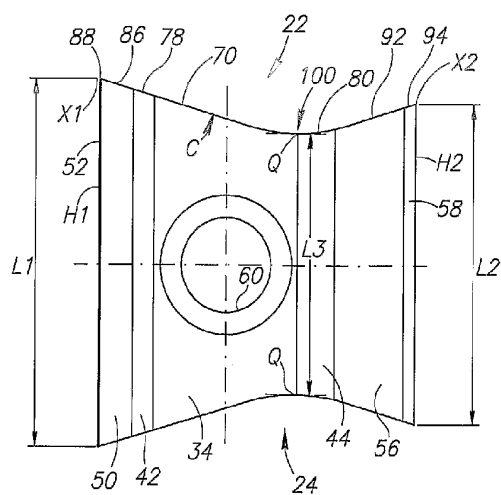


FIG. 6

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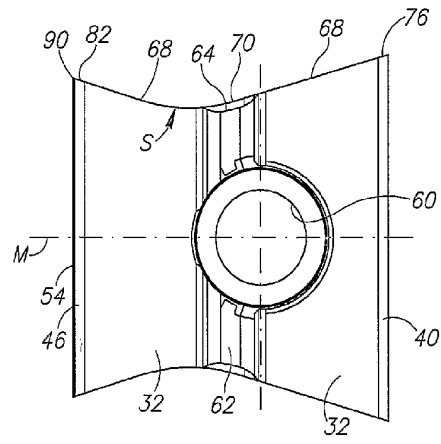


FIG. 7

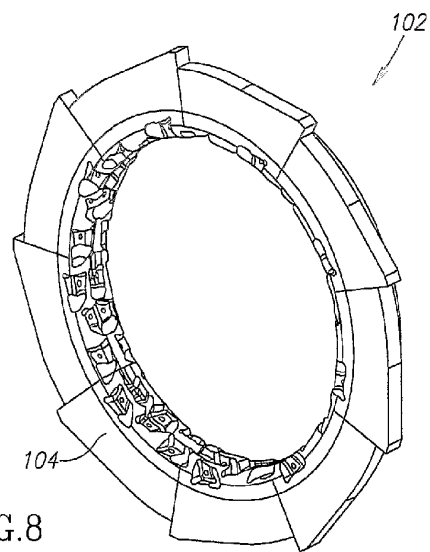


FIG. 8

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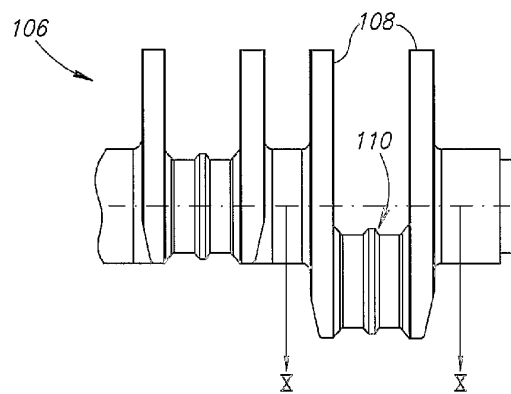
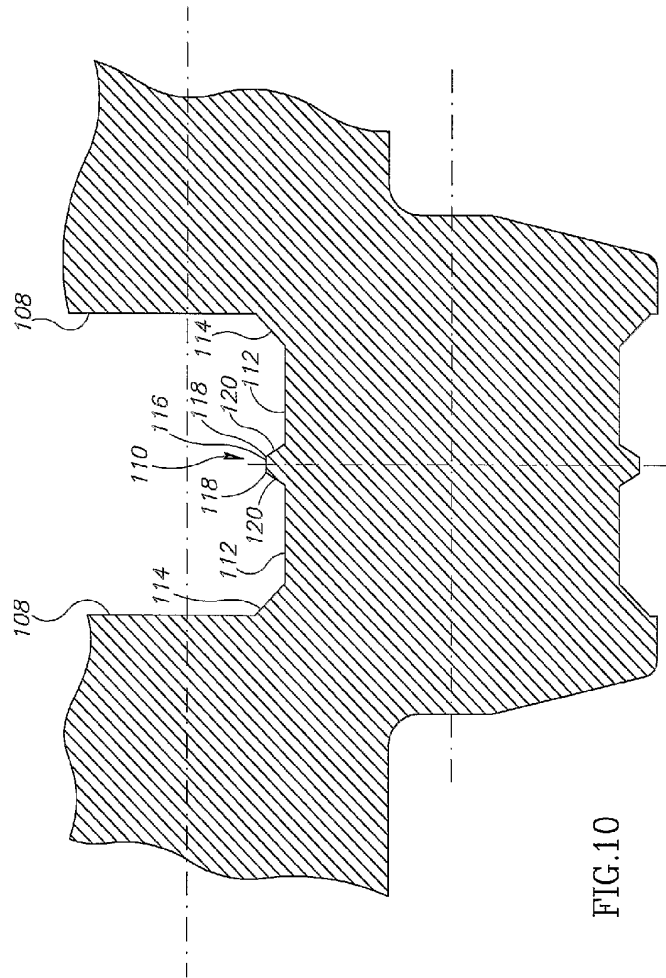


FIG.9

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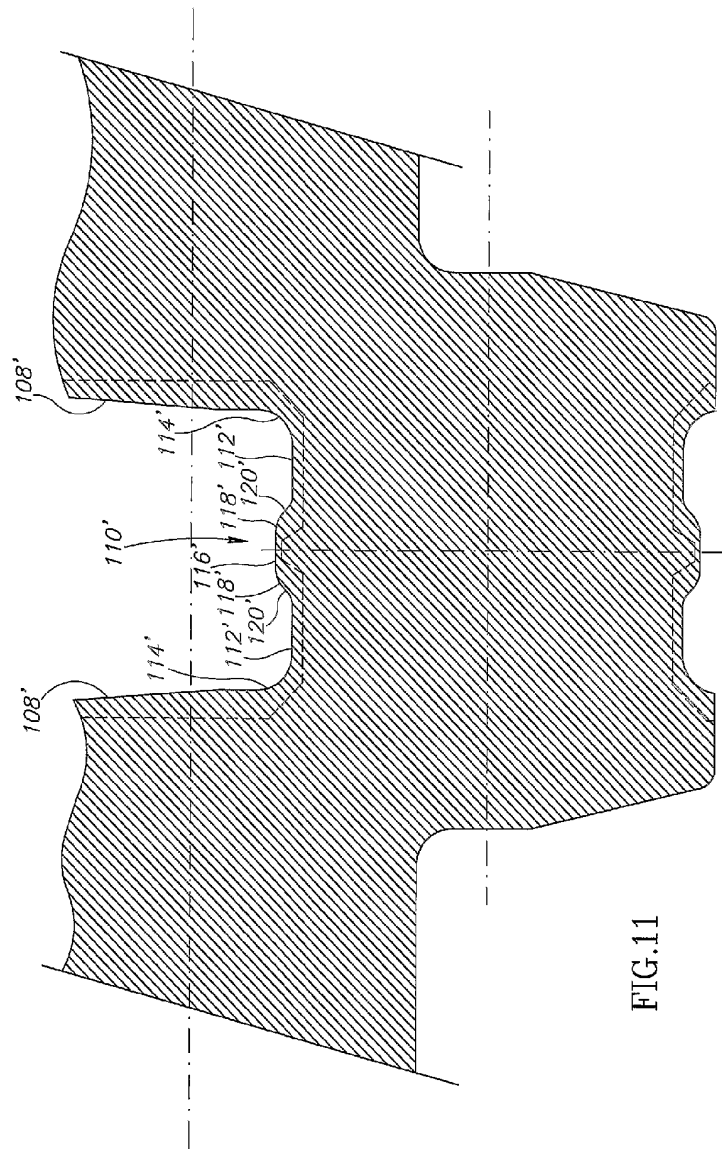


FIG. 11

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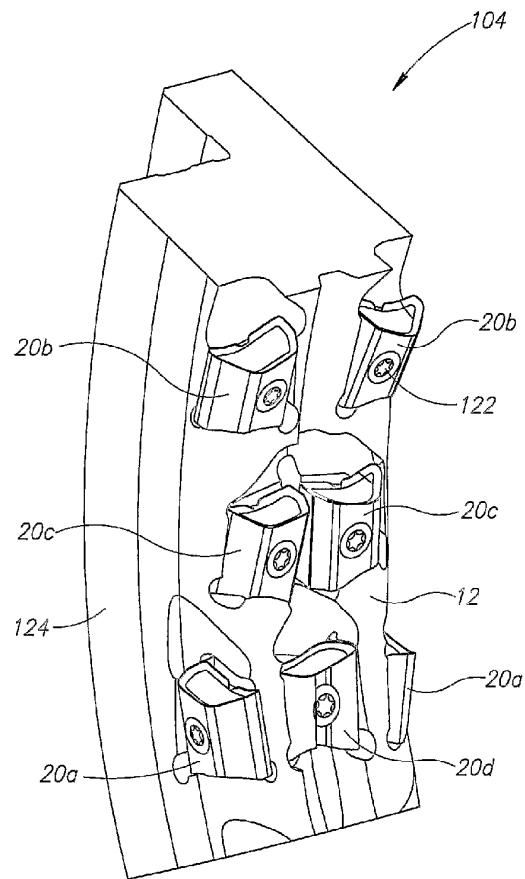


FIG.12

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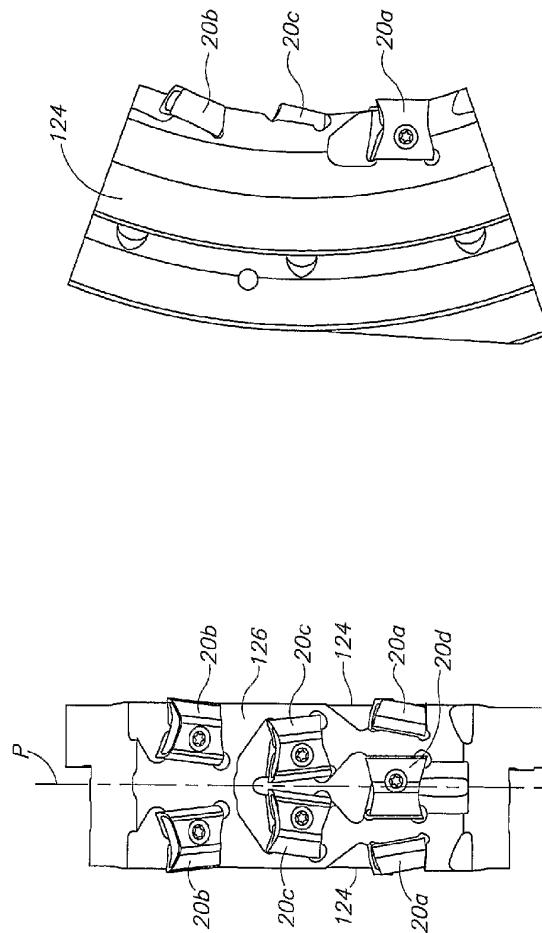


FIG.14

FIG.13