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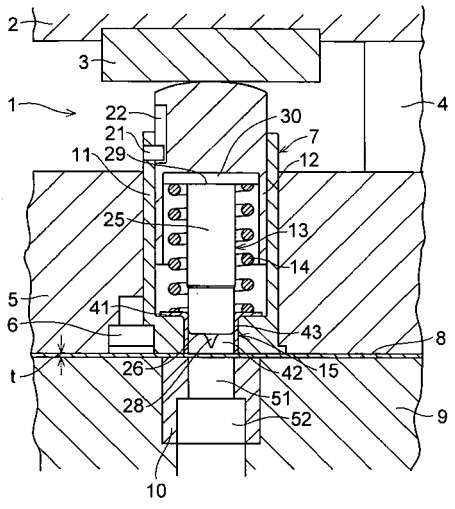
(54) PUNCH FOR THIN-PLATE METAL AND PUNCH DEVICE FOR THIN-PLATE METAL WITH THE PUNCH

(57) An apparatus 1 for punching sheet metal includes an upper die holder 2 which is raised and lowered by a hydraulic ram and the like; a pressing plate 3 secured to the upper die holder 2; a pressing pad 5 suspended from the upper die holder 2 through a resilient member 4; a punch holder 7 constructed as a punch unit secured to the pressing pad 5 by means of a bolt 6 and the like; a lower die 9 on which sheet metal 8 to be subjected to punching is placed; and a die 10 embedded in the lower die 9.

[Fig. 1]



EP 1 621 268 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a punch for punching sheet metal and an apparatus for punching sheet metal having the punch.

BACKGROUND ART

[0002] A punching apparatus has been proposed in which a punch, which includes a cylindrical body having a smaller outside diameter than the hole diameter of a die and a conical projection provided on one end face of this cylindrical body, is pressed against sheet metal to form a pierced hole in the sheet metal. As the punch is further inserted into the hole in the die in a state in which the movement of the sheet metal is restricted by the projection inserted in the pierced hole, the sheet metal is fractured around the end face of the cylindrical body of the punch, thereby allowing a through hole of substantially the same diameter as that of the hole in the die to be formed in the sheet metal.
Patent Document 1: JP-A-2002-153920

DISCLOSURE OF THE INVENTION

PROBLEMS THAT THE INVENTION IS TO SOLVE

[0003] According to such a punching apparatus, the sheet metal is positioned by the projection, and a through hole is formed by applying mainly a tensile force rather than a shearing force to the sheet metal, so that the through hole can be formed accurately in the sheet metal without producing burrs. However, in connection with such as the thickness of the sheet metal and the diameter and the like of the through hole to be formed in the sheet metal, there are cases where the pierced hole cannot be formed desirably in the sheet metal by the projection. Moreover, as a result of the fact that cutting based on the shearing force mainly takes place with respect to the sheet metal, rather than fracture based on the tensile force, there are possibilities that the through hole cannot be accurately formed in the sheet metal, and that burrs may occur in the sheet metal after the formation of the through hole.

[0004] As a result of repeatedly conducting strenuous studies in view of the above-described aspects, the present inventors came to complete the present invention after fmding out that a through hole can be formed accurately in the sheet metal by a projection of a particular shape and the like, and burrs are not produced in the sheet metal after the formation of the through hole. Accordingly, an object of the present invention is to provide a punch and a punching apparatus having the punch, in which even if the thickness of the sheet metal where a through hole is to be formed is different, and even if the size, e.g., the diameter, and shape of the through hole to be formed in the sheet metal are different, punching can be optimally performed with respect to the sheet metal having a different thickness and the through hole of a different size and shape, and which make it possible to form a through hole with no burrs and at an accurate position.

MEANS FOR SOLVING THE PROBLEMS

[0005] A punch for punching sheet metal in accordance with a first aspect of the invention comprises: a punch body; and a projection formed in the shape of one of a cone and a pyramid and provided integrally on one end face of the punch body, the projection having a base with an outer edge inscribing an imaginary circle which is concentric with a center of an imaginary circle inscribed by an outer edge of the end face, and which has a smaller diameter than a diameter of that imaginary circle, wherein an angle θ formed by the end face and a tangential line, which intersects an axis passing through the center of the imaginary circle inscribed by the outer edge of the end face, and which touches both a distal end face of the projection and the imaginary circle inscribed by the outer edge of the end face, is not less than 25° and not more than 60°, and a ratio e/L between, on the one hand, a difference e between a radius D1/2 of the imaginary circle inscribed by the outer edge of the end face and a radius d1/2 of the imaginary circle inscribed by the outer edge of the base and, on the other hand, a length L of a circumference of the imaginary circle inscribed by the outer edge of the end face, is a value which is not less than 0.05 and not more than 0.14.

[0006] In the punch for punching sheet metal in accordance with the invention, a pierced hole is first formed in the sheet metal by the projection, the movement of the sheet metal is restricted by the projection inserted in this pierced hole, and the sheet metal is subsequently fractured around the end face of the punch body, thereby forming a through hole in the sheet metal. However, the present invention is based on the following view: With such a punch, if the projection is too low, the projection comes off the pierced hole, which makes it impossible to restrict the movement of the sheet metal. If the projection is too high, the bending, breakage, or the like of the projection can occur, which requires frequent replacement. In addition, if the diameter of the imaginary circle inscribed by the base of the projection becomes close to the diameter of the imaginary circle inscribed by the end face of the punch body, the sheet metal cannot be fractured satisfactorily due to the effect of the pierced hole. If the diameter of the imaginary circle inscribed by the base of the projection is extremely smaller than the diameter of the imaginary circle inscribed by the end face of the punch body, the bending, breakage, or the like of the projection can occur, which requires frequent replacement.

[0007] As a result of repeatedly conducting strenuous studies on the basis of the above-described view, the

present inventors found out that even if the thickness of the sheet metal where a through hole is to be formed is different, and even if the size, e.g., the diameter, and shape of the through hole to be formed in the sheet metal are different, if the angle θ is not less than 25°, it is possible to effectively prevent the coming off of the projection from the pierced hole. In addition, if the ratio e/L is not less than 0.05, the sheet metal can be satisfactorily fractured by eliminating the effect of the pierced hole. Moreover, if the angle θ is not more than 60° and the ratio e/L is not more than 0.05, it is possible to satisfactorily avoid the bending, breakage, or the like of the projection. Thus, according to the punch for punching sheet metal in accordance with the first aspect of the invention, it is possible to optimally perform punching with respect to the sheet metal having a different thickness and the through hole having a different size and a different shape, thereby making it possible to form the through hole with no burrs and at an accurate position.

[0008] In the present invention, the distal end of the projection may be pointed or slightly rounded.

[0009] Preferably, as in the punch in accordance with a second aspect of the invention, the angle θ is less than 30° and not more than 55°, and the ratio e/L is not less than 0.09 and not more than 0.12.

[0010] The outer edge of the end face may not be chamfered. However, to reduce the effect of shear constituting the cause of burrs and more satisfactorily tension-fracture the sheet metal, the outer edge of the end face is preferably chamfered with a radius of curvature R of between 0.3 mm and 3 mm, as in the punch in accordance with a third aspect of the invention.

[0011] A diameter D1 of the imaginary circle inscribed by the outer edge of the end face is preferably not more than 100 mm as in the punch in accordance with a fourth aspect of the invention, more preferably not more than 35 mm as in the punch in accordance with a fifth aspect of the invention, and still more preferably not more than 30 mm as in the punch in accordance with a sixth aspect of the invention.

[0012] Preferably, as in the punch in accordance with a seventh aspect of the invention, the punch is arranged such that as a pierced hole is formed in the sheet metal by the projection, and the punch body is further inserted into a hole of a die in a state in which the movement of the sheet metal is restricted by the projection inserted in the pierced hole, the sheet metal is fractured around the end face of the punch body, thereby forming a through hole in the sheet metal, and the punch is used for an apparatus for punching sheet metal.

[0013] In a case where the punch body is formed in the shape of a circular cylinder, and the outer edge of its end face is formed in the shape of a circle, the hole of the die is usually a circular hole, as in that of an eighth aspect of the invention. In a case where the punch body is formed in a shape other than the circular cylinder, and the outer edge of its end face is formed in a shape other than the circle, the hole of the die should preferably have a shape corresponding to the shapes of the punch body and the outer edge of its end face.

[0014] The punch body may be formed in the shape of a circular cylinder, and the outer edge of the end face of the punch body may be formed in the shape of a circle, as in the punch in accordance with a ninth aspect of the invention; the punch body may be formed in the shape of a prism including a triangular prism, and the outer edge of the end face of the punch body may be formed in the shape of a polygon including a triangle, as in the punch in accordance with a 10th aspect of the invention; or the punch body may be formed in the shape of an elliptic cylinder, and the outer edge of the end face of the punch body may be formed in the shape of an ellipse, as in the punch in accordance with an 11th aspect of the invention. Thus, the punch body and the outer edge of its end face may have various shapes in connection with the through hole to be formed. In addition, the shapes of the punch body and the outer edge of its end face are not limited to the shapes of a circular cylinder, a prism, and an elliptic cylinder, as well as a circle, a polygon, and an ellipse, and the punch body and the outer edge of its end face may have other shapes in connection with the through hole to be formed.

[0015] The projection may be formed in the shape of a circular cone, and the outer edge of the base of the projection may be formed in the shape of a circle, as in the punch in accordance with a 12th aspect of the invention; the projection may be formed in the shape of an elliptic cone, and the outer edge of the base of the projection may be formed in the shape of an ellipse, as in the punch in accordance with a 13th aspect of the invention; and the projection may be formed in the shape of a pyramid including a triangular pyramid, and the outer edge of the base of the projection may be formed in the shape of a polygon including a triangle, as in the punch in accordance with a 14th aspect of the invention. Such a projection and the outer edge of its base may have various shapes in connection with the thickness of the sheet metal where the through hole is to be formed, as well as the through hole to be formed. In addition, the shapes of the projection and the outer edge of its base are not limited to the shapes of a circular cone, an elliptic cone, and a pyramid, as well as a circle, an ellipse, and a polygon, and the projection and the outer edge of its base may have other shapes in connection with the thickness of the sheet metal where the through hole is to be formed, as well as the through hole to be formed.

[0016] An apparatus for punching sheet metal in accordance with a first aspect of the invention comprises: the punch for punching sheet metal according to any one of the above-described aspects; and the die having the hole into which the punch is inserted, wherein a ratio D1/D2 of a diameter D2 of an imaginary circle inscribed by an outer edge of the hole of the die with respect to the diameter D1 of the imaginary circle inscribed by the outer edge of the end face is not less than 0.80, and if the thickness of the sheet metal to be punched is assumed

to be t, a difference f between the radius D1/2 of the imaginary circle inscribed by the outer edge of the end face and a radius D2/2 of the imaginary circle inscribed by the outer edge of the hole of the die is not less than 0.15t.

[0017] In the punching apparatus in accordance with the invention, a through hole is formed in the sheet metal by mainly causing tensile fracture to occur by applying slight shear to the sheet metal by means of the punch and the die. However, if the ratio D1/D2 is excessively small, shear does not practically take place, and if the difference f is excessively small, shear mainly takes place, and the tensile fracture fails to take place. If the ratio D1/D2 is not less than 0.80, and the difference f is not less than 0.15t, as in the punching apparatus in accordance with the first aspect, tensile fracture is mainly caused to occur in addition to slight shear, making it possible to effectively form the through hole in the sheet metal.

[0018] If the ratio D1/D2 is not less than 0.85, as in the punching apparatus in accordance with a second aspect of the invention, it is possible to form the through hole in the sheet metal more effectively.

[0019] The difference f as a clearance of the punch with respect to the hole of the die is sufficient if it is not less than 0.15t. Preferably, however, it suffices if the difference f is not more than 2 mm, as in the punching apparatus in accordance with a third aspect of the invention.

[0020] As in the punching apparatus in accordance with a fourth aspect of the invention, the punching apparatus is arranged such that as a pierced hole is formed in the sheet metal by the projection, and the punch body is further inserted into the hole of the die in a state in which the movement of the sheet metal is restricted by the projection inserted in the pierced hole, the sheet metal is fractured around the end face of the punch body, thereby forming a through hole in the sheet metal.

[0021] In any one of the above-described punching apparatuses, as in the punching apparatus in accordance with a fifth aspect of the invention, the die may further include a small hole which is continuous with the hole and has an outer edge inscribing an imaginary circle of a diameter D3 which is smaller than the diameter D2 of the imaginary circle inscribed by the outer edge of the hole and is greater than diameter D1 of the imaginary circle inscribed by the outer edge of the end face. If such a small hole is provided, punch waste (scraps) produced after the formation of the through hole can be held in the small hole. Therefore, even if the hole and the small hole are disposed obliquely or horizontally, in other words, even if an attempt is made to effect the formation of the through hole obliquely or horizontally by moving the punch obliquely or horizontally, it is possible to eliminate the drawback that the punch waste falls in the small hole and cannot be discharged from the small hole, so that the through hole can be formed continuously in the consecutively supplied sheet metal.

[0022] As in the punching apparatus in accordance with a sixth aspect of the invention, at least one of the hole and the small hole may be formed in the shape of a circle, a polygon including a triangle, or an ellipse in correspondence with the shape of the punch body.

[0023] As for the sheet metal which is punched by the punching apparatus in accordance with the invention, its thickness is 0.4 mm to 2.0 mm or thereabouts to obtain a satisfactory result. To obtain a more satisfactory result, however, its thickness is 0.6 mm to 1.6 mm or thereabouts.

[0024] A punch unit in accordance with a first aspect of the invention comprises: a case; a slider fitted to the case vertically slidably; the punch according to any one of first to 14th aspects fitted in the slider vertically slidably; and returning means disposed in the slider and adapted to return the punch and the slider to their initial positions by upwardly resiliently urging the punch and the slider.

[0025] As in the punch unit in accordance with a second aspect of the invention, the punch unit in accordance with the first aspect preferably further comprises: a slide guiding member provided in the case so as to guide the vertical movement of the punch.

[0026] As in the punch unit in accordance with a third aspect of the invention, the slider may have a recess and may be adapted to engage at the recess a detent pin secured to the case, so that the slider does not come off the case by the resiliency of the returning means. As in the punch unit in accordance with a fourth aspect of the invention, the returning means preferably has a coil spring; however, the present invention is not limited to the same, and another resilient member may be used.

ADVANTAGES OF THE INVENTION

[0027] According to the present invention, it is possible to provide a punch and a punching apparatus having the punch, in which even if the thickness of the sheet metal where a through hole is to be formed is different, and even if the size and shape of the through hole to be formed in the sheet metal are different, punching can be optimally performed with respect to the sheet metal having a different thickness and the through hole of a different size and shape, and which make it possible to form a through hole with no burrs and at an accurate position.

BEST MODE FOR CARRYING OUT THE INVENTION

[0028] Hereafter, a more detailed description will be given of the present invention on the basis of the preferred embodiments illustrated in the drawings. It should be noted that the present invention is not limited to these embodiments.

[0029] In Figs. 1 to 4, an apparatus 1 for punching sheet metal in accordance with this embodiment includes an upper die holder 2 which is raised and lowered by a hydraulic ram and the like; a pressing plate 3 secured to the upper die holder 2; a pressing pad 5 suspended from the upper die holder 2 through a resilient member 4; a

punch holder 7 constructed as a punch unit secured to the pressing pad 5 by means of a bolt 6 and the like; a lower die 9 on which sheet metal 8 to be subjected to punching is placed; and a die 10 embedded in the lower die 9.

[0030] The punch holder 7 includes a hollow cylindrical case 11 secured to the pressing pad 5 by means of the bolt 6 and the like; a hollow cylindrical slider 12 fitted to the case 11 vertically slidably; a punch 13 fitted in the slider 12 vertically slidably; a returning means having a coil spring 14 which is disposed in the slider 12 and is adapted to return the punch 13 and the slider 12 to their initial positions by upwardly resiliently urging the punch 13 and the slider 12 by means of the punch 13; and a slide guiding member 15 provided in the case 11 so as to guide the vertical movement of the punch 13.

[0031] The slider 12 has a recess 22, and is adapted to engage at the recess 22 a detent pin 21 secured to the case 11, so that the slider 12 does not come off the case 11 by the resiliency of the coil spring 14. The slider is adapted to be pressed downward by the pressing plate 3 when the upper die holder 2 is lowered.

[0032] The punch 13 for punching the sheet metal 8 includes a punch body 25 formed in the shape of a circular cylinder; a projection 28 formed in the shape of one of a cone and a pyramid (circular cone in this embodiment) and provided integrally on one circular end face 26 of the punch body 25, the projection 28 having a circular base 27 with a circular outer edge 31 inscribing an imaginary circle which is concentric with the center of an imaginary circle touched by a circular outer edge 35 of the end face 26 (in the case of the circular end face 26, such an imaginary circle agrees with the circular outer edge 35 of that end face 26), and which has a smaller diameter d1 than an outside diameter D1 of that imaginary circle (in the case of the circular base 27, the imaginary circle having the diameter d1 agrees with the circular outer edge 31 of that base 27); and a collar portion 30 provided integrally on the other circular end face 29 of the punch body 25.

[0033] In the punch 13, an angle θ formed by the end face 26 and a tangential line 37, which intersects an axis O of the punch body 25 passing through the center of the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the center of the circular outer edge 35 of the end face 26, and which touches both a distal end face 36 of the projection 28 and the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the outer edge 35 of the end face 26, is not less than 25° and not more than 60°. A ratio e/L between, on the one hand, a difference e between a radius D1/2 of the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the circular outer edge 35 itself, and a radius d1/2 of the imaginary circle inscribed by the circular outer edge 31 of the base 27 of the projection 28, i.e., the circular outer edge 31 itself, and, on the other hand, a length L (= πD1) of the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the length of the outer edge 35 itself, is a value which is not less than 0.05 and not more than 0.14. The outer edge 35 of the end face 26 is chamfered with a radius of curvature R of not less than 0.3 mm and not more than 3 mm.

[0034] The angle θ may be not less than 30° and not more than 55°, and the ratio e/L may be not less than 0.09 and not more than 0.12.

[0035] The coil spring 14 abuts against the collar portion 30 at one end thereof and a flange portion 41 of the slide guiding member 15 at the other end thereof. The slide guiding member 15 has, in addition to the flange portion 41, a cylindrical portion 43 formed integrally with the flange portion 41 and fitted in the case 11 in a hole 42 of the case 11, and slidably guides and supports a lower end portion of the punch body 25 of the punch 13 on the inner peripheral surface of the cylindrical portion 43.

[0036] The die 10 has a circular hole 51 which is a hole into which the punch 13 is inserted, as well as a circular hole 52 continuous with the circular hole 51 and having a larger diameter than the circular hole 51 so as to discharge punch waste 57. A ratio D1/D2 of a diameter D2 of an imaginary circle inscribed by a circular outer edge 53 of the circular hole 51 (in this embodiment, this imaginary circle and the circular outer edge 53 of the circular hole 51 agree) with respect to a diameter D1 of the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the circular outer edge 35, is not less than 0.80. If the thickness of the sheet metal 8 to be punched is assumed to be t, a difference (clearance) f between the radius D1/2 of the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the circular outer edge 35 itself, and a radius D2/2 of the imaginary circle inscribed by the circular outer edge 53 of the circular hole 51 of the die 10, i.e., the circular outer edge 53 itself of the circular hole 51, is not less than 0.15t and not more than 2 mm.

[0037] The ratio D1/D2 may be not less than 0.85, and the diameter D1 may be not more than 100 mm, not more than 35 mm, or not more than 30 mm.

[0038] In the above-described punching apparatus 1, as the pressing plate 3, the pressing pad 5, and the punch holder 7 are lowered in conjunction with the lowering of the upper die holder 2, the sheet metal 8 placed on the lower die 9 is pressed by the pressing pad 5 and is fixed by being clamped between the lower die 9 and the pressing pad 5. At the same time, the slider 12 is pressed by the pressing plate 3, and the punch 13 is lowered in conjunction with the lowering of the slider 12. As the punch 13 is lowered, a pierced hole 55 is formed in the sheet metal 8 by the projection 28, as shown in Fig. 5. In a state in which the movement of the sheet metal 8 is restricted by the projection 28 inserted in the pierced hole 55, the punch 13 is further lowered, and the punch body 25 of the punch 13 is inserted into the circular hole 51 of the die 10. Thereupon, the sheet metal 8 is fractured around the end face 26 of the punch body 25, thereby forming a through hole 56 in the sheet metal 8, as shown in Fig. 6.

[0039] Incidentally, with the punch 13, since the angle θ is not less than 25°, even if the diameter of the through hole 56 to be formed in the sheet metal 8 is different, it is possible to effectively prevent the coming off of the projection 28 from the pierced hole 55. In addition, since the ratio e/L is not less than 0.05, the sheet metal 8 can be satisfactorily tension-fractured by eliminating the effect of the pierced hole 55. Moreover, since the angle θ is not more than 60° and the ratio e/L is not more than 0.05, it is possible to satisfactorily avoid the bending, breakage, or the like of the projection 28. Thus, it is possible to optimally perform punching with respect to the sheet metal 8 having different thicknesses t and the through holes 56 having different diameters, thereby making it possible to form the through hole 56 with no burrs and at an accurate position.

[0040] Moreover, since the outer edge 35 of the end face 26 is chamfered with a radius of curvature R of not less than 0.3 mm and not more than 3 mm, it is possible to reduce the effect of shear constituting the cause of burrs and more satisfactorily tension-fracture the sheet metal 8. Furthermore, since the ratio D1/D2 is not less than 0.80, and the difference f is not less than 0.15t, tensile fracture is mainly caused to occur in addition to slight shear, making it possible to effectively form the through hole 56 in the sheet metal 8.

[0041] With the punching apparatus 1, the through hole 56 is formed by vertically moving the punch 13, but the through hole 56 may be formed in an inclined portion of the sheet metal 8 by obliquely moving the punch 13.

[0042] In addition, although with the punching apparatus 1 the die 10 is constructed by including the circular hole 51 into which the punch 13 is inserted as well as the circular hole 52 for discharging the punch waste 57, the die 10 may alternatively be constructed by further including, in addition to the circular hole 51 and the circular hole 52, a small hole, i.e., a small circular hole 61 in this embodiment, which is continuous with the circular hole 51 and has a circular outer edge 60 inscribing an imaginary circle of a diameter D3 which is smaller than the diameter D2 of the imaginary circle inscribed by the circular outer edge 53 of the circular hole 51, i.e., the circular outer edge 53 itself of the circular hole 51, and which is greater than diameter D1 of the imaginary circle inscribed by the circular outer edge 35 of the end face 26, i.e., the circular outer edge 35 itself (in the case of such a small circular hole 61, the imaginary circle of the diameter D3 and the circular outer edge 60 of the small circular hole 61 agree), as shown in Fig. 7. If the punch 13 is inserted down into such a small circular hole 61 disposed between the circular hole 51 and the circular hole 52, and an attempt is made to discharge the punch waste 57 through the small circular hole 61, the punch waste 57 which is produced after the formation of the through hole 56 can be held in the small circular hole 61. Therefore, even if the circular hole 51, the circular hole 52, and the small circular hole 61 are disposed obliquely or horizontally, in other words, even if an attempt is made to effect the formation of the through hole 56 obliquely or horizontally by moving the punch 13 obliquely or horizontally, it is possible to eliminate the drawback that the punch waste 57 falls in the small circular hole 61 and cannot be discharged from the small circular hole 61, so that the through hole 56 can be formed continuously in the consecutively supplied sheet metal 8.

[0043] In the above-described punching apparatus 1, the punch body 25 is formed in the shape of a circular cylinder, and the hole of the die 10 is also the circular hole 51 corresponding to the shape of the punch body 25. Alternatively, however, as shown in Figs. 8 to 13, the punch body 25 may be formed in the shape of a regular quadrangular prism, a quadrangular prism, an elliptic cylinder, and the outer edge 35 of the end face 26 of the punch body 25 may be formed in the shape of a regular quadrangle (square), a quadrangle (rectangle), or an ellipse. In this case, as the die 10, one whose hole is the hole 51 in the form of a regular quadrangle (square), a quadrangle (rectangle), or an ellipse corresponding to the shape of the punch body 25 is used.

[0044] As shown in Figs. 8 and 9, also in the case of the punch 13 in which the punch body 25 is formed in the shape of a regular quadrangular prism, which is one of prisms including a triangular prism, and the outer edge 35 of the end face 26 of the punch body 25 is formed in the shape of a regular quadrangle, which is one of polygons including a triangle, as well as the die 10 having the hole 51 formed in the shape of a regular quadrangle, which is one of polygons including a triangle, settings are provided as follows: The angle θ formed by the end face 26 and the tangential line 37, which intersects the axis O of the punch body 25 passing through the center of an imaginary circle 71 inscribed by the outer edge 35 of the end face 26, and which touches both the distal end face 36 of the projection 28 and the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is not less than 25° and not more than 60°. The ratio e/L between, on the one hand, the difference e between the radius D1/2 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26 and the radius d1/2 of the imaginary circle inscribed by the circular outer edge 31 of the base 27 of the projection 28, i.e., the circular outer edge 31 itself, and, on the other hand, the length L (= πD1) of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is a value which is not less than 0.05 and not more than 0.14. The outer edge 35 of the end face 26 is chamfered with the radius of curvature R of not less than 0.3 mm and not more than 3 mm. The ratio D1/D2 of the diameter D2 of an imaginary circle 72 inscribed by the outer edge 53 of the regular quadrangular hole 51 with respect to the diameter D1 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is not less than 0.80. If the thickness of the sheet metal 8 to be punched is assumed to be t, the difference f between the radius D1/2 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26 and the radius D2/2 of the imaginary circle 72 inscribed

by the outer edge 53 of the regular quadrangular hole 51 of the die 10, is not less than 0.15t and not more than 2 mm.

[0045] In addition, as shown in Figs. 10 to 12, also in the case of the punch 13 in which the punch body 25 is formed in the shape of a quadrangular prism, which is one of prisms including a triangular prism, and the outer edge 35 of the end face 26 of the punch body 25 is formed in the shape of a quadrangle, which is one of polygons including a triangle, as well as the die 10 having the hole 51 formed in the shape of a quadrangle (rectangle), which is one of polygons including a triangle, settings are provided as follows: The angle θ formed by the end face 26 and the tangential line 37, which intersects the axis O of the punch body 25 passing through the center of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, and which touches both the distal end face 36 of the projection 28 and the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is not less than 25° and not more than 60°. The ratio e/L between, on the one hand, the difference e between the radius D1/2 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26 and the radius d1/2 of the imaginary circle inscribed by the circular outer edge 31 of the base 27 of the projection 28, i.e., the circular outer edge 31 itself, and, on the other hand, the length L (= πD1) of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is a value which is not less than 0.05 and not more than 0.14. The outer edge 35 of the end face 26 is chamfered with the radius of curvature R of not less than 0.3 mm and not more than 3 mm. The ratio D1/D2 of the diameter D2 of the imaginary circle 72 inscribed by the outer edge 53 of the quadrangular hole 51 with respect to the diameter D1 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is not less than 0.80. If the thickness of the sheet metal 8 to be punched is assumed to be t, the difference f between the radius D1/2 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26 and the radius D2/2 of the imaginary circle 72 inscribed by the outer edge 53 of the quadrangular hole 51 of the die 10, is not less than 0.15t and not more than 2 mm.

[0046] Furthermore, as shown in Fig. 13, also in the case of the punch 13 in which the punch body 25 is formed in the shape of an elliptic cylinder and the outer edge 35 of the end face 26 of the punch body 25 is elliptical, as well as the die 10 having an elliptical hole 51, settings are provided as follows: The angle θ formed by the end face 26 and the tangential line 37, which intersects the axis O of the punch body 25 passing through the center of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, and which touches both the distal end face 36 of the projection 28 and the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is not less than 25° and not more than 60°. The ratio e/L between, on the one hand, the difference e between the radius D1/2 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26 and the radius d1/2 of the imaginary circle inscribed by the circular outer edge 31 of the base 27 of the projection 28, i.e., the circular outer edge 31 itself, and, on the other hand, the length L (= πD1) of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is a value which is not less than 0.05 and not more than 0.14. The outer edge 35 of the end face 26 is chamfered with the radius of curvature R of not less than 0.3 mm and not more than 3 mm. The ratio D1/D2 of the diameter D2 of the imaginary circle 72 inscribed by the outer edge 53 of the elliptical hole 51 with respect to the diameter D1 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26, is not less than 0.80. If the thickness of the sheet metal 8 to be punched is assumed to be t, the difference f between the radius D1/2 of the imaginary circle 71 inscribed by the outer edge 35 of the end face 26 and the radius D2/2 of the imaginary circle 72 inscribed by the outer edge 53 of the elliptical hole 51 of the die 10, is not less than 0.15t and not more than 2 mm.

[0047] Although the projection 28 formed in the shape of a circular cone is used in the above-described punching apparatus 1, a projection 28 formed in the shape of a hexagonal pyramid, which is one of polygonal pyramids including a triangular pyramid, may alternatively be used, as shown in Figs. 14 and 15. As shown in Figs. 14 and 15, also in the case of the punch 13 in which, for example, the punch body 25 is formed in the shape of a circular cylinder and the outer edge 35 of the end face 26 of the punch body 25 is formed in the shape of a circle, and in which the projection 28 is formed in the shape of a hexagonal pyramid and the outer edge 31 of the base 27 of the projection 28 is hexagonal, settings are provided as follows: The angle θ formed by the end face 26 and the tangential line 37, which intersects the axis O of the punch body 25 passing through the center of an imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the circular outer edge 35 of the end face 26, and which touches both the distal end face 36 of the hexagonal pyramid-shaped projection 28 and the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the circular outer edge 35 of the end face 26, is not less than 25° and not more than 60°. The ratio e/L between, on the one hand, the difference e between the radius D1/2 of the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the circular outer edge 35 itself, and the radius d1/2 of an imaginary circle 73 inscribed by the hexagonal outer edge 31 of the base 27 of the projection 28, and, on the other hand, the length L (= πD1) of the imaginary circle inscribed by the outer edge 35 of the end face 26, i.e., the outer edge 35 itself, is a value which is not less than 0.05 and not more than 0.14. The outer edge 35 of the end face 26 is chamfered with the radius of curvature R of not less than 0.3 mm and not more than 3 mm. Meanwhile, the thickness t and the difference f are set in the same way as described above.

[0048] In the respective embodiments shown in Figs. 8 through 15, the angle θ may be not less than 30° and not more than 55°, and the ratio e/L may be not less than

0.09 and not more than 0.12. The ratio D1/D2 may be not less than 0.85, and the diameter D1 may be not more than 100 mm, not more than 35 mm, or not more than 30 mm.

[0049] In addition, the punch holder 7 such as the one shown in Fig. 16 may be used instead of the punch holder 7 in the apparatus 1 for punching sheet metal shown in Fig. 1. In the punch holder 7 shown in Fig. 16, the collar portion 30 provided integrally on the other circular end face 29 of the punch body 25 is positioned by being inserted and secured in a circular cavity 75 of the slider 12. The slide guiding member 15 is omitted, and the lower end portion of the punch body 25 is slidably guided and supported by, instead of the slide guiding member 15, a hollow cylindrical inner peripheral surface 76 of the case 11 defining the hole 42. A detent pin 77 is threadedly secured in the slider 12 in which the recess 22 is omitted. The detent pin 77 is adapted to engage the case 11 in an elongated hole 78 provided in the case 11 so that the slider 12 will not come off the case 11 by the resiliency of the coil spring 14. The coil spring 14 abuts at one end thereof against a spring seat 79 engaged with the collar portion 30 and at the other end thereof against an annular end 80 of the case 11, and is disposed in the case 11 concentrically with the punch 13 in such a manner as to surround the punch 13. The punch holder 7 shown in Fig. 16 is secured to the pressing pad 5 at an annular collar 82 of the case 11 by means of the bolt 6 and an engaging plate 81. Also with the punch holder 7 in Fig. 16, which is constructed as such a punch unit, in the same way as the punch holder 7 shown in Fig. 1, as the pressing plate 3 is lowered in conjunction with the lowering of the upper die holder 2, the slider 12 is pressed by the pressing plate 3, and the punch 13 is lowered in conjunction with the lowering of the slider 12. As the punch 13 is lowered, the pierced hole 55 is formed in the sheet metal 8 by the projection 28, as shown in Fig. 5. When the punch 13 is further lowered in a state in which the movement of the sheet metal 8 is restricted by the projection 28 inserted in the pierced hole 55, and the punch body 25 of the punch 13 is inserted into the circular hole 51 of the die 10, the sheet metal 8 is fractured around the end face 26 of the punch body 25, as shown in Fig. 6, thereby forming the through hole 56 in the sheet metal 8.

BRIEF DESCRIPTION OF THE DRAWINGS

[0050]

Fig. 1 is a cross-sectional view of a preferred embodiment of the present invention;
Fig. 2 is an explanatory side view of a portion of a punch used in the embodiment shown in Fig. 1;
Fig. 3 is a front elevational view of the punch shown in Fig. 2;
Fig. 4 is an explanatory diagram of the punch and a die used in the embodiment shown in Fig. 1;
Fig. 5 is a diagram explaining the operation of the embodiment shown in Fig. 1;
Fig. 6 is a diagram explaining the operation of the embodiment shown in Fig. 1;
Fig. 7 is a cross-sectional view of a portion of another preferred embodiment of the present invention;
Fig. 8 is an explanatory side view of a portion of another preferred example of the punch;
Fig. 9 is a front elevational view illustrating the relationship between the punch and the die shown in Fig. 8;
Fig. 10 is one explanatory side view of a portion of still another preferred example of the punch;
Fig. 11 is another explanatory side view of the punch shown in Fig. 10;
Fig. 12 is a front elevational view illustrating the relationship between the punch shown in Figs. 10 and 11 and the die;
Fig. 13 is a front elevational view illustrating the relationship between the die and the punch in accordance with a further preferred example;
Fig. 14 is an explanatory side view of a still further preferred example of the punch;
Fig. 15 is a front elevational view illustrating the relationship between the punch and the die shown in Fig. 14; and
Fig. 16 is a cross-sectional view of a portion of still another preferred embodiment of the present invention.

DESCRIPTION OF REFERENCE NUMERALS AND SIGNS

[0051]

1: punching apparatus
2: upper die holder
3: pressing plate
4: resilient member
5: pressing pad
6: bolt
7: punch holder
8: sheet metal
9: lower die
10: die

Claims

1. A punch for punching sheet metal comprising: a punch body; and a projection formed in the shape of one of a cone and a pyramid and provided integrally on one end face of said punch body, said projection having a base with an outer edge inscribing an imaginary circle which is concentric with a center of an imaginary circle inscribed by an outer edge of the end face, and which has a smaller diameter than a diameter of that imaginary circle, wherein an angle θ formed by the end face and a tangential line, which

intersects an axis passing through the center of the imaginary circle inscribed by the outer edge of the end face, and which touches both a distal end face of said projection and the imaginary circle inscribed by the outer edge of the end face, is not less than 25° and not more than 60°, and a ratio e/L between, on the one hand, a difference e between a radius D1/2 of the imaginary circle inscribed by the outer edge of the end face and a radius d1/2 of the imaginary circle inscribed by the outer edge of the base and, on the other hand, a length L of a circumference of the imaginary circle inscribed by the outer edge of the end face, is a value which is not less than 0.05 and not more than 0.14.

2. The punch for punching sheet metal according to claim 1, wherein the angle θ is less than 30° and not more than 55°, and the ratio e/L is not less than 0.09 and not more than 0.12.

3. The punch for punching sheet metal according to claim 1 or 2, wherein the outer edge of the end face is chamfered with a radius of curvature R of not less than 0.3 mm and not more than 3 mm.

4. The punch for punching sheet metal according to any one of claims 1 to 3, wherein a diameter D1 of the imaginary circle inscribed by the outer edge of the end face is not more than 100 mm.

5. The punch for punching sheet metal according to any one of claims 1 to 3, wherein a diameter D1 of the imaginary circle inscribed by the outer edge of the end face is not more than 35 mm.

6. The punch for punching sheet metal according to any one of claims 1 to 3, wherein a diameter D1 of the imaginary circle inscribed by the outer edge of the end face is not more than 30 mm.

7. The punch for punching sheet metal according to any one of claims 1 to 6, wherein as a pierced hole is formed in the sheet metal by said projection, and said punch body is further inserted into a hole of a die in a state in which the movement of the sheet metal is restricted by said projection inserted in the pierced hole, the sheet metal is fractured around the end face of said punch body, thereby forming a through hole in the sheet metal, and wherein said punch for punching sheet metal is used for an apparatus for punching sheet metal.

8. The punch for punching sheet metal according to claim 7, wherein the hole of said die is a circular hole.

9. The punch for punching sheet metal according to any one of claims 1 to 8, wherein said punch body is formed in the shape of a circular cylinder, and the outer edge of the end face of said punch body is formed in the shape of a circle.

10. The punch for punching sheet metal according to any one of claims 1 to 7, wherein said punch body is formed in the shape of a prism including a triangular prism, and the outer edge of the end face of said punch body is formed in the shape of a polygon including a triangle.

11. The punch for punching sheet metal according to any one of claims 1 to 7, wherein said punch body is formed in the shape of an elliptic cylinder, and the outer edge of the end face of said punch body is formed in the shape of an ellipse.

12. The punch for punching sheet metal according to any one of claims 1 to 11, wherein said projection is formed in the shape of a circular cone, and the outer edge of the base of said projection is formed in the shape of a circle.

13. The punch for punching sheet metal according to any one of claims 1 to 11, wherein said projection is formed in the shape of an elliptic cone, and the outer edge of the base of said projection is formed in the shape of an ellipse.

14. The punch for punching sheet metal according to any one of claims 1 to 11, wherein said projection is formed in the shape of a pyramid including a triangular pyramid, and the outer edge of the base of said projection is formed in the shape of a polygon including a triangle.

15. An apparatus for punching sheet metal comprising: said punch for punching sheet metal according to any one of claims 1 to 14; and said die having the hole into which said punch is inserted, wherein a ratio D1/D2 of a diameter D2 of an imaginary circle inscribed by an outer edge of the hole of said die with respect to the diameter D1 of the imaginary circle inscribed by the outer edge of the end face is not less than 0.80, and if the thickness of the sheet metal to be punched is assumed to be t, a difference f between the radius D1/2 of the imaginary circle inscribed by the outer edge of the end face and a radius D2/2 of the imaginary circle inscribed by the outer edge of the hole of said die is not less than 0.15t.

16. The apparatus for punching sheet metal according to claim 15, wherein the ratio D1/D2 is not less than 0.85.

17. The apparatus for punching sheet metal according to claim 15 or 16, wherein the difference f is not more than 2 mm.

18. The apparatus for punching sheet metal according to any one of claims 15 to 17, wherein as a pierced hole is formed in the sheet metal by said projection, and said punch body is further inserted into the hole of said die in a state in which the movement of the sheet metal is restricted by said projection inserted in the pierced hole, the sheet metal is fractured around the end face of said punch body, thereby forming a through hole in the sheet metal.

19. The apparatus for punching sheet metal according to any one of claims 15 to 18, wherein said die further includes a small hole which is continuous with the hole and has an outer edge inscribing an imaginary circle of a diameter D3 which is smaller than the diameter D2 of the imaginary circle inscribed by the outer edge of the hole and is greater than diameter D1 of the imaginary circle inscribed by the outer edge of the end face.

20. The apparatus for punching sheet metal according to any one of claims 15 to 19, wherein at least one of the hole and the small hole is formed in the shape of a circle, a polygon including a triangle, or an ellipse.

21. A die used for the apparatus for punching sheet metal according to any one of claims 15 to 20.

22. A method of forming a through hole in sheet meal by the apparatus for punching sheet metal according to any one of claims 15 to 20, comprising the steps of: forming a pierced hole in the sheet metal by said projection, and further inserting said punch body into the hole of said die in a state in which the movement of the sheet metal is restricted by said projection inserted in the pierced hole, so as to fracture the sheet metal around the end face of said punch body, thereby forming a through hole in the sheet metal.

23. A punch unit comprising: a case; a slider fitted to said case vertically slidably; said punch according to any one of claims 1 to 14 fitted in said slider vertically slidably; and returning means disposed in said slider and adapted to return said punch and said slider to their initial positions by upwardly resiliently urging said punch and said slider.

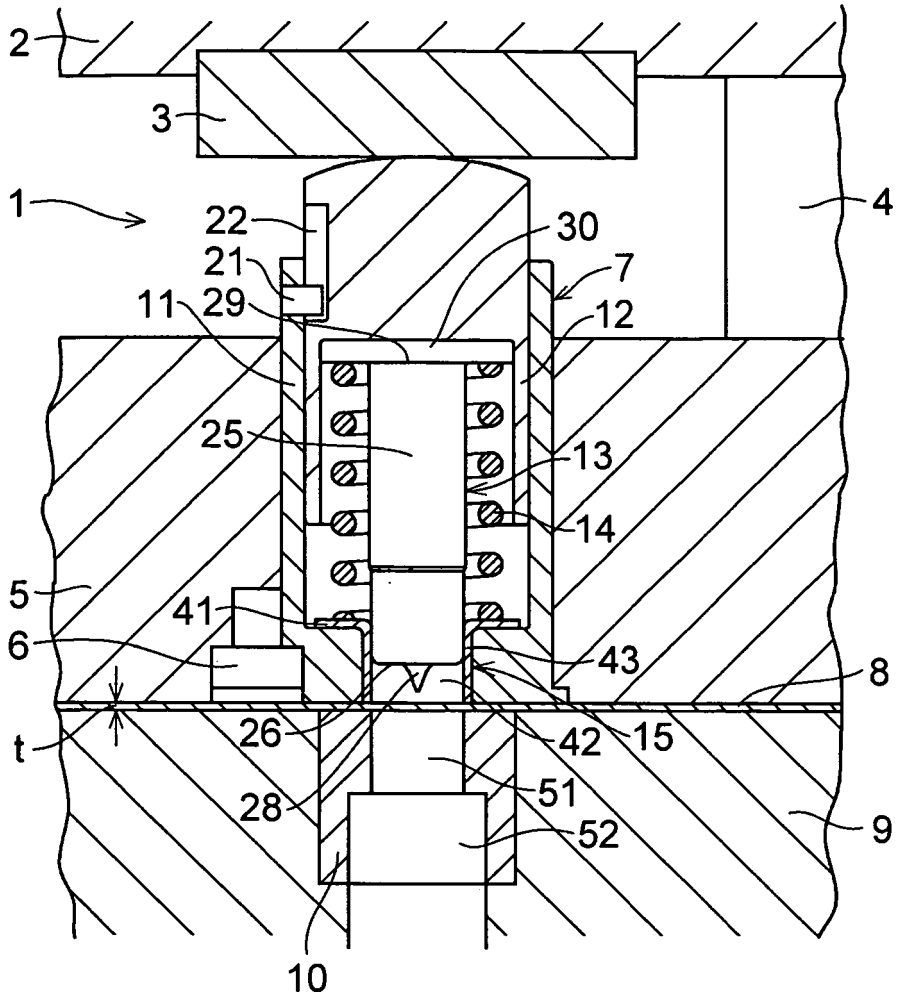
24. The punch unit according to claim 23, further comprising: a slide guiding member provided in said case so as to guide the vertical movement of said punch.

25. The punch unit according to claim 23 or 24, wherein said slider has a recess and is adapted to engage at the recess a detent pin secured to said case, so that said slider does not come off said case by the resiliency of said returning means.

26. The punch unit according to claim any one of claims 23 to 25, wherein said returning means has a coil spring.

27. The punch unit according to claim any one of claims 23 to 25 which is used for the apparatus for punching sheet metal according to any one of claims 15 to 20.

[Fig. 1]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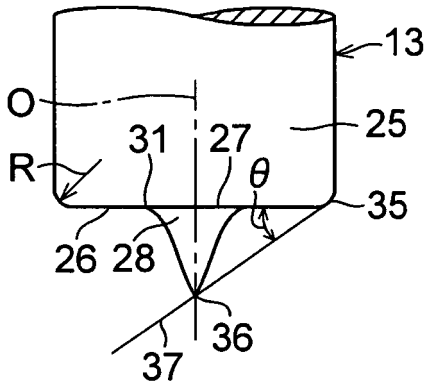
[Fig. 2]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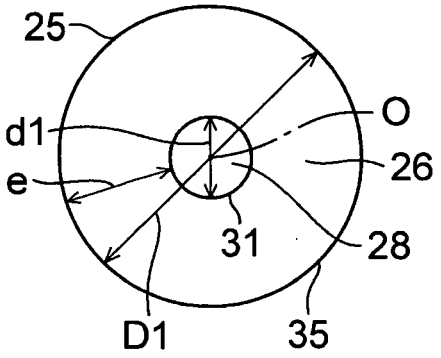
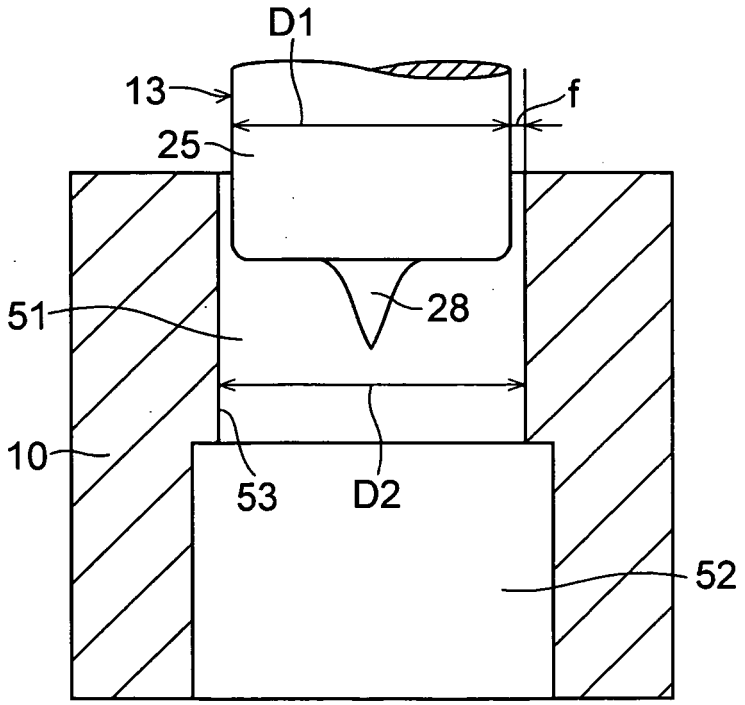
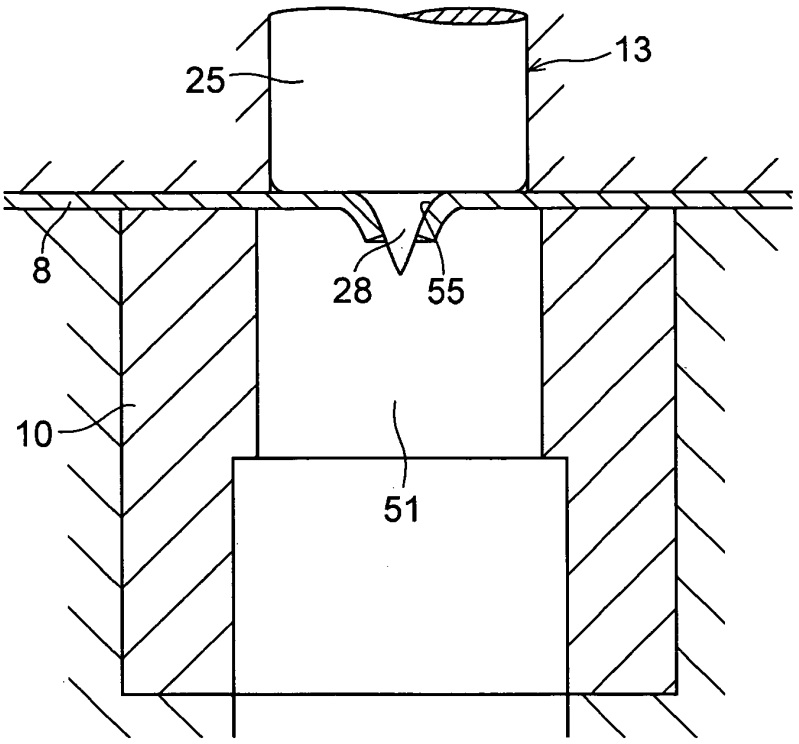
[Fig. 3]



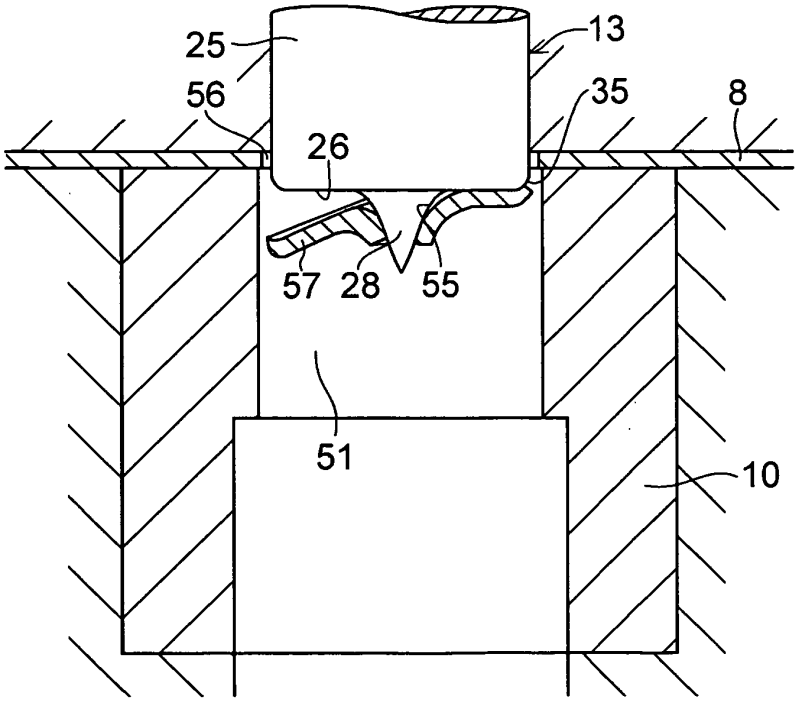
[Fig. 4]



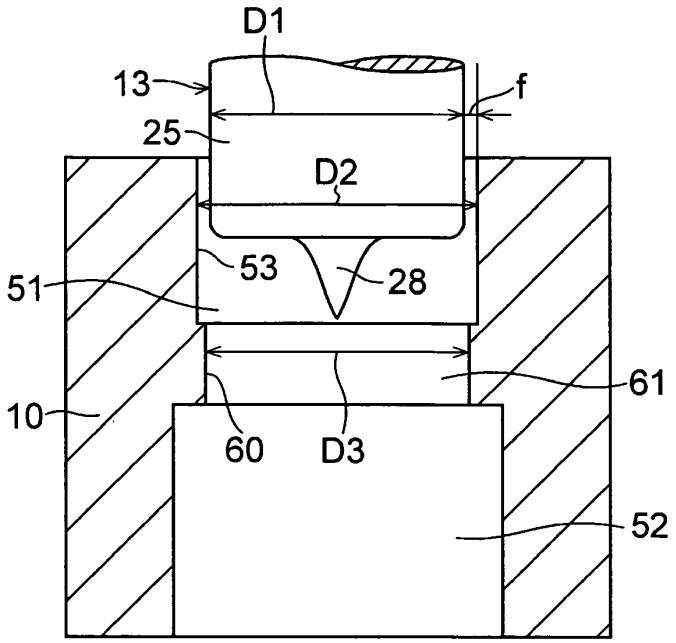
[Fig. 5]



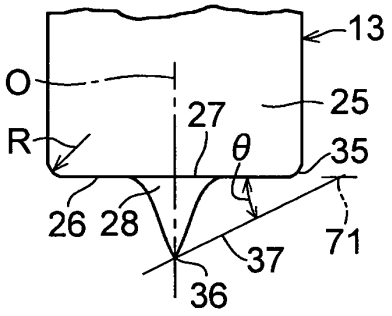
[Fig. 6]



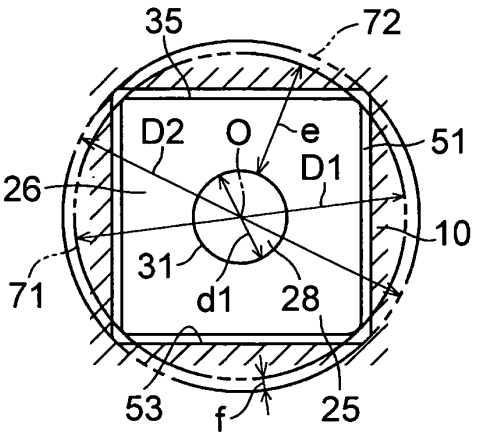
[Fig. 7]



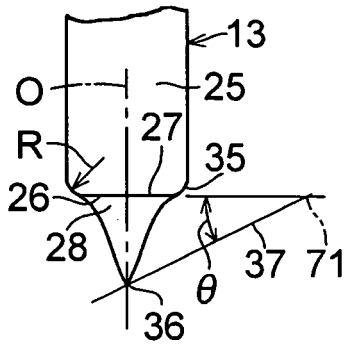
[Fig. 8]



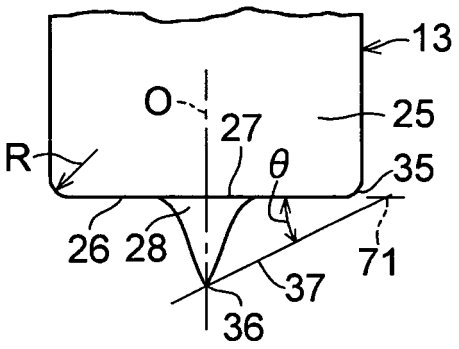
[Fig. 9]



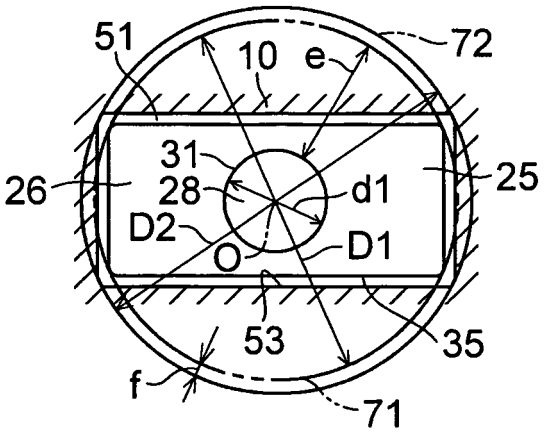
[Fig. 10]



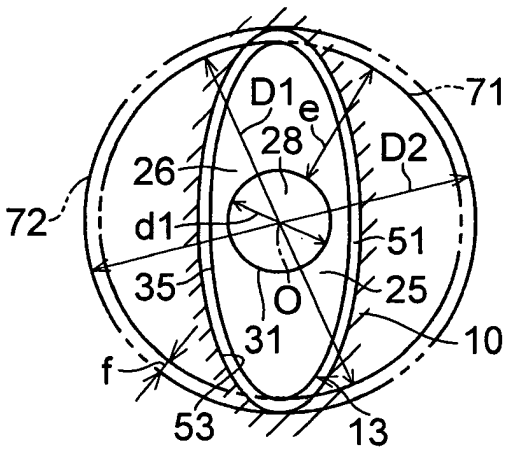
[Fig. 11]



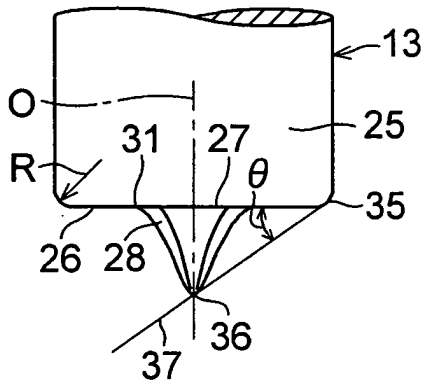
[Fig. 12]



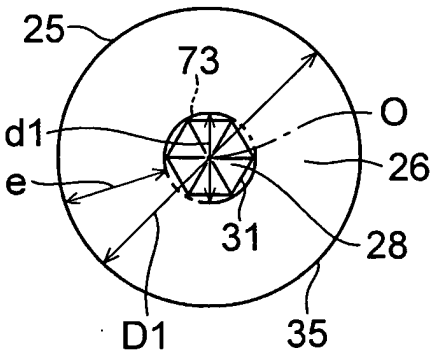
[Fig. 13]



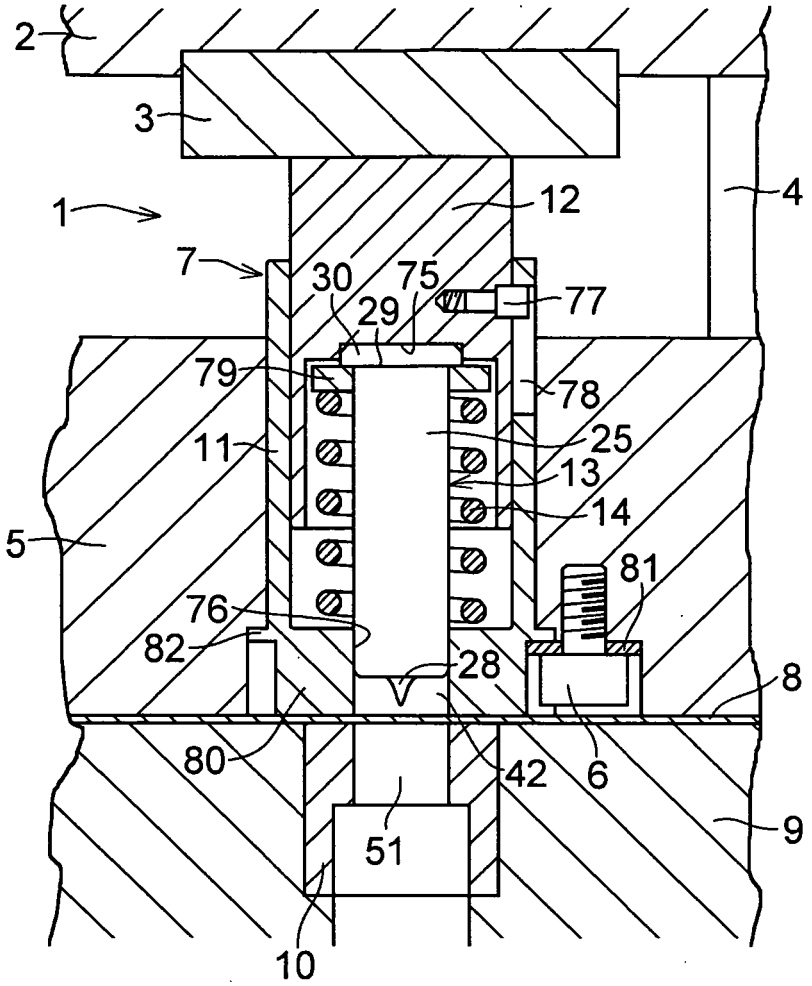
[Fig. 14]



[Fig. 15]



[Fig. 16]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/005668

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] B21D28/34

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)
Int.Cl[7] B21D28/34, 28/16

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

Jitsuyo Shinan Koho	1926-1996	Jitsuyo Shinan Toroku Koho	1996-2004
Kokai Jitsuyo Shinan Koho	1971-2004	Toroku Jitsuyo Shinan Koho	1994-2004

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.
X	JP 2002-321023 A (Amada Co., Ltd., Kabushiki Kaisha Apurotekku), 05 November, 2002 (05.11.02), Full text; all drawings (Family: none)	1-27
X	JP 2002-153920 A (Yugen kaisha Wanzu), 28 May, 2002 (28.05.02), Full text; all drawings (Family: none)	1-27

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search 27 July, 2004 (27.07.04)	Date of mailing of the international search report 10 August, 2004 (10.08.04)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2004/005668

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 420/1990(Laid-open No. 95123/1991) (Kabushiki Kaisha OEC), 27 September, 1991 (27.09.91), Full text; all drawings (Family: none)	1-22
X	JP 4-138824 A (Yasuo ONO), 13 May, 1992 (13.05.92), Full text; all drawings (Family: none)	1-22

Form PCT/ISA/210 (continuation of second sheet) (January 2004)