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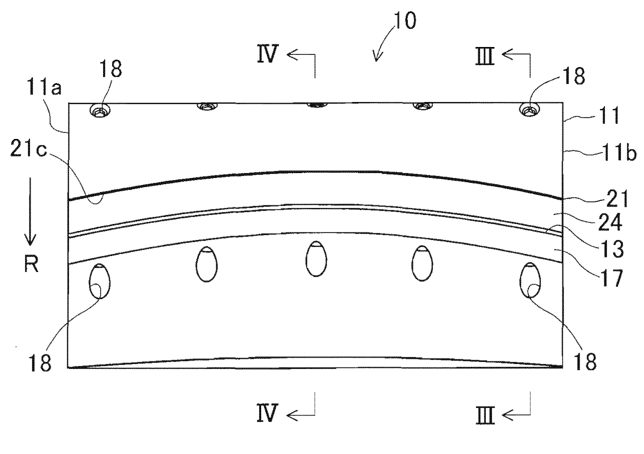
(54) **ROTARY CUTTING TOOL**

(57) Provided is a rotary cutting tool that can increase the overall flexural rigidity of blades used therein, even with blades having small thicknesses. A cutter head for woodworking has fitting grooves formed at circumferential four positions on an outer peripheral side of a body. The fitting groove is curved in small measure in an arc shape in a direction opposite to a direction of rotation of the body. The fitting groove is symmetric on both sides of the body. The fitting grooves are each mounted with a blade and a wedge bar. The blade is a long and thin plate having a nearly rectangular shape and elastically deformable. The blade is made of a steel material or a cemented carbide and about 0.5 mm in thickness. The blade is curved in an arc shape that corresponds to the shape of the fitting groove in a direction opposite to a direction of rotation R and then fixated in the curved state. A twist angle representing an angle of inclination of a cutting edge in each blade from a shaft center on an outer peripheral surface of the body is a negative twist angle that changes in a curve on the side of one end surface of the body but is a positive twist angle that changes in a curve on the side of the other end surface of the body.

Fig. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a rotary cutting tool, for example, a planar head, a milling cutter with a shaft, and a cutter head for molder equipped with plate-shaped blades.

BACKGROUND ART

[0002] A known example of such rotary cutting tools is disclosed in the Patent Document 1; a cutter head for woodworking where straight knives, which are straight cutting blades, are fitted in blade grooves that are formed in the outer peripheral surface of the body of the cutter head in parallel with the axial direction thereof. When the straight knives are used, however, a cutting resistance generated while a work material is being cut is applied to all of the blades at the same time, and the blades, if having a small flexural rigidity, are easily buckled. To avoid the problem, it is necessary that the blades should be increased in thickness to ensure a flexural rigidity. This requires a large volume of expensive blade materials, unnecessarily increasing the cost of the blades. Another problem with the straight knives is loud noises during the cutting operation that may worsen the work environment.

[0003] A known cutting device for woodworking disclosed in the Patent Document 2, for example, deals with such a noise problem. The cutting device has fitting grooves spirally formed in the outer peripheral surface of its cutter head, and blades spirally twisted are fitted in the fitting grooves. According to the cutting device, the cutting resistance generated while the work material is being cut is applied to the blades along the spirals, and thus noises during the cutting operation are effectively reduced. However, the blades of this cutting device also have a relatively small flexural rigidity, though it may not be as small as that of the straight knives, and the problem of buckling remains unsolved with thin blades. This cutting device has other problems described below. A lateral force is applied to the work material on one end side of the blade, which easily causes burr and/or chipping at an either side edge of the work material. These unfavorable events more easily occur in work materials made of fibrous woods having directionality. Further, the work material is subject to the force exercised by the twisted blade in one of the lateral directions. The application of the force moves the work material in the lateral direction, thereby destabilizing the cutting operation.

CITATION LIST

Patent Document

[0004]

Patent Document 1: Japanese Patent No. 3474503
Patent Document 2: Japanese Patent Application Laid-Open No. 50-54974

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0005] The invention is accomplished to solve these problems. The invention provides a rotary cutting tool wherein the flexural rigidity of overall blades used therein is increased so that a cutting operation can be stably performed even with thin blades. The invention further provides a rotary cutting tool that can avoid the occurrence of burr and/or chipping at both side edges of a work material and facilitate the flow of chips generated from the work material during the cutting operation.

MEANS FOR SOLVING PROBLEMS

[0006] In order to achieve the above object, a rotary cutting tool according to the invention has blades having an equal thickness and fitted on an outer peripheral surface of a body of the tool that rotates around a shaft center, wherein, assuming a direction of rotation of the body as a direction of 12 o'clock, a twist angle representing an angle of inclination of a cutting edge in each blade from the shaft center is positive when the cutting edge is inclined clockwise from the shaft center but is negative when the cutting edge is inclined counterclockwise from the shaft center, and the cutting edge includes a portion inclined through the positive twist angle and a portion inclined through the negative twist angle.

[0007] According to the invention, the cutting edge includes the portions respectively inclined clockwise through the positive twist angle from the shaft center of the body and inclined counterclockwise through the negative twist angle from the shaft center. Then, the depth of each blade is three-dimensionally secured in the circumferential direction, and the blade thereby has a higher flexural rigidity than its original flexural rigidity before bending. This technical feature imparts a high flexural rigidity even to thin blades. According to the invention, the bent blades are used. This prevents that the whole cutting edge contacts a work material at once, thereby succeeding in noise reduction during the cutting operation. According to the invention, the cutting edge includes the portions respectively inclined through the positive and negative twist angles, oppositely directed forces are laterally applied to the work material during the cutting operation and hence counteract each other. This controls a cutting resistance imposed on the work material during the cutting operation in one of the lateral directions, thereby preventing the work material from moving in the lateral direction. As a result, the cutting operation performed by the rotary cutting tool is stabilized.

[0008] According to the invention, preferably, the blades are bent in a protruding shape in a direction opposite to the direction of rotation of the body, and the twist angles of the both end portions of the cutting edge are positive and negative. Thereby, an inward force generated by the cutting edge is applied to the work material on both end sides of the cutting edge during the cutting operation. With this technical feature, the invention effectively prevents the occurrence of burr and/or chipping at the both side edges of the work material.

[0009] Further, according to the invention, the blades may be bent in a protruding shape in the direction of rotation of the body, and the twist angles of the both end portions of the cutting edge may be positive and negative. Thereby, chips generated while the material is being cut can be discharged from the center to two opposite ends of the blade on both end sides of the cutting edge. With this technical feature, the invention facilitates the flow of the chips.

[0010] Further, according to the invention, when the blades are each set with an apex of the bend of the blade being displaced from the center of the blade in a cutting device where a side edge of the work material is a reference position, a point of division between the positive and negative twist angles of the cutting edge may be provided in vicinity of an end part of the body. With this technical feature, the twist angles of the cutting edge are always positive and negative at the both side edges of any work materials having small widths. In the invention when the blade is bent in a protruding shape in the direction opposite to the direction of rotation, therefore, the occurrence of burr and/or chipping is effectively prevented from happening at the both side edges of the work material irrespective of any widths of the work material. On the other hand, when the blade is bent in a protruding shape in the direction of rotation, the flow of chips can be facilitated.

[0011] Further, according to the invention, the rotary cutting tool may have a structure where the blades are inserted in fitting grooves of the body and held down therein by using wedge bars, and the blades having flat bottom surfaces are received by flat bottom surfaces of the fitting grooves. With this technical feature, the production of the blades and fitting grooves is simplified, and the blades can be easily and accurately fitted in the fitting grooves.

EFFECT OF THE INVENTION

[0012] According to the invention, the cutting edge includes the portions respectively inclined clockwise through the positive twist angle and inclined counterclockwise through the negative twist angle. The depth of each blade is three-dimensionally secured in the circumferential direction, and the blade thereby has a higher flexural rigidity than its original flexural rigidity before bending. As a result, the blades can be reduced in thickness and accordingly reduced in price. Then, the rotary cutting tool can be made available at low prices. According to the invention, the blades are bent in a protruding shape in the direction opposite to the direction of rotation of the body, and the twist angles at both ends of the cutting edge are positive and negative. This effectively prevents the occurrence of burr and/or chipping at the both side edges of the work material. This technical advantage is particularly effective with work materials made of fibrous woods having directionality. According to the invention, the blades are bent in a protruding shape in the direction of rotation of the body, and the twist angles at both ends of the cutting edge are positive and negative. This facilitates the flow of chips generated by the cutting operation.

[0013] According to the invention, when the blade is installed in a cutting device where a side edge of the work material is a reference position, the point of division between the positive and negative twist angles of the cutting edge may be provided in vicinity of an end part of the body. As a result, the twist angles of the cutting edge are always positive and negative at the both side edges of any work materials having small widths. According to the invention, depending on whether the blade is bent in a protruding shape in the direction of rotation or the direction opposite thereto, the flow of chips is facilitated or the occurrence of burr and/or chipping is prevented from happening at the both side edges of the work material irrespective of any widths of the work material. According to the invention, the blades are inserted in fitting grooves formed in the body and held down therein by using wedge bars, and the blades having flat bottom surfaces are received by flat bottom surfaces of the fitting grooves. As a result, the blades and the fitting grooves can be easily produced with low cost, and the blades can be easily and accurately fitted in the fitting grooves.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a front view of a cutter head according to an example 1 of the invention.

Fig. 2 is a right side view of the cutter head.

Fig. 3 is a cross-sectional view of the illustration of Fig. 1 along the direction of a line III-III.

Fig. 4 is a cross-sectional view of the illustration of Fig. 1 along the direction of a line IV-IV.

Fig. 5A is a front view of a blade in a curved state.

Fig. 5B is a bottom view of the curved blade.

Fig. 5C is a right side view of the curved blade.

Fig. 6A is a front view of a wedge bar.

Fig. 6B is a bottom view of the wedge bar.

Fig. 6C is a right side view of the wedge bar.

Fig. 7 is an illustration of a twist angle of a cutting edge.

Fig. 8 illustrates a shape of the blade fitted in the cutter head according to a modified example 1 of the invention.

Fig. 9 illustrates a shape of the blade fitted in the cutter head according to a modified example 2 of the invention.

Fig. 10 illustrates a shape of the blade fitted in the cutter head according to a modified example 3 of the invention.

Fig. 11 illustrates a shape of the blade fitted in the cutter head according to a modified example 4 of the invention.

Fig. 12 illustrates a shape of the blade fitted in the cutter head according to a modified example 5 of the invention.

Fig. 13 illustrates a shape of the blade fitted in the cutter head according to a modified example 6 of the invention.

Fig. 14 illustrates a shape of the blade fitted in the cutter head according to a modified example 7 of the invention.

Fig. 15 illustrates a shape of the blade fitted in the cutter head according to a modified example 8 of the invention.

Fig. 16 is a front view of a cutter head according to an example 2 of the invention.

Fig. 17 is a right side view of the cutter head.

Fig. 18A is a front view of a blade in a curved state.

Fig. 18B is a bottom view of the curved blade.

Fig. 18C is a right side view of the curved blade.

Fig. 19 illustrates a shape of the blade fitted in the cutter head according to a modified example 9 of the invention.

Fig. 20 illustrates a shape of the blade fitted in the cutter head according to a modified example 10 of the invention.

Fig. 21 illustrates a shape of the blade fitted in the cutter head according to a modified example 11 of the invention.

Fig. 22 illustrates a shape of the blade fitted in the cutter head according to a modified example 12 of the invention.

Fig. 23 illustrates a shape of the blade fitted in the cutter head according to a modified example 13 of the invention.

Fig. 24 illustrates a shape of the blade fitted in the cutter head according to a modified example 14 of the invention.

Fig. 25 illustrates a shape of the blade fitted in the cutter head according to a modified example 15 of the invention.

Fig. 26 illustrates a shape of the blade fitted in the cutter head according to a modified example 16 of the invention.

Fig. 27 is a plan view of a router bit according to an example 3 of the invention.

Fig. 28 is a front view of the router bit.

Fig. 29 is a right side view of the router bit.

Fig. 30 is a cross-sectional view of the illustration of Fig. 28 along the direction of a line A-A.

Fig. 31A is a front view of a blade.

Fig. 31B is a bottom view of the blade.

Fig. 32A is a front view of a blade according to a modified example 17 of the invention.

Fig. 32B is a bottom view of the blade according to the modified example 17.

MODES FOR CARRYING OUT THE INVENTION

[0015] An embodiment of the invention is hereinafter described referring to the drawings. Figs. 1, 2, 3, and 4 are respectively a front view, a right side view, a cross-sectional view along the direction of a line III-III, and a cross-sectional view along the direction of a line IV-IV of a cutter head for woodworking according to an example 1 of the invention. This cutter head is illustrated as an example of the rotary cutting tool according to the invention, examples of which are cutter head and planar head.

[0016] A cutter head for woodworking 10 has four fitting grooves 13 formed in a body 11 made of a metal. The body 11 has an elongated cylindrical shape with a shaft hole 12 formed at the center thereof. The fitting grooves 13 are formed in an identical shape at four positions circumferentially spaced at equal intervals on the outer periphery of the body 11. The fitting grooves 13 are dented substantially in radial directions of the body 11 and penetrating through between end surfaces 11a and 11b along the axial direction of the body 11. As illustrated in Fig. 2, the fitting grooves 13 each has a nearly rectangular shape in cross section when viewed from the lateral side. According to this example, vicinity of the end surface 11a is a reference position at which a work material is positionally adjusted.

[0017] The fitting groove 13 is curved in an arc shape in a direction opposite to a direction of rotation R of the body 11. The fitting groove 13 has a shape symmetric about the axial direction of the body 11. The fitting groove 13 is inclined so that a rake angle is a positive angle. A front wall surface 14 and a rear wall surface 15 of the fitting groove 13 are respectively located on the forward side and the backward side in the direction of rotation. These front and rear wall surfaces are equally spaced from each other along the entire length of the fitting groove 13. A bottom wall surface 16 of the fitting groove 13 is a flat surface perpendicular to the front and rear wall surfaces 14 and 15 and extending in parallel with the axial direction. An angle of inclination of the rear wall surface 15 from the radial direction represents a rake angle δ that equals 15° on the end surfaces 11a and 11b of the body 11 when a blade 21, which will be described later, is already mounted. The angle of inclination increases along the curve of the fitting groove 13 up to 25° at a maximum at the center of the body 11 in the longitudinal direction thereof. As described, the fitting groove 13 is curved in an arc shape, and the bottom wall surface 16 of the fitting groove 13 is in parallel with the shaft. Hence, upper edges of the front and rear wall surfaces 14 and 15 are each recessed in a curved arc shape relative to the bottom wall surface 16 when viewed from the forward side in the direction of rotation.

[0018] The body 11 has dented notches 17 formed in the direction of rotation R at positions near the upper edges of the front wall surfaces 14. The dented notches 17 are curved and dented in small measure from the outer peripheral surface and extending between the both ends of the body 11 in the axial direction thereof. The body 11 further has fitting holes 18. The fitting holes 18 are formed more forward in the direction of rotation R than the dented notches 17 at five positions; a middle position and positions near the right-hand and left-hand ends in the axial direction, and intermediate positions therebetween. The fitting holes 18 are through holes extending substantially in parallel with one another. The fitting holes 18 are each extending through to the fitting groove 13 along a direction perpendicular to the shaft of the body 11 and a direction of inclination of the dented notch 17. The fitting holes 18 each has a cylindrical entry part 18a exposed from the surface of the body 11, and a threaded part 18b constituting a thread groove at the tip of the entry part 18a. In the fitting hole 18, a bolt 19 is inserted from the side of the entry part 18a and screwed into the threaded part 18b so that a tip side of the bolt 19 protrudes into the fitting groove 13.

[0019] The fitting grooves 13 is each mounted with a blade 21 and a wedge bar 24. As illustrated in Figs. 5A to 5C, the blade 21 is a long and thin plate having a nearly rectangular shape and elastically deformable. The blade 21 is made of a steel material or a cemented carbide and approximately 0.5 mm in thickness. The blade 21 curved as illustrated in the drawings has a length almost equal to that of the fitting groove 13. Referring to Fig. 5B, a fitting surface 21a of the blade 21 on the lower edge side is straight, and a flank face 21b of the blade 21 on the upper edge side having a cutting edge 21c has an arc shape whose center in the longitudinal direction of the flank face 21b is recessed inward. The flank face 21b of the blade 21 has a clearance angle that equals 0°. In the blade 21, a predefined area of a rake face 21d including the cutting edge 21c on one side thereof is coated with a hard film 22. The hard film 22 is a chromium nitride film containing CrN, Cr_2N or a mixture of CrN and Cr_2N. The thickness of the hard film 22 is approximately 0.5 to 10 μm.

[0020] As illustrated in Figs. 6A to 6C, the wedge bar 24 has an elongated square bar shape that is curved in an arc shape that corresponds to the shape of the fitting groove 13. In the wedge bar 24, a front side surface 24a on the forward side in the direction of rotation and a rear side surface 24b on the backward side in the direction of rotation have an equal overall length, and a bottom surface 24c is a flat surface extending perpendicular to the front side surface 24a and the rear side surface 24b. Describing the curved shape of the wedge bar 24, the front side surface 24a is recessed and the rear side surface 24b is bulging. An upper surface 24d of the wedge bar 24 is recessed in a curved arc shape between the front side surface 24a and the rear side surface 24b for chips to be collected therein. In the front side surface 24a near the upper surface 24d, securing holes 25 are formed at five positions; a middle position and positions near the right-hand and left-hand ends in the longitudinal direction, and intermediate positions therebetween. With the wedge bar 24 having been inserted in the fitting groove 13, the securing hole 25 is located coaxial with the fitting hole 18 of the body 11 at a position corresponding to a position where the fitting hole 18 is opening in the fitting groove 13.

[0021] For the blade 21 and the wedge bar 24 to be fitted in the fitting groove 13 of the body 11, first, the wedge bar 24 is inserted in the fitting groove 13. Then, the bottom surface 24c is placed on the bottom wall surface 16 of the fitting groove 13, and both ends of the wedge bar 24 are adjusted to be flush with the end surfaces 11a and 11b of the body 11. Then, the blade 21, being curved with the rake face 21d thereof facing the wedge bar 24, is inserted and fitted in an arc-shaped interval between the rear wall surface 15 of the fitting groove 13 and the rear side surface 24b of the wedge bar 24. The fitting surface 21a is then pushed against the bottom wall surface 16 of the fitting groove 13. Then, the bolt 19 is inserted in the fitting hole 18 from the side of the entry part 18a, and screwed into the threaded part 18b and fastened. As a result, a tip of the bolt 19 is inserted in the securing hole 25 formed in the front side surface 24a of the wedge bar 24 so as to press down the wedge bar 24. Further, the blade 21 is pushed against the rear wall surface 15 of the fitting groove 13. As a result, the blade 21 and the wedge bar 24 are firmly secured in the fitting groove 13. The blade 21 can be bent in an arc shape and then fitted in the fitting groove 13. By such a simple handling that does not need twisting, the blade 21 can be easily fitted in the fitting groove 13.

[0022] The blade 21 is suitably adjusted to the shape of the fitting groove 13 and secured therein, and the flank face 21b including the cutting edge 21c of the blade 21 protrudes by 0.5 mm from the outer peripheral surface of the body 11. The ridges of the upper surface 24d and the rear side surface 24b of the wedge bar 24 are situated inward by approximately 1 mm from the cutting edge 21c of the blade 21. The upper surface 24d is adjusted to incline by an equal degree to the inclination of the dented notch 17 exposed from the outer peripheral surface of the body 11. By thus providing the upper surface 24d of the wedge bar 24 and the dented notch 17 of the body 11 on the side of the rake face 21d of the blade 21, chips generated by the cutting operation are smoothly discharged.

[0023] After the blade 21 is held down in the fitting groove 13 of the body 11 by using wedge bars and thereby securely fitted therein, a twist angle, which is an angle of inclination of the cutting edge 21c from the shaft center on the outer peripheral surface of the body 11, is a negative twist angle that changes in a curve on the side of the end surface 11a of the body 11 but is a positive twist angle that changes in a curve on the side of the other end surface 11b of the body 11. As illustrated in Fig. 7, assuming the direction of rotation R of the body 11 as a direction of 12 o'clock, the twist angle θ of the cutting edge 21c is positive when the cutting edge is inclined clockwise (CW) from a shaft center J but is negative when the cutting edge is inclined counterclockwise (CCW) from the shaft center J. The four blades 21 securely fitted in the fitting grooves 13 of the body 11 are subjected to jointing with grindstone to correct any variability of outer diameters of the cutting edges 21c. Since the blades 21 according to the example are as small in thickness as approximately 0.5 mm, the jointing conventionally targeted for cutting edges may be performed to all of the outer peripheral flank faces 21b. The flank faces 21b are subjected to cylindrical grinding and thereby formed in an arc shape with a constant radius, and the clearance angle γ becomes 0°.

[0024] According to the example 1 described so far, each blade 21 is bent in a protruding shape in the direction opposite to the direction of rotation of the body 11, and the twist angles on the sides of the end surfaces 11a and 11b of the blade 21 are negative and positive. Then, the depth of each blade 21 is three-dimensionally secured in the circumferential direction, and the flexural rigidity of the blade 21 is thereby increased. This technical feature of the example 1 certainly promises such a high flexural rigidity although the thickness of each blade 21 is as small as approximately 0.5 mm. In consequence of that, the use of any costly materials for the blades 21 is minimized in the example 1, and the blades 21 can be made available at prices far lower than those of the conventional blades having thicknesses of approximately 3 mm. According to the example 1, on the both end sides of the cutting edge 21c are the portions inclined through the positive and negative twist angles. Therefore, oppositely directed forces are laterally applied to the work material during the cutting operation and hence counteract each other. This controls a cutting resistance imposed on the work material during the cutting operation in one of the lateral directions, thereby preventing the work material from moving in the lateral direction. As a result, the cutting operation performed by the cutter head 10 is stabilized.

[0025] According to the example 1, each blade 21 is curved in an arc shape in the direction opposite to the direction of rotation R, and the twist angles θ at the both end portions of the blade 21 are negative and positive. Thereby, an inward force generated at the cutting edge 21c is applied to the work material at the both side edges thereof. This effectively prevents the occurrence of burr and/or chipping at the both side edges of the work material. This technical advantage is particularly effective with work materials made of fibrous woods having directionality. According to the example 1, the bent blades 21 are used. This prevents that the whole cutting edge 21c contacts a work material at once, thereby succeeding in noise reduction during the cutting operation.

[0026] Since the thickness of each blade 21 is reduced in the example 1, the flank face 21b and the clearance angle can be both reduced. As a result, a wear width of the flank face 21b can be reduced to an extent of [blade thickness ÷ cos (rake angle δ) ÷ cos (twist angle θ)]. According to the example 1, the rake face 21d is coated with the hard film 22. This avoids excessive abrasion of the rake face 21d, thereby providing a better durability. According to the example 1, the rake face 21d is coated with the hard film 22, and thus the abrasion of the flank face 21b of the blade 21 is more aggressive than the rake face 21d. This avoids any heavy contact between the flank face 21b and the work material, thereby reducing the cutting resistance of the blade 21. The portion with the shaft hole 12 in the body 11 according to the example 1 may be formed in compliance with the hydroclamp spec, in which case positions of the cutting edges can be very accurately set. The wedge bar 24 may be provided in one piece or may be divided in several short pieces.

[0027] Next, modified examples 1 to 8 of the example 1 are hereinafter described referring to Figs. 8 to 15. The modified examples 1 to 8 illustrate different arrangements of the blade according to the example 1. The drawings illustrate the blade alone, omitting the fitting groove and the wedge bar. According to the example 1, the both ends of the blade 21 are situated on a line in parallel with the shaft center. According to the modified example 1, two ends of a blade 21A are not both situated on a line (K) in parallel with the shaft center as illustrated in Fig. 8.

[0028] According to the example 1, the blade 21 is symmetric with the apex of curve thereof being positioned at the center in the longitudinal direction. According to the modified example 2, a blade 21B is located with an apex of curve T being displaced to vicinity of the end surface 11a of the body 11 as illustrated in Fig. 9. According to the modified example 2, the twist angles of the cutting edge may be always negative and positive at both ends in the cross direction of any work materials having widths smaller than the length of the body 11. When a work material made of a fibrous wood having directionality, for example, is cut, the modified example 2 effectively controls the occurrence of burr and/or chipping at both side edges of such a work material irrespective of any widths thereof.

[0029] In contrast to the blade 21 having one curved portion according to the example 1, a blade 21C according to the modified example 3 includes two continuous arc-shaped portions forming a wavy shape as illustrated in Fig. 10.

[0030] Instead of the blade 21 curved in an arc shape according to the example 1, a blade 21D according to the modified example 4 is symmetrically bent at the center in the longitudinal direction as illustrated in Fig. 11.

[0031] A blade 21E according to the modified example 5 is similar to the blade according to the modified example 4 except that an apex of curve U is displaced to vicinity of the end surface 11a of the body 11 as illustrated in Fig. 12. Similarly to the modified example 2, the modified example 5 can prevent the occurrence of burr and/or chipping at the both side edges of the work material irrespective of any widths of the work material.

[0032] In contrast to the blade 21D having one bent portion according to modified example 4, a blade 21F according to the modified example 6 includes a plurality of bent portions that are continuously formed as illustrated in Fig. 13.

[0033] As illustrated in Fig. 14, a blade 21G according to the modified example 7 has an intermediate portion linearly extending in parallel with the axial direction and arc-shaped portions on both end sides thereof.

[0034] Instead of the blade 21C according to the modified example 3, the modified example 8 provides a blade 21H having one curved portion and a nearly half-length curved portion that are continuous in an arc shape, forming an S-like wavy shape as illustrated in Fig. 15. Similarly to the example 1, these modified examples 1 to 8 ensure a flexural rigidity with thin blades. The modified examples 1 to 7 accomplish the effect of burr and/or chipping prevention at the both side edges of the work material. However, the modified example 8 alone fails to accomplish such an effect on the side of one end surface of the body 11.

[0035] An example 2 of the invention is hereinafter described referring to Figs. 16 and 17.

[0036] In contrast to the cutter head 10 according to the example 1, a cutter head for woodworking 30 according to the example 2 has fitting grooves 33 formed in an outer peripheral surface of a cylindrical body 31 having a shaft hole 32. The fitting groove 33 is curved in a manner that protrudes in a direction of rotation R and has symmetric ends on both sides of the body 31. A wedge bar 37 is curved in a direction opposite to the direction illustrated in Fig. 6A.

[0037] As illustrated in Figs. 18A to 18C, a blade 35 fitted in the fitting groove 33 is an elastically deformable thin plate made of the same material as that of the blade 21. In the illustration of Fig. 18B, a fitting surface 35a on the lower edge side is straight, and a flank face 35b on the upper edge side including a cutting edge 35c protrudes outward in an arc shape. The flank face 35b of the blade 35 has a clearance angle γ that equals 0°. A predefined area of a rake face 35d including the cutting edge 35c on one side thereof is coated with a chromium nitride hard film 36. The blade 35 is fitted in the fitting groove 33 and held down with the wedge bar 37. The blade 35 thus fitted is curved in a manner that protrudes in the direction of rotation R of the body 31. Then, a twist angle, which is an angle of inclination of the cutting edge 35c from the shaft center on the outer peripheral surface of the body 31, is a positive twist angle that changes in a curve on the side of an end surface 31a of the body 31 but is a negative twist angle that changes in a curve on the side of the other end surface 31b of the body 31. The positive and negative twist angles of the cutting edge 35c are similar to that of the example 1.

[0038] According to the example 2 described so far, the blade 35 is bent in the direction of rotation R of the body 31, and the twist angles of the cutting edge 35c on the sides of the end surfaces 31a and 31b are positive and negative. Therefore, the depth of each blade 35 is three-dimensionally secured in the circumferential direction, and the blade 35 thereby has a higher flexural rigidity than its original flexural rigidity before bending. This technical feature of the example 2 certainly promises such a high flexural rigidity although the thickness of each blade 35 is as small as approximately 0.5 mm. In consequence of that, the use of any costly materials for the blades 35 is significantly reduced in the example 2 similarly to the example 1, and the blades 35 can be made available at prices far lower than those of the conventional blades having the thicknesses of approximately 3 mm. According to the example 2, the cutting edge 35c has the portions inclined through the positive and negative twist angles on the sides of the end surfaces 31a and 31b. Therefore, oppositely directed forces are laterally applied to the work material during the cutting operation and hence counteract each other. This controls a cutting resistance imposed on the work material during the cutting operation in one of the lateral directions, thereby preventing the work material from moving in the lateral direction. As a result, the cutting operation performed by the cutter head 30 is stabilized.

[0039] According to the example 2, the blade 35 is bent in a manner that protrudes in the direction of rotation R, and the twist angles of the cutting edge 35c on the both end sides thereof are positive and negative. Thereby, chips generated while the material is being cut can be discharged sideways from the center of the work material during the cutting operation. This technical feature becomes a particularly great advantage when cutting hard objects made of materials such as metals and resins where the occurrence of burr at side edges is less of a problem. According to the example 2, the bent blades 35 are used. This prevents that the whole cutting edge 35c contacts the work material at once, thereby succeeding in noise reduction during the cutting operation. Since the thickness of each blade 35 is reduced to approximately 0.5 mm in the example 2, the flank face can be reduced. As a result, a wear width of the flank face can be reduced to an extent of [blade thickness ÷ cos (rake angle) ÷ cos (twist angle)]. Moreover, the rake face 35d is coated with the hard film 36. This avoids excessive abrasion of the rake face 35d, thereby providing a better durability similarly to the example 1.

[0040] Referring to Figs. 19 to 26 are described modified examples 9 to 16 wherein the blade 35 according to the example 2 is bent in different manners.

[0041] Describing a blade 35A according to the modified example 9 referring to Fig. 19, two ends of the blade 35A on both sides thereof are not both situated on a line (K) in parallel with the shaft center.

[0042] Describing a blade 35B according to the modified example 10 referring to Fig. 20, an apex of curve V of the blade 35B is displaced to vicinity of the end surface 31a of the body 31.

[0043] Describing a blade 35C according to the modified example 11 referring to Fig. 21, the blade 35C includes, instead of just one curved portion, two continuous portions that are curved in an arc shape forming a wavy shape.

[0044] Describing a blade 35D according to the modified example 12 referring to Fig. 22, the blade 35D is not curved in an arc shape but is symmetrically bent at the center in the longitudinal direction.

[0045] Describing a blade 35E according to the modified example 13 referring to Fig. 23, an apex W of the blade 35E is displaced to vicinity of the end surface 31a of the body 31.

[0046] Describing a blade 35F according to the modified example 14 referring to Fig. 24, the blade 35F includes, instead of just one bent portion, a plurality of bent portions that are continuously formed.

[0047] As illustrated in Fig. 25, a blade 35G according to the modified example 15 has an intermediate portion linearly extending in parallel with the axial direction and arc-shaped portions on both end sides thereof.

[0048] Instead of the blade 35C according to the modified example 11, the modified example 16 provides a blade 35H having one curved portion and a nearly half-length curved portion that are continuous in an arc shape, forming an S-like wavy shape as illustrated in Fig. 26. Similarly to the example 2, these modified examples 9 to 16 ensure a flexural rigidity with thin blades. The modified examples 9, 10, 12, 13, and 15 accomplish the effect of facilitating the discharge of chips generated by the cutting operation. However, the modified examples 11, 14, and 16 fail to accomplish such an effect on the side of one end surface of the body 31.

[0049] An example 3 of the invention is hereinafter described referring to Figs. 27 to 30. A router bit for woodworking 40 according to the example 3 is a milling cutter with shaft to which the invention is applied, wherein chamfer portions are provided on both end sides of blades 51 as illustrated in Fig. 27. In the router bit 40, a cylindrical body 41 and a shank unit 42 provided for the body 41 to be mounted in a rotary cutting device are coaxially coupled with each other. The body 41 has fitting grooves 43 formed at symmetric two positions of an outer peripheral surface thereof. The fitting groove 43 has a front wall surface 44 and a rear wall surface 45 respectively located on the forward side and the backward side in a direction of rotation of R of the body 41. The front wall surface 44 is a flat surface extending substantially in a radial direction. The rear wall surface 45 is a surface curved in an arc shape in a direction opposite to the direction of rotation.

[0050] The fitting groove 43 further has a bottom wall surface 46 that is a flat surface in parallel with the axial direction. A wedge bar 55 and a blade receiver 61 are inserted in the fitting groove 43, respectively on the side of the front wall surface 44 and on the side of the rear wall surface 45. The blade 51 is sandwiched between the wedge bar 55 and the blade receiver 61. The blade 51 is a thin plate made of the same material as that of the blade 21 according to the example 1. As illustrated in Figs. 31A and 31B, an upper surface of the blade 51 is a flank face 52, and the blade 51 has an intermediate portion 53 recessed in an arc shape similarly to the example 1, and chamfer portions 54. The chamfer portions 54 are bulging in a nearly semi-arc shape and continuous from the intermediate portion 53 on both end sides of the blade 51.

[0051] A front side surface 55a of the wedge bar 55 facing the front wall surface 44 is a flat surface. A rear side surface 55b of the wedge bar 55 is a curved surface bulging in an arc shape that corresponds to the shape of the rear wall surface 45, and a bottom surface 55c thereof is a flat surface. An upper side surface 55d of the wedge bar 55 is curved on longitudinally both sides thereof in a protruding shape that corresponds to the shape of the blade 51. When the blade 51 is curved and fitted along the rear side surface 55b, the whole wedge bar 55 exactly overlaps the blade 51 except its upper cutting edge. The blade receiver 61 is a metal thick plate having a given thickness. The blade receiver 61 is bent in an arc shape that corresponds to the shape of the rear wall surface 45. A front side surface 61a of the blade receiver 61 is a recessed curved surface, and a rear side surface 61b thereof is a bulging curved surface. A bottom surface 61c of the blade receiver 61 is a flat surface. Similarly to the upper side surface 55d of the wedge bar 55, an upper side surface 61d of the blade receiver 61 is protruding on longitudinally both sides thereof. The front side surface 61a overlaps the blade 51, and the rear side surface 61b closely contacts the rear wall surface 45 of the fitting groove 43. The wedge bar 55, the blade 51, and the blade receiver 61 are inserted and fitted in the fitting groove 43. A bolt (not illustrated in the drawings) is inserted in each of fitting holes 47 formed in the body 41 on the forward side of the fitting groove 43 in the direction of rotation. Then, the bolts are fastened, and the blades 51 are thereby mounted in the body 41.

[0052] In the example 3, the intermediate portion 53 of the blade 51 cuts the work material in a manner similar to the example 1, and an effect similar to that of the example 1 is accordingly achieved. The chamfer portions 54 of the blade 51 on the both end sides thereof chamfer the both side edges of the work material. According to the example 3, the chamfer portions 54 of the thin blade 51 are protruding from the outer peripheral surface of the body 41. The chamfer portions 54 thus protruding are firmly and securely held between the wedge bar 55 and the blade receiver 61, and the blade 51 thereby has a large strength. Thus, the example 3 is advantageous in that the usual cutting operation and chamfering can be performed at the same time with such a thin and inexpensive blade 51.

[0053] A modified example 17 of the blade according to the example 3 is described referring to Figs. 32A and 32B.

[0054] In a blade 51A according to the modified example 17, a middle part 53a of the intermediate portion 53 between the bent chamfer portions 54 has a flat surface, and parts on the outer sides of the middle part 53a are curved in an arc shape. In the blade 51A, its bottom and middle part 53a have flat surfaces, and the intermediate portion 53 has a constant rake angle.

[0055] The examples 1 and 2 and the modified embodiments thereof described one cutter head. A plurality of cutter heads may be coupled with each other in the axial direction, wherein blades of the adjacent cutter heads are displaced relative to each other. A plurality of blades may have grooves formed on cutting-edge sides thereof, so that a work material can be cut into separate pieces.

[0056] The different shapes of the blade fitted in the cutter head are suggested in the modified examples 1 to 8 of the example 1 and the modified examples 9 to 16 of the example 2. These shapes of the blade are, however, only some examples. The blade may be fitted in the cutter head in any other possible shapes. Though the examples 1, 2, and 3 and the modified examples thereof use the thin blades, any blades having regular thicknesses may be used. According to the examples 1, 2, and 3 and the modified examples thereof, the invention is applied to the cutter head for woodworking and the router bit provided as the rotary cutting tool. However, the invention is also applicable to forming cutters. Further, the invention is not limited to cutting tools for woodworking but is also applicable to rotary cutting tools for cutting metal objects. The invention has been described and illustrated in detail in the examples and the modified examples thereof. However, the invention is not necessarily limited thereto, and various modifications, additions and alterations may be made to the invention without departing from the spirit and scope of the invention.

INDUSTRIAL APPLICABILITY

[0057] The rotary cutting tool according to the invention includes a cutting edge of a blade including a portion inclined clockwise through a positive twist angle and a portion inclined counterclockwise through a negative twist angle. Then, the depth of each blade is three-dimensionally secured in the circumferential direction, and the blade thereby has a higher flexural rigidity than its original flexural rigidity before bending. This allows the blade to be downsized in thickness, thereby making the blade available at lower prices.

DESCRIPTION OF REFERENCE SYMBOLS

[0058]

10: Cutter head for woodworking
11: Body
13, 13A to 13G: fitting groove
18: Fitting hole
21, 21A to 21H: blade
21c: Cutting edge
24, 24A to 24G: wedge bar
30: Cutter head for woodworking
31: Body
33, 33A to 33G: Fitting groove
35, 35A to 35H: Blade
35c: Cutting edge
37, 37A to 37G: Wedge bar
40: Router bit for woodworking
41: Body
43: Fitting groove
51: Blade
55: Wedge bar
61: Blade receiver

Claims

1. A rotary cutting tool having blades having an equal thickness and fitted in an outer peripheral surface of a body of the tool that rotates around a shaft center, wherein, assuming a direction of rotation of the body as a direction of 12 o'clock, a twist angle representing an angle of inclination of a cutting edge in each blade from the shaft center is positive when the cutting edge of the blade is inclined clockwise from the shaft center but is negative when the cutting edge is inclined counterclockwise from the shaft center, and the cutting edge includes a portion inclined through the positive twist angle and a portion inclined through the negative twist angle.

2. The rotary cutting tool according to claim 1, wherein the blades are bent in a protruding shape in a direction opposite to the direction of rotation of the body, and the twist angles of the both end portions of the cutting edge are positive and negative.

3. The rotary cutting tool according to claim 1, wherein the blades are bent in a protruding shape in the direction of rotation of the body, and the twist angles of the both end portions of the cutting edge are positive and negative.

4. The rotary cutting tool according to claim 2 or 3, wherein an apex of the bend in each of the blades is displaced from a center of the blade.

5. The rotary cutting tool according to any one of claims 1 to 4, wherein the blades are inserted in fitting grooves of the body and held down in the fitting grooves by using wedge bars, and the blades having flat bottom surfaces are received by flat bottom surfaces of the fitting grooves.

Fig. 1

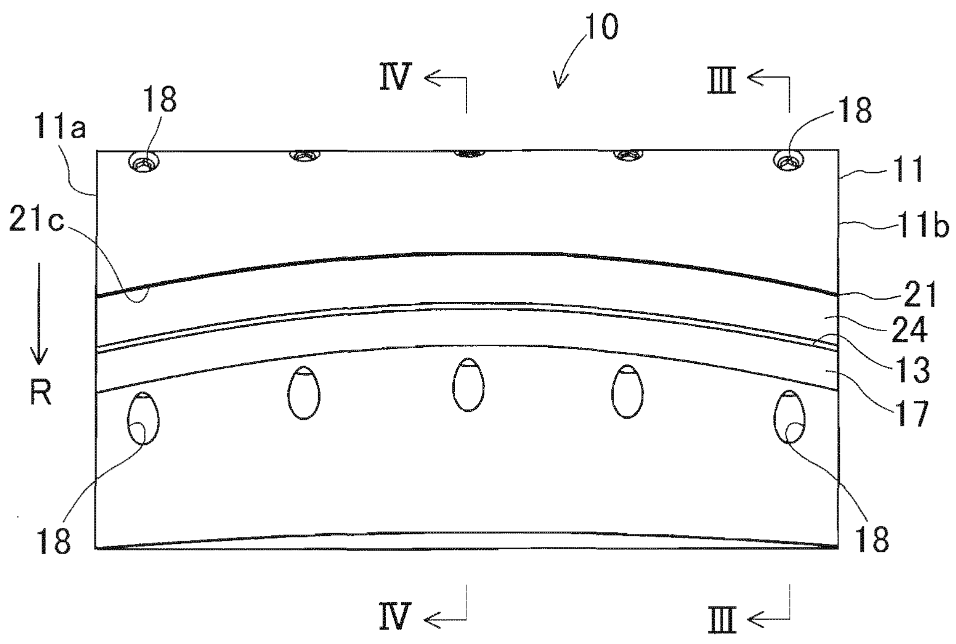

10
IV
III
18
11a
18
11
11b
21c
21
24
13
R
17
18
18
IV
III

Fig. 2

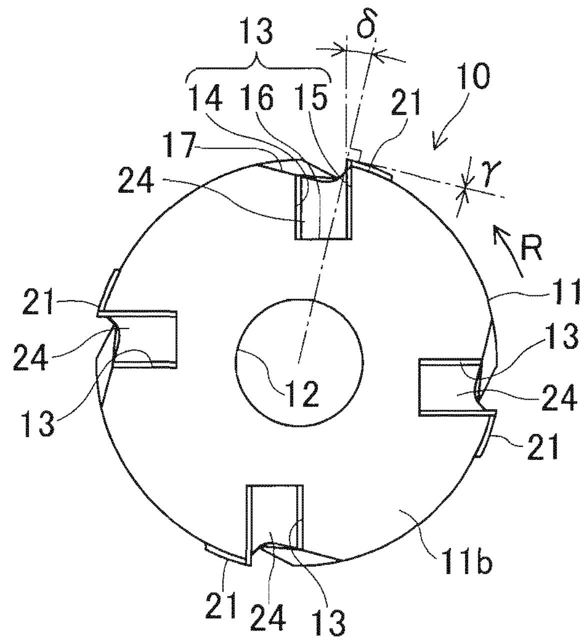

13
δ
14 16 15
10
21
17
γ
24
R
11
21
13
24
24
12
13
21
11b
21 24 13

Fig. 3

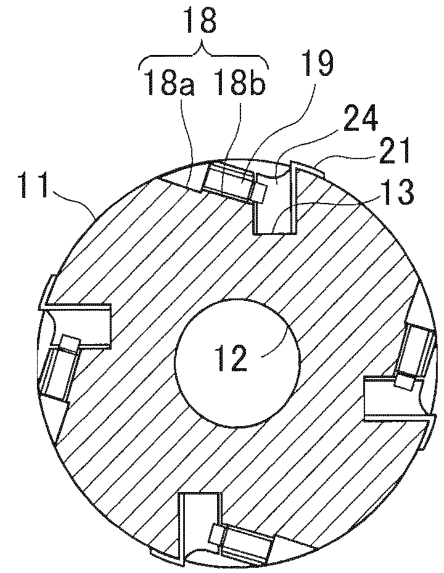


Fig. 4

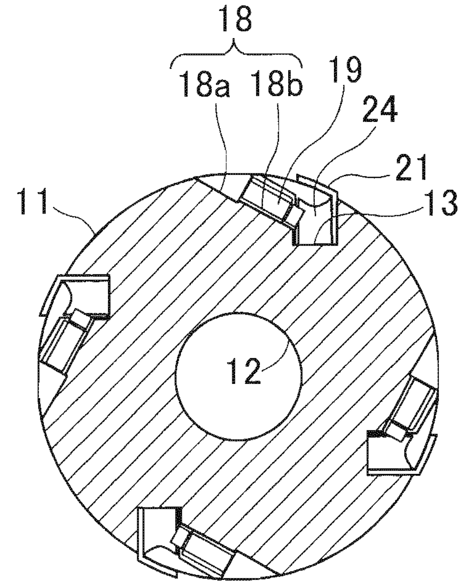


Fig. 5A

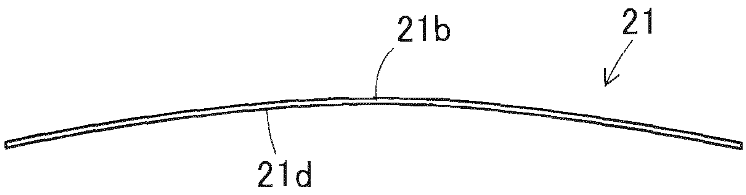


Fig. 5B

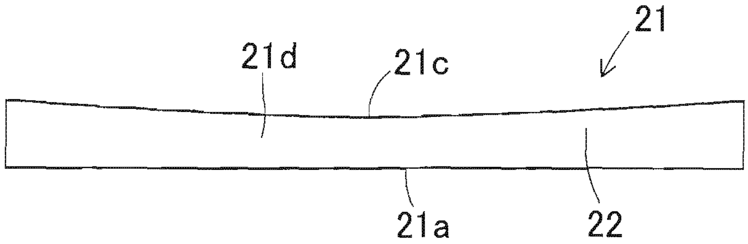


Fig. 5C

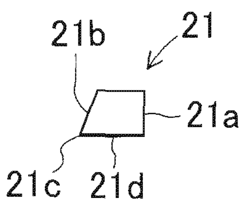


Fig. 6A

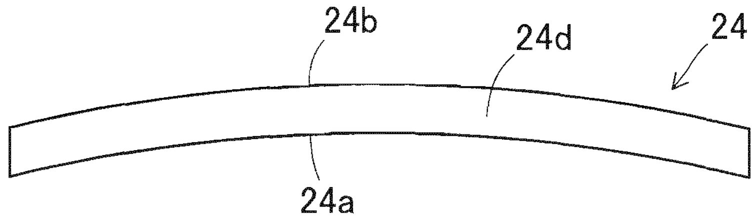


Fig. 6B

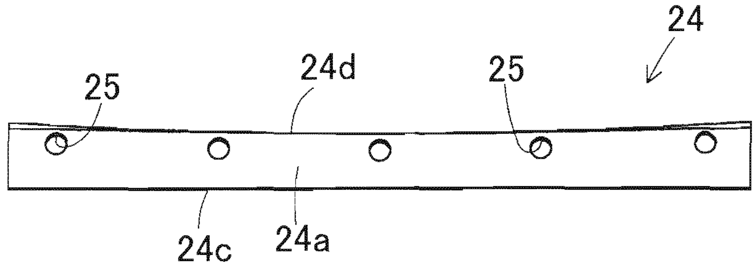


Fig. 6C

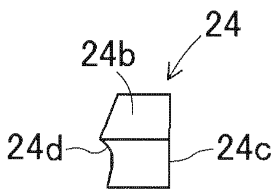


Fig. 7

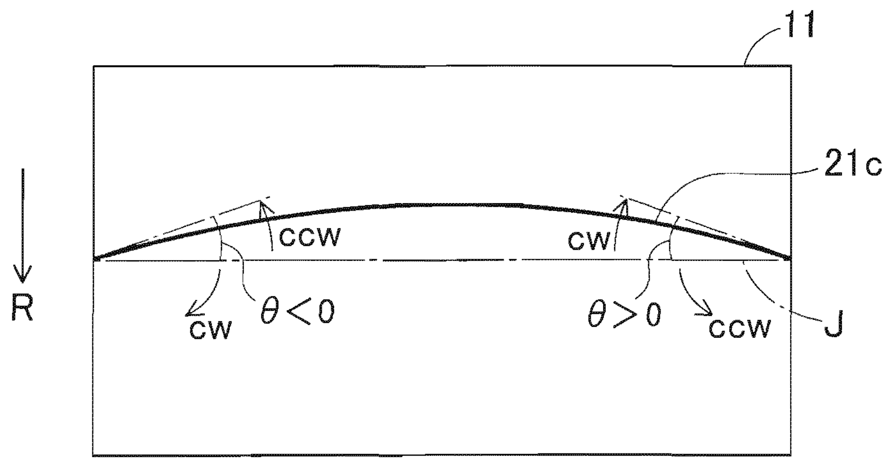


Fig. 8

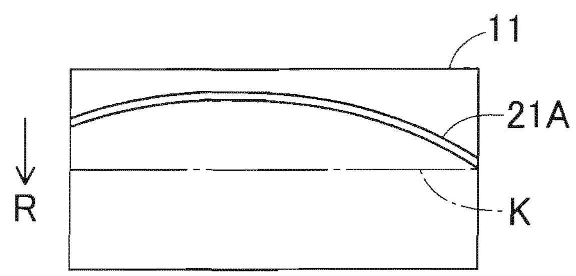


Fig. 9

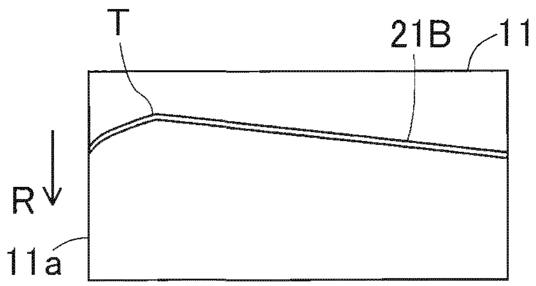


Fig. 10

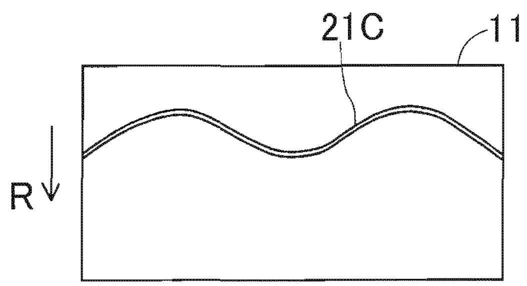


Fig. 11

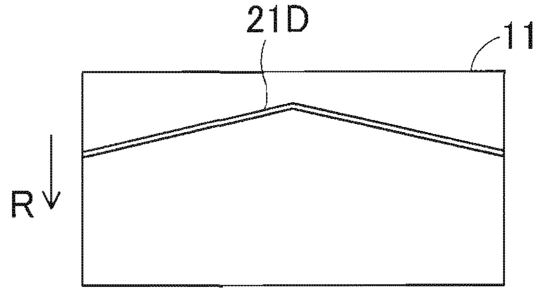


Fig. 12

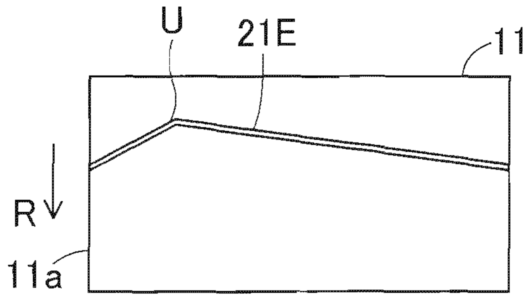


Fig. 13

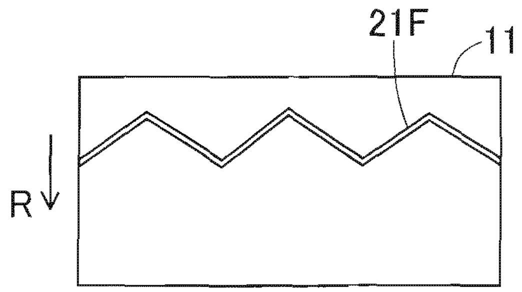


Fig. 14

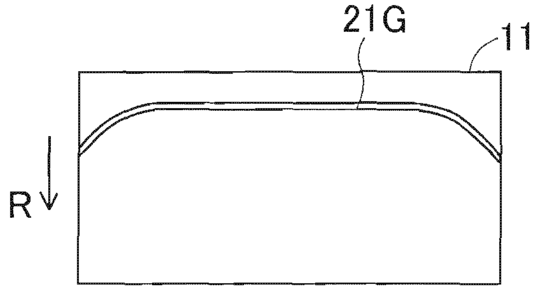


Fig. 15

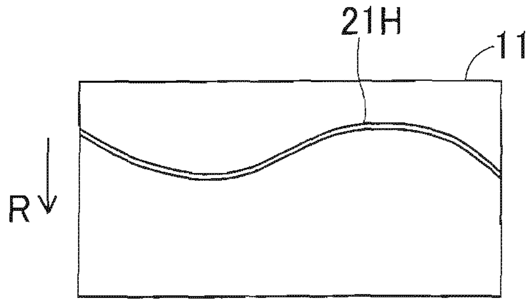


Fig. 16

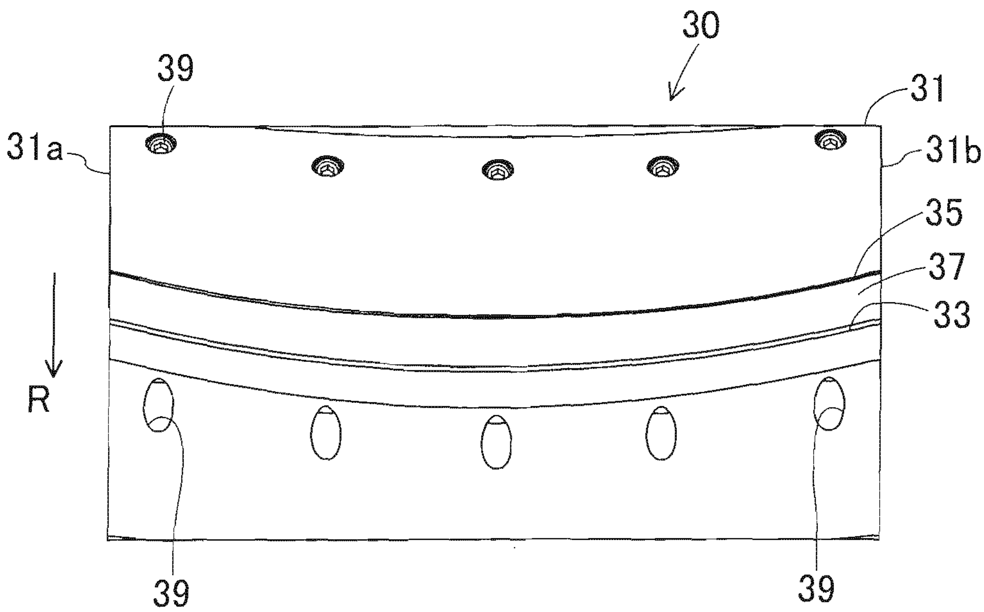


Fig. 17

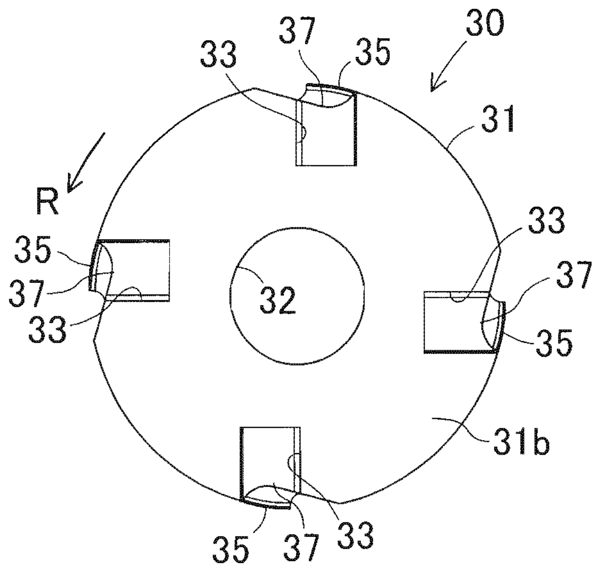


Fig. 18A

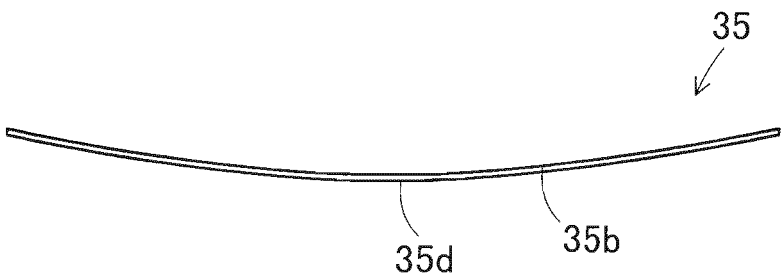


Fig. 18B

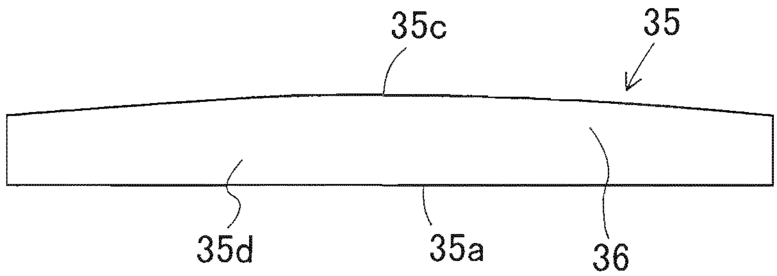


Fig. 18C

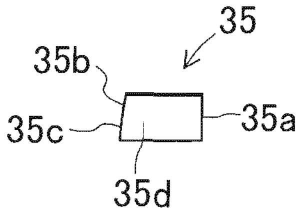


Fig. 19

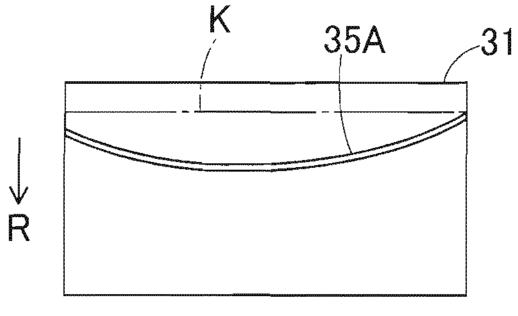


Fig. 20

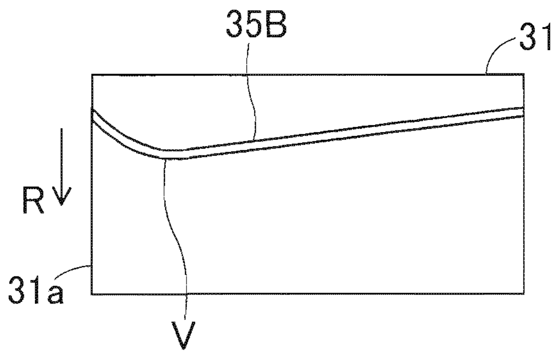


Fig. 21

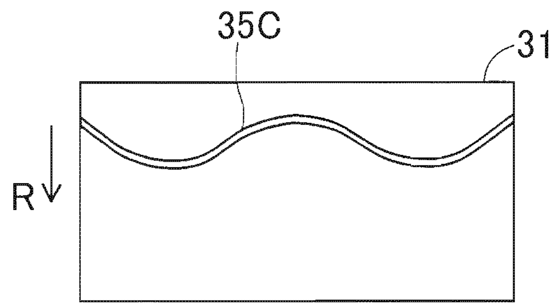


Fig. 22

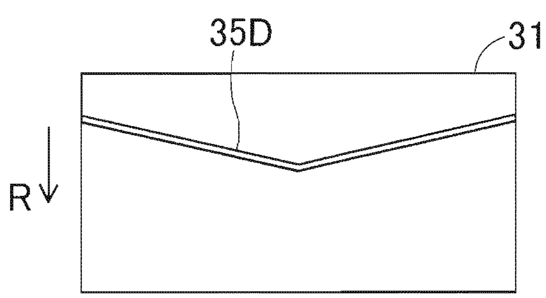


Fig. 23

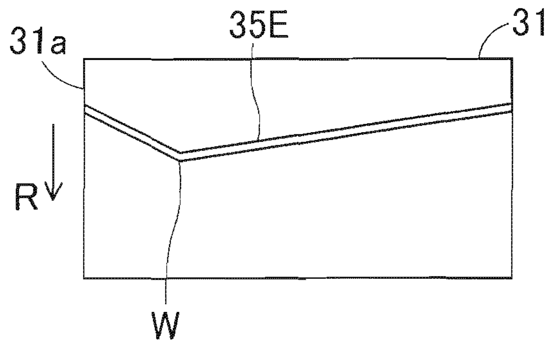


Fig. 24

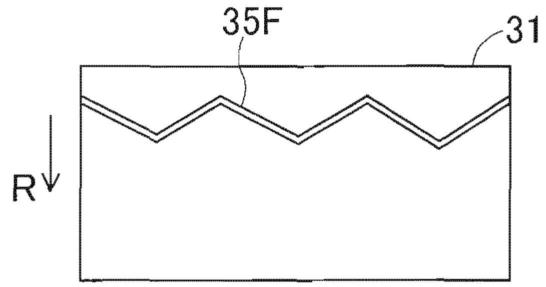


Fig. 25

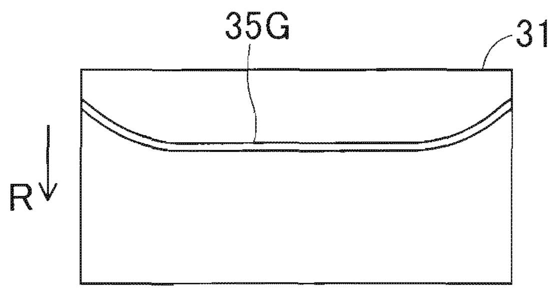


Fig. 26

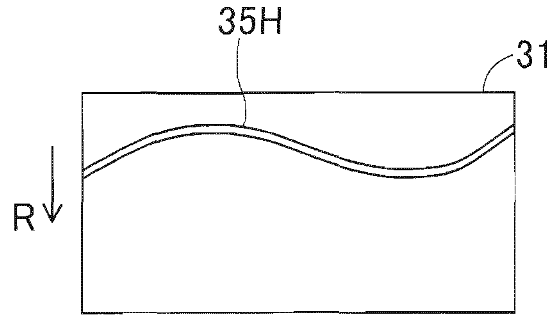


Fig. 27

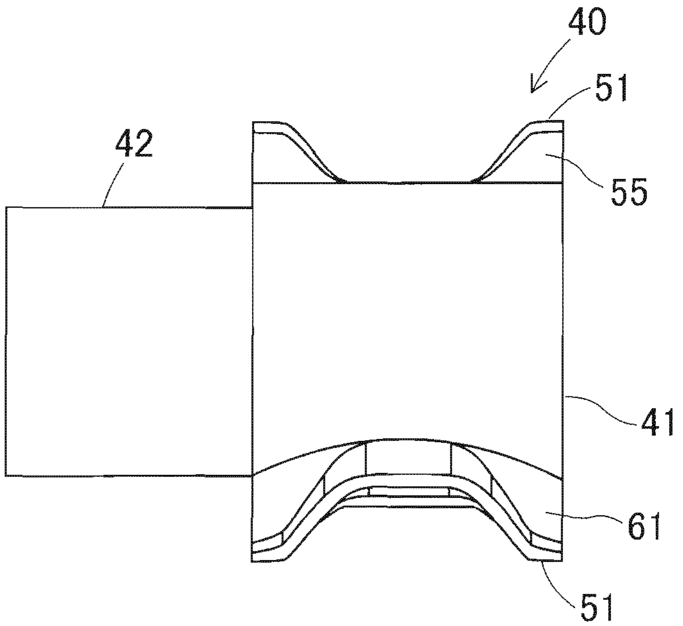


Fig. 28

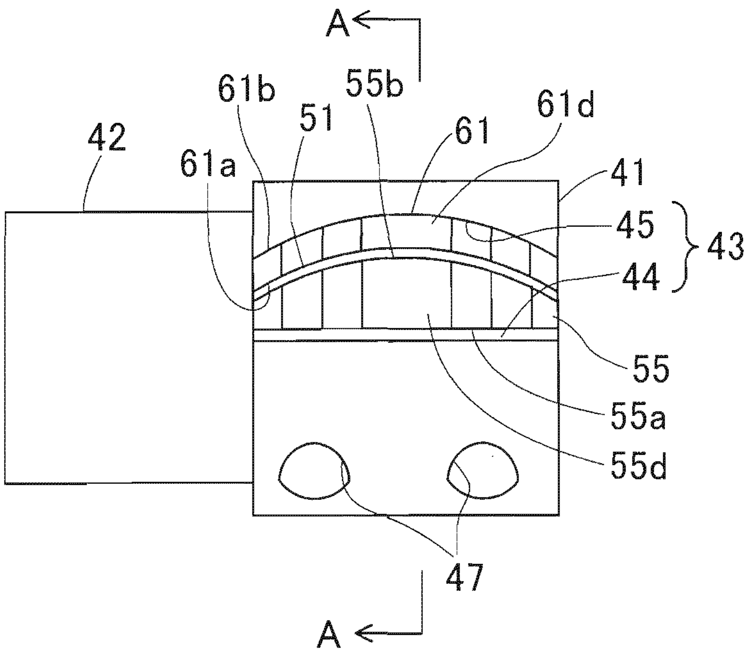
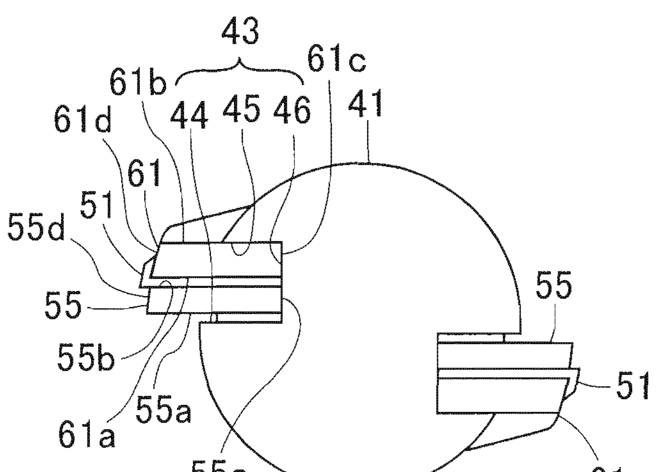

A
61b
55b
61d
51
61
42
61a
41
45
43
44
55
55a
55d
47
A

Fig. 29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61c
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61d
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55d
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55
55b
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55a
61a
55c
61

Fig. 30

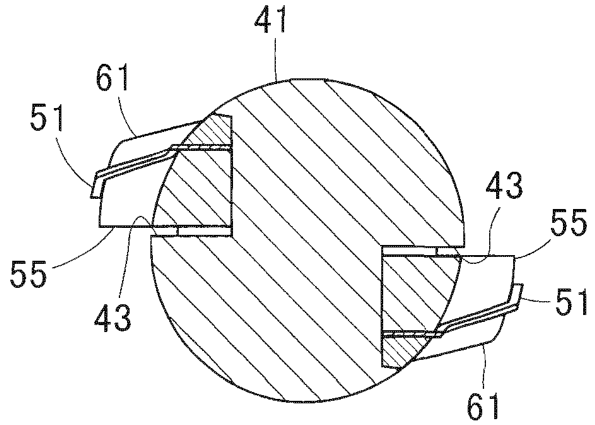


Fig. 31A

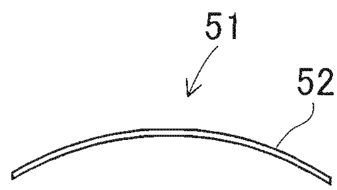


Fig. 31B

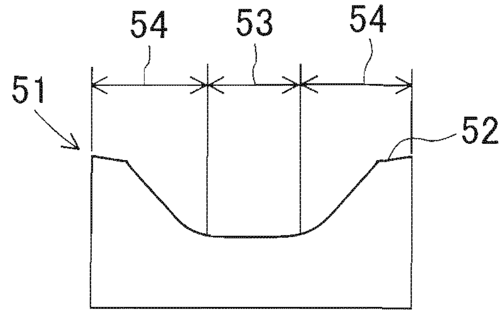


Fig. 32A

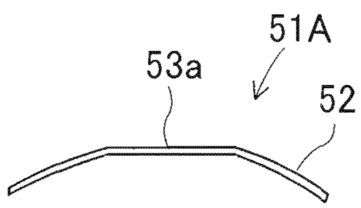
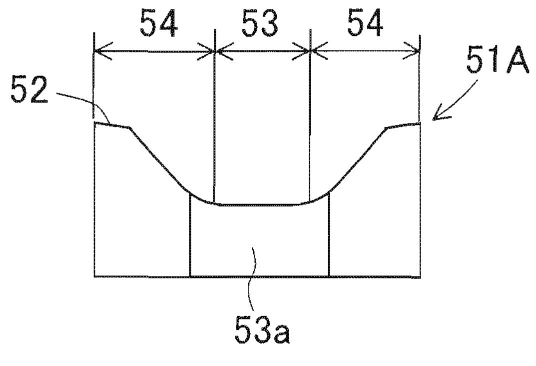


Fig. 32B



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/002356

A. CLASSIFICATION OF SUBJECT MATTER
B27G13/04(2006.01)i, *B23C5/04*(2006.01)i

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)
B27G13/04, B23C5/04

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, 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.
Y	GB 2080192 A (Joseph Thomas WOLF), 03 February 1982 (03.02.1982), page 2, line 24 to page 3, line 59; fig. 1 to 4 (Family: none)	1-5
Y	JP 2010-521329 A (SMS Demag AG.), 24 June 2010 (24.06.2010), abstract; claim 7; paragraphs [0011], [0022], [0024], [0029]; fig. 1 to 3 & US 2011/0044773 A1 & EP 2136952 A1 & WO 2008/113314 A1 & DE 102007014262 A1 & CA 2679959 A & CN 101631635 A & KR 10-2009-0130862 A	1-5

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

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INTERNATIONAL SEARCH REPORT

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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.
A	JP 58-197003 A (Gianfranco Cecchi), 16 November 1983 (16.11.1983), claims; fig. 3 to 6 & US 4485858 A & EP 0092092 A2	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3474503 B **[0004]**
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