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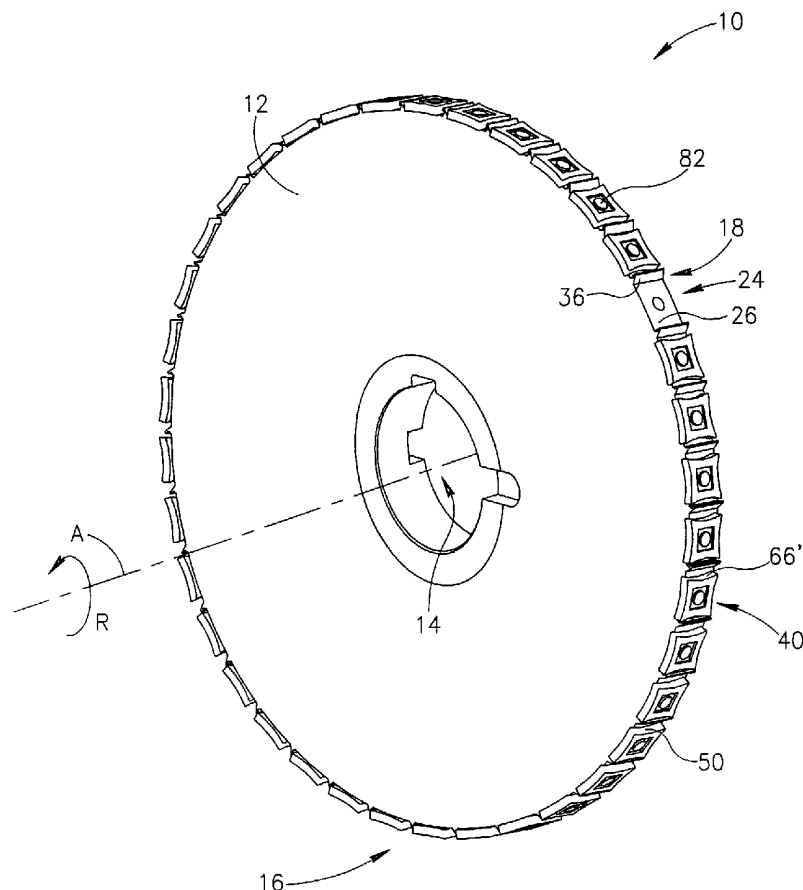
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[Continued on next page]

(54) Title: ROTARY CUTTING TOOL



(57) Abstract: A rotary cutting tool (10) having the general form of a circular disk (12) with cutting inserts (40) secured tangentially to the circumference of the tool's body, for metal machining in general and for machining cam lobes. The cutting inserts (40) have concave side surfaces (50, 52, 54, 56) and concave cutting edges (66, 68, 70, 72).



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## ROTARY CUTTING TOOL

### FIELD AND BACKGROUND OF THE INVENTION

This invention relates to rotary cutting tools having a tool body the general form of a circular disk with cutting inserts secured tangentially to the circumference of the tool body, for metal machining in general and for machining cam lobes of camshafts of internal combustion engines in particular. Such cutting tools normally employ groups of two or more cutting inserts arranged in a circumferentially staggered formation. The individual cutting edges of the cutting inserts in each group are generally oriented at non-zero lead angles. Consequently, each cutting insert has a non-zero axial component cutting force acting on it. Since the cutting inserts are staggered, the cutting tool is unbalanced with respect to the axial component cutting forces.

### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a cutting tool of the above general nature that replaces each group of cutting inserts arranged in a staggered formation by a single indexable cutting insert giving rise to a balanced cutting tool with respect to the axial component cutting forces.

In accordance with the present invention there is provided a rotary cutting tool comprising:

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a tool body in the form of a circular disk having a center and a periphery, with an axis of rotation passing through the center of the disk and a plurality of chip clearance recesses opening outwardly from and spaced angularly around the disk periphery, each chip clearance recess having a leading end and a trailing end;

5 a plurality of insert receiving pockets, each insert receiving pocket having an associated chip clearance recess and comprising a tangentially extending pocket base having a leading end and a trailing end, the leading end of the pocket base being adjacent the trailing end of the associated chip clearance recess and the trailing end of the pocket base being connected to a generally radially  
10 extending pocket rear surface;

a plurality of indexable cutting inserts, each cutting insert comprising an upper surface, a lower surface and a peripheral side surface therebetween, the peripheral side surface comprising four component side surfaces, each component side surface being joined to an adjacent side surface by a side corner,  
15 an opposite pair of the component side surfaces forming front and rear component side surfaces, each component side surface meeting the upper and lower surfaces at upper and lower component cutting edges, respectively, at least outer portions of each upper and lower component cutting edge extending generally inwardly from adjacent side corners and at least outer portions of each  
20 component side surface extending generally inwardly from adjacent side corners,

each cutting insert being removably retained in a given insert receiving pocket, wherein the lower surface of the cutting insert abuts the tangentially extending pocket base, the rear component side surface of the cutting insert abuts at two spaced apart abutment surfaces of the radially extending pocket rear surface,  
25 the front component side surface forming a rake surface and the upper component cutting edge of the front component side surface forming an operative cutting edge with outer portions of the operative cutting edge forming equally leading portions thereof.

In order to secure the cutting inserts in position, the pocket base has a

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radially extending threaded bore and each cutting insert of the plurality of cutting inserts has a through bore extending between the upper and lower surfaces and containing midpoints thereof, and each cutting insert is secured by a screw extending through the through bore and tightened into the threaded bore.

5 In accordance with a preferred embodiment of the present invention, each upper and lower component cutting edge is generally concave in form and each component side surface is generally concave in form extending inwardly from adjacent side corners.

10 Preferably, the upper and lower surfaces of the cutting insert each have a flat central portion for abutting the pocket base.

Further preferably, the upper and lower component cutting edges and the component side surfaces are divided into three portions, two outer portions and an inner portion, and the cutting insert is thicker in the region of the inner portion of the upper and lower component cutting edges than in the region of the  
15 outer portion thereof.

## BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

20 **Fig. 1** is a perspective view of a rotary cutting tool in accordance with the present invention;

**Fig. 2** is a perspective top view of a cutting insert receiving pocket in the rotary cutting tool shown in Fig. 1;

25 **Fig. 3** is a perspective view of a cutting insert retained in the rotary cutting tool in accordance with the present invention;

**Fig. 4** is a top view of the cutting insert shown in Fig. 3;

**Fig. 5** is a top view of a cutting insert receiving pocket in the rotary cutting tool shown in Fig. 1 with a cutting insert retained therein.

**Fig. 6** is a cross section taken along the line VI-VI in Fig. 5; and

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Fig. 7 is a front view of the cutting insert of the invention showing a component side surface having a chip-forming groove.

#### DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

5 Attention is drawn to the drawings in general and to Fig. 1 in particular, showing a rotary cutting tool in accordance with the present invention. The rotary cutting tool **10** comprises a tool body **12** in the form of a circular disk having a center **14** and a periphery **16**. The rotary cutting tool **10** has an axis of rotation **A** that passes through the center **14** of the tool body **12**. The tool body  
10 **12** has a plurality of chip clearance recesses **18** opening outwardly from and spaced angularly around the tool body **12** periphery **16**, each chip clearance recess having a leading end **20** and a trailing end **22**. It will be appreciated that the leading end **20** precedes the trailing end **22** with respect to the direction of rotation **R** of the rotary cutting tool **10**.

15 Associated with each chip clearance recesses **18** is an insert receiving pocket **24**. All the insert receiving pockets are at the same radial distance from the center **14** of the tool body **12**. Each insert receiving pocket **24** comprises a tangentially extending pocket base **26** having a leading end **28** and a trailing end **30**. The leading end **28** of the pocket base being adjacent the trailing end **22** of  
20 the associated chip clearance recess **18**. The trailing end **30** of the pocket base **26** being connected to a generally radially extending, substantially upright, pocket rear surface **32**. It will be appreciated that the term radially extending, is defined with respect to the axis of rotation **A**, whereas the term upright, is defined relative to the pocket base **26**. The pocket rear surface **32** and the pocket base **26** are  
25 separated by a stress relief groove **34**. It will be appreciated that when a workpiece (e.g., cam lobe) is machined, a leading portion of a given part of the cutting tool **10** will reach the workpiece before the trailing portion of that given part, as the cutting tool rotates.

As can be seen in the figures, each chip clearance recess **18** has a sloping

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chip deflecting surface 36 that slopes upwardly from the trailing end 22 of the chip clearance recess 18 to the leading end 20 thereof where it joins a circumferential portion 38 at the periphery 16 of the tool body 12. As can be clearly seen in Figs. 2 and 6, the chip clearance recess 18 together the associated  
5 insert receiving pocket 24 form a peripheral recess in the periphery 16 of the tool body 12. The circumferential portions 38 on either side of such a peripheral recess belong to the circumference of the tool body, which would be a complete cylindrical surface if it were not for the presence of the peripheral recesses.

In each insert receiving pocket 24 there is retained an indexable cutting  
10 inserts 40. Each cutting insert 40 comprising an upper surface 42, a lower surface 44 and a peripheral side surface 46 therebetween. The upper surface 42 and lower surfaces 44 each have a flat central portion 48. The peripheral side surface 46 comprises four component side surfaces 50, 52, 54, 56, each component side surface being joined to an adjacent side surface by a side corner  
15 58, 60, 62, 64. An opposite pair of component side surfaces form front 50 and rear 54 component side surfaces. In terms of the rotation of the rotary cutting tool 10, the front component side surface 50 is situated at the leading end of the cutting insert 40, whereas the rear component side surface 54 is situated at the trailing end of the cutting insert 40. Similarly, the side corners 58, 64 adjacent  
20 the front component side surface 50 are leading side corners. Furthermore, each cutting insert 40 is oriented symmetrically with respect to the plane of rotation of the cutting tool 10 and therefore the leading side corners 58, 64 are equally leading side corners. Each component side surface 50, 52, 54, 56 meets the upper surface at upper component cutting edges 66', 68', 70', 72'. Likewise, each  
25 component side surface 50, 52, 54, 56 meets the lower surface at lower component cutting edges 66'', 68'', 70'', 72''.

As seen in Fig. 3 and especially in the top view of the cutting insert 40 in Fig. 4, each upper component cutting edge 66', 68', 70', 72' and each lower component cutting edge 66'', 68'', 70'', 72'' is generally concave in form and

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each component side surface **50**, **52**, **54**, **56** is generally concave in form extending inwardly from adjacent side corners **58**, **60**, **62**, **64**. By generally concave is meant herein that the upper and lower component cutting edges and the component side surfaces could be, but do not have to be, strictly concave in the sense that portions thereof may be straight as long as they extend inwardly. With reference to Fig. 4, it will be noted that the operative cutting edge **66'** (upper component cutting edge) is divided into three portions, two outer portions **66<sub>O</sub>'** and an inner portion **66<sub>I</sub>'**. The two outer portions **66<sub>O</sub>'** of the upper component cutting edge **66'** are linear sections extending inwardly from adjacent side corners **58**, **64** to the inner portion **66<sub>I</sub>'** and the inner portion **66<sub>I</sub>'** is a circular. In accordance with the definition given herein, the upper component cutting edge **66'** is generally concave. In a similar manner all the upper component cutting edges and all the lower component cutting edge and the component side surfaces are generally concave and divided into three portions with the same geometry as the upper component cutting edge **66'**.

The cutting insert **40** is removably retained in the insert receiving pocket **24** with the lower surface **44** of the cutting insert **40** abutting the tangentially extending pocket base **26** and two spaced apart abutment regions **74** of the rear component side surface **54** abutting the radially extending pocket rear surface **32** at two spaced apart abutment surfaces **76** that substantially match in shape the abutment regions **74** of the rear component side surface **54** of the cutting insert **40**. It should be noted that the two spaced apart abutment regions **74** of the rear component side surface **54** are linear sections extending inwardly from adjacent side corners **60**, **62**, as described above with respect to the upper component cutting edge **66'**.

With the cutting insert **40** retained in the insert receiving pocket **24**, the front component side surface **50** forms a rake surface of the cutting insert **40** and the upper component cutting edge **66'** of the front component side surface **50** forms an operative cutting edge of the cutting insert **40**, with the outer portions **66<sub>O</sub>'**



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forming leading portions of the operative cutting edge 66'. It should be noted that the two outer portions 66o' extend linearly inwardly with the same slope. It will be appreciated that cutting forces acting on the operative cutting edge 66' can be resolved into two mutually perpendicular component cutting forces, an axial and a tangential component. Since the two outer portions 66o' extend linearly inwardly with the same slope and since they lead by equal amounts, the axial component cutting forces acting on the two outer portions 66o' will be equal in magnitude but opposite in direction, and will therefore cancel each other out, giving rise to a balanced rotary cutting tool 10.

10           The pocket base 26 has a radially extending threaded bore 76 and the cutting insert 40 has a through bore 80 extending between the upper 42 and lower 44 surfaces. The through bore 80 is centrally located and therefore contains the midpoints of the upper 42 and lower 44 surfaces. The cutting insert 40 is removably retained in the insert receiving pocket 24 by a screw 82 which extends  
15           through the through bore 80 and is tightened into the threaded bore 76.

          It will be appreciated that in order to machine a straight line on a section of a workpiece such as a cam lobe, the operative cutting edge has to lie on the cylindrical circumference of the tool body 12 and therefore the cutting insert 40 has to be thicker in the region of the inner portion 66i' than in the region of the  
20           outer portion 66o' of the operative cutting edge 66'. The same thickness relationship holds for all the component cutting edges. For a cutting insert having an average thickness of about 6 millimeters, a side length of about 20 millimeters with the central portion of the component side surface recessed by about 3 millimeters and for a tool body having a diameter of approximately 30 centimeters,  
25           the difference in thickness between the inner and outer portions of the cutting insert will be approximately 0.1 millimeter.

          The cutting insert of the preferred embodiment is completely indexable in the sense that all four upper component cutting edges and all four lower component cutting edges can be used as operative cutting edges.

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Although not an essential feature of the present invention, it will appreciated that the component side surfaces can include chip forming elements such as chip forming grooves and chip deflectors. As a non-limiting example, a component side surface of the cutting insert **40** of the invention can be provided  
5 with a chip forming groove **84** as shown in a front view of the cutting insert in Fig. 7.

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

**CLAIMS:****1.** A rotary cutting tool comprising:

a tool body in the form of a circular disk having a center and a periphery, with an axis of rotation passing through the center of the disk and a plurality of  
5 chip clearance recesses opening outwardly from and spaced angularly around the disk periphery, each chip clearance recess having a leading end and a trailing end;

a plurality of insert receiving pockets, each insert receiving pocket having an associated chip clearance recess and comprising a tangentially extending pocket base having a leading end and a trailing end, the leading end of the pocket  
10 base being adjacent the trailing end of the associated chip clearance recess and the trailing end of the pocket base being connected to a generally radially extending pocket rear surface;

a plurality of indexable cutting inserts, each cutting insert comprising an upper surface, a lower surface and a peripheral side surface therebetween, the  
15 peripheral side surface comprising four component side surfaces, each component side surface being joined to an adjacent side surface by a side corner, an opposite pair of the component side surfaces forming front and rear component side surfaces, each component side surface meeting the upper and lower surfaces at upper and lower component cutting edges, respectively, at least  
20 outer portions of each upper and lower component cutting edge extending generally inwardly from adjacent side corners and at least outer portions of each component side surface extending generally inwardly from adjacent side corners,

each cutting insert being removably retained in a given insert receiving pocket, wherein the lower surface of the cutting insert abuts the tangentially  
25 extending pocket base, the rear component side surface of the cutting insert abuts the radially extending pocket rear surface at two spaced apart abutment surfaces, the front component side surface forming a rake surface and the upper component cutting edge of the front component side surface forming an operative cutting edge.

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2. The rotary cutting tool according to Claim 1, wherein the pocket base has a radially extending threaded bore and each cutting insert of the plurality of cutting inserts has a through bore extending between the upper and lower surfaces and containing midpoints thereof, and each cutting insert is removably retained  
5 by a screw extending through the through bore and tightened into the threaded bore.

3. The rotary cutting tool according to Claim 1, wherein each upper and lower component cutting edge is generally concave in form and each component side surface is generally concave in form extending inwardly from adjacent side  
10 corners.

4. The rotary cutting tool according to Claim 1, wherein the upper and lower surfaces of the cutting insert each have a flat central portion.

5. The rotary cutting tool according to Claim 1, wherein the upper and lower component cutting edges and the component side surfaces are divided into  
15 three portions, two outer portions and an inner portion, the two outer portions being linear sections and the inner portion being a circular and wherein the cutting insert is thicker in the region of the inner portion than in the region of the outer portion.

6. The rotary cutting tool according to Claim 1, wherein the upper and  
20 lower component cutting edges and the component side surfaces are divided into three portions, two outer portions and an inner portion, and the cutting insert is thicker in the region of the inner portion of the upper and lower component cutting edges than in the region of the outer portion thereof.

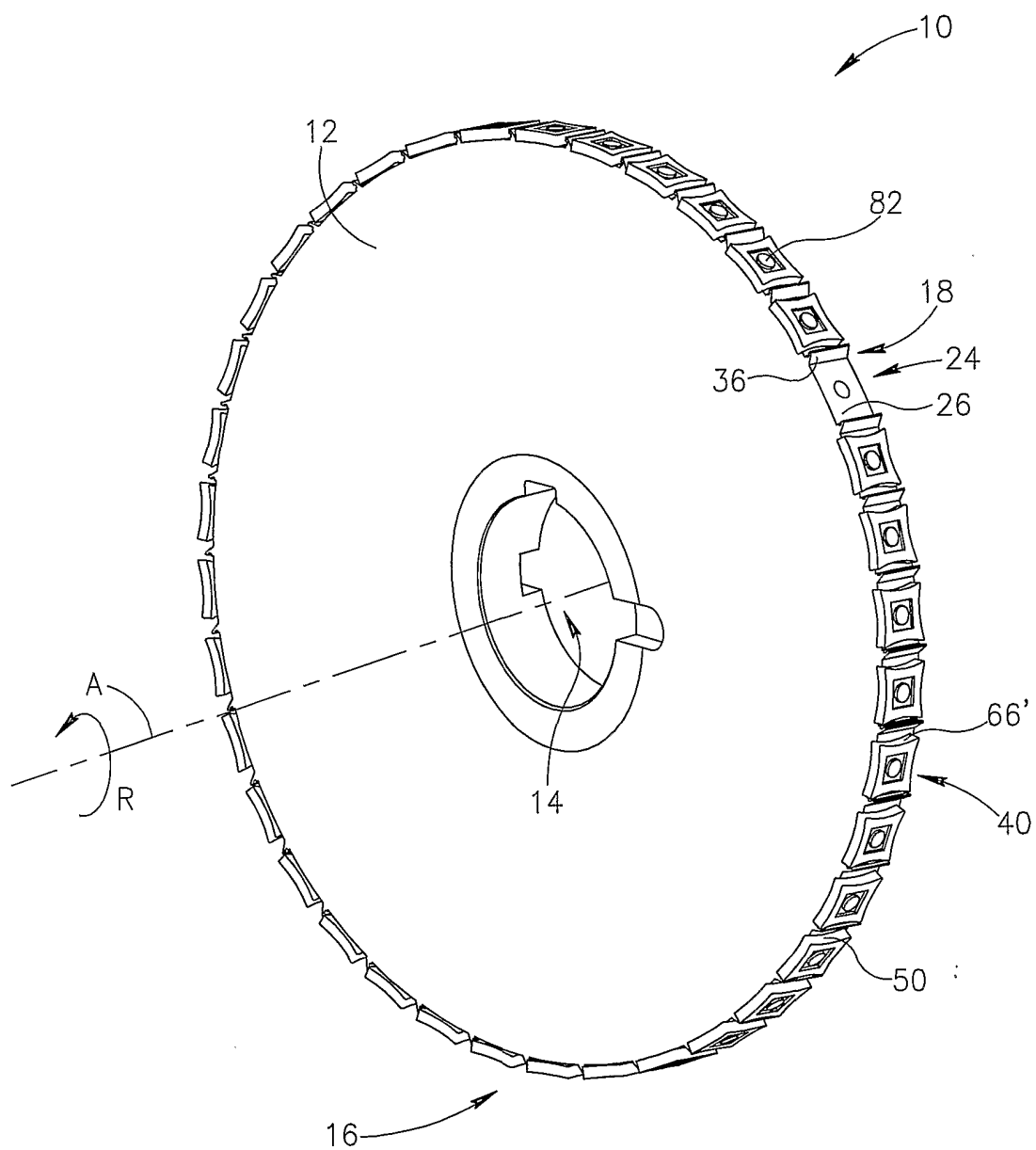
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FIG.1

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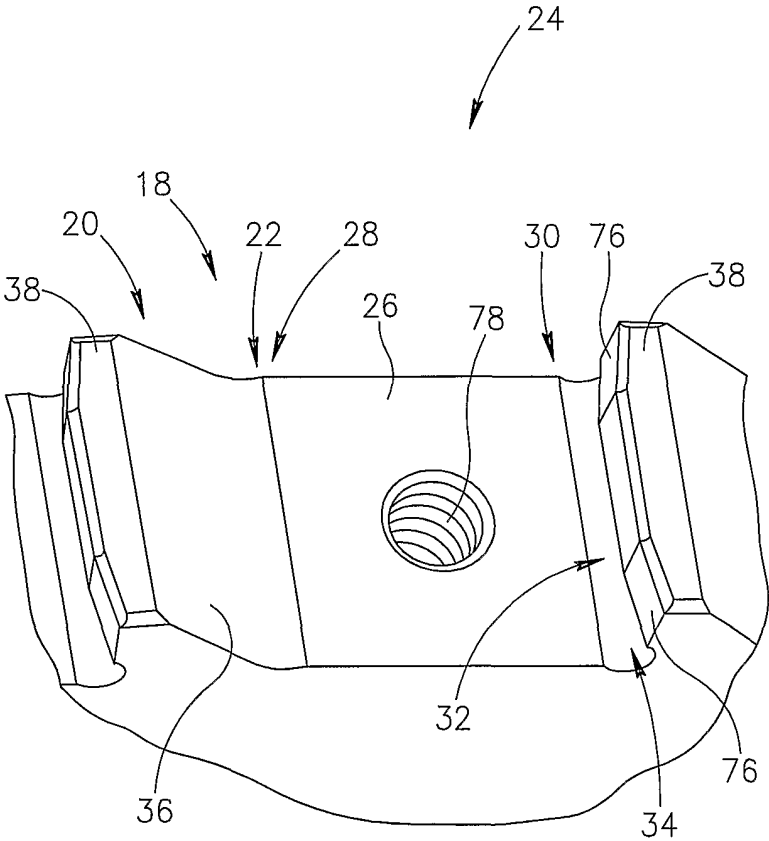
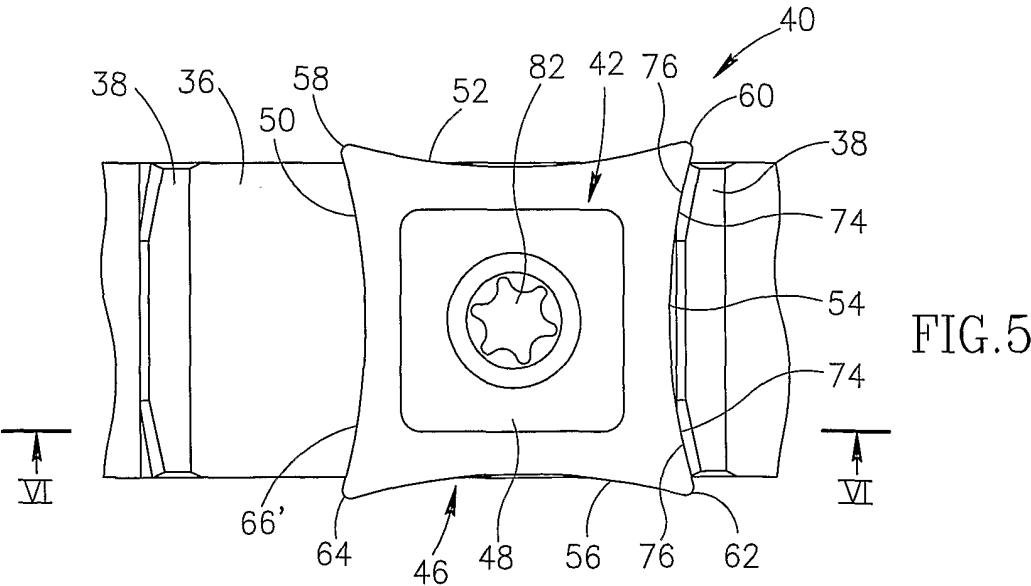
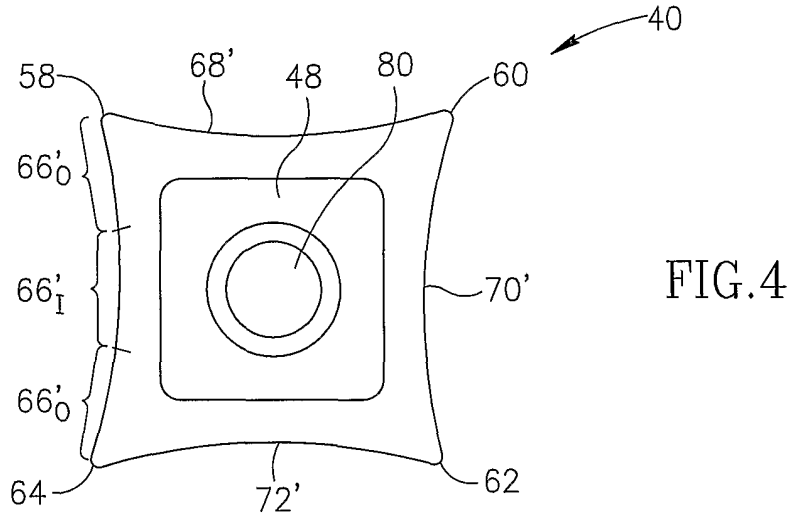
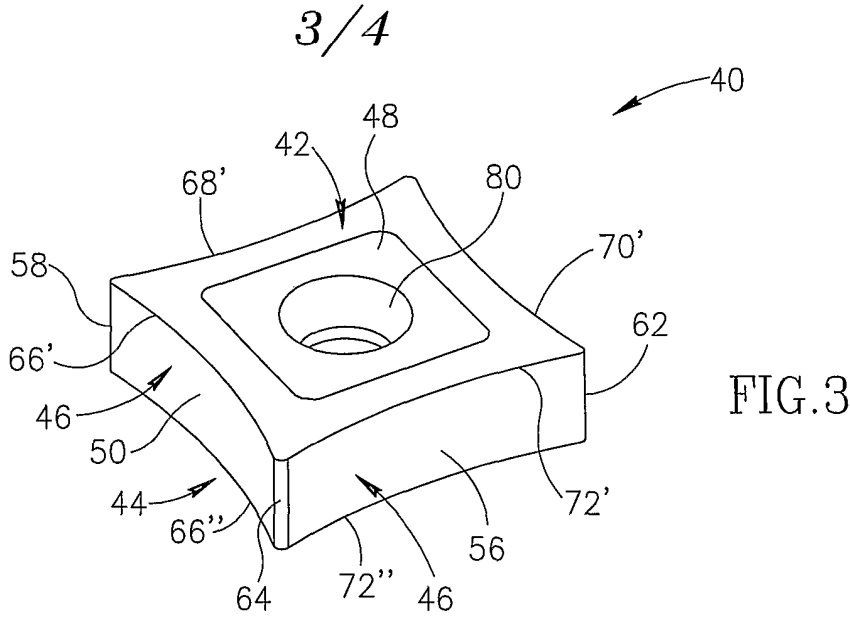


FIG.2



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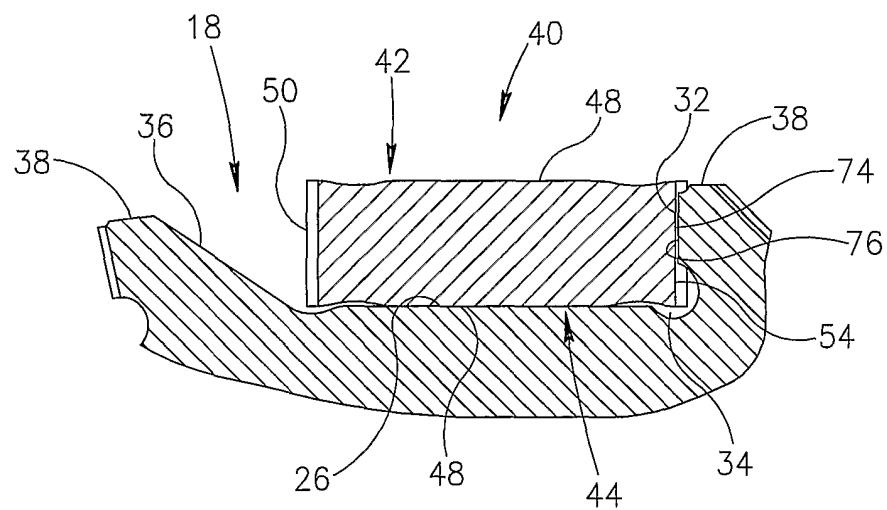


FIG.6

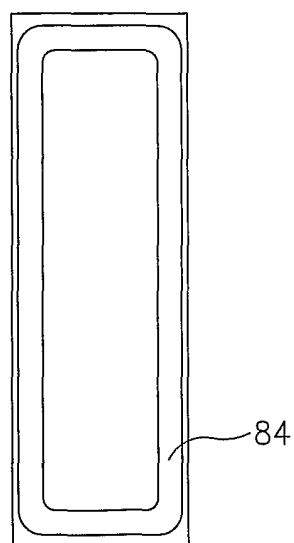


FIG. 7



## INTERNATIONAL SEARCH REPORT

Int. Application No

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**A. CLASSIFICATION OF SUBJECT MATTER**  
 IPC 7 B23C5/08 B23C5/20

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)

IPC 7 B23C B23D

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

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

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	8 April 1981 (1981-04-08) page 2, line 2 - line 15; figures 1,2	3
X	US 5 211 212 A (CARLSON)	3
A	18 May 1993 (1993-05-18) column 3, line 52 -column 4, line 15; figures 4-6	4-6
A	US 6 074 137 A (BETMAN)	
	13 June 2000 (2000-06-13) figures 7,11	
A	WO 98 33615 A (ISCAR)	
	6 August 1998 (1998-08-06) figures 7A,7B	



Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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