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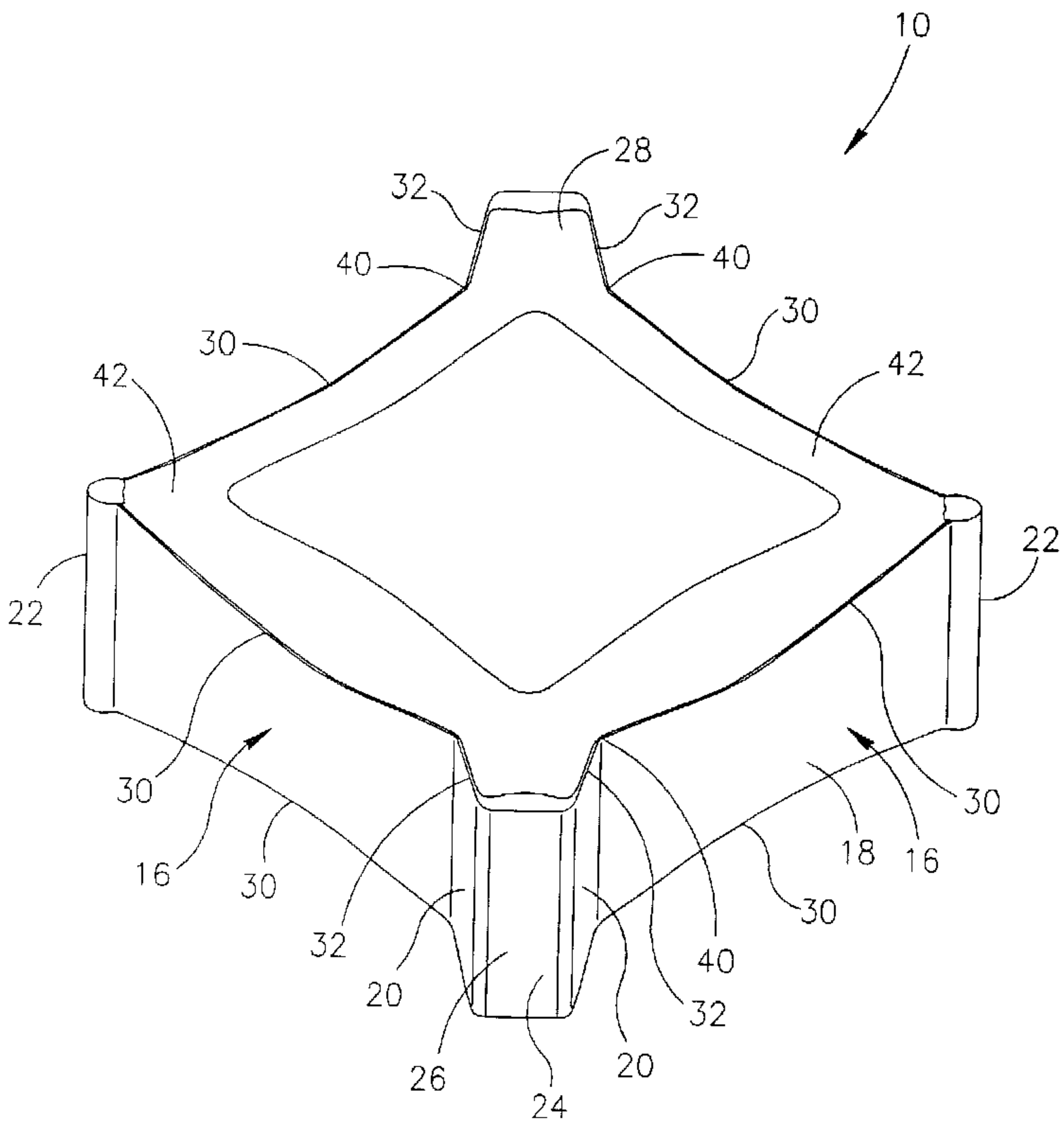
(54) Title: MILLING CUTTER AND CUTTING INSERT THEREFOR



(57) Abrégé/Abstract:
An indexable cutting insert (10) for use in a milling cutter (50). The cutting insert (10) having four identical side surfaces (16) extending between generally square shaped top (12) and bottom surfaces (14) with two diametrically opposite protuberances (28) extending away from each other in a top or bottom view of the cutting insert (10). The cutting insert (10) has eight identical major (30) and minor cutting edges (32). The milling cutter (50) having the general form of a circular disk (52) with a plurality of the cutting inserts (10) releasably mounted in insert pockets (54) angularly around the periphery (58) of the cutter. The cutting inserts (10) are arranged to produce a profile (60) on a workpiece (62) having a central straight section (60) and two beveled sections (60', 60") on either side of the central straight section (60).

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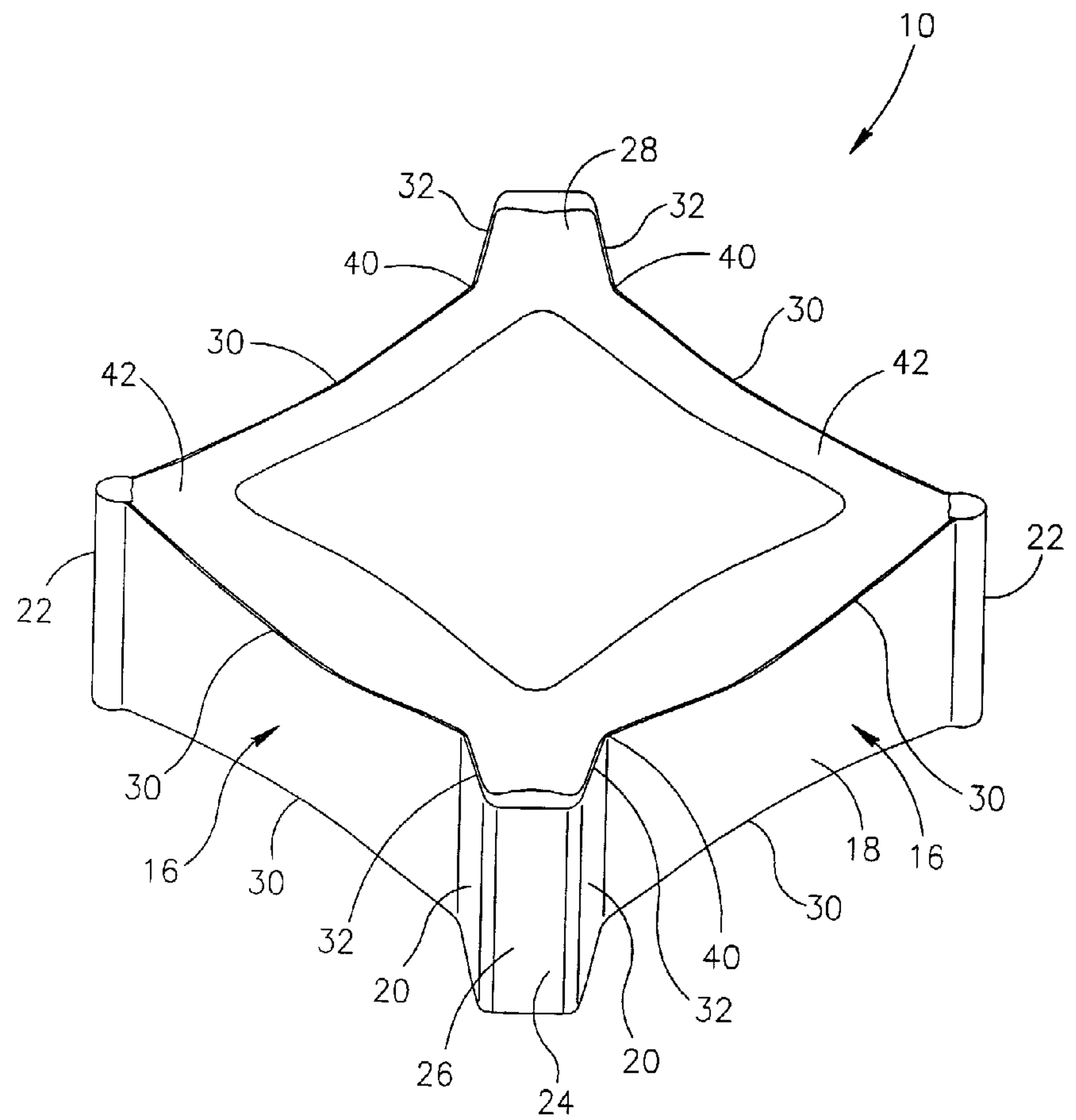
(54) Title: MILLING CUTTER AND CUTTING INSERT THEREFOR



(57) Abstract: An indexable cutting insert (10) for use in a milling cutter (50). The cutting insert (10) having four identical side surfaces (16) extending between generally square shaped top (12) and bottom surfaces (14) with two diametrically opposite protuberances (28) extending away from each other in a top or bottom view of the cutting insert (10). The cutting insert (10) has eight identical major (30) and minor cutting edges (32). The milling cutter (50) having the general form of a circular disk (52) with a plurality of the cutting inserts (10) releasably mounted in insert pockets (54) angularly around the periphery (58) of the cutter. The cutting inserts (10) are arranged to produce a profile (60) on a workpiece (62) having a central straight section (60) and two beveled sections (60', 60'') on either side of the central straight section (60).

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MILLING CUTTER AND CUTTING INSERT THEREFOR

FIELD OF THE INVENTION

The present invention relates to a milling cutter and a cutting insert for machining metal workpieces in general and the cams of camshafts in particular.

BACKGROUND OF THE INVENTION

A milling cutter of this type is disclosed in JP 2000052131. The milling cutter disclosed in this publication comprises groups of two tangentially oriented cutting inserts arranged in pairs a circumferentially staggered formation. The two inserts of a given pair overlap at least partially when superimposed. As shown in Fig. 8 of this publication the milling cutter is only suitable for machining the flank (outer peripheral curved surface) of the cams of a camshaft.

Another milling cutter for machining the cams of camshafts is disclosed in JP 11138325. This milling cutter not only machines the flank of a cam but also chamfers the edges of the flank. The milling cutter disclosed in this publication also comprises groups of cutting inserts arranged in a circumferentially staggered formation. There are first pairs of cutting inserts that at least partially overlap when superimposed that machine the flank of the cam, as in JP 2000052131. In addition, there are second pairs of cutting inserts, different from the first pairs, located on the rim on the cutter in a circumferentially staggered manner, that chamfer the edges of the flank.

It is an object of the present invention to provide a milling cutter and a cutting insert capable of machining the flank of a cam of a camshaft and also of chamfering the edges of the flank, wherein the milling cutter comprises groups of two radially oriented identical cutting inserts arranged in a circumferentially staggered formation and each cutting insert has eight cutting edges.

SUMMARY OF THE INVENTION

In accordance with the present invention there is provided an indexable cutting insert for use in a milling cutter comprising:

generally square shaped top and bottom surfaces;

four substantially identical side surfaces extending between the top surface and the bottom surface;

two diametrically opposite protuberances extending away from each other in a top or bottom view of the cutting insert, each protuberance having a peripheral side surface comprising an intermediate side surface and two minor side surfaces, the intermediate side surface being located between and merging with the two minor side surfaces, each side surface comprising a major side surface connected to an adjacent minor side surface, adjacent major side surfaces merging at two diametrically opposite corner edges of the cutting insert;

eight identical major cutting edges, comprising four major cutting edges formed at the intersection of the major side surfaces with the top surface and four major cutting edges formed at the intersection of the major side surfaces with the bottom surface; and

eight identical minor cutting edges, comprising four minor cutting edges formed at the intersection of the minor side surfaces with the top surface and four minor cutting edges formed at the intersection of the minor side surfaces with the bottom surface, each minor cutting edge being connected to an adjacent major cutting edge.

In accordance with a preferred embodiment of the present invention, the minor cutting edges are shorter than the major cutting edges and form therewith an obtuse angle in a top or bottom view of the cutting insert.

Further in accordance with a preferred embodiment of the present invention, each side surface has a varying height dimension.

Preferably, the height dimension has a minimum value in a central region of the side surface.

Further preferably, the height dimension decreases monotonically from a maximum value at an outer region of the side surface to the minimum value at the central region.

Typically, the top and bottom surfaces are provided with a chip groove adjacent and extending longitudinally along the major and minor cutting edges.

Preferably, the top surface is provided with a top abutment surface generally centrally located with respect to the major cutting edges and the bottom surface is provided with a bottom abutment surface generally centrally located with respect to the major cutting edges and generally facing away from the top abutment surface.

In accordance with a preferred embodiment, the top and bottom abutment surfaces are flat and parallel to each other and separated by a given distance.

Further in accordance with a preferred embodiment, the given distance between the top and bottom abutment surfaces is at least equal to the maximum value of the height dimension of the side surfaces.

If desired, the cutting insert is provided with a land extending from the major and minor cutting edges towards the chip groove.

There is also provided in accordance with the present invention, a milling cutter comprising a tool body having the general form of a circular disk and a plurality of identical cutting inserts releasably mounted in insert pockets;

the tool body having two oppositely facing generally circular side faces connected by a peripheral mounting face, an axis of rotation passing through the side faces, the axis of rotation defining a direction of rotation of the milling cutter;

the insert pockets being spaced angularly around the peripheral mounting face;

the cutting inserts comprising:

generally square shaped top and bottom surfaces;

four substantially identical side surfaces extending between the bottom surface and the top surface;

two diametrically opposite protuberances extending away from each other in a top or bottom view of the cutting insert, each protuberance having a peripheral side surface comprising and intermediate side surface and two minor side surfaces, the intermediate side surface being located between and merging with the two minor side surfaces, each side surface comprising a major side surface connected to an adjacent minor side surface, adjacent major side surfaces merging at two diametrically opposite corner edges of the cutting insert;

eight identical major cutting edges, formed at the intersection of the major side surfaces with the top and bottom surfaces; and

eight identical minor cutting edges, formed at the intersection of the minor side surfaces with the top and bottom surfaces, each minor cutting edge being connected to an adjacent major cutting edge;

the cutting inserts being arranged in a staggered formation in pairs with one of the top or bottom abutment surfaces of each cutting insert facing in the direction of rotation,

a first cutting insert of a given pair of cutting inserts having a radially and axially outermost first protuberance protruding axially at least partially from a first side face of the tool body, a second cutting insert of the given pair of cutting inserts having a radially and axially outermost second protuberance protruding axially at least partially from a second side face of the tool body.

In accordance with a preferred embodiment, the first cutting insert has a first major cutting edge located at a given radial distance from the axis of rotation and the second cutting insert has a second major operative cutting edge located at the same given radial distance.

Generally, the first and second protuberances protrude radially at least partially from the peripheral mounting face.

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:

Fig. 1 is a perspective view of the cutting insert in accordance with the present invention;

Fig. 2 is a top view of the cutting insert illustrated in Fig. 1;

Fig. 3 is a side view of the cutting insert illustrated in Fig. 1;

Fig. 4 is a cross section of a portion of the cutting insert along the line IV-IV in Fig. 2;

Fig. 5 is a cross section of a portion of the cutting insert along the line V-V in Fig. 2;

Fig. 6 is a perspective view of a milling cutter in which are seated cutting inserts in accordance with the present invention;

Fig. 7 is a perspective view of a portion of the milling cutter shown in Fig. 5;

Fig. 8 is a radial end view of a portion of the milling cutter shown in Fig. 5; and

Fig. 9 is a partial view showing how two cutting inserts of the milling cutter shown in Fig. 5 are mutually superimposed to produce the required profile in a workpiece.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Attention is first drawn to Figs. 1 to 3. The cutting insert **10** in accordance with the present invention has generally square shaped top **12** and bottom **14** surfaces. The cutting insert can be manufactured by pressing and sintering or by injection molding. Four substantially identical side surfaces **16** extend between the top surface **12** and the bottom surface **14**. The side surfaces **16** are designed to be identical, however, as a result of the manufacturing process one or more of the side surfaces may be slightly different from the required design. For example, it is known that during sintering the cutting insert shrinks and that the shrinkage may be non-uniform. Therefore, substantially identical means herein, as identical as can be achieved taking into consideration manufacturing tolerances. Each side surface **16** comprises a major side surface **18** connected to an adjacent minor side surface **20**. Adjacent major side surfaces **18** merge at two diametrically opposite corner edges **22**.

Adjacent minor side surfaces **20** merge at an intermediate side surface **24**. The two adjacent minor side surfaces **20** and the intermediate side surface **24** form the peripheral side surface **26** of a protuberance **28** protruding outwardly from the cutting insert **10**. There are two diametrically opposite protuberances **28** that extend away from each other, in a top or bottom view of the cutting insert **10**, as can be seen in Fig. 2.

The intersection of each major side surface **18** with the top **12** or bottom **14** surface defines a major cutting edge **30**. There are eight substantially identical major cutting edges **30**. The intersection of each minor side surface **20** with the top **12** or bottom **14** surface defines a minor cutting edge **32**. There are eight substantially identical minor cutting edges **32**. Each minor cutting edge **32** is connected to an adjacent major cutting edge **30**. In accordance with a preferred embodiment of the present invention, the minor cutting edges **32** are shorter than the major cutting edges **30** and form therewith an obtuse angle α in a top or bottom view of the cutting insert **10**, as can be seen in Fig. 2.

For each side surface **16** a height dimension **H** is defined as the vertical height of the side surface in a side view of the cutting insert (see Fig. 3). In other words, the height dimension **H** is the distance between a first point P_1 on the major cutting edge **30** associated with the bottom surface **14** and a vertically opposite second point P_2 on the major cutting edge **30** associated with the top surface **12**. In accordance with a preferred embodiment of the present invention, each side surface **16** has a varying height dimension **H**. Preferably, the height dimension **H** has a minimum value H_{min} in a central region **34** of the side surface **16**. Further preferably, the height dimension **H** decreases monotonically from a maximum value H_{max} at an outer region **36** of the side surface **16** to the minimum value H_{min} at the central region **34**.

With reference to Fig. 3, two planes are defined. A median plane **M** located midway between the top and bottom surfaces **12, 14** and a reference plane **N** parallel to the median plane **M** and passing through the outer extremities **38** of the minor cutting edges **32** associated with the top surface **12**. A similar reference plane associated with the bottom surface **14** could also be defined, however, it is redundant since the cutting insert **10** has mirror symmetry with respect to the median plane **M**.

For a given side surface **16** the major and minor cutting edges **30, 32** associated with the given side surface have a varying slope that is directly related to the varying height dimension. The minor cutting edge **32** extends from its outer extremity **38** to a point **40** where it merges with the major cutting edge **30** whilst sloping away from the reference plane **N** and towards the median plane **M**. The major cutting edge **30** comprises two sections, a first section 30_1 extends from the point **40**, where it merges with the minor cutting edge **32**, towards the central region **34** of the side surface **16** whilst sloping away from the reference plane **N** and towards the median plane **M**, a second section 30_2 extends from the central region **34** of the side surface **16** whilst sloping towards the reference plane **N** and away from the median plane **M**. Reference is also made to Figs. 4 and 5 showing a chip groove **42** provided in the top and bottom surfaces **12, 14**. The chip groove **42** is adjacent to and extends longitudinally along the major and minor cutting edges

30, 32.

The top surface 12 is provided with a top abutment surface 44 generally centrally located with respect to the major cutting edges 30 and the bottom surface 14 is provided with a bottom abutment surface 46 generally centrally located with respect to the major cutting edges 30 and generally facing away from the top abutment surface 44. In accordance with a preferred embodiment, the top and bottom abutment surfaces 44, 46 are flat and parallel to each other. The distance between the top and bottom abutment surfaces 44, 46 is at least equal to the maximum value H_{max} of the height dimension H of the side surfaces. The cutting insert 10 is provided with a land 48 extending from the major and minor cutting edges 30, 32 towards the chip groove 42.

Attention is now drawn to Figs. 6 to 8, showing a milling cutter 50, comprising a tool body 52 having the general form of a circular disk and a plurality of identical cutting inserts 10, in accordance with the present invention, releasably mounted in insert pockets 54. In Fig. 6 only three cutting inserts 10 are shown and the same three cutting inserts are shown in Figs. 7 and 8. The tool body 52 has two oppositely facing generally circular side faces 56 connected by a peripheral mounting face 58. An axis of rotation A passes through the side faces 56 and defines a direction of rotation R of the milling cutter 50.

The insert pockets 54 are spaced angularly around the peripheral mounting face 58 and the cutting inserts 10 are arranged in a staggered formation in pairs with one of the top or bottom abutment surfaces 44, 46 of each cutting insert 10 facing in the direction of rotation R. A first cutting insert 10' of a given pair of cutting inserts has a radially and axially outermost first protuberance 28' protruding axially at least partially from a first side face 56' of the tool body 52. A second cutting insert 10" of the given pair of cutting inserts has a radially and axially outermost second protuberance 28" protruding axially at least partially from a second side face 56" of the tool body 52. Generally, the first and second protuberances 28', 28" protrude radially at least partially from the peripheral mounting face **58**.

Attention is now drawn to Fig. 9 showing how the two cutting inserts **10'**, **10''** of the milling cutter **50** produce a required profile **60, 60'**, **60''** in a workpiece **62**. The workpiece being the cam of a camshaft. In the figure the two cutting inserts **10'**, **10''** mutually superimposed with the first cutting insert **10'**, represented by a solid line, being in front of the second cutting insert **10''**, which is represented by a dashed line. The required profile in the workpiece comprises a central straight section **60** (the flank of the cam) and two beveled sections **60'**, **60''** (the chamfered edges of the flank) on either side of the central straight section **60**. The first beveled section **60'** is formed by the first minor cutting edge **32'** associated with the first protuberance **28'** of the first cutting insert **10'**, whereas the second beveled section **60''** is formed by the second minor cutting edge **32''** associated with the second protuberance **28''** of the second cutting insert **10''**. The central straight section **60** is formed by both the first major cutting edge **30'** of the first insert **10'** and the second major cutting edge **30''** of the second insert **10''**, which, as can be seen overlap. Since, the first major cutting edge **30'** of the first insert **10'** and the second major cutting edge **30''** of the second insert **10''** overlap, they are located at the same radial distance from the axis of rotation.

Referring to Fig. 8 it can be seen that the fact that the major cutting edge **30 (30'**, **30'')** slopes as described above, introduces an inherent axial rake thereby avoiding the necessity of positioning the top surface **12** of the cutting insert **10** at an angle to the axis of rotation **A**. Consequently, the angular pitch between adjacent cutting inserts can be reduced giving rise to the well-known advantages of close pitch milling cutters. It will be apparent that a further advantage of the cutting insert in accordance with the teachings of the present invention is the possibility of using the same cutting inserts in milling cutters of different widths. Therefore, by adjusting the axial overlap of the cutting inserts, the length of the central straight section **60** in the workpiece can be altered. Yet a further advantage of the present invention is that the milling cutter uses a single type of cutting insert that can be indexed eight times and that can be used as either a right-hand or left-hand cutting insert when mounted on the milling cutter.

As can be seen in Figs. 7 and 8, the cutting insert **10** is retained in the insert pocket **54** by means of a wedge **64**, which abuts the top abutment surface **44** of the insert **10**. The wedge **64** being secured to the tool body **52** of the milling cutter **50** by a screw **66**. The insert **10** is wedged between the wedge **64** and a support surface **68** of the insert pocket **54**. The support surface **68** faces the direction of rotation **R**. As can be seen, the bottom surface **14** of the insert **10** abuts the support surface **68** in the region of protrusion **28** and the corner edge **22**, thereby supporting the insert **10** against cutting forces when the milling cutter **50** is in operation. As can be seen in Fig. 3, this arrangement is made possible by the fact that both the corner edges **22** and the protrusions have the same height $\mathbf{H_{max}}$, and also by the fact that the corner edges **22** are cylindrical in shape, giving them a larger surface area than would be obtained by a corner edge that would be formed merely by the intersection of adjacent major side surfaces **18**.

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

CLAIMS:

1. An indexable cutting insert (10) for use in a milling cutter (50) comprising:

generally square shaped top and bottom surfaces (12, 14);

four substantially identical side surfaces (16) extending between the top surface (12) and the bottom surface (14);

two diametrically opposite protuberances (28) extending away from each other in a top or bottom view of the cutting insert (10), each protuberance (28) having a peripheral side surface (26) comprising an intermediate side surface (24) and two minor side surfaces (20), the intermediate side surface (24) being located between and merging with the two minor side surfaces (20), each side surface (16) comprising a major side surface (18) connected to an adjacent minor side surface (20), adjacent major side surfaces (18) merging at two diametrically opposite corner edges (22) of the cutting insert (10);

eight identical major cutting edges (30), comprising four major cutting edges (30) formed at the intersection of the major side surfaces (18) with the top surface (12) and four major cutting edges (30) formed at the intersection of the major side surfaces (18) with the bottom surface (14); and

eight identical minor cutting edges (32), comprising four minor cutting edges (32) formed at the intersection of the minor side surfaces (20) with the top surface (12) and four minor cutting edges (32) formed at the intersection of the minor side surfaces (20) with the bottom surface (14), each minor cutting edge (32) being connected to an adjacent major cutting edge (30).

2. The cutting insert according to claim 1, wherein the minor cutting edges (32) are shorter than the major cutting edges (30) and form therewith an obtuse angle (α) in a top or bottom view of the cutting insert (10).

3. The cutting insert according to claim 1, wherein each side surface (16) has a varying height dimension (H).

4. The cutting insert according to claim 3, wherein the height dimension (H) has a minimum value (H_{min}) in a central region (34) of the side surface (16).

5. The cutting insert according to claim 4, wherein the height dimension (H) decreases monotonically from a maximum value (H_{max}) at an outer region (36) of the side surface (16) to the minimum value (H_{min}) at the central region.

6. The cutting insert according to claim 1, wherein the top and bottom surfaces (12, 14) are provided with a chip groove (42) adjacent and extending longitudinally along the major and minor cutting edges (30, 32).

7. The cutting insert according to claim 1, wherein the top surface (12) is provided with a top abutment surface (44) generally centrally located with respect to the major cutting edges (30) and the bottom surface (14) is provided with a bottom abutment surface (46) generally centrally located with respect to the major cutting edges (30) and generally facing away from the top abutment surface (44).

8. The cutting insert according to claim 7, wherein the top and bottom abutment surfaces (44, 46) are flat and parallel to each other and separated by a given distance.

9. The cutting insert according to claim 8, wherein the given distance between the top and bottom abutment surfaces (44, 46) is at least equal to the maximum value (H_{max}) of the height dimension (H) of the side surfaces (16).

10. The cutting insert according to claim 6, wherein the cutting insert (10) is provided with a land (48) extending from the major and minor cutting edges (30, 32) towards the chip groove (42).

11. A milling cutter (50) comprising a tool body (52) having the general form of a circular disk and a plurality of identical cutting inserts (10) releasably mounted in insert pockets (54);

the tool body (52) having two oppositely facing generally circular side faces (56) connected by a peripheral mounting face (58), an axis of rotation (A) passing through the side faces (65), the axis of rotation (A) defining a direction of rotation (R) of the milling cutter (50);

the insert pockets (54) being spaced angularly around the peripheral mounting face (58);

the cutting inserts (10) comprising:

generally square shaped top and bottom surfaces (12, 14);

four substantially identical side surfaces (16) extending between the top surface (12) and the bottom surface (14);

two diametrically opposite protuberances (28) extending away from each other in a top or bottom view of the cutting insert (10), each protuberance (28) having a peripheral side surface (26) comprising and intermediate side surface (24) and two minor side surfaces (20), the intermediate side surface (24) being located between and merging with the two minor side surfaces (20), each side surface (16) comprising a major side surface (18) connected to an adjacent minor side surface (20), adjacent major side surfaces (18) merging at two diametrically opposite corner edges (22) of the cutting insert (10);

eight identical major cutting edges (30), formed at the intersection of the major side surfaces (18) with the top and bottom surfaces (12, 14); and

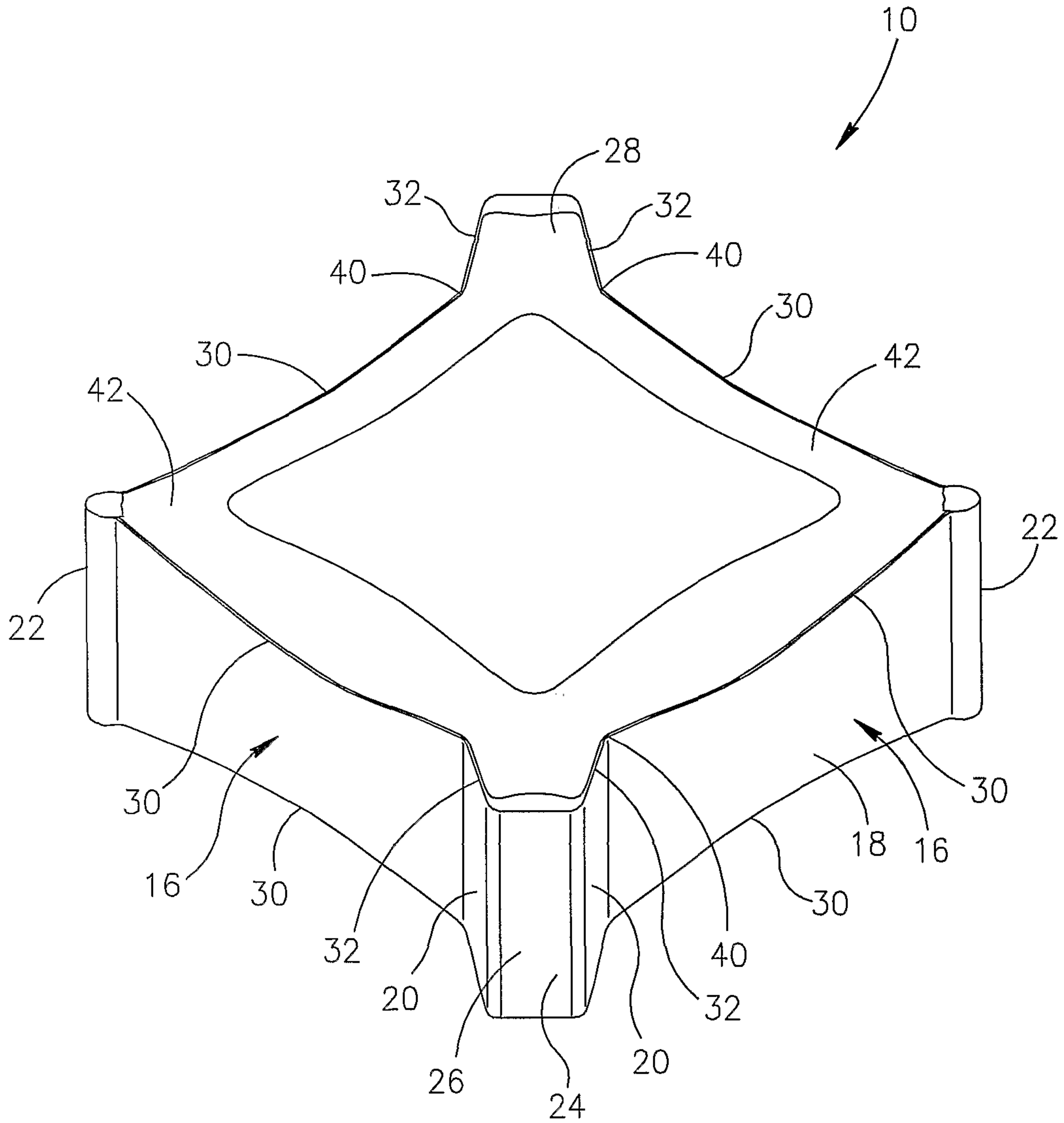
eight identical minor cutting edges (32), formed at the intersection of the minor side surfaces (18) with the top and bottom surfaces (12, 14), each minor cutting edge (32) being connected to an adjacent major cutting edge (30);

the cutting inserts (10) being arranged in a staggered formation in pairs with one of the top or bottom abutment surfaces (44, 46) of each cutting insert (10) facing in the direction of rotation (R),

a first cutting insert (10') of a given pair of cutting inserts having a radially and axially outermost first protuberance (28') protruding axially at least partially from a first side face (56') of the tool body (52), a second cutting insert (10") of the given pair of cutting inserts having a radially and axially outermost second protuberance (28") protruding axially at least partially from a second side face (56") of the tool body (52).

12. The milling cutter according to claim 11, wherein the first cutting insert (10') has a first major cutting edge (30') located at a given radial distance from the axis of rotation (A) and the second cutting insert (10") has a second major cutting edge (30") located at the same given radial distance.

13. The milling cutter according to claim 12, wherein the first and second protuberances (28', 28") protrude radially at least partially from the peripheral mounting face (58).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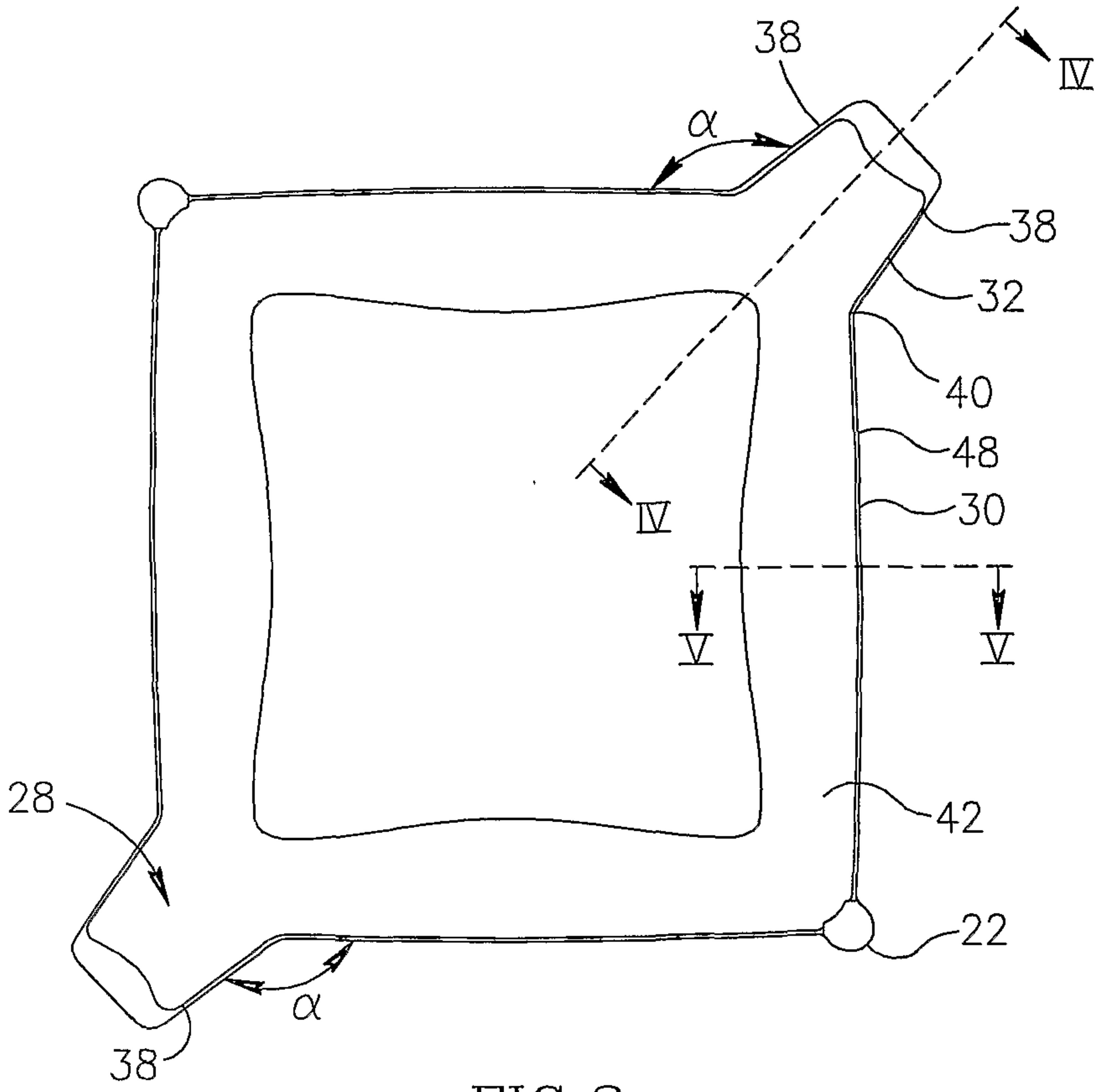
20
32
26
24

FIG.1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V
V
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22
α
38

FIG.2

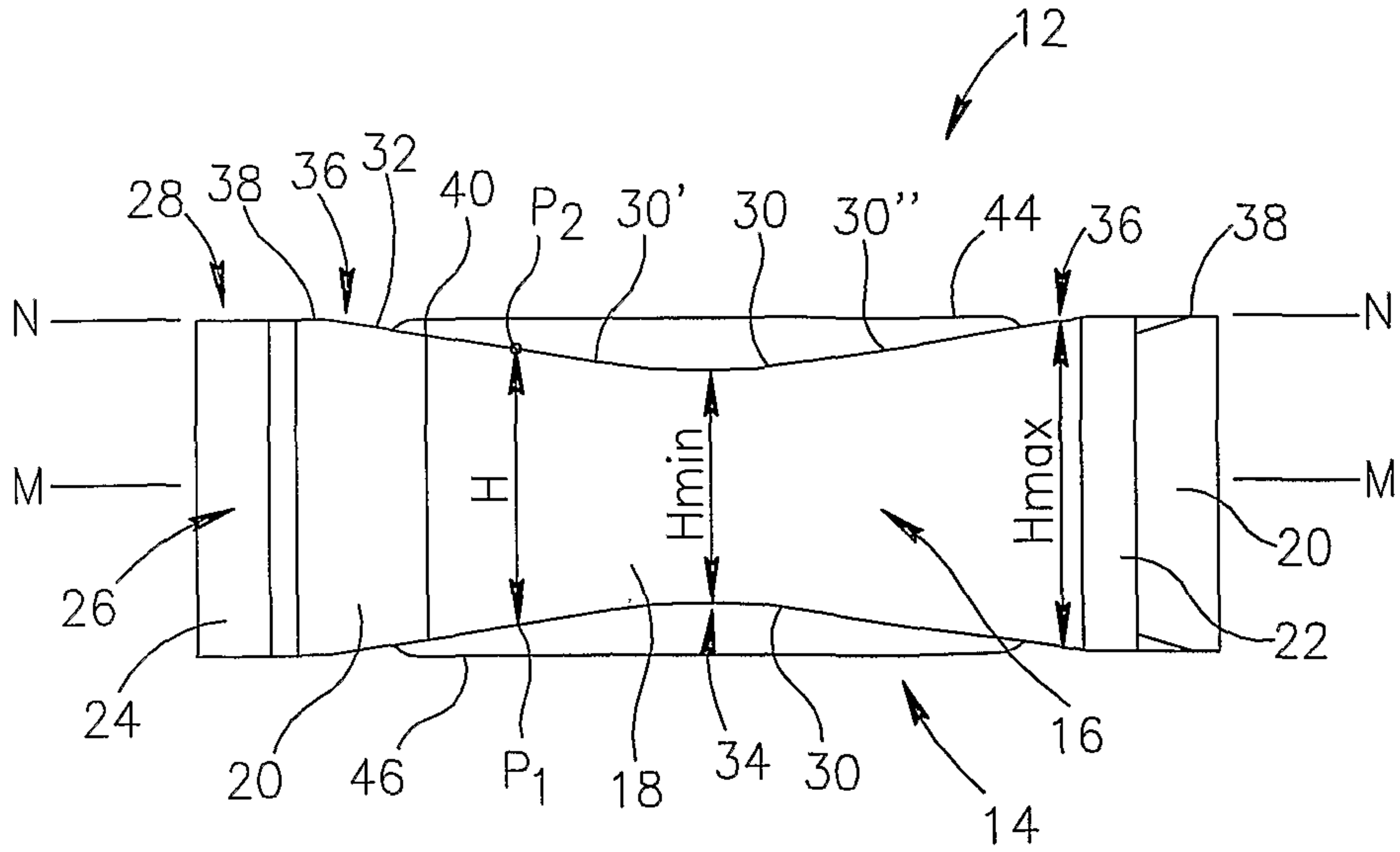
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FIG.3

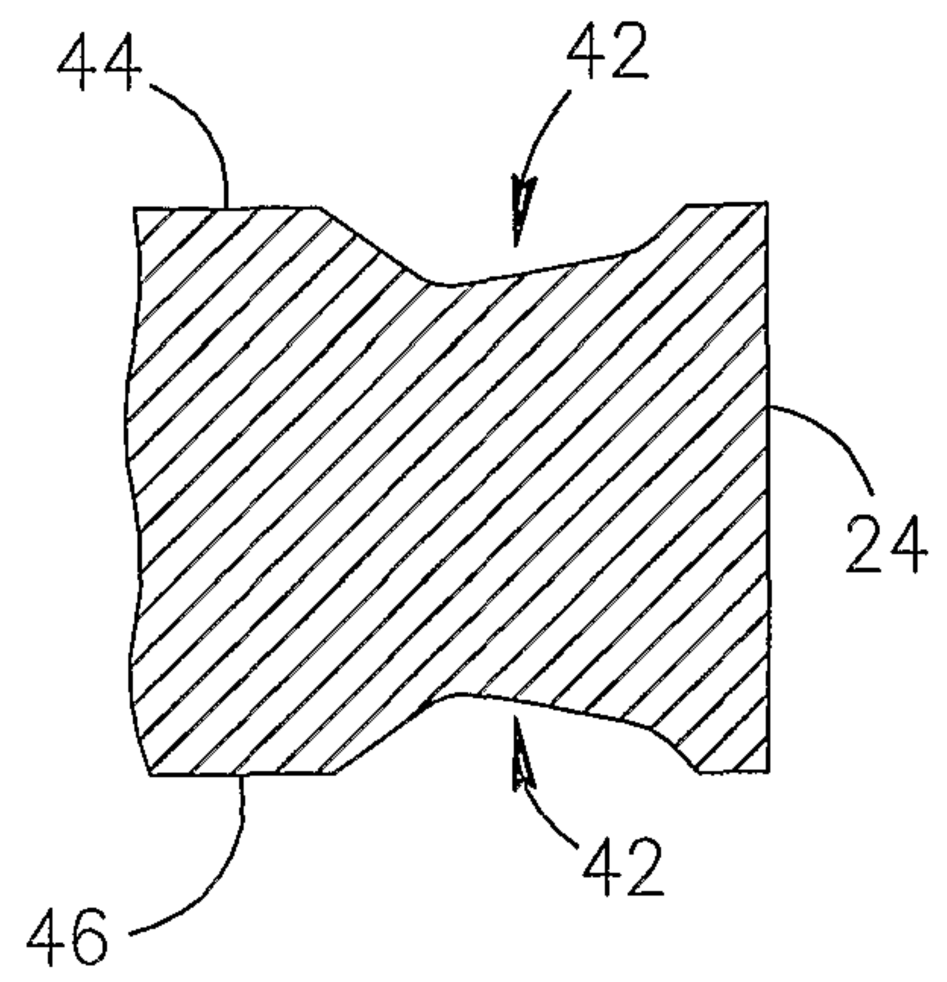


FIG.4

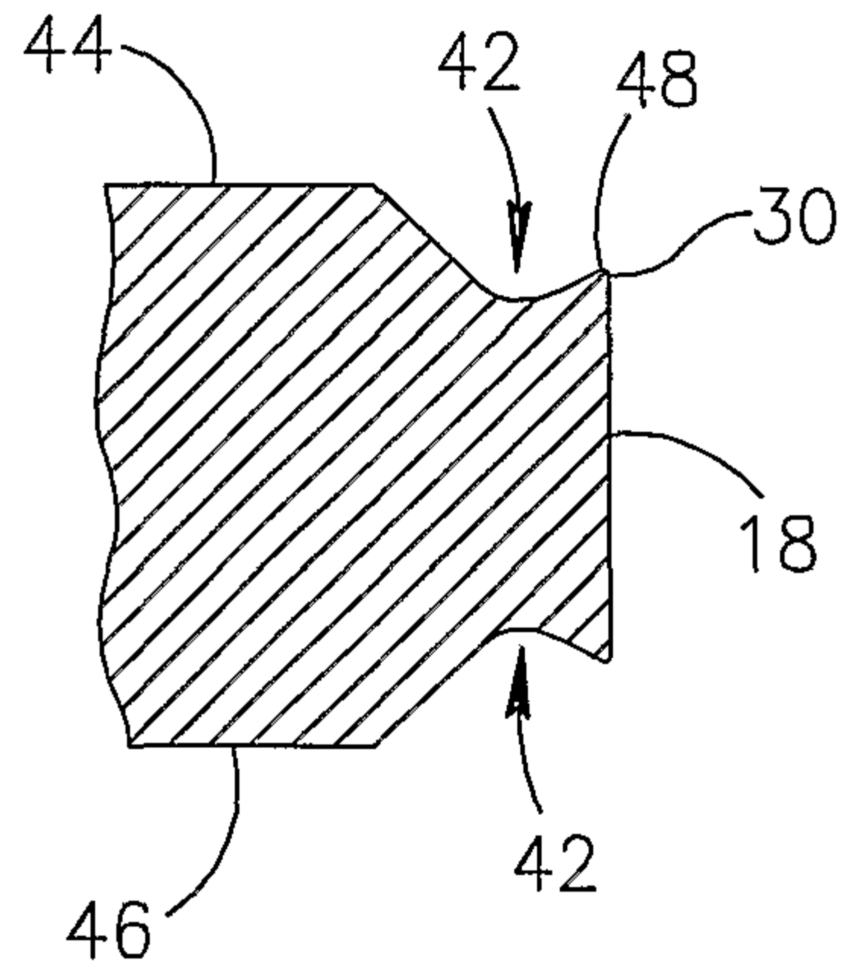


FIG.5

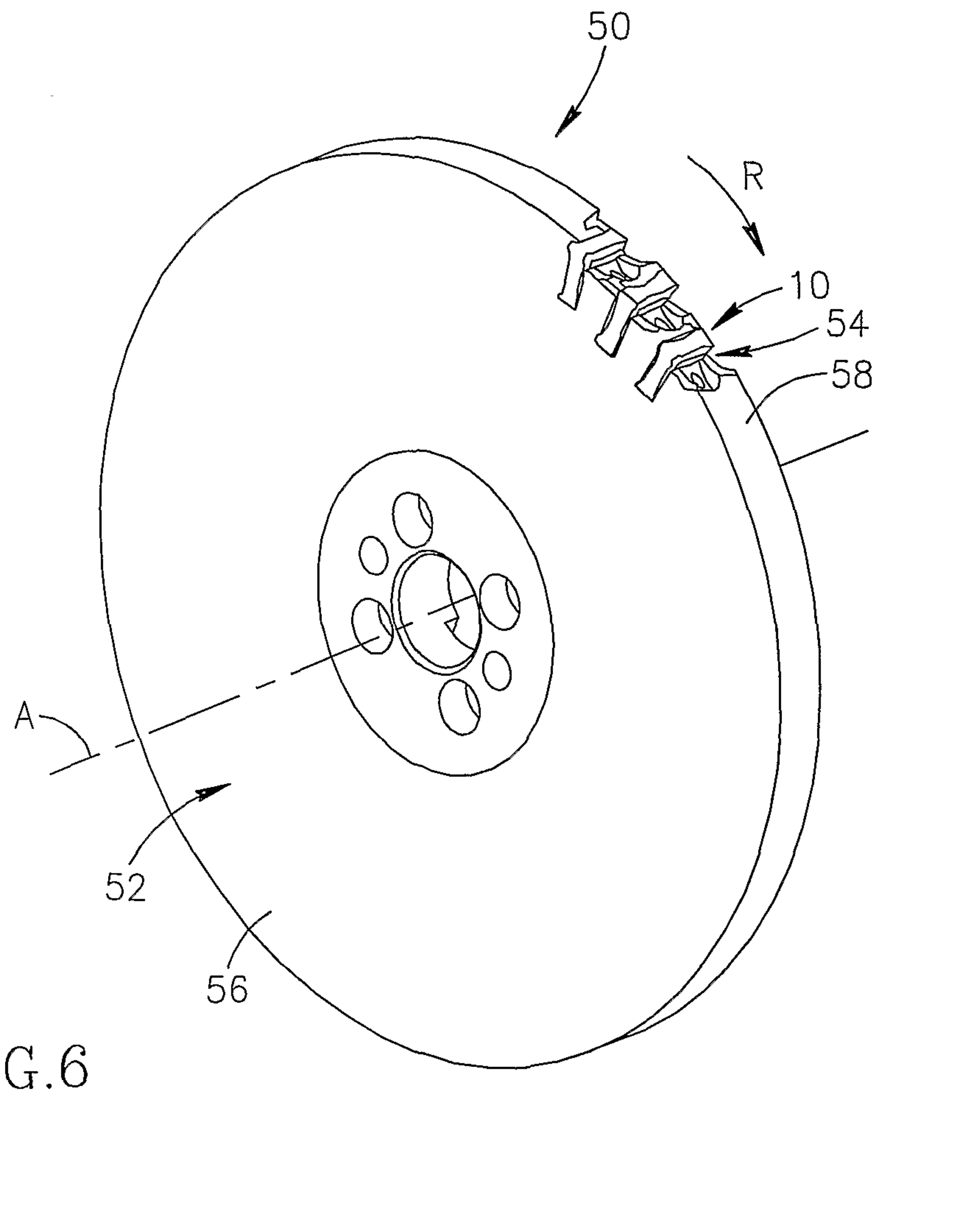


FIG.6

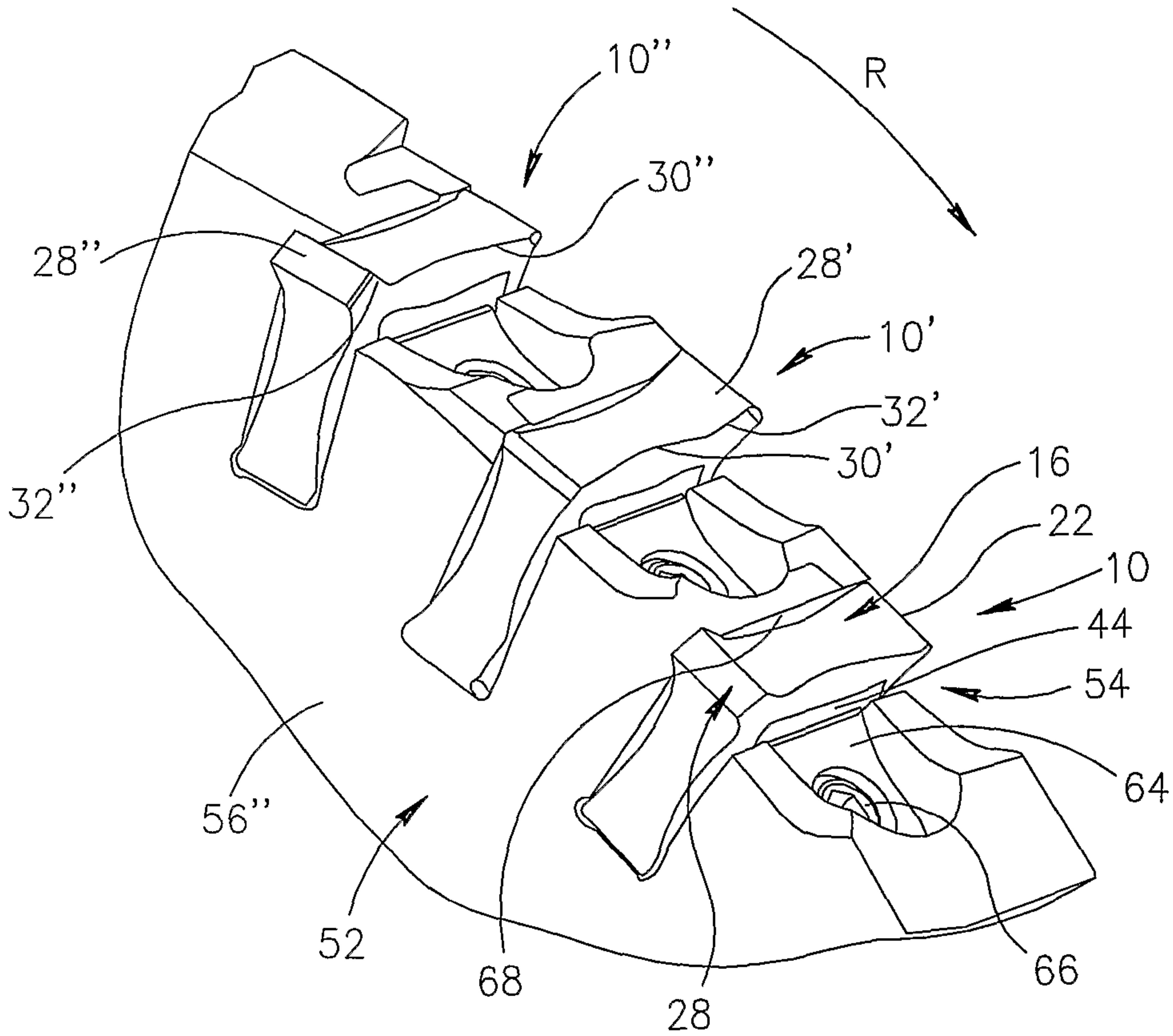


FIG.7

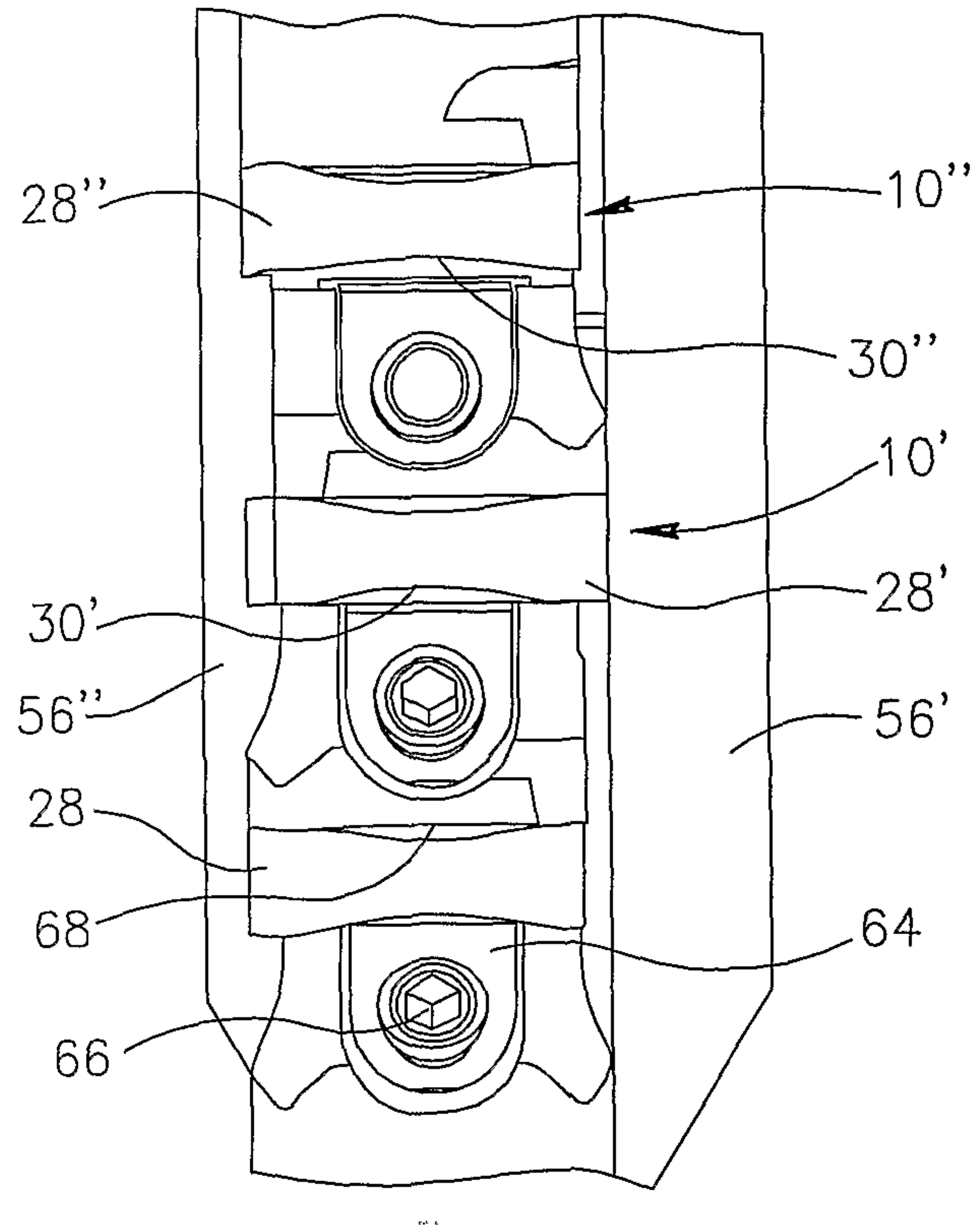


FIG.8

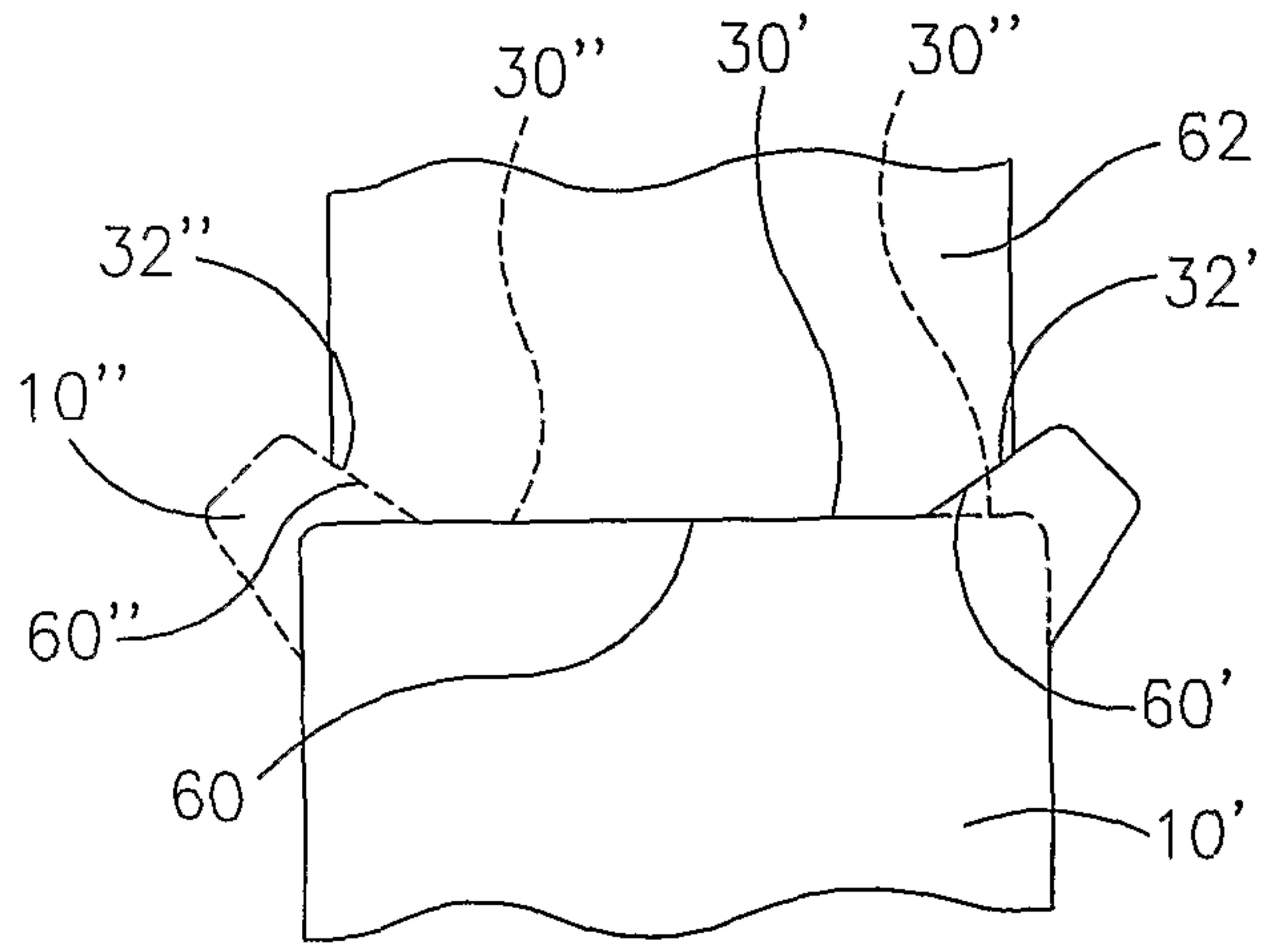
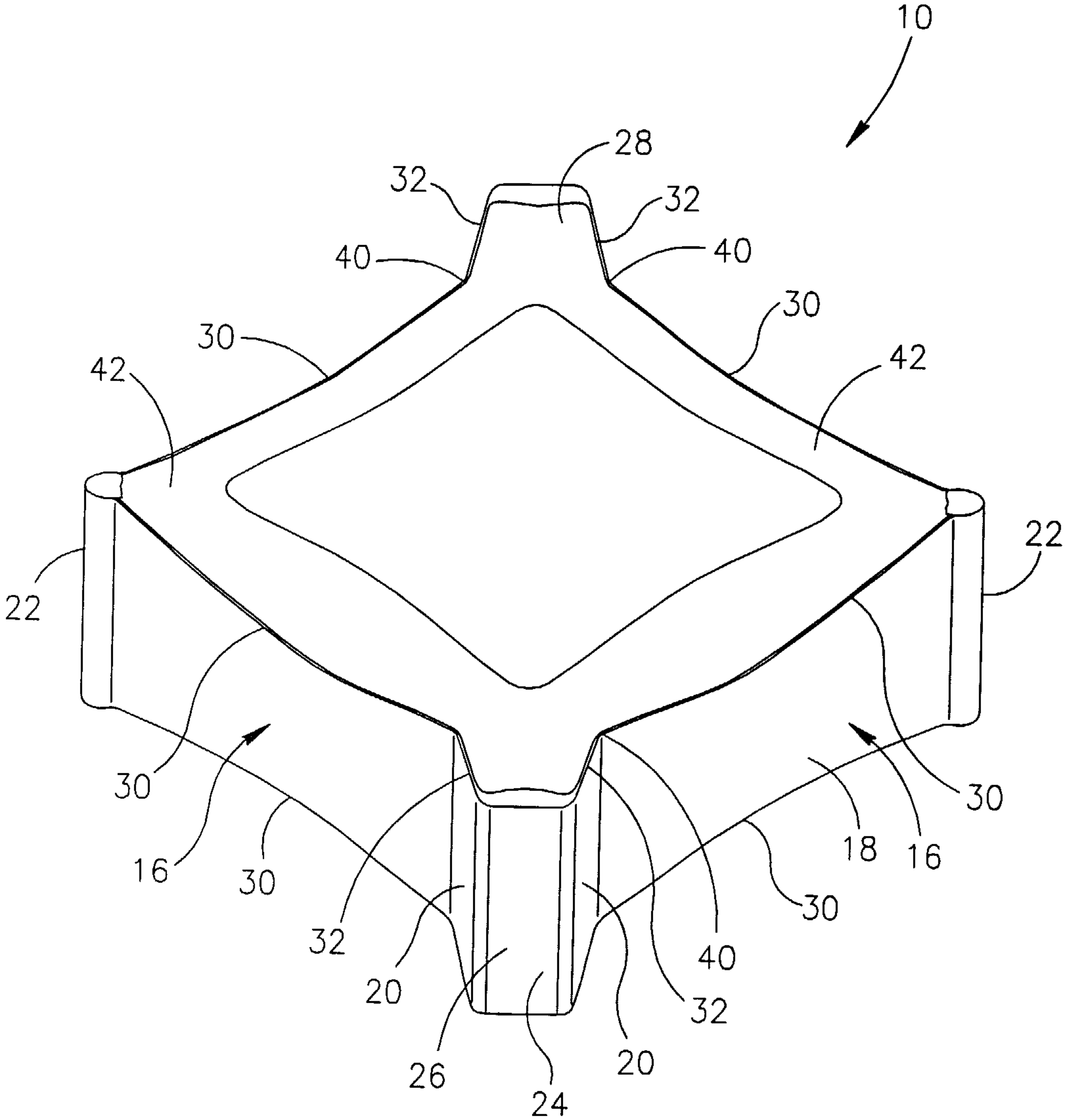


FIG.9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