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(72) Inventors:
• **OISHI, Masatoshi**
Hatsukaichi-shi
Hiroshima 739-0411 (JP)
• **ARAMIZU, Teruo**
Fujisawa-shi
Kanagawa 252-0811 (JP)

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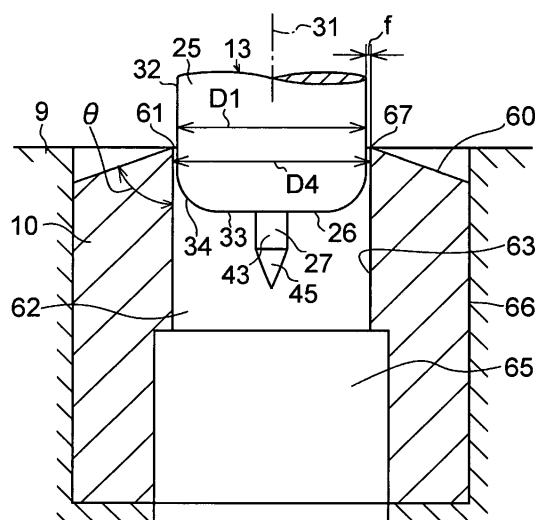
(71) Applicants:
• **Ones CO., LTD.**
12-12 Miyajimaguchi 1-chome
Hatsukaichi-shi
Hiroshima 739-0411 (JP)
• **Oiles Corporation**
Tokyo 105-8584 (JP)

(74) Representative: **Jackson, Martin Peter et al**
J.A. Kemp & Co.
14 South Square
Gray's Inn
London WC1R 5JJ (GB)

(54) **THIN PLATE METAL PUNCHING DIE AND THIN PLATE METAL PUNCHING APPARATUS PROVIDED WITH THE DIE**

(57) A sheet metal punching apparatus 1 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 thin sheet metal 8 to be subjected to punching is placed; and a die 10 embedded in the lower die 9.

FIG. 4



Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002]

[Patent Document 1] JP-A-2005-262263

[Patent Document 1] JP-A-2002-153920

[0003] A punching apparatus has been proposed in which a punch, which includes a cylindrical punch body having a smaller outside diameter than the hole diameter of a die and a conical projection formed integrally on one end face of this cylindrical punch body, is pressed against sheet metal to form in advance a pierced hole in the sheet metal by the projection of the punch. As the punch body is further inserted into the circular hole of the die through the opening of the circular 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 in cooperation with the punch body around an annular edge of an inner peripheral surface of the die, which defines one end of the circular hole of the die, to thereby form a through hole in the sheet metal (refer to Patent Documents 1 and 2).

DISCLOSURE OF THE INVENTION

PROBLEMS THAT THE INVENTION IS TO SOLVE

[0004] According to such a punching apparatus, the sheet metal is positioned by the projection, and a through hole corresponding to the shape of the outer peripheral surface of the punch body is formed by applying mainly a tensile force rather than a shearing force to the sheet metal by the punch body and the die to thereby tear off the sheet metal between the punch body and the die, so that the through hole can be formed accurately in the sheet metal without producing burrs. However, in the case of the sheet metal with a plate thickness of 0.8 mm or more, for instance, cutting based on a shearing force rather than cutting based on a tensile (tearing-off) force constitutes the principal force. As a result, there is a possibility that large burrs due to shearing are undesirably formed on one surface of the sheet metal around the through hole.

[0005] Accordingly, in the case of the sheet metal with a plate thickness not exceeding 0.8 mm, the punching apparatuses proposed in Patent Documents 1 and 2 are extremely effective, but are not yet sufficiently satisfactory for the sheet metal with a plate thickness of 0.8 mm or more in terms of the occurrence of large (high) burrs.

[0006] The present invention has been devised in view of the above-described aspects, and its object is to provide a die for punching sheet metal and a sheet metal punching apparatus having the die, which make it possible to effect punching with respect to not only sheet metal not exceeding 0.8 mm but also sheet metal of 0.8 mm or more while making it possible to sufficiently avoid the occurrence of burrs.

10 MEANS FOR OVERCOMING THE PROBLEMS

[0007] A die for punching sheet metal in accordance with the invention comprises: an end face opposing sheet metal to be punched; a through hole which is open at the end face and into which a punch is inserted through an opening in the end face; and an inner peripheral surface defining the through hole, wherein the end face and the inner peripheral surface are contiguously connected to each other with an acute angle θ at the opening of the through hole in the end face.

[0008] According to the above-described die for punching sheet metal, since the mutually contiguous connection of the end face and the inner peripheral surface is effected with the acute angle θ , i.e., since the mutually contiguously connected portion between the end face and the inner peripheral surface, which constitutes the die edge of the die, has the acute angle θ , when the sheet metal is punched in cooperation with the punch, an extremely large concentrated stress can be generated in the sheet metal at the mutually contiguously connected portion between the end face and the inner peripheral surface with the acute angle θ . As a result, the elongation of the sheet metal can be suppressed as much as possible, and the sheet metal can be cut at the mutually contiguously connected portion between the end face and the inner peripheral surface. Hence, it is possible to effect punching with respect to not only the sheet metal with a plate thickness not exceeding 0.8 mm but also the sheet metal with a plate thickness of 0.8 mm or more while making it possible to sufficiently avoid the occurrence of burrs.

[0009] In a preferred example, the end face extends in such a manner as to be inclined with respect to an axis of the punch, and the inner peripheral surface extends in parallel to the axis of the punch, and wherein the end face extending in the inclined manner and the inner peripheral surface extending in parallel are contiguously connected to each other with an acute angle θ at the opening of the through hole in the end face. In another preferred example, the end face extends perpendicularly to the axis of the punch, and the inner peripheral surface extends in such a manner as to be inclined with respect to the axis of the punch, and wherein the end face extending perpendicularly and the inner peripheral surface extending in the inclined manner are contiguously connected to each other with an acute angle θ at the opening of the through hole in the end face.

[0010] The acute angle θ may be as small as possible,

but if it is too small, the mechanical strength declines, possibly causing early deterioration and damage of the die edge. From such a viewpoint, the acute angle θ is preferably 45° to 87° , more preferably 65° to 85° , or still more preferably 75° to 83° .

[0011] The opening which constitutes the shape of the hole in the punched sheet metal is not limited to the shape of a circle, and may be formed in the shape of an ellipse, an elongated circle, a triangle, a rectangle including a square and an oblong rectangle, a polygon, or other shape. In the case of a shape having corners, such as a rectangle including a square and an oblong rectangle, a polygon, or the like, corners may be rounded, as required.

[0012] A sheet metal punching apparatus in accordance with the invention comprises: the die for punching sheet metal according to any one of the above-described aspects; and the punch which is inserted into the through hole of the die, wherein the punch includes a columnar punch body having a tubular surface extending in parallel to the axis and a projection provided integrally on one end face of the punch body on a side of insertion into the through hole of the die, the one end face of the punch body provided with the projection including an annular surface surrounding a bottom plane of the projection and extending perpendicularly to the axis and a curved surface extending from an annular outer edge of the annular surface to an annular edge of the tubular surface, whereby the sheet metal is punched in cooperation with the end face and the inner peripheral surface of the die which are contiguously connected to each other with the acute angle θ on the one hand, and the curved surface of the punch body on the other hand.

[0013] The die in accordance with the invention and the sheet metal punching apparatus in accordance with the invention using the die are not limited to those which are used for punching sheet metal with a plate thickness exceeding 0.8 mm, but may be used in the punching of sheet metal with a plate thickness of 0.8 mm or less. If they are used for punching such sheet metal, it is possible to manufacture punched sheet metal which is free of burrs and can be extremely satisfactory, as compared with conventional ones.

[0014] In the invention, the curved surface of the punch may preferably have a radius of curvature R of 0.1 mm to 5 mm in order to subject the sheet metal to tensile fracture more satisfactorily while reducing the effect of shear constituting a cause of burring.

[0015] If the thickness of the sheet metal is assumed to be t , the difference, i.e., a clearance, between the punch body and the inner peripheral surface of the die defining the through hole at the portion of the die edge is sufficient if it is not less than $0.15t$ and not more than 2 mm.

[0016] As for the sheet metal which is punched by the sheet metal 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.

ADVANTAGES OF THE INVENTION

[0017] According to the present invention, it is possible to provide a die for punching sheet metal and a sheet metal punching apparatus having the die, which make it possible to effect punching with respect to not only sheet metal not exceeding 0.8 mm but also sheet metal of 0.8 mm or more while making it possible to sufficiently avoid the occurrence of burrs.

[0018] Hereafter, a more detailed description will be given of the present invention on the basis of the preferred embodiment illustrated in the drawings. It should be noted that the present invention is not limited to such an embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

Fig. 1 is a cross-sectional view of a preferred embodiment of the present invention;

Fig. 2 is an explanatory 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 front elevational view of the die used in 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 diagram explaining the operation of the embodiment shown in Fig. 1;

Fig. 8 is a diagram explaining the operation of the embodiment shown in Fig. 1;

Fig. 9 is a diagram explaining the operation of the embodiment shown in Fig. 1;

Fig. 10 is a cross-sectional view of another preferred embodiment of the die in accordance with the present invention;

Fig. 11 is a front elevational view of the other preferred embodiment of the die in accordance with the present invention;

Fig. 12 is a front elevational view of still another preferred embodiment of the die in accordance with the present invention; and

Fig. 13 is a cross-sectional view of the still other preferred embodiment of the die in accordance with the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0020] In Figs. 1 to 5, a sheet metal punching apparatus 1 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 thin sheet metal 8 to be subjected to punching is placed; and a die 10 embedded in the lower die 9.

[0021] 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 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.

[0022] The slider 12 has a recess 21, and is adapted to engage at the recess 21 a detent pin 22 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 12 is adapted to be pressed downward by the pressing plate 3 when the upper die holder 2 is lowered.

[0023] The punch 13 for punching the sheet metal 8 includes a punch body 25 formed in the shape of a circular cylinder; a projection 27 formed integrally on a circular end face 26, i.e., one end face, of the punch body 25; and a collar 29 provided integrally on a circular end face 28, i.e., other end face, of the punch body 25.

[0024] The punch body 25 has a cylindrical surface 32 serving as a tubular surface extending in parallel to an axis 31, an annular surface 33 extending perpendicularly to the axis 31, and a curved surface 34 extending from an outer edge of the annular surface 33 to an outer edge of the cylindrical surface 32. The diameter $D1 (= 2 \times r1)$ of the punch body 25 is in the range of 1 mm to 25 mm, 1 mm to 10 mm, or 1 mm to 5 mm, and the radius of curvature $r2$ of the curved surface 34 is in the range of 0.1 mm to 5 mm.

[0025] The projection 27 includes a cylindrical portion 43 with a height h and a conical portion 45, the cylindrical portion 43 having a circular bottom plane 41 and a circular top plane 42 with a smaller diameter $D3 (= 2 \times r3)$ than the diameter $D1$ of the circular end face 26, the circular bottom plane 41 and the circular top plane 42 being disposed concentrically with that circular end face 26, the cylindrical portion 43 being provided integrally at the circular bottom plane 41 on the one circular end face 26 of the punch body 25; and the conical portion 45 having a circular bottom plane 44 with the same diameter as the diameter $D3$ of the circular top plane 42, the circular bottom plane 44 being disposed concentrically with that circular top plane 42, the conical portion 45 being provided integrally at the circular bottom plane 44 on the circular top plane 42 of the cylindrical portion 43. The circular bottom plane 41 of the cylindrical portion 43 is surrounded by the annular surface 33 of the punch body 25.

[0026] In the above-described punch 13, if it is assumed that the radius of the punch body 25 is $r1 (= D1 \times 1/2)$, the radius of curvature of the curved surface 34 is $r2$, the radius of the cylindrical portion 43 is $r3 (= D3 \times 1/2)$, the height of the cylindrical portion 43 is h , and the thickness of the sheet metal 8 to be punched is t , then $r3 < r1 - r2$, and $h > t + r3$.

[0027] The coil spring 14 abuts against the collar 29 at one end thereof and a flange portion 51 of the slide guiding member 15 at the other end thereof. The slide guiding member 15 has, in addition to the flange portion 51, a cylindrical portion 53 formed integrally with the flange portion 51 and fitted in the case 11 in a hole 52 of the case 11, and slidably guides and supports a lower end portion of the punch body 25 of the punch 13 by the inner peripheral surface of the cylindrical portion 53.

[0028] The die 10 has an annular end face 60 opposing the sheet metal 8 to be punched; a circular hole 62 which is open at the end face 60 and serves as a through hole into which the punch body 25 of the punch 13 is inserted through an opening 61 in the end face 60; an inner peripheral surface 63 defining the circular hole 62; a circular hole 65 continuous with the circular hole 62 and having a larger diameter than the circular hole 62 to discharge a punched scrap 64 (see Fig. 9); and a cylindrical outer peripheral surface 66.

[0029] The end face 60 constituting an outer surface of a truncated cone extends in such a manner as to be inclined with respect to the axis 31 of the punch 13, and the inner peripheral surface 63 constituting a cylindrical surface extends in parallel to the axis 31 of the punch 13. The end face 60 extending in the inclined manner and the inner peripheral surface 63 extending in parallel are contiguously connected to each other with an acute angle θ at the opening 61 of the circular hole 62 in the end face 60. Thus, the die 10 has a die edge 67 with the acute angle θ at the opening 61.

[0030] The ratio $D1/D4$ of the diameter $D4$ of the circular hole 62 to the diameter $D1$ of the circular end face 26 is not less than 0.80, and if the thickness of the sheet metal 8 to be punched is assumed to be t , the difference (clearance) f between the radius $r1 (= D1 \times 1/2)$ of the circular end face 26 and the radius $r4 (= D4 \times 1/2)$ of the circular hole 62 of the die 10 is not less than $0.15t$ and not more than 2 mm. The die 10 is embedded in the lower die 9 by being fitted and secured at its outer peripheral surface 66.

[0031] 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 pressing down of the slider 12. As the punch 13 is lowered, a pierced hole 71 is formed in the sheet metal 8 by the conical portion 45 of the projection

27, as shown in Fig. 6, and subsequently by the cylindrical portion 43. In a state in which the movement of the sheet metal 8 is restricted by the cylindrical portion 43 of the projection 27 inserted in the pierced hole 71, the punch 13 is further lowered, and the punch body 25 of the punch 13 is inserted into the circular hole 62 of the die 10, as shown in Fig. 7, whereby the sheet metal 8 in contact with the annular surface 33 of the circular end face 26 is pressed by that annular surface 33 and is lowered in conjunction with the lowering of the punch body 25. In this lowering, the sheet metal 8 at its portion located between the curved surface 34 of the circular end face 26 and the die edge 67 of the die 10 is pulled and elongated by the curved surface 34 of the circular end face 26 and the die edge 67 of the die 10, and the sheet metal 8 is subsequently torn off and fractured on the die edge 67 side of the die 10 in conjunction with shearing, as shown in Fig. 8. After the fracturing of the sheet metal 8 on the die edge 67 side of the die 10, the punch 13 is raised, while the punched scrap 64 is discharged through the circular hole 65, as shown in Fig. 9; thus, a through hole 72 is formed in the sheet metal 8.

[0032] Incidentally, in the die 10, since the mutually contiguous connection of the end face 60 and the inner peripheral surface 63 is effected with the acute angle θ , i.e., since the die edge 67 of the die 10 has the acute angle θ , when the sheet metal 8 is punched in cooperation with the punch body 25 of the punch 13, an extremely large concentrated stress is generated in the sheet metal 8 at the mutually contiguously connected portion between the end face 60 and the inner peripheral surface 63 with the acute angle θ . As a result, the elongation of the sheet metal 8 in the vicinity of the die edge 67 can be suppressed as much as possible, and the sheet metal 8 can be cut accurately at the mutually contiguously connected portion between the end face 60 and the inner peripheral surface 63. Hence, it is possible to effect punching with respect to not only the sheet metal with a plate thickness not exceeding 0.8 mm but also the sheet metal with a plate thickness of 0.8 mm or more while sufficiently avoiding the occurrence of burrs.

[0033] Moreover, with the punching apparatus 1 which is adapted to effect punching in the sheet metal 8 in cooperation with the end face 60 and the inner peripheral surface 63 which are contiguously connected to each other with the acute angle θ , and the curved surface 34, the projection 27 has the cylindrical portion 43 which is integrally provided on the one annular surface 33 of the punch body 25 and has the circular bottom plane 41 and the circular top plane 42. Therefore, even if the conical angle of the distal end of the conical portion 45 of the projection 27 is made large so as to make it possible to obtain sufficient strength and durability, and even if the overall projection 27 is made high so as to make it possible to prevent the projection 27 from coming off the pierced hole 71 after the formation of the pierced hole 71 by the projection 27, the annular surface 33 surrounding the circular bottom plane 41 of the cylindrical portion 43

of the projection 27 and extending perpendicularly to the axis 31 can be secured on the circular end face 26 of the punch body 25 with a sufficient breadth. Hence, the through hole 72 can be formed in the sheet metal 8 with high precision by reliably fracturing the sheet metal 8 around the die edge 67 of the die 10 in cooperation with the punch body 25. Moreover, since the curved surface 34 has the radius of curvature r_2 of 0.1 mm to 5 mm, the sheet metal 8 can be subjected to tensile fracture more satisfactorily while reducing the effect of shear constituting a cause of burring here. In addition, since the ratio $D1/D4$ is not less than 0.80, and the difference f is not less than $0.15t$, tensile fracture can be mainly caused in addition to some shear, thereby making it possible to effectively form the through hole 72 in the sheet metal 8.

[0034] According to the die 10 having the inclined end face 60, it is unnecessary to further process the end face 60 in correspondence with the shape of the sheet metal 8, thereby making it possible to attain cost reduction.

[0035] With the punching apparatus 1, the through hole 72 is formed by vertically moving the punch 13, but the through hole 72 may be formed in an inclined portion of the sheet metal 8 by obliquely moving the punch 13.

[0036] With the above-described die 10, although the die edge 67 having the acute angle θ is embodied by the end face 60 which extends in such a manner as to be inclined with respect to the axis 31 of the punch 13, an arrangement may be provided in substitution thereof or in conjunction therewith such that, as shown in Fig. 10, the inner peripheral surface 63 is formed as an inner surface of a truncated cone by being extended in such a manner as to be inclined with respect to the axis 31 of the punch 13, and the end face 60 and the inner peripheral surface 63 are contiguously connected to each other with the acute angle θ at the opening 61 of the circular hole 62 in the end face 60. In this case, the end face 60 may extend perpendicularly to the axis 31 of the punch 13.

[0037] Although the opening 61 in the above-described embodiment is formed in the shape of a circle, an arrangement may be provided in substitution thereof, the opening 61 may be formed in the shape of a quadrangle with its corners rounded, as shown in Fig. 11, or an elongated circle, as shown in Fig. 12, or another shape such as an ellipse, a triangle, a rectangle, or a polygon.

[0038] In addition, with the die 10 in the above-described embodiment, the circular hole 65 is formed continuously with the circular hole 62, but an arrangement may be provided such that, as shown in Fig. 13, a circular hole 75, which has an only slightly smaller diameter than the diameter of the circular hole 62, is concentric with the circular hole 62, and has a larger diameter than the diameter of the punch body 25, is interposed between the circular hole 62 and the circular hole 65. In this case, in the lowering of the punch 13 after the formation of the through hole 72, the punched scrap 64 is pushed out to the circular hole 75, and in the raising of the punch 13 after the pushing out of the punched scrap 64 to the cir-

cular hole 75, the punched scrap 64 is caught by an inner peripheral surface 76 of the die 10, which defines the circular hole 75, so that the punched scrap 64 can be reliably discharged to the circular hole 65 without being raised by being dragged by the punch 13.

Claims

1. A die for punching sheet metal comprising:

an end face opposing sheet metal to be punched; a through hole which is open at said end face and into which a punch is inserted through an opening in said end face; and an inner peripheral surface defining said through hole, wherein said end face and said inner peripheral surface are contiguously connected to each other with an acute angle θ at the opening of said through hole in said end face.

2. The die for punching sheet metal according to claim 1, wherein said end face extends in such a manner as to be inclined with respect to an axis of said punch, and said inner peripheral surface extends in parallel to the axis of said punch, and wherein said end face extending in the inclined manner and said inner peripheral surface extending in parallel are contiguously connected to each other with an acute angle θ at the opening of said through hole in said end face.

3. The die for punching sheet metal according to claim 1 or 2, wherein said end face extends perpendicularly to the axis of said punch, and said inner peripheral surface extends in such a manner as to be inclined with respect to the axis of said punch, and wherein said end face extending perpendicularly and said inner peripheral surface extending in the inclined manner are contiguously connected to each other with an acute angle θ at the opening of said through hole in said end face.

4. The die for punching sheet metal according to any one of claims 1 to 3, wherein the acute angle θ is 45° to 87° .

5. The die for punching sheet metal according to any one of claims 1 to 3, wherein the acute angle θ is 65° to 85° .

6. The die for punching sheet metal according to any one of claims 1 to 3, wherein the acute angle θ is 75° to 83° .

7. The die for punching sheet metal according to any one of claims 1 to 6, wherein the opening is formed in the shape of a circle, an ellipse, an elongated circle, a triangle, a rectangle, or a polygon.

8. A sheet metal punching apparatus comprising: the die for punching sheet metal according to any one of claims 1 to 7; and said punch which is inserted into said through hole of said die, wherein said punch includes a columnar punch body having a tubular surface extending in parallel to the axis and a projection provided integrally on one end face of said punch body on a side of insertion into said through hole of said die, said one end face of said punch body provided with said projection including an annular surface surrounding a bottom plane of said projection and extending perpendicularly to the axis and a curved surface extending from an annular outer edge of said annular surface to an annular edge of said tubular surface, whereby the sheet metal is punched in cooperation with said end face and said inner peripheral surface of said die which are contiguously connected to each other with the acute angle θ on the one hand, and said curved surface of said punch body on the other hand.

FIG. 1

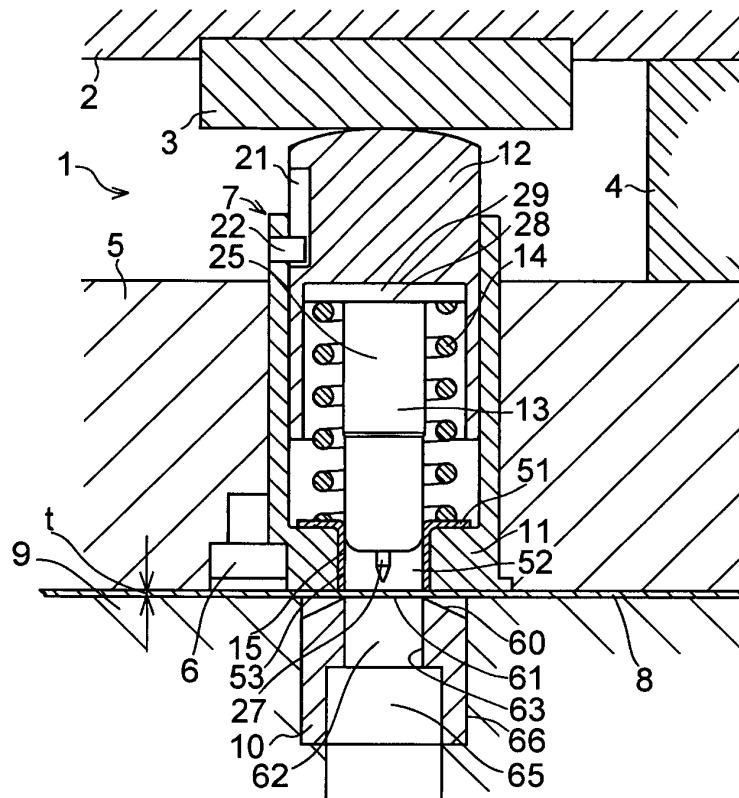


FIG. 2

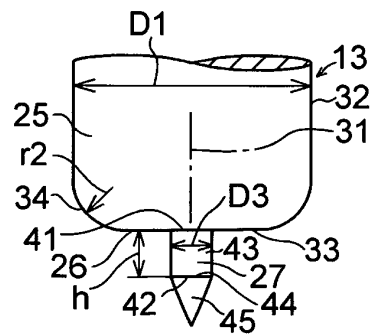


FIG. 3

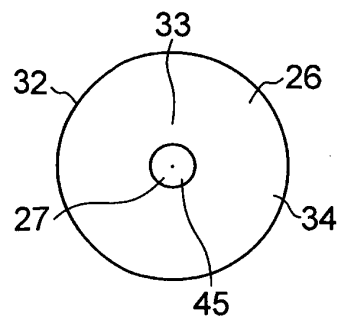


FIG. 4

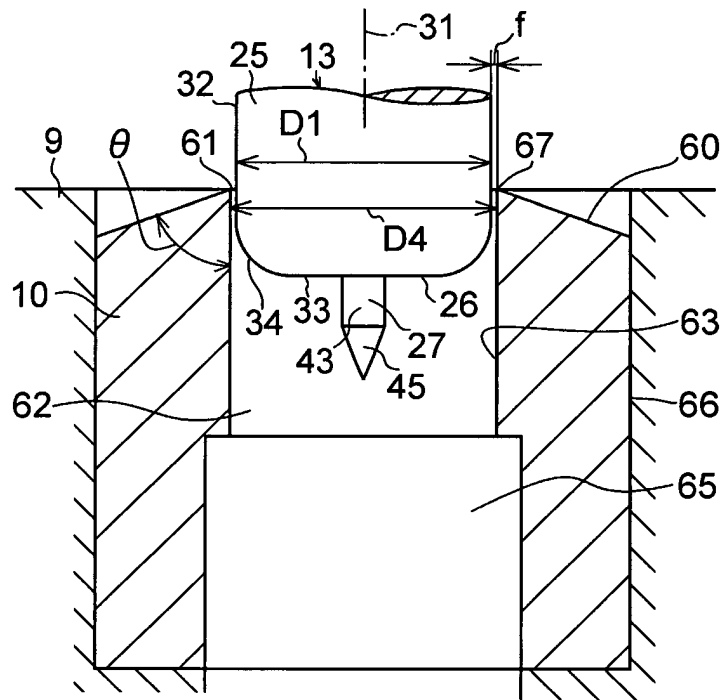


FIG. 5

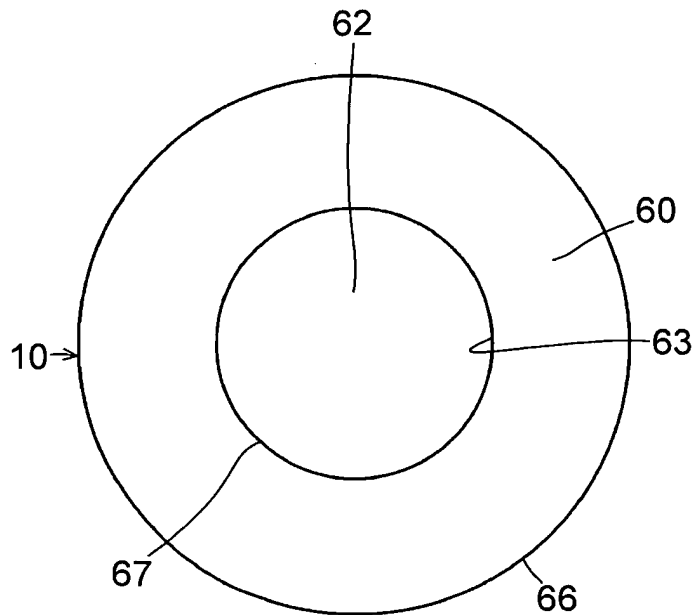


FIG. 6

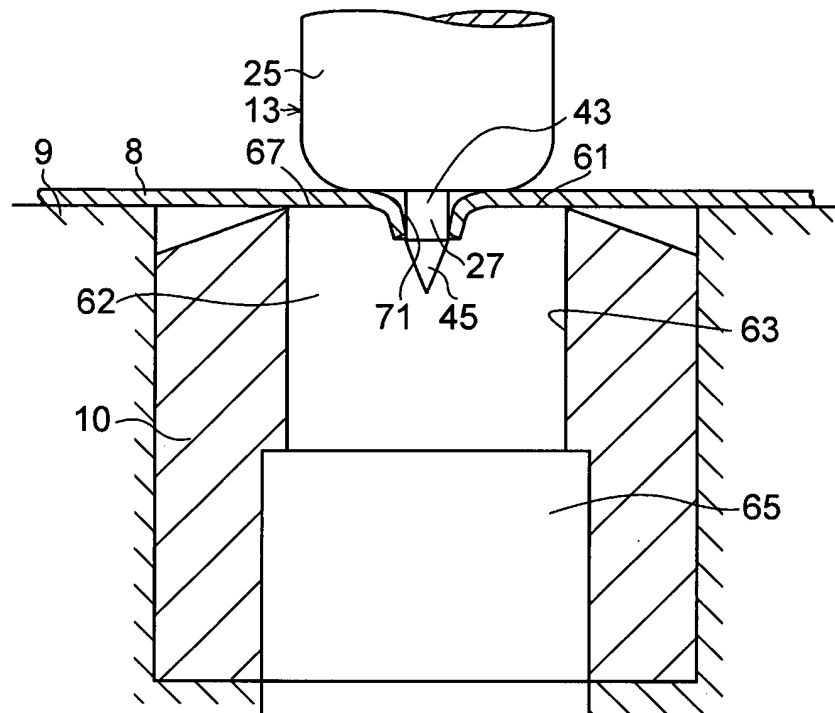


FIG. 7

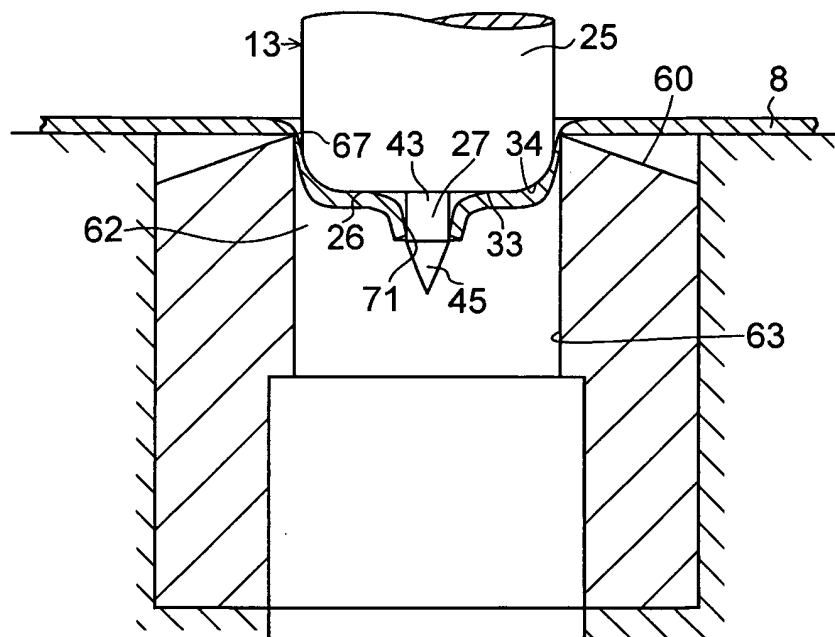


FIG. 8

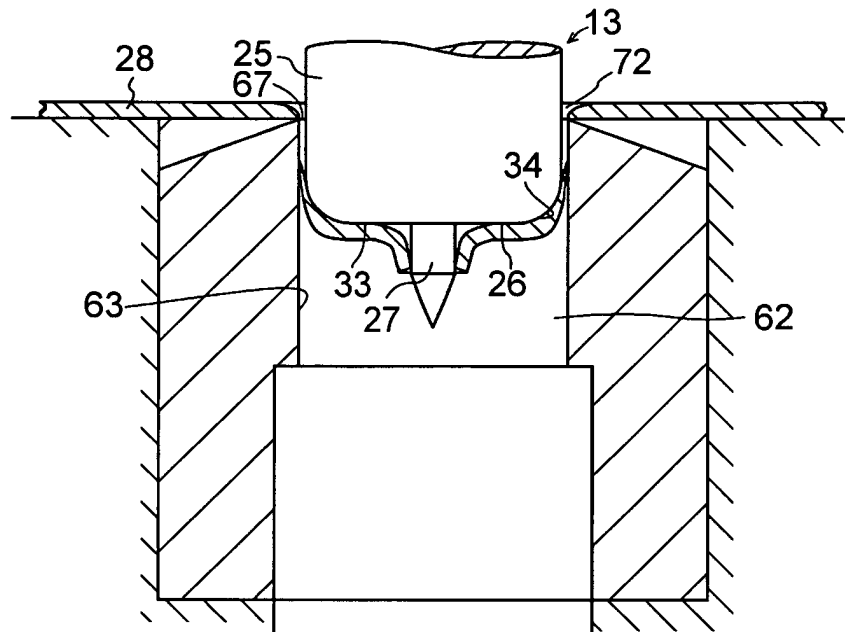


FIG. 9

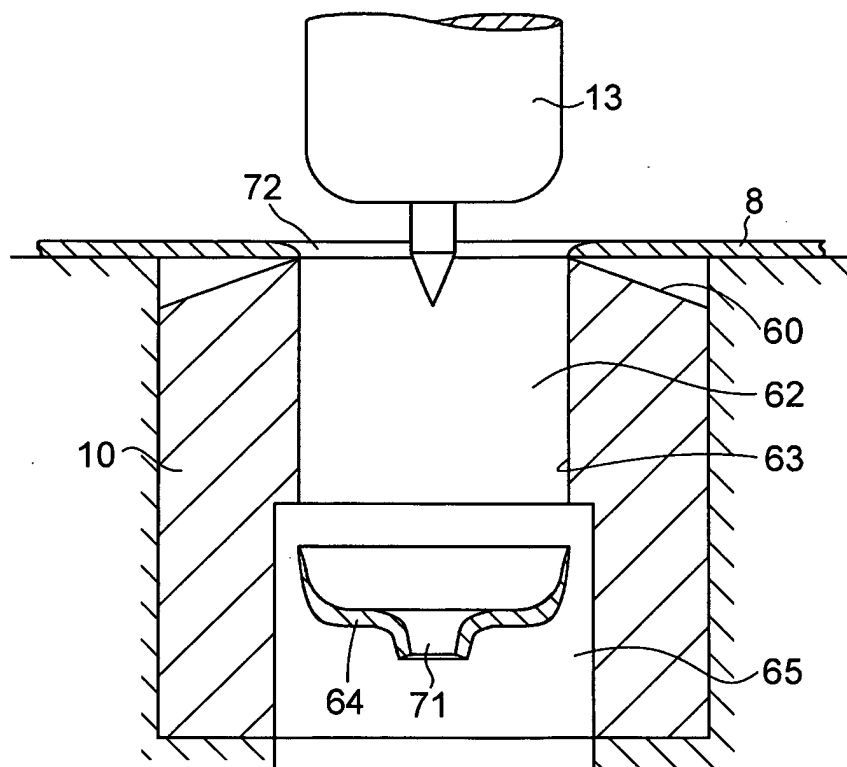


FIG. 10

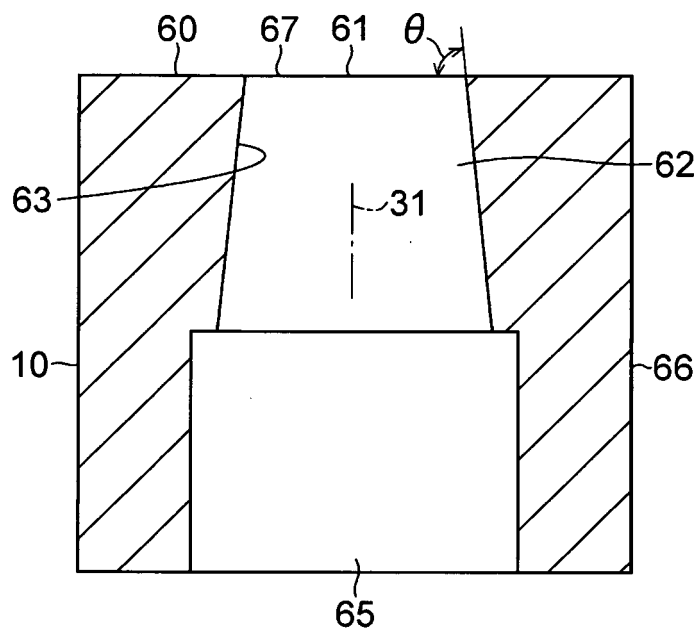


FIG. 11

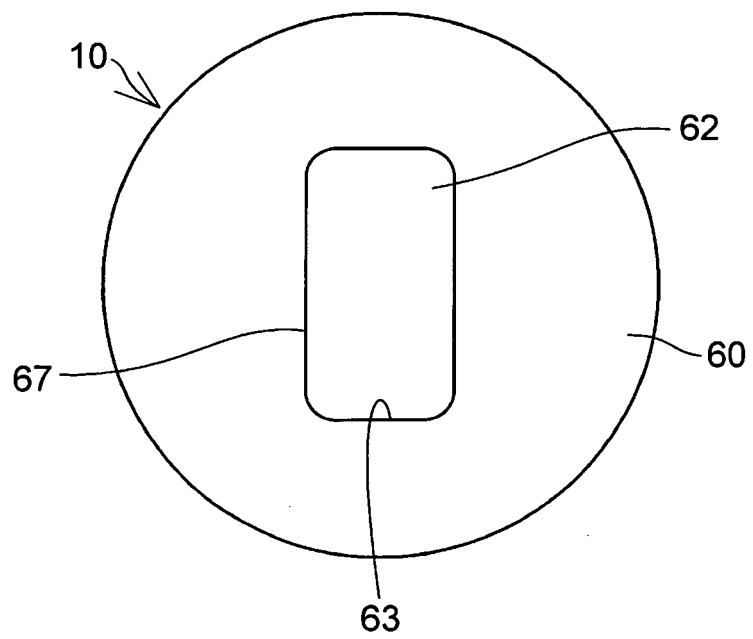


FIG. 12

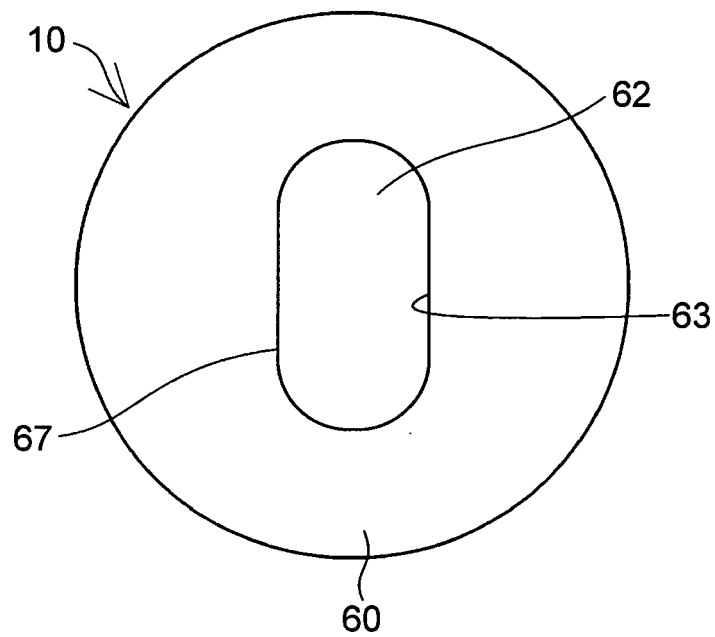
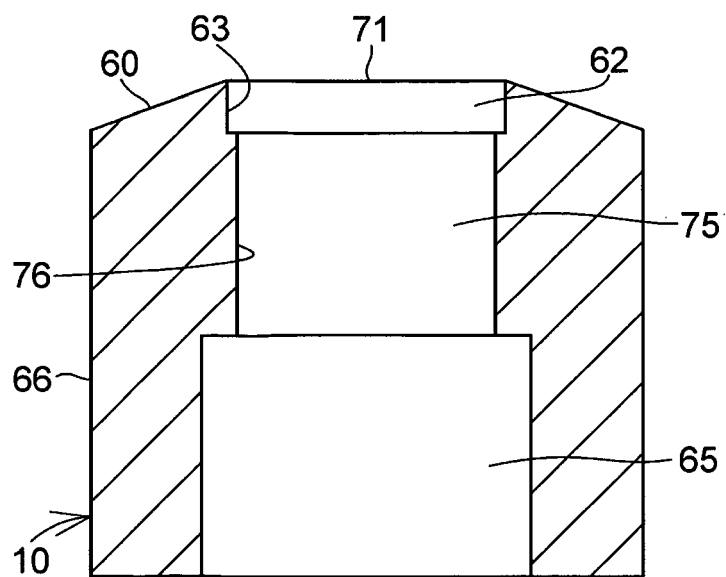


FIG. 13



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2008/001280

A. CLASSIFICATION OF SUBJECT MATTER

B21D28/34 (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)

B21D28/34

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 1996-2008

Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

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 Y	JP 2909714 B2 (Sumihiro GOTO), 23 June, 1999 (23.06.99), Par. Nos. [0009] to [0011]; Figs. 4, 5 (Family: none)	1, 2, 4-7 8
X Y	JP 62-292398 A (Hitachi Chemical Co., Ltd.), 19 December, 1987 (19.12.87), Page 2, upper right column, line 18 to lower right column, line 5; Fig. 1 (Family: none)	1, 2, 4-7 8
X Y	JP 3-99728 A (Toyota Motor Corp.), 24 April, 1991 (24.04.91), Page 2, lower right column, lines 3 to 19; Fig. 1 (Family: none)	1, 3-7 8

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

* Special categories of cited documents:

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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.
Y	WO 2004/096464 A1 (Ones Co., Ltd.), 11 November, 2004 (11.11.04), Full text & EP 1621268 A1 & US 2006/0107721 A1 & KR 2006/3028 A & CN 1780704 A	8

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Patent documents cited in the description

- JP 2005262263 A [0002]
- JP 2002153920 A [0002]