(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 123 764 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
16.08.2001 Bulletin 2001/33

(21) Application number: **99931517.9**

(22) Date of filing: **23.07.1999**

(51) Int Cl.7: **B21J 5/02**, B21K 23/04, C22C 9/04

(86) International application number:
PCT/JP99/03964

(87) International publication number:
WO 00/05008 (03.02.2000 Gazette 2000/05)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE

(30) Priority:
24.07.1998 JP 20917398
29.09.1998 JP 27579298
06.10.1998 JP 28463798
04.12.1998 JP 34556298
24.12.1998 JP 36814998
16.03.1999 JP 7015599
16.03.1999 JP 7015699
19.03.1999 JP 7667299
28.04.1999 JP 12285699
04.06.1999 JP 15729799

(71) Applicant: **TOTO LTD.**
Kitakyushu-shi, Fukuoka-ken 802-8601 (JP)

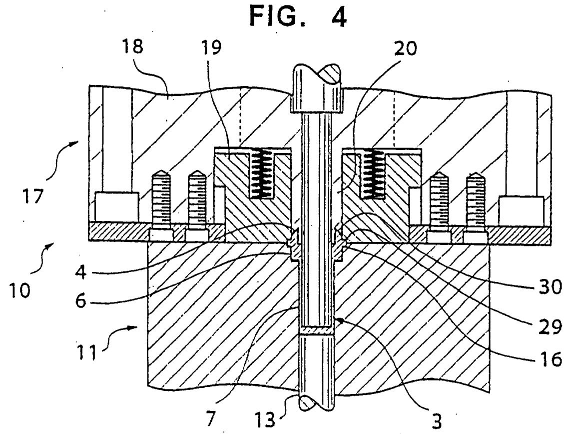
(72) Inventors:
- **SATOH, Takahiro, Toto Ltd**
  Kita-kyushu-shi, Fukuoka 802-8601 (JP)
- **SHIRAISHI, Masateru, Toto Ltd**
  Kita-kyushu-shi, Fukuoka 802-8601 (JP)
- **SUGIMOTO, Ryoichi, Toto Ltd**
  Kita-kyushu-shi, Fukuoka 802-8601 (JP)
- **NAKAMURA, Katsuaki, Toto Ltd**
  Kita-kyushu-shi, Fukuoka 802-8601 (JP)
- **AZUMA, Hiroshi, Toto Ltd**
  Kita-kyushu-shi, Fukuoka 802-8601 (JP)
- **YAMAUCHI, Atsushi, Toto Ltd**
  Kita-kyushu-shi, Fukuoka 802-8601 (JP)
- **UCHIO, Kenji, Toto Ltd**
  Kita-kyushu-shi, Fukuoka 802-8601 (JP)

(74) Representative: **HOFFMANN - EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(54) DIE FORGING METHOD

(57) A die forging method of the present invention is, in the pre-forging step, to form a inserted part 4, a flange part and a stepped inserted part 6 of a spout tip of faucet 3 by an upper outer punch 20 and an upper die 19. In the hole forming step thereafter, a recessed and protruded part 7 is formed by driving an upper inner punch 21 into a forging material while a die pin 13 is in touch with one end surface of the forging material and moving back under applying a back pressure thereto. Since a part of the forging material is filled in a die cavity in the forging step, a shape of the forming part in the forging step can be accurately created. Accordingly, a die forging method having characteristics of high productivity or forming accuracy, etc., can be provided.

FIG. 4



EP 1 123 764 A1

Description

Technical field to which the invention belongs

[0001] The present invention relates to a die forging method.

Prior art and problems to be solved by the invention

[0002] In Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631, there is disclosed a forming technique in which an inner punch and an outer punch (a hollow die pin) are respectively provided to a lower die and an upper die for forging a metal formed product, and the punches are designed to be independently drivable. And, after forming by an upper and lower dies and an upper and lower outer punches, and then, forming by an upper and lower inner punches is carried out to improve flow of materials whereby improvement in quality of the product can be accomplished.

[0003] In Japanese Provisional Patent Publication number Kokai Sho. 58(1983)-84632, a closed type forging method for a ultraplastic metal is described. According to this forging method, there is disclosed that a dimensional accuracy can be heightened by forming a void for filling at the inside of a die by movement of a movable portion provided at a part of the die, wherein the part moves when a forming power becomes a certain value in the course of forging forming, and flowing an excessive metal therein and removing the excessive part at a later stage.

[0004] In Japanese Patent Provisional Publication number Kokai Hei. 1(1989)-228638, there is disclosed a forging method in which a part of a forged material is pushed out to a side direction in a pre-forging step and the pushed out part is formed in a post-forging step. In this method, both steps are carried out by using two different dies.

[0005] In Japanese Provisional Patent Publication number Kokai Hei. 2(1990)-274341, there is disclosed a forging method in which a forging material is pushed out to a side direction and a gear is formed at the tip part of the pushed out part.

[0006] In Japanese Provisional Patent Publication number Kokai Hei. 4 (1992)-17934, there is disclosed a forging method in which a deep hole is formed by driving a punch into a forging material while moving a die pin back under applying a back pressure thereto.

[0007] In Japanese Provisional Patent Publication number Kokai Hei. 4(1992)-344845, there is disclosed a method of forging while gradually increasing a back pressure.

[0008] In Japanese Provisional Patent Publication number Kokai Hei. 7(1995)-236937, there is disclosed a method in which an pushed out part to the side direction is formed by compressing a forging material using upper and lower dies, and then a punch is driven into the forging material thereby further pushing out the pushed out part to the side direction, and then a gear is formed at the tip of said part.

[0009] At pages 109 and 110 of a Summary of the Japanese Light Metal Association, 89th Autumn Meeting (1995), there is disclosed a method of forging for forming a scroll for compressor (spiral impellers) under applying a back pressure thereto.

[0010] An object of the present invention is to provide a die forging method having characteristics such as high productivity and forming accuracy, and the like.

Means for solving the problems, and function and advantageous effect

[0011] To solve the above-mentioned problems, one embodiment of a die forging method of the present invention is:

a die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape; which comprises a pre-forging step and a hole forming step thereafter by using an identical die, in the above-mentioned pre-forging step, forging is carried out so that at least a part of the above-mentioned forging material is forged to fill in a cavity of the die to obtain a part of a shape of a formed product, and in the above-mentioned hole forming step, the hole is formed by driving a punch into said forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto.

[0012] Incidentally, in the present invention, a preferable embodiment of "moving back under applying a back pressure thereto" is, in the case of a die inner pressure is higher than the back pressure, naturally moving back occurs depending on the pressure difference.

[0013] In the die forging method of Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631, a die pin is moved back before a forging material is filled in a die cavity in the pre-forging step. On the other hand, in the die forging method in this embodiment of the present invention, part of the forging material is filled in a die cavity in a forging step (closed forging) so that a shape of the forming part in the pre-forging step can be accurately prepared.

[0014] A die forging method of another embodiment of the present invention comprises a pre-forging step and a hole forming step thereafter by using an identical die, in the above-mentioned pre-forging step, a part of a shape of a formed product is obtained and, in the above-mentioned hole forming step, a hole is formed by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto, wherein the die pin is not moved during the above-mentioned pre-forging step.

[0015] In the die forging method of Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631, a die pin is moved during a pre-forging step.

On the other hand, in the die forging method in this embodiment of the present invention, the die pin is not moved until forming of an outer shape of a formed product is finished so that forging can be carried out stably and a shape of the formed part in the pre-forging step can be accurately prepared.

[0016] A die forging method of another embodiment of the present invention comprises a hole forming step and a post-forging step thereafter by using an identical die, in the above-mentioned hole forming step, a hole is formed by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto and, in the above-mentioned post-forging step, a part of a shape of a formed product is obtained by forging at least a part of the above-mentioned forging material.

[0017] As for Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631 and Japanese Patent Publication number Kokai Hei. 4(1992)-344845, they do not have an another forging step after a hole forming step. On the other hand, in the die forging method in this embodiment of the present invention, complex and various forming can be carried out in the post-forging step.

[0018] A die forging method of another embodiment of the present invention comprises a hole forming step and a pre- or post-forging step by using an identical die, wherein in the above-mentioned hole forming step, a hole is formed by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto and, in the forging step, the above-mentioned die pin is maintained not to move basically back against a forming pressure of the forging material.

[0019] In Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631, pressing force of the punch for pressure forming is changed depending on the steps, but in this embodiment of the present invention, a maintaining force of the die pin, which is used only for back pressure and never forcing into the forging material, is changed.

[0020] A die forging method of another embodiment of the present invention comprises a hole forming step wherein a hole is formed by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto and the above-mentioned punch is driven from a direction other than the moving back direction of the above-mentioned die pin or the opposite direction of the same.

[0021] In Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631, a punch driving direction is an opposite direction to the moving back direction of the die pin, and in Japanese Patent Publication number Kokai Hei. 4(1992)-344845, it is limited only to the same direction. According to the die forging method in this embodiment of the present invention, a punch is driven from a direction other than the moving back direction of the die pin or the opposite direction of the above so that a product having a complicated and various shapes, such as a tee, can be formed.

[0022] In a die forging method of another embodiment of the present invention, forging is carried out by pressurizing the forging material using a die for die forging an outer shape of a formed product and a punch for forming an recessed part of the formed product in combination from the same direction, and moving a die pin back under applying a back pressure thereto during the forging.

[0023] The die disclosed in Japanese Provisional Patent Publication number Sho. 55(1980)-156631 (Reference numeral 2' in Fig. 10 of said publication) is not forced into while forging.

[0024] According to the die forging method in this embodiment of the present invention, a product having a complicated shape, such as shuttlecock wheel, can be formed.

[0025] In a die forging method of another embodiment of the present invention, forging is carried out by pressurizing the forging material using a plural number of punches for forming a plural number of recessed parts from a same direction, and moving a die pin back under applying a back pressure thereto during the forging.

[0026] In Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631, a punch for forming a recessed part is each one at top and bottom. On the other hand, according to this embodiment of the present invention, forging is carried out by pressurizing a forging material using a plural number of punches for forming a plural number of recessed parts from the same direction, so that a product having a complex and various shapes, such as deep hole with steps, can be formed.

[0027] In the die forging method of this embodiment, forming may be carried out by using the above-mentioned die and the punch at different timings. Or else, forming may be carried out by using a plural number of punches at different timings.

[0028] If the die and the punch (or a plural number of punches) are operated simultaneously, there is a fear of causing a defect such as defect unfilled material with in the forging die near the base of the punch during forging. However, by using the two at different timings and carrying out forming, such a defect can be prevented.

[0029] In a die forging method of another embodiment of the present invention, forging is carried out by driving a plural number of punches into the forging material from different directions simultaneously to carry out forming and by moving a die pin back under applying a back pressure thereto during the forging.

[0030] According to the die forging method of this embodiment of the present invention, a forging formed product having a complicated and various shapes, such as a tee, can be obtained.

[0031] A die forging method of another embodiment of the present invention comprises a forging step by driving a punch into the forging material or by pressing a die to the forging material while a die pin is in touch with one end surface of said forging material and moving back under applying a back pressure thereto,

wherein a plural number of die pins are provided to form a plural number of holes.

[0032] According to the die forging method of this embodiment of the present invention, a product with a complicated shape having a number of holes, such as a multi-header, can be formed.

[0033] In the die forging method in this embodiment, it is preferred that the above-mentioned plural number of die pins are operated successively along a time difference and the above-mentioned plural number of holes are successively formed. By employing such a method, a flow of a material is simple than simultaneously forming a plural number of holes by simultaneously operating the die pins, so that defects such as roll in or defect unfilled material with in the gorging die can be reduced.

[0034] A die forging method of another embodiment of the present invention comprises a forging step in which forging is completed by advancing a punch or a die to a predetermined position by pressing the punch or the die to the forging material while a die pin is in touch with one end surface of the forging material and pressured thereto, wherein in this step, when a die inner pressure is a predetermined pressure or lower, the above-mentioned die pin is not moved back and, when a die inner pressure exceeds said predetermined pressure, the die pin is moved back.

[0035] In Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631, Japanese Provisional Patent Publication number Kokai Hei. 4(1992)-344845, or Japanese Provisional Patent Publication number Kokai Hei. 4(1992)-17934, there is no idea to flow excess forging material out freely.

[0036] In Japanese Patent Publication number Kokai Sho. 58(1983)-84632, a closed type forging method for a ultraplastic metal is disclosed, in this forging method, when a forming power is reached to a certain value in the course of forging forming, a void for filling is formed at a inside of a die by moving a movable portion arranged at a part of a die, an excess metal is poured therein, and then, the excess part is removed later to improve a dimensional accuracy. However, according to this method, inside of the die is not a closed state (filled up state) when an excess metal is poured into the void for filling. In the die forging method of this embodiment of the present invention, the die pin is moved back depending on the pressure of a material in the die, i.e., the die pin is moved back while maintaining the closed state.

[0037] A die forging method of another embodiment of the present invention comprises a hole-forming step by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and the die pin is moving back under applying a back pressure to the forging material, wherein a recessed or protruded part is provided at the end surface of the above-mentioned die pin, which applies the back pressure, and a part of product shape is formed by using the recessed or protruded part.

[0038] In Japanese Provisional Patent Publication number Kokai Sho. 55(1983)-156631 and two others, the end surface of the die pin, which applies a back pressure, is a flat surface without a recessed or protruded part. According to the die forging method of this embodiment of the present invention, a protruded part or a recessed part can be shaped at the formed surface, thus a forged formed product having complicated and various shapes can be obtained.

[0039] A die forging method of another embodiment of the present invention comprises a pushing out step by forming an pushed out part by forging, and a forming step by forming the pushed out part to a predetermined shape by forging further, wherein the above-mentioned both steps are carried out in an identical die.

[0040] In Japanese Provisional Patent Publication number Kokai Hei. 1(1989)-228638, a pushing out step and a forming step are carried out in different dies. In Japanese Provisional Patent Publication number Kokai Hei. 2(1990)-274341 and Japanese Provisional Patent Publication number Kokai Hei. 7(1995)-236937, a punch or a die is not pressed to a pushed out part and forming is carried out only by pushing out. As compared with these prior art techniques, according to this embodiment of the present invention, to the pushing out part pushed out in the pushing out step, forging is carried out by a punch, etc., in the forming step so that a filling property of a material is better as compared with forming only by pushing out. Also, the pushing out step and the forming step are carried out in an identical die so that kind of dies required decreases and the cost of the die is less. Further, it is not necessary to transfer the forging material to the other press during forging so that its productivity is high.

[0041] A die forging method of another embodiment of the present invention comprises a pushing out step by forming an pushed out part by forging, and a forming step by forming the pushed out part to a predetermined shape by forging further, wherein the above-mentioned pushing out part is pushed out to the same direction or the opposite direction with or to the forging in the above-mentioned pushing out step.

[0042] In Japanese Provisional Patent Publication number Kokai Hei 1(1989)-228638, a pushing out part is pushed out to the side direction of the forging direction. "The same direction or the opposite direction with or to the forging" in the die forging method of this embodiment of the present invention means to push out a part of the forging material to the same direction with or the opposite direction of the moving direction of the die or pin at forging. According to the die forging method, a forging formed product having complicated and various shapes can be obtained.

[0043] A die forging method of another embodiment of the present invention comprises a pushing out step by forming a pushed out part by forging, and a forming step by forming the pushed out part to a predetermined shape by forging further, wherein a forging material is forged a plural number of times in the above-mentioned pushing out step.

[0044] In Japanese Provisional Patent Publication number Kokai Hei 1(1989)-228638, upper and lower punches are simultaneously pressed to push out. In the die forging method of this embodiment of the present invention, since a forging material is forged a plural number of times in the pushing out step, the forming of the pushed out part is smoothly carried out, as compared with the forming of all pushed out parts by one time forging, so that a flash at the pushed out par hardly occurs.

[0045] In a die forging method of another embodiment of the present invention, while driving a first punch into the forging material, the forging material is processed by a second punch or a die without moving said first punch back.

[0046] According to the die forging method of this embodiment of the present invention, it is advantageous that a shape deformation at the formed part by the first punch dose not occur.

[0047] In a die forging method of another embodiment of the present invention, a hole is formed by driving a first punch into a forging material, and forming around the hole by a second punch or a die without drawing out said punch after finishing of forming said hole.

[0048] In Japanese Provisional Patent Publication number Kokai Sho. 55(1980)-156631, forging around a hole is carried out before finishing of the hole forming. According to the die forging method of this embodiment of the present invention, after finishing of a hole forming, peripheral area of the hole is formed by forming by a second punch or a die without drawing out the punch.

[0049] In a die forging method of another embodiment of the present invention, a forging material is formed to a predetermined shape by subjecting to plastic fluidization in a forging die under pressure; which comprises a first step by making a cavity at a side of one end part of the above-mentioned forging material, a second step by pressing the above-mentioned forging material from the other side of the above-mentioned forging material to push out said one end part of the above-mentioned forging material and fill the above-mentioned cavity whereby forming an outer shape thereof, thereby obtaining a pushed out body, and a third step by driving a punch into the above-mentioned pushed out body from said one end surface of the end part to an axis direction after the above-mentioned second step to form a recessed part in the above-mentioned pushed out body.

[0050] By continuously forming a pushed out part and a recessed part on the forging material, yield of the material, productivity and forming accuracy can be heightened and forging failure is hardly occurred. Also, an outer shape of the pushed out part can be accurately formed.

[0051] Also, after forming a first recessed part, a second recessed part with a larger diameter and shallower than the first recessed part may be continuously formed at the pushed out part by using a second punch arranged at an outer peripheral of the punch. In this case, a fluidity inhibition of the material, which occurs in the case of simultaneously forming of the first recessed part and the second recessed part, does not occur and defect unfilled material with in the forging die of the pushed out part can be prevented.

[0052] Moreover, when a recess is provided at a part of the die pin, a protruded part can be formed at a part of the end surface of the forging material simultaneously with forming the pushed out part.

[0053] In a die forging method of another embodiment of the present invention, a forging material is formed to a predetermined shape by subjecting to plastic fluidization in a forging die under pressure; which comprises a step A by forming an recessed part by driving a punch into the forging material from a end surface of one end part of the above-mentioned forging material to the axis direction, and thereafter, a step B by forming a second recessed part with a larger diameter and shallower than the first recessed part at the above-mentioned end surface by using a second punch arranged at an outer peripheral of the punch, wherein the die pin contacted to the other end of the above-mentioned forging material is moved back under applying a back pressure thereto.

[0054] Flow back, which is caused in the case that the volume of the recessed part of the forging material is pushed up to the opposite direction of the punch, does not occur, and the forging material fluidizes continuously and smoothly so that small cracks on the product do not occur. Also, a pressure of the punch may only be set to substantially the same as the working force to the material whereby buckling of the punch does not occur and a depth of the recessed part can be freely set.

[0055] In a die forging method of another embodiment of the present invention, a forging material is formed by subjecting to plastic fluidization in a forging die under pressure to obtain a formed product which has a closed bottom cylindrical shape as a whole and also has a protruded part having an undercut; wherein the method comprises a first step by pushing out an starting part of the above-mentioned protruded part at the tip of the above-mentioned forging material, and after the above-mentioned first step, a second step by pushing out the above-mentioned protruded part to the side direction by pushing said original part from the opposite direction to the pushing out direction.

[0056] By forming the cylindrical part and the protruded part having an undercut continuously, yield of the material, productivity and forming accuracy can be heightened. Also, cracks at the cylindrical part and a defect of fold at or below the surface layer at the undercut part can be prevented so that forging failure can be hardly caused.

[0057] In a die forging method of another embodiment of the present invention, a forging material is formed by subjecting to plastic fluidization in a forging die under pressure to obtain a formed product having a closed bottom cylindrical shape; wherein the method comprises a step A by a back extrusion forming the cylindrical part by driving a punch into the center portion of the above-mentioned forging material while forming the outer surface of the cylindrical part by a die cavity surface and applying a back pressure to the end surface of the cylindrical part,

a step B by firstly drawing the above-mentioned punch used for forming the above-mentioned cylindrical part when removing the above-mentioned formed product, and
a step C by removing the above-mentioned formed product from the die used for forming the outer surface of the above-mentioned cylindrical part, after the above-mentioned step B.

[0058] By lowering a drawing force of the punch and the die, deformation of the formed product can be prevented and the formed product can be surely removed.

[0059] As clearly seen from the above explanation, according to the present invention, die forging methods having characteristic features such as high productivity or forming accuracy can be provided.

BRIEF EXPLANATION OF THE DRAWINGS

[0060] Fig. 1 is a drawing schematically showing a structure of a faucet made of brass and formed by the die forging method according to the first example of the present invention, and Fig. 1(A) is a plane view, Fig. 1 (B) is a side sectional view and Fig. 1(C) is a perspective view.

[0061] Fig. 2 is a sectional view schematically showing an apparatus for forging the spout tip of faucet of Fig. 1 and forging steps thereof.

[0062] Fig. 3 is a sectional view schematically showing an apparatus for forging the spout tip of faucet of Fig. 1 and forging steps thereof.

[0063] Fig. 4 is a sectional view schematically showing an apparatus for forging the spout tip of faucet of Fig. 1 and forging steps thereof.

[0064] Fig. 5 is a drawing schematically showing a construction of a hydraulic controlling system of the forging machine for brass material shown in Figs. 2, 3 and 4.

[0065] Fig. 6 is a sectional view showing enlarged details of a lower die set 11 and a upper die set 17 of the brass material forging machines 10 shown in Figs. 2 to 4, and a forging material 3A.

[0066] Fig. 7 is a sectional view showing enlarged details of a lower die set 11 and a upper die set 17 of the brass material forging machines 10 shown in Figs. 2 to 4, and a forging material 3A.

[0067] Fig. 8 is a sectional view showing enlarged details of a lower die set 11 and a upper die set 17 of the brass material forging machines 10 shown in Figs. 2 to 4, and a forging material 3A.

[0068] Fig. 9 is a sectional view showing enlarged details of a lower die set 11 and a upper die set 17 of the brass material forging machines 10 shown in Figs. 2 to 4, and a forging material 3A.

[0069] Fig. 10 is a stroke diagram of the die or punch during forging forming.

[0070] Fig. 11 is a sectional view showing the structure of a flange formed by the die forging method according to the second example of the present invention.

[0071] Fig. 12 is a sectional view showing a semi-finished forged product of the flange of Fig. 11.

[0072] Fig. 13 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the flange of Fig. 12.

[0073] Fig. 14 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the flange of Fig. 12.

[0074] Fig. 15 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the flange of Fig. 12.

[0075] Fig. 16 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the flange of Fig. 12.

[0076] Fig. 17 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the flange of Fig. 12.

[0077] Fig. 18 is a drawing showing the structure of a shuttlecock wheel according to the third example of the present invention, and Fig. 18(A) is a plane view and Fig. 18(B) is a sectional view.

[0078] Fig. 19 is a drawing showing the structure of the semi-finished forged product of the shuttlecock wheel of Fig. 18, and Fig. 19(A) is a plane view and Fig. 19(B) is a sectional view.

[0079] Fig. 20 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0080] Fig. 21 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0081] Fig. 22 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0082] Fig. 23 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0083] Fig. 24 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the shuttlecock wheel of Fig.

19.

[0084] Fig. 25 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0085] Fig. 26 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0086] Fig. 27 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0087] Fig. 28 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0088] Fig. 29 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0089] Fig. 30 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0090] Fig. 31 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0091] Fig. 32 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0092] Fig. 33 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0093] Fig. 34 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0094] Fig. 35 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0095] Fig. 36 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0096] Fig. 37 is a sectional view schematically showing an apparatus and forging steps of another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0097] Fig. 38 is a drawing showing the structure of a water meter formed by the die forging method according to the sixth example of the present invention, and Fig. 38(A) is a front sectional view and Fig. 38(B) is a partial sectional plane view.

[0098] Fig. 39 is a drawing showing the structure of the semi-finished forged product of the water meter of Fig. 38, and Fig. 39(A) is a front sectional view and Fig. 39(B) is a partial sectional plane view.

[0099] Fig. 40 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0100] Fig. 41 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0101] Fig. 42 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0102] Fig. 43 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0103] Fig. 44 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0104] Fig. 45 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0105] Fig. 46 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0106] Fig. 47 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0107] Fig. 48 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0108] Fig. 49 is a drawing showing a SCC(Stress Corrosion Cracking) resistance test equipment.

[0109] Fig. 50 is a drawing showing a erosion resistance test equipment.

[0110] Fig. 51 is a graph showing erosion resistance test results.

[0111] Fig. 52 is a drawing showing the structure of a lightening shaft formed by the die forging method according to the seventh example of the present invention, and Fig. 52(A) is a perspective view and Fig. 52(B) is a sectional view.

[0112] Fig. 53 is a drawing showing the structure of the semi-finished forged product of the lightening shaft of Fig. 52, and Fig. 53(A) is a perspective view and Fig. 53(B) is a sectional view.

[0113] Fig. 54 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 53.

[0114] Fig. 55 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 53.

[0115] Fig. 56 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 53.

[0116] Fig. 57 is a drawing showing the structure of a lightening shaft formed by the die forging method according to the eighth example of the present invention, and Fig. 57(A) is a perspective view and Fig. 57(B) is a sectional view.

[0117] Fig. 58 is a drawing showing the structure of the semi-finished forged product of the lightening shaft of Fig. 57, and Fig. 58(A) is a perspective view and Fig. 53(B) is a sectional view.

[0118] Fig. 59 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 58.

[0119] Fig. 60 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 58.

[0120] Fig. 61 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 58.

[0121] Fig. 62 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 58.

[0122] Fig. 63 is a drawing showing the structure of a hand shower supporting fitting formed by the die forging method according to the ninth example of the present invention, and Fig. 63(A) is a plane sectional view and Fig. 63(B) is a side surface sectional view.

[0123] Fig. 64 is a sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the hand shower supporting fitting of Fig. 63.

[0124] Fig. 65 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 63.

[0125] Fig. 66 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 63.

[0126] Fig. 67 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 63.

[0127] Fig. 68 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 63.

[0128] Fig. 69 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 63.

[0129] Fig. 70 is a drawing showing the structure of a flush valve lid formed by the die forging method according to the tenth example of the present invention.

[0130] Fig. 71 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 70.

[0131] Fig. 72 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 70.

[0132] Fig. 73 is a sectional view schematically showing an apparatus and forging steps for forging hand shower supporting fitting of Fig. 70.

[0133] Fig. 74 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 70.

[0134] Fig. 75 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 70.

[0135] Fig. 76 is a sectional view schematically showing an apparatus and forging steps for forging the hand shower supporting fitting of Fig. 70.

[0136] Fig. 77 is a sectional view schematically showing an apparatus and forging steps for forging hand shower supporting fitting of Fig. 70.

[0137] Fig. 78 is a side surface sectional view showing the structure of a H-shaped bushing formed by the die forging method according to the eleventh example of the present invention.

[0138] Fig. 79 is a sectional view schematically showing an apparatus and forging steps for forging the H-shaped bushing of Fig. 78.

[0139] Fig. 80 is a sectional view schematically showing an apparatus and forging steps for forging the H-shaped bushing of Fig. 78.

[0140] Fig. 81 is a side surface sectional view showing the structure of a tee formed by the die forging method according to the twelfth example of the present invention.

[0141] Fig. 82 is a sectional view schematically showing an apparatus and forging steps for forging the tee of Fig. 81.

[0142] Fig. 83 is a sectional view schematically showing an apparatus and forging steps for forging the tee of Fig. 81.

[0143] Fig. 84 is a sectional view schematically showing an apparatus and forging steps for forging the tee of Fig. 81.

[0144] Fig. 85 is a sectional view schematically showing an apparatus and forging steps for forging the tee of Fig. 81.

[0145] Fig. 86 is a sectional view schematically showing an apparatus and forging steps for forging the tee of Fig. 81.

[0146] Fig. 87 is a side sectional view showing the structure of a multi header formed by the die forging method according to the thirteenth example of the present invention.

[0147] Fig. 88 is a sectional view schematically showing an apparatus and forging steps for forging the multi header of Fig. 87.

[0148] Fig. 89 is a sectional view schematically showing an apparatus and forging steps for forging the multi header of Fig. 87.

[0149] Fig. 90 is a sectional view schematically showing an apparatus and forging steps for forging the multi header of Fig. 87.

[0150] Fig. 91 is an assembling drawing showing a faucet apparatus according to the fourteenth example of the present invention.

[0151] Fig. 92 is a drawing of parts of the faucet apparatus of Fig. 1 in which machining has finished, and Fig. 92(A) is a plane view, Fig. 92(B) is a longitudinal sectional view and Fig. 92(C) is a side view.

[0152] Fig. 93 is a drawing showing an semi-finished forged product of the parts of the faucet apparatus of Fig. 92, and Fig. 93(A) is a plane view, Fig. 93(B) is a longitudinal sectional view and Fig. 93(C) is a side view.

[0153] Fig. 94 is a plane view schematically showing an apparatus for forging the semi-finished forged product of the parts of the faucet apparatus of Fig. 93.

[0154] Fig. 95 is a side sectional view schematically showing an apparatus for forging the semi-finished forged product of the parts of the faucet apparatus of Fig. 93.

[0155] Fig. 96 is a sectional view schematically showing a step for forging the semi-finished forged product of the parts of the faucet apparatus of Fig. 93.

[0156] Fig. 97 is a sectional view schematically showing a step for forging the semi-finished forged product of the parts of the faucet apparatus of Fig. 93.

[0157] Fig. 98 is a sectional view schematically showing a step for forging the semi-finished forged product of the parts of the faucet apparatus of Fig. 93.

[0158] Fig. 99 is a sectional view schematically showing a step for forging the semi-finished forged product of the parts of the faucet apparatus of Fig. 93.

[0159] Fig. 100 is a sectional view schematically showing a step for forging the semi-finished forged product of the parts of the faucet apparatus of Fig. 93.

[0160] Fig. 101 is a drawing showing the structure of a shower hanger according to the fifteenth example of the present invention, and Fig. 101(A) is a perspective view, Fig. 101(B) is a side view, Fig. 101(C) is a front view and Fig. 101(D) is a plane view.

[0161] Fig. 102 is a sectional view schematically showing an apparatus and forging steps for forging the shower hanger of Fig. 101.

[0162] Fig. 103 is a sectional view schematically showing an apparatus and forging steps for forging the shower hanger of Fig. 101.

[0163] Fig. 104 is a sectional view schematically showing an apparatus and forging steps for forging the shower hanger of Fig. 101.

[0164] Fig. 105 is a sectional view schematically showing an apparatus and forging steps for forging the shower hanger of Fig. 101.

[0165] Fig. 106 is a sectional view schematically showing an apparatus and forging steps for forging the shower hanger of Fig. 101.

[0166] Fig. 107 is a sectional view schematically showing an apparatus and forging steps for forging the shower hanger of Fig. 101.

[0167] Fig. 108 is a sectional view schematically showing an apparatus and forging steps for forging the shower hanger of Fig. 101.

[0168] Fig. 109 is a longitudinal sectional view showing the structure of a part X according to the sixteenth example of the present invention.

[0169] Fig. 110 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0170] Fig. 111 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0171] Fig. 112 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0172] Fig. 113 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0173] Fig. 114 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0174] Fig. 115 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0175] Fig. 116 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0176] Fig. 117 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0177] Fig. 118 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0178] Fig. 119 is a drawing schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0179] Fig. 120 is a longitudinal sectional view showing the structure of a part Y according to the sixteenth example of the present invention.

[0180] Fig. 121 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0181] Fig. 122 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0182] Fig. 123 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0183] Fig. 124 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0184] Fig. 125 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0185] Fig. 126 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0186] Fig. 127 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0187] Fig. 128 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0188] Fig. 129 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0189] Fig. 130 is a drawing schematically showing an apparatus and forging steps for forging the part Y of Fig.

120.

[0190] Fig. 131 is a longitudinal sectional view showing the structure of a part Z according to the seventeenth example of the present invention.

[0191] Fig. 132 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0192] Fig. 133 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0193] Fig. 134 is a sectional view schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0194] Fig. 135 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0195] Fig. 136 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0196] Fig. 137 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0197] Fig. 138 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0198] Fig. 139 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0199] Fig. 140 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0200] Fig. 141 is a drawing schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

EMBODIMENTS OF THE INVENTION

[0201] In the following, explanation will be made by referring to the drawings.

[0202] Fig. 1 is a drawing schematically showing a structure of a faucet made of brass and formed by the die forging method according to the first example of the present invention, and Fig. 1(A) is a plane view, Fig. 1 (B) is a side sectional view and Fig. 1(C) is a perspective view.

[0203] In faucets equipped at a kitchen or a bathroom, a part called a spout is provided. At an inside portion near to the tip of the spout, a spout tip of faucet 3 made of brass has been attached.

[0204] The upper end part of the spout tip of faucet 3 made of brass of this example is substantially a D-shaped inserted part 4. At the edge of the inserted part 4, an inclined surface 4a as a guide is provided. And, at the spout tip of faucet 3, a flange part 5 having a diameter slightly larger than the inserted part 4, a stepped inserted part 6, and a recessed and protruded part 7 extending to downward from the stepped inserted part 6 are integrally provided. This recessed and protruded part 7 is a relatively small sized closed bottom cylindrical shape having a protruded part 7b with a circular sectional shape and a recessed part 7a at the inside thereof. The protruded part 7b is formed on a extended line of the recessed part forming direction at the same time of forming with the recessed part 7a.

[0205] As will be mentioned below, the part other than the recessed and protruded part 7 can be formed in a final state by forming the brass material to the state, in which a volume of a forming cavity becomes substantially equal to the volume of the brass material (a state in which the forging material is fulfilled in the cavity) after die-clamping and an early stage of forming (pre-forging step). And the recessed and protruded part 7 is continuously formed in a following deep hole forming step.

[0206] The spout tip of faucet 3 has a plural number of sharp edge parts 6a. In the above-mentioned pre-forging step, these plural number of sharp edge parts 6a can be also formed with high accuracy.

[0207] Next, a preferred property of the preferred brass material as mentioned above will be explained. This brass material preferably has the following crystal structure in order to lower flow stress at the time of forging forming.

(a) It comprises a crystal structure having an average crystal grain diameter of 15 μm or lower,
(b) an apparent Zn content is 37 to 50% by weight, an Sn content is 1.7 to 2.2% by weight, and
(c) a crystal structure having an areal ratio of an α phase being 44 to 65%, an areal ratio of a β phase being 10 to 55% and an areal ratio of a γ phase being 1 to 25%.

[0208] Fig. 2 to Fig. 4 are sectional views schematically showing the apparatus and forging steps for forging the spout tip of faucet of Fig. 1.

[0209] The brass material forging machine 10 has a body flame (not shown in the drawing), a lower die set 11, and an upper die set 17 corresponding to the lower die set 11. The lower die set 11 has a lower die 12, a die pin 13, and a first hydraulic cylinder 14 which can retain and drive the die pin 13 up and down. The lower die 12 is fixed and the upper surface of the lower die 12 is flat. At the center portion of this lower die 12, a pin inserting hole 15 extending to the vertical direction with a circular sectional surface is provided. The die pin 13 is slidably mounted up and down in the pin inserting hole 15. By the pin inserting hole 15 and the die pin 13, an outer shape of the recessed and protruded part 7 of the spout tip of faucet 3 is formed.

[0210] Near the pin inserting hole 15 on the upper surface of the lower die 12, a step forming hole 16 (also refer to Fig. 6) is formed, which is connected to the upper end of the pin inserting hole 15. This step forming hole 16 is provided to form a stepped inserted part 6 of the spout tip of faucet 3.

[0211] The first hydraulic cylinder 14 is provided at the downward of the die pin 13 to the vertical direction, and the upper end part of a piston rod 14a of the first hydraulic cylinder 14 is connected to the die pin 13. By the first hydraulic cylinder 14, the die pin 13 can be retained at the position shown in Fig. 3 or Fig. 4, also is pulled down while applying a retaining force to the die pin 13. Furthermore, by the cylinder 14, the die pin 13 can be moved to upward to eject the spout tip of faucet 3 after forming.

[0212] The upper die set 17 has an upper slide 18 and an upper die 19. The upper die set 17 also has an upper outer punch 20 and an upper inner punch 21. The upper slide 18 moves up and down by a main hydraulic cylinder 22. The upper inner punch 21 moves up and down by a third hydraulic cylinder 23. The upper slide 18 is movably guided vertically up and down along a guided part, which is slidably engaged to a guide part provided at the body flame, and moved up and down by the main hydraulic cylinder 22.

[0213] At the center portion of the lower part of the upper slide 18, a recessed part 24 with a circular sectional shape is so provided as to open at a lower surface. At least upper tip part of the upper die 19 is slidably mounted up and down in the recessed part 24. At the upper end part of the upper die 19, a flange part 19a is formed and said flange part 19a is stopped to a stopping plate 25 fixed to the lower surface of the upper slide 18.

[0214] The lower surface of the upper die 19 is provided to be a flat surface contacting with the upper surface of the lower die 12. At the upper part of the upper die 19, a plural number of springs receiving holes 26 are so formed that whose upper end is open. To these spring receiving holes 26, compression springs 27 are inserted, respectively. The upper end of these compression springs 27 are supported by the upper end wall surface of the recessed part 24, and the upper die 19 is elastically biased strongly downward by these compression springs 27.

[0215] At the center part of the upper die 19, a punch inserting hole 28 having substantially D-shaped sectional shape is provided to the vertical direction, into which the upper outer punch 20 and the upper inner punch 21 can be fed into. Into the punch inserting hole 28, the upper outer punch 20 and the upper inner punch 21 are slidably inserted.

[0216] At the lower surface part of the upper die 19, a flange forming part 29 (also refer to Fig. 6) positioned at the outside of the punch inserting hole 28 is provided. This flange forming part 29 is provided to form the flange part 5 of the spout tip of faucet 3. At the die-clamped state of Fig. 2, the flange forming part 29 of the upper die 19 is connected to the step forming part 16 of the lower die 12.

[0217] The upper outer punch 20 is integrally formed with the upper slide 18, and slidably inserted into the punch inserting hole 28. The outer shape of the sectional surface of the upper outer punch 20 is provided to be a substantially D-shape. At the lower tip part of the upper outer punch 20, a inserted part forming part 30 (also refer to Fig. 6) for forming the inserted part 4 of the spout tip of faucet 3 is formed. As shown in Fig. 2, in the die-clamped state, the inserted part forming part 30 is spatially connected to the step forming part 16.

[0218] The upper inner punch 21 is mainly provided to form the recessed and protruded portion 7 of the spout tip of faucet 3 and has a circular sectional shape. The upper inner punch 21 is slidably inserted into an inner punch inserting hole 31 up and down at the center portion of the upper outer punch 20. The upper inner punch 21 is connected to the piston rod 23a of the third hydraulic cylinder 23 provided over thereof and drivable up and down by the cylinder 23 freely movable up and down.

[0219] Incidentally, in Fig. 2, a brass raw material 3A with a short column shape is set in a die. The brass raw material 3A is formed to the spout tip of faucet 3 shown in Fig. 4 through an semi-finished formed material 3B shown in Fig. 3.

[0220] Next, hydraulic control systems of the brass material forging machine shown in Figs. 2, 3 and 4 are explained.

[0221] Fig. 5 is a drawing schematically showing a construction of a hydraulic controlling system of the brass material forging machine shown in Figs. 2, 3 and 4.

[0222] This hydraulic control system has a hydraulic feeding machine 41 which feeds a hydraulic pressure to a first hydraulic cylinder 14, a second hydraulic cylinder 22 and a third hydraulic cylinder 23. Also, it has a hydraulic circuit containing electromagnetic directional switching valves 42 to 44 and electromagnetic proportional relief valves 45 and 46. Also, it has a plural number of detection switches 47 and control units 48. The hydraulic feeding machine 41 has a hydraulic pump, a driving motor, an oil tank, etc. which are not shown in the drawing.

[0223] The electromagnetic directional switching valve 42 is provided at an oil line that feeds a hydraulic pressure to the second hydraulic cylinder 22, the electromagnetic directional switching valve 43 is provided at an oil line that feeds a hydraulic pressure to the first hydraulic cylinder 14, and the electromagnetic directional switching valve 44 is provided at an oil line that feeds a hydraulic pressure to the third hydraulic cylinder 23.

[0224] The electromagnetic proportional relief valves 45 is connected to an oil line that feeds a hydraulic pressure to the first hydraulic cylinder 14, and a hydraulic pressure set at the electromagnetic proportional relief valves 45 is fed to the cylinder 14. According to the arrangement of the electromagnetic proportional relief valves 45, a back pressure of the die pin 13 is controlled. Similarly, the electromagnetic proportional relief valves 46 is connected to an oil line to feed a hydraulic pressure to the third hydraulic cylinder 23, and a hydraulic pressure controlled by the electromagnetic proportional relief valves 46 is fed to the cylinder 23.

[0225] A plural number of detection switches 47 contains a detection switch for detecting the upper limit position and the lower limit position of the upper die 19, a detection switch for detecting the upper limit position and the lower limit position of the upper inner punch 21, etc.

[0226] A control unit 48 has a microcomputer and input-output interface. In the ROM of the microcomputer, a control program is stored for controlling the hydraulic feeding machine 41, the electromagnetic directional switching valves 42 to 44 and the electromagnetic proportional relief valves 45 and 46 based on the detection signal from a plural number of the detection switches 47. The microcomputer carriers out controlling according to the control program.

[0227] Next, a method of forging and forming the spout tip of faucet 3 by using the above-mentioned forging machine 10 is explained in detail.

[0228] Figs. 6 to 9 are sectional views showing enlarged details of a lower die set 11 and an upper die set 17 of the brass material forging machine 10 shown in Figs. 2 to 4, and a forging material 3A.

[0229] Fig. 10 is a stroke diagram of the die or punch during forging forming.

[0230] First, as shown in Fig. 6, in the state that the upper inner punch 21 and the upper outer punch 20 are lifted, the forging material 3A made of the brass material heated at about 300 to 600°C is set in the step forming hole 16 of the lower die 12. However, during the forging forming mentioned below, the brass raw material 3A is formed under maintaining the temperature to 550°C or lower. Here, to realize flashless forming, the volume of the brass raw material 3A is so set as to equal to the net volume of the spout tip of faucet 3.

[0231] Next, as shown in Fig. 7, the upper die 19 is fed down to contact the lower surface of the upper die 19 to the upper surface of the lower die 12 and to die-clamp the upper die set 17 to the lower die set 11. This clamping is carried out by switching the electromagnetic directional switching valve 42 shown in Fig. 5 to extend a piston rod 22a of the second hydraulic cylinder 22 and going down the upper slide 18. At the die-clamping state, the lower end of the upper outer punch 20 and the lower end of the upper inner punch 21 is located on a coincident plane, and closely faced to the upper end surface of the brass raw material 3A. This state corresponds to time t1 to t2 of Fig. 10.

[0232] Next, a setting pressure of the electromagnetic proportional relief valve 45 is set to a high pressure to set a retaining force (a pressing force or a supporting force) of the die pin 13 to a high value. At the same time, by operating the electromagnetic directional switching valve 43, the first hydraulic cylinder 14 is driven to set the height position of the die pin 13 so that the upper end of the die pin 13 is located on a coincident plane with the lower end of the step forming hole 16 as shown in Fig. 8. When the position of the die pin 13 is determined, then the electromagnetic directional switching valve 43 is switched to the block position a.

[0233] Next, the upper outer punch 20 and the upper inner punch 21 are integrally driven to go down and, as shown in Fig. 8, the brass raw material 3A is formed to the state that the volume of the forming cavity C becomes substantially equal to the volume of the brass raw material 3A. At this state, forming (pre-forging step) of parts other than the recessed and protruded part 7 (refer to Fig. 9) (that is, the inserted part 4, the flange part 5 and the stepped inserted part 6) is finished. During this forming, at the state in setting pressures of the electromagnetic proportional relief valves 45 and 46 to high pressure, the electromagnetic directional switching valves 42 and 44 are switched to synchronously drive the piston rod 22a of the second hydraulic cylinder 22 and the piston rod 23a of the third hydraulic cylinder 23 down.

[0234] During the pre-forging step, the electromagnetic directional switching valve 43 is retained at the block position a. Since an oil in the hydraulic system is a non-compressive fluid, an oil pressure of a head side oil room (lower side oil room) of the first hydraulic cylinder 14 is maintained at a high level during the pre-forging step and the die pin 13 does not move back downward. Accordingly, in the pre-forging step, the brass raw material 3A is formed into a semi-finished formed material 3B as shown in Fig. 8 (or Fig. 3) by a closed forging. This state corresponds to the time t2 to t3 of Fig. 10.

[0235] Next, as shown in Fig. 9, the upper inner punch 21 is moved downward and also the die pin 13 is moved back downward. According to this action, the recessed and protruded part 7 is formed continuously following to the above-mentioned pre-forging step. During this deep hole forming, the electromagnetic proportional relief valve 45 is switched to a lower pressure than the pressure of the upper inner punch 21, the electromagnetic directional switching valve 43 is switched to a rod moving back position b, and further the retention force (back pressure) of the die pin 13 is retained to low value through a throttle 43a of the rod moving back position b of the electromagnetic directional switching valve 43. This state corresponds to the time t3 to t4 of Fig. 10.

[0236] By setting the value of the electromagnetic proportional relief valve 45 to a sufficiently low value, and setting suitably the degree of the throttle 43a of the electromagnetic directional control valve 43 in relation to the going down rate of the upper inner punch 21, a hydraulic pressure of a head side oil room of the first hydraulic cylinder 14 can be maintained to a low value. Also, a going down force of the upper inner punch 21 is optionally set through the electromagnetic proportional relief valve 46 and the setting pressure is set to a relatively low pressure capable of forming.

[0237] Incidentally, in the deep hole forming step, the recessed and protruded part 7 is formed by using a part of the material of the semi-finished formed product 3B shown in Fig. 8, which is located under the upper inner punch 21. Thus, the volume of the brass material at the part is so set that it is substantially equal to the net volume of the recessed and protruded part 7. If this condition is satisfied, the position of the upper end of the die pin 13 during forming the semi-finished formed product 3B is not limited to the positions shown in Fig. 7 and Fig. 8, and may be set slightly higher or lower than the position shown in the drawings.

[0238] After finishing of the above-mentioned forging forming, the upper die set 17 is returned to the upper limit position. Next, the die pin 13 is elevated to the upper limit position by the hydraulic cylinder 14. Accordingly, the spout tip of faucet 3 which forming is finished is ejected to remove from the lower die set 11.

[0239] According to the forging forming method as mentioned above, the following function and effects can be obtained.

(1) In the pre-forging step, in the state that the retaining force of the die pin 13 is set sufficiently high and the die pin 13 is retained at the predetermined position, the brass raw material 3A is formed to the state that the volume of the forming cavity C becomes substantially equal to the volume of the brass raw material 3A (until the forging material is filled in the cavity C), whereby forming of the part other than the recessed and protruded part 7 (the inserted part 4, the flange part 5 and the stepped inserted part 6) is finished. Accordingly, before starting the forming of the recessed and protruded part 7, the parts other than the recessed and protruded part 7 can be formed substantially without flash at good accuracy. In particular, the parts other than the recessed and protruded part 7 can be upsettingly formed similarly to the forging under a hydrostatic pressure so that crack defect caused by frictional force acting between the brass material and the lower die 12 hardly occurs.

(2) In the pre-forging step, when the piston rod 14a of the hydraulic cylinder 14 is constructed to be able to move back while maintaining the retaining force for retaining the die pin 13 relatively high, weight distribution of the brass raw material 3A can be absorbed by moving said piston rod 14a back.

(3) In the deep hole forming step, following the forming of a part other than the recessed and protruded part 7, while the part other than the recessed and protruded part 7 is closed in the die, the upper inner punch 21 is went down to drive the punch 21 into the forging material 3A. At this time, the retaining force of the die pin 13 is switched to low and the recessed and protruded part 7 is formed while moving the die pin 13 back under applying thereto back pressure. Thus, the brass material does not fluidize to upward during forming of the recessed and protruded part 7 so that the recessed and protruded part 7 can be formed at good precision without flash even if a pressing force of the upper inner punch 21 is not so heightened.

(4) In the deep hole forming step, the brass material does not fluidize back upward during forming of the recessed and protruded part 7 so that a defect of fold at or below the surface due to difference of fluidization of the brass material at the edge part 16a is hardly generated. Accordingly, a sharp shaped part having an edge part 16a can be formed. Also, during forming of the recessed and protruded part 7, the material does not fluidize to upward, and increase of resistance due to frictional force caused between the brass material and the lower die 13 dose not occur so that it is not necessary to heighten the pressing force of the upper inner punch 21 whereby buckling of the upper inner punch 21 is hardly generated and durability is improved.

(5) A first hydraulic cylinder 14 is used as a retaining means to retain the die pin 13 and the retaining force of the die pin 13 is changed by changing the hydraulic pressure of the head side oil room of the first hydraulic cylinder 14 whereby the retaining force of the die pin 13 can be optionally controlled.

(6) Forging forming is carried out at the state of maintaining the temperature of the brass material at 550°C or lower so that, even a member having a shape, which the depth of the recessed portion 7a thereof is deep and a long forging time is required, can be always forged at a constant flow stress. Incidentally, the temperature of 550°C is a tempering temperature or lower of a hot tool steel (JIS SKD61, etc.) usually used for this kind of a die so that durability of the die can be sufficiently ensured.

[0240] In the die forging method as mentioned above, as the forging material, brass having good workability is one of the preferred materials. However, for using it as water facilities for a house, the conventionally used brass involved problems in corrosion resistance, etc. as compared with bronze. However, if the formed product after cooling is at least one of the crystal structures of (1) to (3) shown below, the problem of corrosion resistance, etc. can be below an allowable level.

(1) a crystal structure wherein areal ratios of an $\alpha+\beta$ phase and a β phase are 20% or higher, average crystal grain sizes of an α phase and a β phase are 15 μm or smaller, and an Sn concentration in the β phase is 1.5 wt% or more,

(2) a crystal structure wherein areal ratios of an $\alpha+\gamma$ phase and a γ phase are 3 to 30%, an average crystal grain size of an α phase is 15 μm or smaller, an average crystal grain size (a short axis) of the γ phase is 8 μm or smaller, an Sn concentration in the γ phase is 8 wt% or higher, and the γ phase is distributed in the grain boundary of the α phase; and

(3) a crystal structure wherein areal ratios of an $\alpha+\beta+\gamma$ phase and an α phase are 40 to 94%, areal ratios of a β phase and an α phase are 3 to 30% respectively, average crystal grain sizes of an α

phase and a β phase are 15 μm or smaller, an average crystal grain size (a short axis) of the γ phase is 8 μm or smaller, an Sn concentration in the γ phase is 8 wt% or higher and the γ phase surrounds the β phase.

[0241] According to crystal structures of above-mentioned (1) ~ (3), as a first characteristic feature, when a dezincification test according to Japan Brass Makers Association Technical Standard JBMA T-303 is carried out, the corrosion resistance, which the maximum dezinking depth is 100 μm or smaller when the working direction is parallel to it, and it is 70 μm or smaller when the working direction is perpendicular to it, can be satisfied.

[0242] As a second characteristic feature, it has an SCC (Stress Corrosion Cracking) resistance that, when a cylindrical sample is exposed to an ammoniacal atmosphere above a 14% aqueous ammonia solution under applying thereto a load of a 180 N/mm^2 for 24 hours, the sample is not broken.

[0243] As a third characteristic feature, it has a 0.2% proof stress or a yield stress of 300 N/mm^2 or higher.

[0244] As a fourth characteristic feature, it has anti-erosion corrosive resistance.

[0245] To obtain the crystal structure as mentioned above, for example, a brass material having a composition of an apparent Zn content of 37 to 50% by weight and an Sn content of 1.7 to 2.2% by weight may be used.

[0246] Here, the term "an apparent Zn content" is used in the meaning of "$\{(B+t\cdot Q)/(A+B+t\cdot Q)\}\times 100$" wherein A is a Cu content (% by weight), B is a Zn content (% by weight), t is a Zn equivalent of the added third element (e.g., Sn), and Q is a content of the third element (% by weight).

[0247] The brass material of the above-mentioned composition preferably has a γ phase having an average crystal grain diameter of the short axis of 15 μm or smaller in the crystal structure of the forging material during forging. According to such a crystal structure during working, even when it is subjected to plastic deformation while recrystallization is caused at a low temperature region of 300 to 550°C, sufficient ductility of the forging material can be ensured.

[0248] By making the difference of the temperatures at the starting of the forging and the finishing of the forging within 20°, at the starting of the working and the finishing of the working the ductility of the raw material can be made substantially constant and formability of the forging material is improved.

[0249] It is also preferred for improving formability that the temperature difference between the forging raw material and the punch or the die is made within 20° or the punch or the die is heated to 300 to 550°C. To carry out the temperature control of the punch or the die like this, for example, a heater and a temperature sensor are provided in the punch or the die and an amount of heat of the heater can be controlled by a temperature controller based on the detected signal output from the temperature sensor.

[0250] Next, the second example is explained.

[0251] Fig. 11 is a sectional view showing the structure of a flange formed by the die forging method according to the second example of the present invention.

[0252] Fig. 12 is a sectional view showing a semi-finished forged product of the flange of Fig. 11.

[0253] The flange 50 in this example has a short tubular shape, and has a flange part 51 to be fixed at predetermined attaching surfaces and a stepped part 52. For forming the flange 50, a semi-finished forged product 50B is firstly forged. The semi-finished forged product 50B has a bottom part 53, a flange starting part 54 having an edge 54a, and a step starting part 55. The lower part 53 and the edge 54a of the flange original part 54 are removed by machining, etc. to obtain the flange of Fig. 11.

[0254] Fig. 13 to Fig. 17 are sectional views schematically showing an apparatus and forging steps for forging the semi-finished forged product of the flange of Fig. 12.

[0255] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12 and an ejector pin 15 which slides in a pin inserting hole of the lower die 12 up and down. The upper die set has an upper die 19, and an upper punch 24 which slides in a punch inserting hole of the upper die 19 up and down by the cylinder. The lower die 12 is fixed and the upper die 19 moves up and down between a die-opening state and a die-clamping state.

[0256] At the upper surface of the lower die 12, a step forming hole 12a is provided. This step forming hole 12a is to form the stepped starting part 55 and the flange starting part 54 of the semi-finished forged product 50B. A part 12b surrounded by the step forming hole 12a is positioned at higher than the other upper surface of the lower die 12. A part 24a of the lower surface of the upper punch 24, which faces to the above-mentioned step forming hole 12a, is provided to be a recessed shape. At the state of die-clamping, the recessed part 24a of the upper punch 24 is connected to the step forming hole 12a of the lower die 12.

[0257] Next, the forging step is explained.

[0258] First, as shown in Fig. 13, at the die-opening state, a heated forging material 50A is set on a part 12b surrounded by the step forming hole 12a of the lower die 12. At this time, the upper punch 24 is positioned at the back of the lower surface of the upper die 19.

[0259] Next, as shown in Fig. 14, the upper die 19 and the punch 24 are simultaneously went down, and the lower surface of the upper die 19 and the upper surface of the lower die 12 are contacted to each other and die-clamped. During this time, the ejector pin 15 is retained at a predetermined position (the upper surface thereof is positioned at the same plane as the surface of the lower die 12). The forged raw material 50A is fluidized and deformed, and a part of the starting part 53' of the bottom part 53 of the semi-finished forged product 50B, a part of starting part 54' of the flange starting part 54 and a part of the starting part 55' of the stepped starting part 55 are formed.

[0260] Next, following to the above, as shown in Fig. 15, only the upper punch 24 is further went down to make a space made by the lower die 12, the upper die 19 and the upper punch 24 in order to have the volume substantially equaled to the volume of the forging raw material 50A. In this step, the forging raw material 50A is filled in the each part so that a semi-finished forged product 50B having the lower part 53, the flange starting part 54 and the stepped starting part 55 are formed.

[0261] After finishing of the forging forming, as shown in Fig. 16, the upper die set is returned to the upper limit position. Subsequently, as shown in Fig. 17, the ejector pin 15 is risen to remove the semi-finished forged product 50B. Finally, the bottom part 53 and the edge 54a of the flange starting part 54 are removed from the semi-finished forged product 50B by machining, etc., to obtain a final flange50.

[0262] According to the die forging method of this example, a hole which becomes the bottom part 53 and the step starting part 55 are formed by the punch 24 and the flange starting part 54 around the hole is continuously formed by the punch 24 so that feeding of a raw material from the center portion to the surroundings becomes smooth whereby formability is improved.

[0263] Next, the third example is explained.

[0264] Fig. 18 is a drawing showing the structure of a shuttlecock wheel according to the third example of the present invention, and Fig. 18(A) is a plane view and Fig. 18(B) is a sectional view.

[0265] Fig. 19 is a drawing showing the structure of the semi-finished forged product of the shuttlecock wheel of Fig. 18, and Fig. 19(A) is a plane view and Fig. 19(B) is a sectional view.

[0266] The shuttlecock wheel of 60 of this example has a hub part 61 and a blade part 62, and an axis hole 63 is penetrated at the center portion. For forming the shuttlecock wheel 60, an semi-finished forged product 60B is firstly forged. The semi-finished forged product 60B has an outer flash part 62a, an edge surface flash part 63a, a raw material placing step part 62b and a punch step part 62c. By removing the outer flash part 62a, the edge surface flash part 63a, the raw material placing step part 62b and the punch step part 62c of the semi-finished forged product 60B by machining, etc., to obtain the shuttlecock wheel of Fig. 18.

[0267] Fig. 20 to Fig. 26 are sectional views schematically showing an apparatus and forging steps for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0268] This brass material forging machine has a lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12 and an ejector pin 15 which slides in a pin inserting hole of the lower die 12 up and down. The upper die set has an upper die 19 provided with an upper outer punch 20 and an upper inner punch 21. The upper outer punch 20 is not connected to a driving source and slidably provided in a punch inserting hole of the upper die 19 up and down. Descending of the upper outer punch 20 is stopped by a stopping surface 19b of the upper die 19. The upper inner punch 21 slides in a punch inserting hole of the upper outer punch 20 up and down. Descending of the upper inner punch 21 is stopped by a stopping surface 20a of the upper outer punch 20.

[0269] At the upper surface of the lower die 12, a step forming hole 12a is provided. This step forming hole 12a is to form the outer flash part 62a, the raw material placing step part 62b, the punch step part 62c, and the edge surface flash part 63a of the semi-finished forged product 60B. At the part of the lower surface of the upper die 19, which faces to the above-mentioned step forming hole 12a, a step forming hole 19a is formed. At the state of die-clamping, these step forming holes 12a and 19a are connected to each other.

[0270] Next, the forging step is explained.

[0271] First, as shown in Fig. 20, at the die-opening state, a heated forging material 60A is set on the step forming hole 12a of the lower die 12. Next, as shown in Fig. 21, the upper die 19 and the upper inner punch 21 are simultaneously gone down, and the lower surface of the upper die 19 is contacted to the upper surface of the lower die 12 and clamped. At this time, the lower surface of the upper outer punch 20 is contacted to the upper surface of the forging material 60A and stopped. Since no load is applied to the upper outer punch 20, the punch 20 is relatively moved back to the upper die 19.

[0272] Next, as shown in Fig. 22, the upper inner punch 21 is went down until contacting with the stopping surface 20a of the upper outer punch 20. Here, part of an edge surface flash part 63a of the axis hole 63 is formed. At this time, the upper outer punch 20 still contacts with the forging material 3A.

[0273] Next, as shown in Fig. 23, the upper inner punch 21 is further gone down. At this time, the upper inner punch 21 is stopped to the stopping surface 20a of the upper outer punch 20, and the upper outer punch 20 and the upper inner punch 21 are simultaneously gone down so that the upper outer punch 20 is contacted to the stopping surface 19b of the upper die 19. At this time, the axis hole 63 is formed. Simultaneously the forging material is fluidized and deformed, and filled in a step forming hole whereby an outer flash part 62a is formed by a material pushed out to outer peripheral and an edge surface flash part 63a is completely formed. With the steps that the axis hole 63 is completely formed by driving into the upper inner punch 21 and a hub part 61 is formed by compressing with the upper outer punch 20, simultaneously, the material is spread out from the center to the peripheral direction whereby the spreading of the raw material becomes uniform and forming property is improved.

[0274] After finishing of the forging forming, as shown in Fig. 24, the upper inner punch 21 is drawn out from the forged product. Thereafter, as shown in Fig. 25, the upper die set is returned to the upper limit position. At this time, the upper outer punch 20 is also raised simultaneously. Subsequently, as shown in Fig. 26, an ejector pin 15 is risen to remove the semi-finished forged product 60B. Incidentally, part of a part 12c of the lower die 12 is also raised like as the ejector pin 15 to support removing of the semi-finished forged product 60B.

[0275] Thereafter, the outer flash part 62a, the edge surface flash part 63a, the raw material placing step part 62b and the punch step part 62c are removed by machining, etc., to obtain an shuttlecock wheel 60 as a final product.

[0276] In the die forging method of the third example, while the upper inner punch 21 (the first punch) is driven into the forging material 60A, the forging material is worked by the upper outer punch 20 (the second punch or die) without moving the upper inner punch 21 (the first punch) back. Thus, there is a merit that a shape deformation dose not occur at the formed part by the upper inner punch 21 (the first punch).

[0277] Next, the fourth example is explained.

[0278] Fig. 27 to Fig. 33 are sectional views schematically showing an apparatus and forging steps of the another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0279] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12 and an ejector pin 15 which slides in a pin inserting hole of the lower die 12 up and down. The upper die set has an upper die 19 provided with an upper outer punch 20 and an upper inner punch 21. The upper outer punch 20 is not connected to a driving source and slidably provided in a punch inserting hole of the upper die 19 up and down. Descending of the upper outer punch 20 is stopped by a lower stopping surface 19a of the upper die 19 and rising thereof is stopped by an upper stopping surface 19b of the upper die 19. The upper inner punch 21 slides in a punch inserting hole of the upper outer punch 20 up and down. Descending of the upper inner punch 21 is stopped by a stopping surface 20a of the upper outer punch 20.

[0280] At the upper surface of the lower die 12, a step forming hole 12a is provided. This step forming hole 12a is to form the outer flash part 62a, the raw material placing step part 62b, the punch step part 62c, and the edge surface flash part 63a of the semi-finished forged product 60B. At the part of the lower surface of the upper die 19, which faces to the above-mentioned step forming hole 12a, the step forming hole 19a is formed. At the state of clamping, these step forming holes 12a and 19a are connected to each other.

[0281] Next, the forging step is explained.

[0282] First, as shown in Fig. 27, at the die opening state, a heated forging material 60A is set on the step forming hole 12a of the lower die 12. The upper outer punch 20 is positioned on the lower stopping surface 19a of the upper die 19. Next, as shown in Fig. 28, the upper die 19 and the upper inner punch 21 are simultaneously went down, and the lower surface of the upper die 19 is contacted to the upper surface of the lower die 12. At this time, however, die-clamping is not carried out. The lower surface of the upper outer punch 20 is contacted to the upper surface of the forging material 60A and stopped. The punch 20 is moved back to the upper stopping surface 19b of the upper die 19 relative to the upper die 19. The forging material 60A is pressed by the upper inner punch 20 and upper die 19 to fluidize and deform, and a part 62' of the shuttlecock wheel is started to forming by the pushed out part to the outer peripheral direction. An edge surface flash part 63a is simultaneously started to being formed.

[0283] Next, as shown in Fig. 29, the upper inner punch 21 is gone down until contacting with the stopping surface 20a of the upper outer punch 20. Here, a part of the edge surface flash part 63a of the axis hole 63 is formed. The Part 62' of the shuttlecock wheel part is simultaneously further formed. At this time, the upper outer punch 20 is moved back due to the movement of the material pushed out by the upper inner punch 21 and the upper die set which dose not die-clamped is also moved back.

[0284] Next, as shown in Fig. 30, the upper inner punch 21 is further gone down. At this time, since the upper inner punch 21 is stopped to the stopping surface 20a of the upper outer punch 20, the upper outer punch 20 and the upper inner punch 21 are simultaneously gone down. Moreover, the upper die 19 is also gone down to die-clamp. At this time, the axis hole 63 is formed. Simultaneously the forging material is fluidized and deformed, and filled in a step forming hole whereby an blade part 62 is completely formed by a material pushed out to outer peripheral and an edge surface flash part 63a is completely formed. Also, the upper inner punch 21 is driven into to form an axis hole 63 completely. With the step that a hub part 61 is formed by compressing with the upper outer punch 20, simultaneously, the material is spread out from the center to the peripheral direction whereby a spreading of the raw material becomes uniform and forming property is improved. Also, in these steps, the upper inner punch 21 is kept inserted into to ensure forming of the axis hole 63.

[0285] After finishing of the forging forming, as shown in Fig. 31, the upper inner punch 21 is drawn out from the forged product. Thereafter, as shown in Fig. 32, the upper die set is returned to the upper limit position. At this time, the upper outer punch 20 is also raised. Subsequently, as shown in Fig. 33, an eject pin 15 is risen to remove the semi-finished forged product 60B. Incidentally, a part 12c of the lower die 12 is also raised like as the ejector pin 15 to remove the semi-finished forged product 60B.

[0286] Thereafter, the outer flash part 62a, the edge surface flash part 63a, the raw material placing step part 62b and the punch step part 62c are removed by machining, etc., to obtain an shuttlecock wheel 60 as a final product.

[0287] In the die forging method of the fourth example, while the upper inner punch 21 (the first punch) is driven into the forging material, the forging material is worked by the upper outer punch 20 (the second punch or die) without moving the upper inner punch 21 (the first punch) back. Thus, there is a merit that a shape deformation dose not occur at the formed part by the upper inner punch 21 (the first punch).

[0288] Next, the fifth example is explained.

[0289] Fig. 34 to Fig. 37 are sectional views schematically showing an apparatus and forging steps of the another example for forging the semi-finished forged product of the shuttlecock wheel of Fig. 19.

[0290] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, a die pin 13 which slides in a punch inserting hole of the lower die 12 up and down, and an ejector pin 15 which slides in a pin inserting hole of the lower die 12 up and down. The upper die set has an upper die 19 and an upper punch 24 which slides a punch inserting hole of the upper die 19 up and down. Descending of the upper punch 24 is stopped by a lower stopping surface 19b of the upper die 19.

[0291] At the upper surface of the lower die 12, a step forming hole 12a is formed. This step forming hole 12a is to form the outer flash part 62a, the raw material placing step part 62b, the punch step part 62c, and the edge surface flash part 63a of the semi-finished forged product 60B. At the part of the lower surface of the upper die 19, which faces to the above-mentioned step forming hole 12a, a step forming hole 19a is also formed. At the state of die-clamping, these step forming holes 12a and 19a are connected to each other.

[0292] Next, the forging step is explained.

[0293] First, as shown in Fig. 34, at the die opening state, a heated forging material 60A is set on the step forming hole 12a of the lower die 12. At this time, the upper surface of the die pin 13 is positioned on the same plane as the surface of the step forming hole 12a and is set at a lower retaining force. Next, as shown in Fig. 35, the upper die 19 and the upper punch 24 are simultaneously went down, and the lower surface of the upper die 19 is contacted to the upper surface of the lower die 12 and die-clamped. At this time, the forging material is fluidized and deformed to fill the each forming holes to form an blade part 62 completely. Simultaneously, since the die pin 13 is set to a lower retaining force (back pressure), the forging material 60A is pushed into whereby the die pin 13 is moved back slightly. Here, an edge surface flash part 63a is partially formed.

[0294] Next, as shown in Fig. 36, the upper punch 24 is went down until contacting with the stopping surface 19a of the upper die 19. Simultaneously, the die pin 13 is moved back. Here, an axis hole 63 is completely formed. After forming the blade part 62 completely, by forming the axis hole 63 by the upper punch 24, an outer shape of the blade part 62 can be accurately formed.

[0295] After finishing of this forging, as shown in Fig. 37, the upper punch 24 is drawn out from the forged product. Thereafter, the upper die set is returned to the upper limit position. Subsequently, the ejector pin 15 is raised to remove the semi-finished forged product 60B.

[0296] Thereafter, the outer flash part 62a, the edge surface flash part 63a, the raw material placing step part 62b and the punch step part 62c are removed by machining, etc., to obtain an shuttlecock wheel 60 as a final product.

[0297] In the die forging method of the fifth example, the forging material 60A is forged by pressurizing using the upper die 19 (a die for die forging an outer shape of the formed product) and the upper punch 24 (a punch for forming the recessed portion of the formed product) in combination from the same direction, and the die pin 13 is moved back under applying a back pressure during forging. Thus, a product having a complicated shape, such as an shuttlecock wheel, can be formed.

[0298] Furthermore, in this embodiment, forming is carried out by using the upper die 19 (die) and the upper punch 24 (punch) at different timings. When the die and the punch (or a plural number of punch) are operated simultaneously, there is a fear of causing a defect such as defect unfilled material with in the forging die near the base part of the upper punch 24 during the forging, etc. However, if the two are used at different timings, or forming is carried out using a plural number of punches at different timings, such defect can be prevented.

[0299] Next, the sixth example is explained.

[0300] Fig. 38 is a drawing showing the structure of a water meter formed by the die forging method according to the sixth example of the present invention, and Fig. 38(A) is a front sectional view and Fig. 38(B) is a partial sectional plane view.

[0301] Fig. 39 is a drawing showing the structure of the semi-finished forged product of the water meter of Fig. 38, and Fig. 39(A) is a front sectional view and Fig. 39(B) is a partial sectional plane view.

[0302] The water meter 70 of this example has a blade inserting part 71, which a rotating blade(not shown in the drawing)is attached at the center thereof, and a lid screw part 72. Also, it has a running water outlet passage 74 extending from an inserting part 71 to the right lower direction and a running water inlet passage 73 extending to the left lower direction. At the tip parts of the running water outlet passage 74 and the running water inlet passage 73, an outlet screw part 74a and an inlet screw part 73a are provided. The semi-finished forged product 70B has, as shown in Fig. 44, flash parts 74b and 73b at the tips of the outlet screw part 74a and the inlet screw part 73a, respectively. Also, at where the each running water passages are getting in the inserting part 71, flash parts 74c and 73c are provided. These flash parts 74b, 73b, 74c and 73c are removed to obtain a finished product of the water meter 70.

[0303] Fig. 40 to Fig. 48 are sectional views schematically showing an apparatus and forging steps for forging the semi-finished forged product of the water meter of Fig. 39.

[0304] Fig. 40 is a side sectional view of the forging machine, Fig. 41 is a plan view and Fig. 42 is a side sectional view of the A-A sectional surface.

[0305] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, left and right side punches 226 and 227, a center punch 228, and an ejector pin 15 which slides in a pin inserting hole of the lower die 12 up and down. The left and right side punches 226 and 227 slide, as shown in Fig. 45, in the punch inserting holes provided at the right and left sides of the lower die 19. The center punch 228 slides, as shown in Fig. 41, in a punch inserting hole provided at the front surface of the lower die 19. The left and right punches inserting holes, are as shown in Fig. 41, positioned along a straight line in the horizontal sectional plane, and the center punch hole and the left and right punches inserting holes are positioned perpendicular on the horizontal sectional surface. Also, the left punch inserting hole and the right punch inserting hole are inclined to the outer downward direction.

[0306] At the upper surface of the lower die 12, a step forming hole 12a is formed. At the part of the lower surface of the upper die 19, which faces to the above-mentioned step forming hole 12a, a step forming hole 19a is formed. At the state of die-clamping, these step forming holes 12a and 19a are connected to each other.

[0307] At the upper die 19, a heater (not shown in the drawing) is built-in. Also, as shown in Fig. 42, heat-insulating materials are wound around the outer peripheral of the lower die 12 and the upper die 19. The die clamping surfaces of the each dies are covered by the heat-insulating material 229 and a stainless steel plate 230 to keep the temperature.

[0308] Next, the forging step is explained.

[0309] First, as shown in Fig. 43, at the die-opening state, a heated forging material 70A is set on the step forming hole 12a on the lower die 12. Next, as shown in Fig. 44, the upper die 19 is went down, and is contacted to the lower die 12 and die-clamped. Next, as shown in Fig. 45, the center punch 228 is driven into. At this time, the forging material 70A is fluidized and deformed, and the blade inserting part 71, the lid screw part 72 and a part of the each running water passages 74' and 73' are formed. After finishing of insertion, a retaining force is still applied to the middle punch 228. Subsequently, as shown in Fig. 46, the left side punch 226 and the right side punch 227 are simultaneously inserted until the stopping surface. Here, the screw parts 74b and 73b of the respective running water flow passages and the flash parts 74c and 73c are formed.

[0310] After finishing of the forging, as shown in Fig. 47, the center punch 228, the left side punch 226 and the right side punch 227 are moved back. Thereafter, as shown in Fig. 48, the upper die set is returned to the upper limit position. Then, the ejector pin 15 is raised to remove the semi-finished forged product 70B. The semi-finished formed product is worked by the above-mentioned machining, etc., to remove unnecessary parts to obtain a final formed product.

[0311] In the die forging method of the sixth example, it comprises a pushing out step by forming a pushed out part by forging, and a forming step of forming the pushed out part to a predetermined shape by further forging, and the above-mentioned both steps are carried out in the identical die.

[0312] Thus, forging is carried out in the forming step by the left and right side punches 226 and 227 (punches, et al.) to the pushed out part pushed out by the pushing out step so that a filling property of the material is better than the case that forming is carried out by pushing out only. Also, the pushing out step and the forging step are carried out in an identical die so that kind of dies required decreases and the cost of the dies is less. Moreover, it is not necessary to transfer the forging material to the other press during forging so that its productivity is high.

[0313] This final formed product has a SCC resistance.

[0314] Fig. 49 is a drawing showing a SCC resistance test equipment.

[0315] The SCC resistance is a characteristic in which a sample is not cracked when it is exposed to an ammonia atmosphere on 14% aqueous ammonia while applying a load of a stress 180 N/mm^2 to the sample. Evaluation of this SCC test is carried out by exposing a sample to a NH_3 vapor atmosphere for 24 hours in a glass desiccator 231 while applying a load vertically to a cylindrical shaped sample 232, and then occurrence of cracks is examined.

[0316] Also, it has an erosion corrosive resistance.

[0317] Fig. 50 is a drawing showing a erosion resistance test equipment.

[0318] The erosion resistance can be measured by using a cylindrical shaped sample 53 having an orifice 233 at the inside thereof, flowing water in the orifice 233 with a flow rate of 40 m/sec for a predetermined time, and then, measuring a clamping torque to a resin stopper 234 required for sealing the orifice under a water pressure of 4.9x105 Pa (Kg/cm^2).

[0319] Fig. 51 is a graph showing erosion resistance test results.

[0320] As a result, as shown in Fig. 51, good characteristics than the conventional brass material can be obtained.

[0321] Next, the seventh example is explained.

[0322] Fig. 52 is a drawing showing the structure of a lightening shaft formed by the die forging method according to the seventh example of the present invention, and Fig. 52(A) is a perspective view and Fig. 52(B) is a sectional view.

[0323] Fig. 53 is a drawing showing the structure of the semi-finished forged product of the lightening shaft of Fig. 52, and Fig. 53(A) is a perspective view and Fig. 53(B) is a sectional view.

[0324] The semi-finished forged product 80 of this example has an axis part 81, an upper small diameter part 82, a large diameter part 83, and a lower small diameter part 84. In the semi-finished forged product 80B, a lightening margin 80a is projected from the lower small diameter part 84. This lightening margin 80a is removed by machining, etc., to obtain a final semi-finished forged product 80.

[0325] Fig. 54 to Fig. 56 are sectional view schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 53.

[0326] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, a die pin 13 which slides in a pin inserting hole of the lower die 12 up and down. The upper die set has an upper die 19, and an upper punch 20 is integrally provided.

[0327] At the upper surface of the lower die 12, a step forming hole 12a is provided. The upper outer punch 20 is inserted to this step forming hole 12a. At the lower surface of the upper outer punch 20, a step forming hole 20b is formed.

[0328] Next, the forging step is explained.

[0329] First, as shown in Fig. 54, at the die opening state, a heated forging material 80A is set on the step forming hole 12a on the lower die 12. Next, as shown in Fig. 55, the upper die 19 is went down, and the lower surface of the upper outer punch 20 is contacted to the upper surface of the forging material 80A. At this time, the lower surface of the upper die 19 is not contacted to the upper surface of the lower die 12. A retaining force is applied to the die pin 13. Under this state, the upper outer punch 20 is subjected the forging material 13 to fluidization and deformation to form parts of the axis part 81, the upper small diameter part 82, the large diameter part 83, and the lower small diameter part 84.

[0330] Also, as shown in Fig. 56, the upper die 19 is went down, and the lower surface of the upper die 19 and the upper surface of the lower die 12 are contacted to each other and die-clamped. At this time, if a load to be applied to the die pin 13 due to pressing of the forging material becomes larger than the retaining force of the die pin 13, an excessive forging material 3A moves the die pin 13 back against the retaining force of the die pin 13. At this time, the excessive forging material 80A is flown into the pin inserting hole of the lower die 12 to form the lightening margin 80a. Also, it is flown into the axis part 81 to form the axis part 81 completely. Finally, the upper die 19 is raised and the die pin 13 is raised to remove the formed product.

[0331] During this forming, to the die pin 13, a retaining force, which is larger than the load applied to the die pin 13 when the forging material 80A is filled in the forming hole, is applied. Thus, the forging material 80A is surely filled into a fine portion of the forming hole and an excessive raw material is flown into the pin inserting hole so that defect unfilled material with in the forging die dose not occur. Also, the material of the moved back part is completely removed in the later step so that the excessive raw material does not cause any bad effect to accuracy. Also, the retaining force of the die pin 13 can be adjustable by a hydraulic cylinder so that the load applied to the die pin 13 when the forging material 80A is filled in the forming hole can be easily known. Accordingly, forging can be carried out with the minimum forming force.

[0332] Also, when it becomes fully filled state during the forging, the retaining force of the die pin 13 is so set as to relatively low, whereby the excessive forging material 80A is contacted to the die pin 13 and moves the die pin 13 back against the retaining force of the die pin 13. And it is flowing into the pin inserting hole while moving the die pin 13 so that a interruption of the forging caused by the high pressure closed state dose not occur and a load applied to the die can be reduced.

[0333] Next, the eighth example is explained.

[0334] Fig. 57 is a drawing showing the structure of a lightening shaft formed by the die forging method according to the eighth example of the present invention, and Fig. 57(A) is a perspective view and Fig. 57(B) is a sectional view.

[0335] Fig. 58 is a drawing showing the structure of the semi-finished forged product of the lightening shaft of Fig. 57, and Fig. 58(A) is a perspective view and Fig. 58(B) is a sectional view.

[0336] The semi-finished forged product 90 had a edge part 91, a hole part 92 and an axis part 93. In the semi-finished forged product 90B, a lightening margin 90a is projected from the axis part 93. This lightening margin 90a is removed by machining, etc., to obtain a final lightening axis 90.

[0337] Fig. 59 to Fig. 62 are sectional views schematically showing an apparatus and forging steps for forging the semi-finished forged product of the lightening shaft of Fig. 58.

[0338] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, a die pin 13 which slides in a pin inserting hole of the lower die 12 up and down. The upper die set has an upper die 19 and a punch 24 which slides in the punch inserting hole up and down.

[0339] At the upper surface of the lower die 12, a step forming hole 12a is provided. At a part of the lower surface of the upper die 19, which faces to the above-mentioned step forming hole 12a, a step forming hole 19a is formed. At the state of die-clamped, these step forming holes 19a and 12a are connected to each other.

[0340] Next, the forging step is explained.

[0341] First, as shown in Fig. 59, at the die opening state, a heated forging material 90A is set in the step forming hole 12a of the lower die 12. At this time, the upper surface of the die pin 13 is positioned at the same plane as the surface of the step forming hole 12a. Next, as shown in Fig. 60, the upper die 19 and the upper punch 24 are simultaneously went down, and the lower surface of the upper die 19 is contacted to the upper surface of the lower die 12, and die-clamped.

[0342] Next, as shown in Fig. 61, the upper punch 24 is went down to a first level. At this time, the forging material is fluidized and deformed, and a part of the edge part 91, the hole part 92 and the axis part 93 are formed. Here, a load applied to the die pin 13 due to pressing of the forging material is equaled to the retaining force of the die pin 13 whereby the die pin 13 is not moved back. Next, as shown in Fig. 62, the upper punch 24 is went down to a second level. At this time, the load applied to the die pin 13 becomes larger than the retaining force, and the excessive forging material 90A moves the die pin 13 back against the retaining force of the die pin 13. Here, the edge part 91 is completely formed, and the excessive forging material 90A is flown into the pin inserting hole whereby a lightening margin 90a is formed.

[0343] Finally, the upper die set is returned to the upper limit position to remove the semi-finished forged product. Thereafter, the lightening margin 90a is removed by machining, etc., to obtain the final lightening shaft 90.

[0344] Next, the ninth example is explained.

[0345] Fig. 63 is a drawing showing the structure of a hand shower supporting fitment formed by the die forging method according to the ninth example of the present invention, and Fig. 63(A) is a plane sectional view and Fig. 63(B) is a side surface sectional view.

[0346] The hand shower supporting fitment 100 of this example has a closed bottom cylindrical shape, and has two recessed parts of a deep recessed part (the first recessed part) 101 to insert the hand shower and a shallow recessed part (the second recessed part) 102 having larger diameter than the above. At the opened tip part, a pushed out part 103 which is pushed out to outer peripheral is provided, and at the closed bottom part, a small projection 104 is provided.

[0347] Fig. 64 to Fig. 69 are sectional views schematically showing an apparatus and forging steps for forging the hand shower supporting fitment of Fig. 63.

[0348] This brass material forging machine has an lower die set and a upper set corresponding to the lower die set. The lower die set has a lower die 12, and a die pin 13 which slides in a pin inserting hole of the lower die 12 up and down. The upper die set has an upper die 19, an upper outer punch 20 and an upper inner punch 21. The upper outer punch 20 slides between the lower stopping surface 19b and the upper stopping surface 19c of the upper die 19 up and down. Further, the upper outer punch 20 is biased upward by a spring 20c. The upper inner punch 21 slides in the punch inserting hole of the upper outer punch 20 up and down.

[0349] At the upper surface of the die pin 13, a recessed part 13a is provided. This recessed part 13a is to form a projection 104 of the hand shower supporting fitment 100. At the lower surface of the upper die 19, a step forming hole 19a is provided.

[0350] Next, the forging step is explained.

[0351] First, as shown in Fig. 64, at the die opening state, a heated forging material 100A is set on the die pin 13 in the lower die 12. At this time, the lower surface of the upper outer punch 20 biased upward is positioned at the same plane as the lower surface of the upper die 19. Next, as shown Fig.65, the upper die 19 and the upper inner punch 21 are gone down simultaneously, the lower surface of the upper die 19 is contacted to the upper surface of the lower die 12 and die clamped. Next, as shown in Fig. 66, the die pin 13 is raised. At this time, the upper inner punch 21 is supported to locate at the position as shown in Fig. 65. The forging material 100A is fluidized and deformed to form a pushed out part 103 and a projection 104 is formed at the end surface. Thus, by providing the recessed part for forming at the die pin 13, forming of a complicated shape can be carried out.

[0352] Next, as shown in Fig. 67, the upper inner punch 21 is gone down. Here, forming of a deep recessed part 101' is started. At this time, the die pin 13 is moved back downward while applying a back pressure to the forging material 100A. The die pin 13 goes down until a volume corresponding to the going down part thereof is equal to the volume corresponding to the forced part by the upper inner punch 21. Subsequently, as shown in Fig. 68, the upper inner punch further goes down. At this time, the upper inner punch 21 is contacted to the upper outer punch 20 and the upper outer punch 20 also simultaneously goes down. Here, a shallow recessed part 102 is formed. The die pin 13 is moved back under applying a back pressure. Thus, by using two punches having different diameters with two steps, it is possible to form a recessed part having different depths without causing inhibition of fluidization of the raw material.

[0353] Thereafter, as shown in Fig. 69, the upper inner punch 21 is raised. Thereafter, the upper die set is returned to the upper limit position, and finally the upper die 19 is raised to remove the formed product.

[0354] By moving back the die pin 13 under applying a back pressure thereto, flow back, which an inner part corresponding to the volume of the recessed part of the forging material 3A is pressed up to the opposite direction of the upper inner punch 21 and the upper outer punch 2, dose not occur, and the forging material 100A fluidizes continuously and smoothly. Thus, small cracks of the product are not generated. Also, a pressing force of the punch may be made substantially the same as the working force of the raw material so that buckling of the punch does not occur and the depth of the recessed part can be freely set.

[0355] Next, the tenth example is explained.

[0356] Fig. 70 is a drawing showing the structure of a flush valve lid formed by the die forging method according to the tenth example of the present invention.

[0357] The flush valve lid 110 of this example has a recessed shape, and has a cylinder part 111 and a tip part 112. At the upper surface of the tip part 112, a knob 113 having an undercut is provided. Also, at the cylinder part 111, a shoulder art 114 is provided.

[0358] Fig. 71 to Fig. 77 are sectional views schematically showing an apparatus and forging steps for forging the hand shower supporting fitment of Fig. 70.

[0359] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, and a lower punch 235 which slides in a punch inserting hole of the lower die 12 up and down. At the outer peripheral of the lower punch 235, a color 236 is attached and biased upward by a spring. The upper die set has an upper die 19, and an upper punch 24 which slides in the punch inserting hole of the upper die 19 up and down. At the outer peripheral of the upper punch 24, a block 237 is provided. This block 237 comprises two parts 237a and 237b, which are symmetrical to the axis direction of the upper punch 24 and biased by a spring to the outer direction perpendicular to the axis.

[0360] At the upper surface of the lower die 12, a step forming hole 12a is provided. The lower surface of the block 237 is formed in a recessed shape. Also, at the parts thereof, which face to the divided parts 237a and 237b of the block 237, a recessed part 237c is provided. This recessed part 237c is to form the knob 113 of the flush valve lid 110.

[0361] Next, the forging step is explained.

[0362] First, as shown in Fig. 71, at the die opening state, a heated forging material 110A is set on the lower punch 235 of the lower die 12. The lower end surface of the block 237 is positioned at lower than the lower surface of the upper die 12. Next, as shown in Fig. 72, the upper die 19 and the upper punch 24 are simultaneously went down, and the lower surface of the block 237 is contacted to the upper surface of the lower die 12 and die-clamped. Here, the heated forging material 110A is fluidized and deformed whereby the tip part 112 and the shoulder part 114 are formed, and simultaneously a starting part 113' of the knob 113 is started to forming at the tip part.

[0363] Next, as shown in Fig. 73, the lower punch 235 is raised. The forging material 110A is further fluidized and deformed, and the starting part 113' of the knob 113 further grows upward. Further, a force stronger than the retaining force of the spring is applied to the upper part of the color 236 of the lower punch 235 so that the cylinder part 111 is completely formed. At this time, back pressure is applied to the color 236 by the spring, and by pressing the lower end of the cylinder part 111, crack of the forging material can be prevented.

[0364] Next, as shown in Fig. 74, the upper punch 24 is gone down. At this time, the starting part of the knob 113 formed at the tip part 112 is pressed to be pushed out to the side direction, and the knob (a protruded part) 113 having an undercut is formed. Thus, by forming the cylinder part 111 and the knob 113 having an undercut continuously, cracks at the cylinder part 111 and a defect of fold at or below the surface layer of the undercut can be prevented and forging defect is hardly caused.

[0365] Thereafter, as shown in Fig. 75, the lower punch 235 gone down. And as shown in Fig. 76, the upper die 19, the upper punch 24 and the block 237 are simultaneously raised. The forged product is hold by the block 237 and raised together. Finally, as shown in Fig. 77, the upper punch 24 is gone down relative to the upper die 19. At this time, the block 237 is opened to left and right by the bias of the spring to release the knob 113 so that the forging finished product 110 is surely removed.

[0366] In the die forging method according to the tenth example, it comprises a step B by firstly drawing out the lower punch 235 (punch) used for forming the cylinder part 111 (cylinder part) when the forging finished product 110 (formed product) is removed, and a step C by drawing out the formed product from the block 237 (die) used for forming the outer peripheral surface of the cylindrical part 111 (cylindrical part) after the step B. Thus, by decreasing the drawing force of the lower punch 235 (punch) or the block 237 (die), deformation of the forging finished product 110 can be prevented and the formed product can be surely removed.

[0367] Next, the eleventh example is explained.

[0368] Fig. 78 is a side surface sectional view showing the structure of a H bushing formed by the die forging method according to the eleventh example of the present invention.

[0369] The H-shaped bushing 120 has an H-shaped sectional surface and has an upper recessed part 121 and a lower recessed part 122, and a flange 123 projected to the outer direction on the outer circumference is formed.

[0370] Fig. 79 and Fig. 80 are sectional views schematically showing an apparatus and forging steps for forging the H-shaped bushing of Fig. 78.

[0371] This brass material forging machine has an lower die set and a upper die set corresponding to the lower set. The lower die set has a lower die 19, a lower inner die pin 238 and a lower outer die pin 239. The lower outer die pin 239 slides in the pin inserting hole of the lower die 19 up and down, and the lower inner die pin 238 slides in the pin inserting hole of the lower outer die pin 239 up and down. The upper die set has an upper die 12, and an upper punch 24 which slides in the punch inserting hole of the upper die 12 up and down. The lower inner die pin 239, the lower outer die pin 239 and the upper punch 24 slide along the identical axis.

[0372] At the upper surface of the lower die 19, a step forming hole 19a is provided. This step forming hole 19a is to form the flange 123. At the part of the lower surface of the upper die 12, which faces to the above-mentioned step forming hole 19a, a step forming hole 12a is formed. This step forming hole 12a is to form the upper recessed part 121.

[0373] Next, the forging step is explained.

[0374] First, at the die-opening state, a heated forging material 120A is set on the upper surface of the inner die pin 238 and the outer die pin 239 of the lower die 12. At this time, the upper surfaces of the each die pins are positioned at the same plane position. Next, as shown in Fig. 79, the upper die 19 and the upper punch 24 are simultaneously went down, and the lower surface of the upper die 19 and the upper surface of the lower die 12 are contacted to each other and die-clamped. At this time, the forging material 120A is fluidized and deformed whereby a part 121' of the upper recessed part 121' and the flange 123 are formed.

[0375] Subsequently, as shown in Fig. 80, the upper punch 24 is gone down further, and simultaneously, the outer die pin 239 gone down. At this time, the volume corresponding to the going down part of the upper punch 24 is equaled to the volume corresponding to the going down part of the outer die pin 239. The inner die pin 238 is retained under applying a high retaining pressure thereto. According to this, the lower recessed part 122 is formed. Thus, by the upper punch 24 and the die pins 238 and 239 provided along the identical axis, a complicated forging having recessed portions on the top and the bottom can be carried out. Finally, the outer die pin 239 is raised to remove the forged product.

[0376] Next, the twelfth example is explained.

[0377] Fig. 81 is a side surface sectional view showing the structure of a tee formed by the die forging method according to the twelfth example of the present invention.

[0378] The tee 130 has a T-shaped cylindrical sectional surface, and has passages 131 and 132 opened to left and right, and the lower passage 133 opened downward perpendicular to the passages. To produce this tee 130, after forming a semi-finished forging product 130B (see Fig.86) firstly, the final product is produced by machining, etc. The semi-finished forging product 3B has a shape having walls at the center of the left and right passages 131 and 132, and between, the left and right passages 131 and 132, and the lower passage 133.

[0379] Fig. 82 to Fig. 86 are sectional views showing schematically an apparatus and forging steps for forging the semi-finished forged product of the tee of Fig. 81.

[0380] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, and a left side punch 226, a right side punch 227, a ring 252 and a lower fixed punch 253. The left and right side punches 226 and 227 slide in the left and right punch inserting holes of the lower die 12 on the identical axis. The ring 252 slides on the outer peripheral of the fixed punch 253 of the lower die 12 up and down. The sliding direction of the ring 252 is perpendicular to the sliding direction of the left and right side punches.

[0381] At the upper surface of the lower die 12, a forming hole 12a is provided. At the lower surface of the upper die 19, a forming hole 19a is formed. These forming holes are connected to each other when they are clamped.

[0382] Next, the forging step is explained.

[0383] First, at the die opening state, a heated forging material 130A is set on the upper surface of the fixed punch 253 and the ring 252 of the lower die 12. At this time, the upper surfaces of the fixed punch 253 and the ring 252 are positioned at the same plane. Next, as shown in Fig. 82, the upper die 19 is went down, and the lower surface of the upper die 19 and the upper surface of the lower die 12 are contacted to each other and die-clamped. Next, as shown in Fig. 83, the left and right side punches 226 and 227 are simultaneously driven into until a first level. At this time, the forging raw material 130A is fluidized and deformed whereby parts of the left and right passages 131' and 132' are formed. The ring 252 has been retained.

[0384] Next, as shown in Fig. 84, the left and right side punches 226 and 227 are driven into until the second level. At this time, the ring 252 is moved back simultaneously. Here, the volume corresponding to the driven into right and left punches is equaled to the volume corresponding to the moved back ring 252. Here, the left and right passages 131 and 132 are further formed, and the lower passage 133 is formed. Thus, by the left and right side punches 226 and 227, and the ring 252 which slides to the direction different from the sliding directions of these side punches, forging of a complicated shape having openings to the three different directions can be carried out.

[0385] Next, as shown in Fig. 85, the left and right side punches 226 and 227 are moved back. Thereafter, as shown in Fig. 86, the ring 252 is raised and the semi-finished forged product 130B is removed. Finally, the remaining walls are machined to obtain a final formed product.

[0386] In the die forging method according to the twelfth example, it comprises hole forming step by forming a hole by driving the left and side punches 226 and 227 (punches) into the forging material while the ring 252 (die pin) is in touch with one end surface of the forging material and moving back under applying a back pressure thereto, the left and right side punches 226 and 227 (punches) are driven into the forging material, and the above mentioned left and right side punches 226 and 227 (punches) are driven from a direction other than the moving back direction of the above-mentioned ring 252 (die pin) or the opposite direction thereof. Thus, since the left and right side punches 226 and 227 (punches) are driven from the direction other than the moving back direction of the above-mentioned ring 252 (die pin) or the opposite direction thereof, a product having a complicated and various shape, such as a tee, can be formed.

[0387] Also, according to this embodiment, forming is carried out by driving the left and right side punches 226 and 227 (a plural number of punches) from the different direction simultaneously and by moving the ring 252 (die pin) back under applying a back pressure thereto during the forging. Thus, a product having a complicated and various shape can be formed.

[0388] Next, the thirteenth example is explained.

[0389] Fig. 87 is a sectional view showing a side surface sectional view showing the structure of a multi header formed by the die forging method according to the thirteenth example of the present invention.

[0390] The multi header 140 of this example has a passage 141 penetrating along the left to right, and three top and bottom passages 142 which is arranged perpendicular to the passage and connected to the passage.

[0391] Fig. 88 to Fig. 90 are sectional views schematically showing an apparatus and forging steps for forging the multi header of Fig. 87.

[0392] This brass material forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, and a left side punch 226, a right side punch 227 and a right hollow pin 255. The left side punch 226 slides in the pin inserting hole of the lower die 12. The right hollow pin 227 slides in the inserting hole of the lower die 12. The right side punch 227 slides in the right hollow pin 255. Further, at the lower die 12, three fixed punches 253 are provided perpendicular to the above-mentioned inserting hole, and a lower hollow die pin 252, which slides the outer peripheral of the fixed punch 253 up and down, is provided.

[0393] Next, the forging step is explained.

[0394] First, at the die opening state, a heated forging material 140A is set at the left, than the most left hollow die pin 252a, on the lower die 12. At this time, the right side punch 227 and the tip end right hollow pin 255 are at the same surface, and the both tip ends are positioned at the left of the hollow die pin 252a. Next, the upper die 19 is gone down, and the lower surface of the upper die 19 is contacted to the upper surface of the lower die and die-clamped. Next, as shown in Fig. 88, the left side punch 226 is driven into the right direction. Simultaneously, the right hollow pin 255 is moved back until near of the most left fixed punch 253a is exposed. Further, the most left lower hollow die pin 252a goes down. At this time, the forging material is fluidized and deformed to form parts of the right and left passages and a part of the most left top and bottom passages are formed.

[0395] Subsequently, as shown in Fig. 89, when the left side punch 226 is further driving into, the most left lower hollow die pin 252a is gone down to the stopping surface. Here, the first top and bottom passages are formed. At this time, the right side punch 227 is not driven. Next, as shown in Fig. 90, the left side punch 227 is further driven into the right direction. Simultaneously, the right hollow pin 255 is moved back so that near of the second fixed punch 253b is exposed. Further, the lower hollow die pin 252b is gone down. At this time, the first lower hollow die pin 252a is stopped and not driven. The forging material is fluidized and deformed whereby parts of the second top and bottom passages are formed. Also, the left side punch 227 is driven into and the lower hollow die pin 252b is gone down to the stopping surface to form the second top and bottom passages. Thus, by providing a plural number of fixed punches 253 at the different axes, forging with a complicated shape can be carried out.

[0396] This operation is repeated in the same times as a number of the top and bottom passages to form a plural number of the top and bottom passages. Finally the formed product has walls at end of the right and left passages, and between, the right and left passages, and, the top and bottom passages. Accordingly, these walls are machined to obtain a final formed product.

[0397] In the die forging method according to the thirteenth example, it comprises a forging step by driving the left side punch 227 (punch) into the forging material or by pressing a die to the forging material while the hollow die pin 252 (die pin) is in touch with one end surface of the forging material and moving back under applying a back pressure thereto, and a plural number of the above-mentioned hollow die pin 252 (die pin) are provided to form a plural number of deep holes. Thus, a product having a complicated shape, such as a multiple header having a number of holes, can be formed.

[0398] Next, another embodiment of the present invention is explained.

[0399] According to the present invention, forging of a water spouting apparatus having a curved hollow part, etc. can be effectively carried out.

[0400] Heretofore, when a water spouting apparatus having a curved hollow part, etc. is to be produced, a forged product having an outline shape is produced by using a bronze casting, etc., and the product is subjected to wide ranges of machining to make a final product shape. This method is susceptible of defects such as pinhole, shrinkage, etc., which are specific to the casting material, and a ratio of non-defect products is bad. Also, a significant amount of machining is carried out and a machining time is long so that it is not suitable for mass production. Moreover, much amount of cutting swarf is generated whereby a yield of the material is poor.

[0401] As a means to solve these technical problems, it can be considered to prepare a formed product having a shape near to the final product by forging forming, but according to the conventional forging forming, a complicated shape, such as a hollow curve part, cannot be formed. However, when the die forging method of the present invention is applied, a product, such as a water spouting apparatus having a hollow curve part which could never be forged by the conventional method, can be formed with a shape near to the final product shape.

[0402] According to this embodiment of the present invention, in a die forging method of a water spouting apparatus, etc., having a container room which has an opening for containing a flow amount or temperature adjusting part, as well as an inlet and an outlet, and a curved outlet which is to connect the above-mentioned outlet formed at an inner wall of the above-mentioned container room and a water spouting port opened to outside, a method comprising the following steps can be provided.

a) a first step by preparing a raw material,
b) a second step by roughly forming an inner wall of the above-mentioned container room while forming the above-mentioned opening by inserting a first punch into the above-mentioned raw material to form a hollow part,
c) a third step by roughly forming an inner wall of the above-mentioned curved outlet by inserting a second punch into the above-mentioned raw material to form a hollow part, and
d) a fourth step by forming the above-mentioned outlet by removing separating walls positioned at the tip sides of the above-mentioned first and second punches.

[0403] According to this die forging method, occurrence of defects such as pinhole or shrinkage, etc. can be prevented. Also, the part which requires to subject to machining is small so that a working time can be shortened and mass production can be realized. Moreover, an amount of cutting swarf is little so that a yield of the material is increased.

[0404] A die forging method in another embodiment comprises the following steps.

a) a first step by preparing a raw material,
b) a second step by roughly forming an inner wall of the above-mentioned container while forming the above-mentioned opening by inserting a first punch into the above-mentioned raw material to form a hollow part,
c) a third step by roughly forming an inner wall of the above-mentioned curved outlet by inserting a second punch into the above-mentioned raw material to form a hollow part, and inserting the above-mentioned second punch so that a separating wall positioned at the tip side of the above-mentioned second punch is near to the above-mentioned container room side than the above-mentioned outlet, and,
d) a fourth step by forming the above-mentioned outlet by removing a separating wall positioned at the tip sides of the above-mentioned first and second punches.

[0405] In this method, in the third step, the above-mentioned second punch can be inserted so that the separating wall positioned at the tip side of the above-mentioned second punch locates at the position near to the above-mentioned container side than the above-mentioned outlet. According to this, removal of the separating wall becomes easier in the above-mentioned fourth step.

[0406] A die forging method in still another embodiment contains the following steps.

a) a first step by preparing a raw material,
b) a second step by roughly forming an inner wall of the above-mentioned container room while forming the above-mentioned opening by inserting a first punch into the above-mentioned raw material to form a hollow part,
c) a third step by roughly forming an inner wall of the above-mentioned curved outlet by inserting a second punch into the above-mentioned raw material to form a hollow part, during which the above-mentioned first punch is still being inserted into the above-mentioned raw material, and
d) a fourth step by forming the above-mentioned outlet by removing a separating wall positioned at the tip sides of the above-mentioned first and second punches.

[0407] In this method, in the third step, forming is carried out while inserting the above-mentioned first punch into the above-mentioned raw material so that deflection of the material at the time of inserting the second punch can be reduced so that a product with high accuracy can be obtained.

[0408] In the above-mentioned third step, an inner wall of the above-mentioned curved outlet is roughly formed by inserting the second punch into the above-mentioned raw material to form a hollow part, and when the above-mentioned second punch is to be inserted so that the separating wall positioned at the tip side of the above-mentioned second punch is near to the above-mentioned container side than the above-mentioned outlet, it may be carried out while the above-mentioned first punch is being inserted into the above-mentioned raw material. In this case, removal of the separating wall becomes further easier.

[0409] A die forging method in the still further embodiment contains the following steps.

a) a first step by preparing a raw material,
b) a second step by roughly forming an inner wall of the above-mentioned container while forming the above-mentioned opening by inserting a first punch, which has, along with the inserting direction, a first part having a first sectional shape and a second part having a second sectional shape in which a predetermined part of the above-mentioned first sectional shape being lacked, into the above-mentioned raw material to form a hollow part,
c) a third step by roughly forming an inner wall of the above-mentioned curved outlet by inserting a second punch into the above-mentioned raw material to form a hollow part, during which the above-mentioned first punch is being still inserted into the

above-mentioned raw material, and the above-mentioned second punch is inserted until the tip thereof is reached to the predetermined part of the above-mentioned first punch, and

d) a fourth step of forming the above-mentioned outlet by removing a separating wall positioned at the tip sides of the above-mentioned first and second punches.

[0410] According to this method, even when it has a shape that the first punch and the second punch are crossed to each other, forming can be carried out with good efficiency.

[0411] In the above-mentioned third step, the inner wall of the above-mentioned curved outlet is roughly formed by inserting the second punch into the above-mentioned raw material to form a hollow part, and at the time when the above-mentioned second punch is inserted so that the separating wall positioned at the tip side of the above-mentioned second punch is near to the above-mentioned container side than the above-mentioned outlet, it is carried out while inserting the above-mentioned first punch into the above-mentioned raw material, and the above-mentioned second punch may be inserted until the tip thereof is reached to the predetermined part of the above-mentioned first punch. In this case, removal of the separating wall becomes further easier.

[0412] In these forging methods, in the above-mentioned first step, it has a gap between the outer peripheral of the above-mentioned raw material and the inner peripheral of the above-mentioned die, in the above-mentioned second step, part of the above-mentioned raw material is swelled out to the above-mentioned gap by insertion of the above-mentioned first punch, and in the third step, the above-mentioned second punch may be inserted into the part of the above-mentioned raw material swelled out to the above-mentioned gap. By forming a hollow part while swelling out the material, the hollow shape can be easily formed and reduction of occurrence of defect can be expected.

[0413] Or else, the above-mentioned outlet may form a curve along with the axis direction.

[0414] Or else, the above-mentioned container room and the above-mentioned outlet may be formed integrally. In this case, as compared with the product in which the above-mentioned container room and the above-mentioned outlet are separately formed and thereafter these are laminated, dimensional accuracy of the product is improved and it is seamless so that a polishing step of the outer shape of the product can be simplified.

[0415] A water spouting apparatus which is one of the embodiments of the present invention comprises a water spouting apparatus having a container which has an opening for containing a flow amount or temperature adjusting part, as well as an inlet and an outlet, and a flow passage which is to connect the above-mentioned outlet formed at an inner wall of the above-mentioned container room and a water spouting port opened to outside, wherein it is formed by forging forming.

[0416] As compared with the product in which the above-mentioned container room and the above-mentioned outlet are separately formed and thereafter these are laminated, it has merits that dimensional accuracy of the product is improved and it is seamless so that a polishing step of the outer shape of the product can be simplified.

[0417] The die forging method of the present invention can be applied to production of a metal forming product having a first hole part and a curved shaped second hole part. This die forging method contains the following steps.

a) a first step by preparing a metal material,

b) a second step by inserting a first punch into the above-mentioned metal material to form a first hole part, and

c) a third step by inserting a second punch into the above-mentioned metal material, during which the above-mentioned first punch is inserted, to form a curved second hole part.

[0418] When the second hole part with a curved shape is formed by inserting the above-mentioned second punch, it is carried out while the first punch is still inserted into the above-mentioned raw material, deflection of the material when the second punch is inserted can be reduced and a product with a higher accuracy can be formed.

[0419] The die forging method in further another embodiment has the following steps.

a) a first step by preparing a metal material,

b) a second step by inserting a first punch, which has, along with the inserting direction, a first part having a first sectional shape and a second part having a second sectional shape in which a predetermined part of the above-mentioned first sectional shape being lacked, into the above-mentioned metal material to form a first hole part, and

c) a third step by inserting a second punch into the above-mentioned metal material, during which the above-mentioned first punch is inserted, until the tip thereof is reached to the predetermined part to form a curved second hole part.

[0420] According to this method, even when it has a shape that the first punch and the second punch are crossed to each other, forming can be carried out with good efficiency.

[0421] In the above-mentioned die forging method, the above-mentioned second punch has a circular arc shape with a constant curvature radius along with the axis direction, and the above-mentioned curved second hole part may be formed by a circumferential movement with the center of the circular arc as the center. By using such a method, a product having a circular arc shaped hollow part at part thereof can be efficiently produced.

[0422] According to the die forging method of the present invention, it can be applied to a production of a metal formed product having a first hole part and a curved shaped second hole part, and being formed a connecting port at the inner wall of the above-mentioned first hole part, the port being connected to the above-mentioned second hole part. This die forging method contains the following steps.

a) a first step by preparing a metal material,
b) a second step by inserting a first punch into the above-mentioned metal material to form a first hollow part whereby roughly forming the above-mentioned first hole part,
c) a third step by inserting a curved second punch into the above-mentioned metal material to roughly form a curved second hollow part whereby roughly forming the above-mentioned second hole part, and
d) a fourth step by removing a separating wall positioned at the tip side of the above-mentioned curved second punch to form the above-mentioned connecting port.

[0423] In this method, in the above-mentioned third step, it is preferred to insert the above-mentioned curved second punch so that the above-mentioned separating wall becomes at the above-mentioned first hole part side than the above-mentioned connecting port. According to this arrangement, removal of the separating wall becomes easier.

[0424] Further another die forging method has the following steps.

a) a first step by placing a metal material in a closed space surrounded by a die at the state of keeping a gap between an inner peripheral of the above-mentioned die,
b) a second step by inserting a first punch into the above-mentioned metal material to form a first hole part and part of the above-mentioned raw material is swelled out into the above-mentioned gap, and
c) a third step by inserting a curved second punch into the part of the above-mentioned metal material swelled out into the above-mentioned gap to form a curved second hole part.

[0425] In a producing apparatus of a metal formed product in an embodiment of the present invention, a first hole part and a curved second hole part are formed by driving a first punch and a curved second punch into a metal material.

[0426] In a producing apparatus of a metal formed product in another embodiment of the present invention, a first hole part and a curved second hole part are formed by inserting a first punch, which has, along with the inserting direction, a first part having a first sectional shape and a second part having a second sectional shape in which a predetermined part of the above-mentioned first sectional shape being lacked, and a curved second punch which is so constituted that it is inserted until the tip of which is reached to the above-mentioned predetermined part, into a metal material. According to this apparatus, even when it has a shape that the first punch and the second punch are crossed to each other, forming can be carried out with good efficiency.

[0427] In the above-mentioned apparatus, a pinion is provided at the above-mentioned curved second punch, and the above-mentioned second punch preferably slides by sliding of a rod member to which a rack with the above-mentioned pinion is formed. Since the punch and the rod member are slid by the rack and the pinion, sliding of the punch and the rod member can be easily synchronized. Thus, it can be applied to forming accompanied by a heavy lord.

[0428] In the above-mentioned apparatus, a linear moving passage having the same axis with the above-mentioned rod member which moves linear may be further provided. According to this, accuracy of a sliding track for the above-mentioned rod member is further improved.

[0429] A producing apparatus of a metal formed product in the other embodiment of the present invention has a first punch, a second punch having a circular arc shape with a constant curvature radius, and a driving means to move the second punch to circumferential movement with the center of said circular arc as a center, and the above-mentioned first punch and the above-mentioned second punch are inserted into a metal material to form a first hole part and a curved second hole part.

[0430] A producing apparatus of a metal formed product in the other embodiment of the present invention has a first punch, a second punch having a circular arc shape with a constant curvature radius, a driving means to move the second punch to circumferential movement with the center of said circular arc as a center, and a circular arc shape movement passage having the same axis with the above-mentioned second punch which moves said circumferential movement, and the above-mentioned first punch and the above-mentioned second punch are inserted into a metal material to form a first hole part and a curved second hole part. By having the circular arc shape movement passage, accuracy of a sliding track for the above-mentioned circular arced second punch is further improved.

[0431] In these apparatuses, a heater may be buried to the above-mentioned first punch and/or the second punch. By providing a heater, temperature control of the punches can be carried out so that setting of forming conditions in accordance with the material becomes easy.

[0432] Also, a heater may be buried at the metal die at a part other than the above-mentioned first punch and the second punch. By providing a heater, temperature control of the punch can be carried out so that setting of forming conditions in accordance with the material becomes easy.

[0433] Next, as the fourteenth example, a tap apparatus having a curved hollow part is explained by referring to drawings.

[0434] Fig. 91 is an assembly drawing showing a tap apparatus according to the fourteenth example of the present invention.

[0435] Fig. 92 is a drawing of parts of the tap apparatus of Fig. 1 in which machining has finished, and Fig. 92(A) is a plane view, Fig. 92(B) is a longitudinal sectional view and Fig. 92(C) is a side view.

[0436] This tap apparatus part 300 has a linear through passage (container) 301 opened to top and bottom, and a curved water spouting passage (curved outlet passage) 303 provided at the wall surface of the through hole 301. The through hole 301 and the water spouting passage 303 are connected to each other.

[0437] Fig. 93 is a drawing showing an semi-finished forged product of a part of the tap apparatus of Fig. 92, and Fig. 93 (A) is a plane view, Fig. 93(B) is a longitudinal sectional view and Fig. 93(C) is a side view.

[0438] The semi-finished forging product 300B of this tap apparatus part 300 has a lower end flash part 301a at part of the lower end of the through passage 301. Also, it has a separating wall flash part (separating wall) 303a at the part into which the wall of the water spouting passage 303 is inserted in the through passage 301. By removing the lower end flash part 301a and the separating wall flash part 303a of the semi-finished forged product by machining, etc., a final tap apparatus part 300 is obtained. The curved outlet 303 of said part 300 is formed to a final product shape at forging step.

[0439] Next, by referring to Fig. 94 and Fig. 95, an apparatus for forging a semi-finished forged product of the tap apparatus part of Fig. 93 is explained. Fig. 94 is a plan view schematically showing an apparatus for forging the semi-finished forged product of the tap apparatus part and Fig. 95 is a side sectional view of said apparatus.

[0440] This forging machine has a lower die set and an upper die set corresponding to the lower die set. The upper die set has an upper die 19. The lower die set has a lower die 12, a side straight punch (a first punch) 460, a curved punch (a second punch) 461, a rotation bar (rod shaped member) 462 for rotating the curved punch 461, and an ejector pin 15 for sliding the pin inserting hole of the lower die 12 up and down. The side straight punch 460 slides horizontally on the upper surface of the lower die 12. At the tip surface of the side straight punch 460, a cut portion 460a is provided. The shape of this cut portion 460a is correspond with a shape of the semi-finished forging product 300B excluding the lower end flash part 301a and the separating wall flash part 303a of the through passage 301.

[0441] At the upper surface of the lower die 12, a step forming hole 12a having a straight part corresponding to the through passage 301 and a curved part corresponding to the water spouting passage 303 is provided. At a part of the lower surface of the upper die 19, which faces to the above-mentioned step forming hole, a straight and curved step forming hole 19a is formed. At a die-clamped state, these step forming holes are connected to each other.

[0442] The curved punch 461 is so provided as to slide on a circular arc having a constant curvature radius along with the vertical axis of the upper surface of the lower die 12. At a part of the outside of the curved punch 461, a pinion 461a is provided. The rotation bar 462 is a straight member and driven by a driving means (not shown in the drawing) to linearly slide on the upper surface of the lower die. At a part of the rotation bar 462, racks 462a are provided. These racks 462a are engaged with the pinion 461a of the curved punch 461.

[0443] When the rotation bar 462 is driven linearly, the curved punch 461 rotates along with the vertical rotating axis on a circular arc. When the curved punch 461 is rotated to the most-inner part by the rotation bar 462 and further the side straight punch 460 is inserted into the most-inner part, the two are positioned not to reach the tip surface of the curved punch 461 to the cut portion 460a of the side straight punch 460. Also, at this time, the tip surface of the curved punch 461 has reached to the inside of the straight step forming hole 12a" over the curved step forming hole 12a'.

[0444] At the upper die 19 and the lower die 12, heaters 463 are provided. Also, a thermocouple 464 is provided at the each dies. The temperature data measured by the thermocouple 464 are sent to a temperature controller, and the temperature of the heater 463 is controlled by the controller. At the each outer peripheral surfaces of the lower die and the upper die, an heat insulating material 465 and an stainless steel cover 466 are wound to maintain the temperature. A sheet shaped heat insulating material 467, an stainless steel plate 468 and a sheet shaped heat insulating material 469 are held between the lower die 12 and a body flame, and between the upper die 19 and the upper slider, heat conductions to the body flame and the upper slider are prevented.

[0445] Next, the forging step is explained.

[0446] Fig. 96 to Fig. 100 are sectional views schematically showing a step for forging the semi-finished forged product of the parts of the tap apparatus of Fig. 93.

[0447] First, as shown in Fig. 96, at the die opening state, each punch 460 and 461 are moved back, and a heated forging material 300A is set to the step forming hole 12a of the lower die 12. At this state, the upper die 19 goes down and contacts with the lower die 12 to die-clamp.

[0448] Next, as shown in Fig. 97, the side straight punch 460 is driven into a forming hole 12". At this time, a part of the forging material 300B is fluidized and deformed, and an upper opening and a hollow part of the semi-finished forging product are formed. Also, a part of the material is swelled out in the curved step forming hole 12a'.

[0449] Next, as shown in Fig. 98, while driving the side straight punch 460 into, the rotation bar 462 is slid on a linear line (upper direction of the drawing). At this time, due to engage of the rack and the pinion, the curved punch 461 rotates to the inside direction (anti-clock direction of the drawing). At this time, the forging material swelled out to the curved step forming hole 12a' is fluidized and deformed by the tip of the curved punch 461 and a hollow part of a water spouting passage is formed.

[0450] Here, since the hollow part is formed by the curved punch 351 while swelling out the material, forming of the hollow shape becomes easy. Also, since the curved punch 461 is driven into while driving the side straight punch 460 into, deflection of the material can be reduced.

[0451] After finishing of the forming, as shown in Fig. 99, the side straight punch 460 is moved back to the left direction of the drawing. Also, the rotation bar 462 is moved back to the lower direction of the drawing, and the curved punch 461 is rotated to the outside direction (clock direction of the drawing) and moved back. Thereafter, the upper die 19 is returned to the upper limit position.

[0452] Subsequently, as shown in Fig. 100, the ejector pin 15 of the lower die 12 is risen to remove the semi-finished forged material 300B.

[0453] This semi-finished formed product is treated by the above-mentioned machining, etc., and unnecessary portions are removed to obtain a final formed product. At this time, the separating wall flash part 303a is present in the cylindrical shaped through passage 301 so that it can be easily removed with the lower edge surface flash part 301a.

[0454] Next, as the fifteenth example, a shower hanger is to be explained.

[0455] Fig. 101 is a drawing showing the structure of a shower hanger according to the fifteenth example of the present invention, and (A) is a perspective view, (B) is a side view, (C) is a front view and (D) is a plane view.

[0456] The shower hanger 310 is a member substantially rectangular shape, having a hook part 311 for hooking the shower at one edge surface and a fixing part 313 to be fixed to the wall at the other edge surface. The hook part 311 comprises a key hole shaped groove 311a penetrating from the front surface to the back surface. The groove 311a is opened to the edge surface. The key hole shaped groove 311a is also slightly inclined to the upper direction from the front surface toward the back surface.

[0457] On the other hand, the fixing part 313 comprises a hole having a predetermined depth cut from the edge surface of the opposed side. This hole is constituted by a box shaped part 313a wherein a sectional surface from the edge surface to a certain height is rectangle, and a H-shaped part 313b wherein a sectional surface from the bottom of the box shaped part to the bottom is H-shaped.

[0458] Fig. 102 to Fig. 108 are sectional views schematically showing an apparatus and forging steps for forging the shower hanger of Fig. 101.

[0459] This forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, a side punch 470 and an ejector pin 15.

[0460] The side punch 470 is so provided as to slide the lower die 12 to the diagonally upper direction. The sectional surface shape of the side punch 470 is the same as the shape of the key hole shaped groove 311a of the hook part 311 of the hanger 310. Also, the sliding direction of the side punch 470 is accorded with the inclined direction of the key hole shaped groove 311a of the hook part 311.

[0461] At the lower die 12, a step forming hole 12a corresponding to the outer shape of the end surface of the hook part 311 is provided.

[0462] The upper die set has an upper die 19 and an upper punch 471 which slides in the upper die up and down. At the upper punch 471, a cut portion 471a corresponding to the shape of the box shape part 313a and the H-shaped part 313b of the fixing part 313 of the hanger 310 is provided.

[0463] Next, the forging step is explained.

[0464] First, as shown in Fig. 102, at the die-opening state, a heated forging material 310A is set to the step forming hole 12a of the lower die 12. Next, as shown in Fig. 103, the upper die 19 goes down and the lower surface of the upper punch 471 is contacted to the forging material 310A. Incidentally, it is not necessarily contacted to each other. Subsequently, as shown in Fig. 104, when the upper punch 471 goes down, then the forging material 310A is fluidized and deformed and a pressed part is flowed into the gap between the side punch 470 of the lower die 12 and the step forming hole 12a to form a hook part 311 at which the key hole state groove is provided. Also, the part fluidized upward is flowed into the cut portion 471a of the upper punch 471 so that the fixing part 313 is formed.

[0465] Next, as shown in Fig. 105, the upper punch 471 is raised. And, as shown in Fig. 106, the upper die 19 is raised. Next, as shown in Fig. 107, the side punch 470 is moved back and as shown in Fig. 108, the ejector pin 15 is raised to remove the formed product.

[0466] Next, as the sixteenth example, a part X is explained.

[0467] Fig. 109 is a longitudinal sectional view showing the structure of a part X according to the sixteenth example of the present invention.

[0468] The part X 320 has a closed bottom cylindrical shape as a whole. At the center of the part X, an axis hole 321 with a constant inner diameter is provided. The outer surface thereof comprises an upper small diameter part 322, a flange part 323, a large diameter part 324 and a lower small diameter part 325 from the top.

[0469] Fig. 110 to Fig. 119 are sectional views schematically showing an apparatus and forging steps for forging the part X of Fig. 1.

[0470] This forging machine has a lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, a lower outer punch 480 which slides in the lower die 12 up and down, and a lower inner punch 481 which slides in the lower outer punch 480 up and down.

[0471] The lower inner punch 481 is connected to an actuator (now shown in the drawing) but the lower outer punch 480 is not connected to the actuator. At the lower end part of the lower outer punch 480, a flange 480a is provided. Rising of the punch 480 is stopped by contacting the flange 480a to an upper stopping surface 12b in the lower die. Descending of the punch 480 is stopped by contacting the flange 480a to a lower stopping surface 12c of the lower die 12.

[0472] The upper die set has an upper die 12 and an upper punch 482 which slides in the upper die up and down. At the upper tip part of said punch 482, a flange 482a is provided. Descending of the punch 482 is stopped by contacting the flange 482a to a lower stopping surface 19c of the upper die 19.

[0473] At the upper surface of the lower die 12, a step forming hole 12a is formed. At a part of the lower surface of the upper die 19, which faces to the above-mentioned step forming hole, a step forming hole 19a is provided. This step forming hole is to form the upper small diameter part and the flange part of the part X. At the die-clamping state, these step forming holes are connected to each other.

[0474] Next, the forging step is explained.

[0475] First, as shown in Fig. 110, at the die opening state, a heated forging material 320A is set at the step forming hole 12a of the lower die 12. Next, as shown in Fig. 111, the upper die 19 and the upper punch 482 are simultaneously gone down, and the lower surface of the upper die 19 is contacted to the upper surface of the lower die 12 to die-clamp.

[0476] Next, as shown in Fig. 112, the lower inner punch 481 and the lower outer punch 480 are raised. At this time, the forging material is pressed from downward, and fluidized and deformed. And the upper small diameter part 322 and the flange part 323 are formed, and a part of the axis hole 321 is starting to be formed.

[0477] Next, as shown in Fig. 113, the upper punch 482 goes down. According to the pressure difference between the pressing force of the upper punch 482 and the back pressure to the lower inner punch 481 and the lower outer punch 480, the lower inner punch 481 and the lower outer punch 480 go down. At this time, the axis hole 321 is further formed. The lower outer punch 480 goes down, as shown in Fig. 114, until the flange 480a of said punch 480 contacts with the lower stopping surface 12c of the lower die 12. At this state, as shown in Fig. 115, the upper punch 482 goes down until the flange 482a contacts with the lower stopping surface 19c, and simultaneously the lower inner punch 481 goes down. At this time, the lower small diameter part 325 is formed and the axis hole 321 is further deeply formed. At the lower inner punch 481, the back pressure is still applied.

[0478] Next, as shown in Fig. 116, the upper punch 482 is raised. Subsequently, as shown in Fig. 117, the upper die 19 is raised. Next, as shown in Fig. 118, the lower inner punch 481 is raised. Finally, as shown in Fig. 119, the lower outer punch 480 is raised with the lower inner punch 481 to remove the formed product.

[0479] Next, as the seventeenth example, a part Y is explained.

[0480] Fig. 120 is a longitudinal sectional view showing the structure of a part Y according to the sixteenth example of the present invention.

[0481] The part Y 330 is a conical shaped solid part as a whole. The part Y 330 has a flange part 331 and under the flange part 331, a large diameter part 332, a small diameter part 333 and an axis part 334 are continuously provided.

[0482] Fig. 121 to Fig. 130 are sectional views schematically showing an apparatus and forging steps for forging the part Y of Fig. 120.

[0483] This forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, a lower inner punch 490 which slides in the lower die 12 up and down, and a double lower outer punch. The lower inner punch 490 is connected to an actuator (now shown in the drawing), but the lower outer punch is not connected to the actuator. The lower outer punch comprises an inside outer punch 491 and an outside outer punch 492.

[0484] At the lower end part of the outside outer punch 492, a flange 492a is provided. Rising of said punch 492 is stopped by contacting the flange 492a to an upper stopping surface 12c of the lower die 12. Descending of the punch 492 is stopped by contacting the flange 492a to a lower outer stopping surface 12d of the lower die 12.

[0485] At the lower end part of the inside outer punch 491, a flange 491a is provided. Rising of said punch 491 is stopped by contacting the flange 491a to the flange 492a of the outside outer punch 492. Descending of the punch 492 is stopped by contacting the flange 492a to a lower inner stopping surface 12e of the lower die 12.

[0486] At the lower die 12, a step forming hole 12a is provided.

[0487] The upper die set has an upper die 19 and an upper punch 493 which slides in the upper die 19 up and down. At the upper end part of the upper punch 493, a flange 493a is provided. Descending of the punch 493 is stopped by contacting the flange 493a to a lower stopping surface 19c of the upper die 19.

[0488] Next, the forging step is explained.

[0489] First, as shown in Fig. 121, at the die opening state, a heated forging material 330A is set at the step forming hole 12a of the lower die 12. Next, as shown in Fig. 122, the upper die 19 and the upper punch 493 simultaneously go down, and the lower surface of the upper die 19 is contacted to the upper surface of the lower die 12 to die-clamp. Next, as shown in Fig. 123, the upper punch 493 goes down.

[0490] Next, as shown in Fig. 124, the upper punch 493 continuously goes down. According to the pressure difference between the pressing force of the upper punch 493 and the back pressure to the lower inner punch 490 and the lower outer punch, the lower inner punch 490 and the lower outer punch simultaneously go down. The outside outer punch 492 goes down until the flange 492a contacts with the outer stopping surface 12d. At this time, parts of the flange part 331 and the large diameter part 332 are starting to be formed. Subsequently, as shown in Fig. 125, the upper punch 493 goes down, and the lower inner punch 490 and the inside outer punch 491 simultaneously go down. The outside outer punch 492 is stopped at a lower stopping surface 12d of the lower die 12. The inside outer punch 491 goes down until it contacts with an inner stopping surface 12e. At this time, the flange part 331 and the large diameter part 332 are further formed, and the small diameter part 333 is starting to be formed.

[0491] Subsequently, as shown in Fig. 126, the upper punch 493 goes down until the flange 493a of said punch 493 contacts with a lower stopping surface 19c of the upper die 19. The lower inner punch 490 continuously goes down. At this time, the flange part 331, the large diameter part 332, the small diameter 333 and the axis part 334 are formed. To the lower inner punch 490, the back pressure is continuously applied.

[0492] Next, as shown in Fig. 127, the upper punch 493 is raised. Subsequently, as shown in Fig. 128, the upper die 19 is raised. Subsequently, as shown in Fig. 129, the lower inner punch 490 is raised. And, as shown in Fig. 130, the lower outer punches 491 and 492 are further raised with the lower inner punch 490 to remove the formed product.

[0493] Next, as the seventeenth example, a part Z is explained.

[0494] Fig. 131 is a longitudinal sectional view showing the structure of a part Z according to the seventeenth example of the present invention.

[0495] The part Z 340 has a cylindrical shape as a whole and a longitudinal sectional surface is H-shaped. The part Z 340 has an upper recessed part 341 and a lower recessed part 342. Near to the upper end of the upper recessed part 341, a flange 343 is provided. At said flange 343, a circular projection part 344 extending upward is provided.

[0496] Fig. 132 to Fig. 141 are sectional views schematically showing an apparatus and forging steps for forging the part Z of Fig. 131.

[0497] This forging machine has an lower die set and a upper die set corresponding to the lower die set. The lower die set has a lower die 12, a lower inner punch 500 which slides in the lower die 12 up and down, and a lower outer punch 501. The lower outer punch 501 is connected to an actuator (not shown in the drawing) but the lower inner punch 500 is not connected to the actuator.

[0498] At the lower outer punch 501, an upper flange 501a is provided at the lower end part thereof. At the lower surface of the flange 501a, a rod 501b is so provided to extend downward. To the lower end part of said rod 501b, a lower flange 501c is attached.

[0499] At the lower end part of the lower inner punch 500, a flange 500a is provided. The rod 501b of the lower outer punch 501 is slidably penetrated in the flange 500a of the lower inner punch 500. Accordingly, the lower inner punch 500 slides between the upper flange 501a and the lower flange 501c of the lower outer punch 501 along with the rod 501b. Descending of the lower inner punch 500 is stopped by contacting the flange 500a to a lower stopping surface 12b of the lower die 12.

[0500] The upper die set has an upper die 19 and an upper punch 502 which slides in the upper die 19 up and down. At the upper end part of the upper punch 502, a flange 502 is provided. The punch 502 is stopped by contacting the flange 502a to a lower stopping surface 19c of the upper die 19.

[0501] At the upper surface of the lower die 21, a forming hole 12a is provided. At the part of the lower surface of the upper die 19, which faces to the above-mentioned forming hole, a step forming hole 19a is provided. These forming holes are connected to each other at the die-clamping state.

[0502] Next, the forging step is explained.

[0503] First, as shown in Fig. 132, at the die opening state, a heated forging material 340A is set at the forming hole 12a of the lower die 12. Next, as shown in Fig. 133, the upper die 19 and the upper punch 502 simultaneously go down, and the lower surface of the upper die 19 is contacted to the upper surface of the lower die 12 to die-clamp.

[0504] Next, as shown in Fig. 134, the lower outer punch 501 is raised with the lower inner punch 500. At this time, the forging material is fluidized and deformed, and the circular projection 344 and the flange 343 are formed by the portion pressed upward.

[0505] Next, as shown in Fig. 135, the upper punch 502 goes down. In accordance with the pressure difference between the pressing force of the upper punch 502 and the back pressure to the lower inner punch 500 and the lower outer punch 501, the lower outer punch 501 and the lower inner punch 500 simultaneously go down. At this time, the upper recessed part 341 is starting to be formed. Subsequently, as shown in Fig. 136, the upper punch 502 continuously goes down, and the lower inner punch 500 simultaneously goes down. The lower inner punch 500 goes down until the flange 500a of said punch 500 is contacted to a lower stopping surface 12b of the lower die 12. At this time, the upper recessed part 341 is further deeply formed.

[0506] Next, as shown in Fig. 137, the upper punch 502 further goes down until the flange 502a of said punch 502 is contacted to a lower stopping surface 19c of the upper die 19. The lower outer punch 501 further goes down along with the rod 500b of the lower inner punch 500. The lower outer punch 501 goes down until the upper flange 501a of said punch 501 is contacted to the flange 500a of the lower inner punch 500. Incidentally, it is not necessarily contacted to each other. At this time, by the upper punch 502, the upper recessed part 341 is completely formed. Further, by going the lower outer punch 501 down, the lower recessed part 342 is formed.

[0507] Next, as shown in Fig. 138, the upper punch 502 is raised. Subsequently, as shown in Fig. 139, the upper die 19 is raised. Next, as shown in Fig. 140, the lower outer punch 501 is raised. Finally, as shown in Fig. 141, the lower inner punch 500 is raised with the lower outer punch 501 to remove the formed product.

Claims

1. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a pre-forging step and a hole forming step thereafter by using an identical die,
wherein, in the above-mentioned pre-forging step, forging is carried out so that at least a part of the above-mentioned forging material is forged to fill in a cavity of the die to obtain a part of a shape of a formed product, and,
in the above-mentioned hole forming step, the hole is formed by driving a punch into said forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto.

2. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a pre-forging step and a hole forming step thereafter by using an identical die,
wherein, in the above-mentioned pre-forging step, a part of a shape of a formed product is obtained and,
in the above-mentioned hole forming step, a hole is formed by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto,
wherein the die pin is not moved during the above-mentioned pre-forging step.

3. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a hole forming step and a post-forging step thereafter by using an identical die,
wherein, in the above-mentioned hole forming step, a hole is formed by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto and,
in the above-mentioned post-forging step, a part of a shape of a formed product is obtained by forging at least a part of the above-mentioned forging material.

4. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a hole forming step and a pre- or post-forging step by using an identical die,
wherein, in the above-mentioned hole forming step, a hole is formed by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto and,
in the forging step, the above-mentioned die pin is maintained not to move basically back against a forming pressure of the forging material.

5. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a hole forming step wherein a hole is formed by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and moving back under applying a back pressure thereto,
wherein the above-mentioned punch is driven from a direction other than the moving back direction of the above-mentioned die pin or the opposite direction of the same.

6. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

wherein forging is carried out by pressurizing the forging material using a die for die forging an outer shape of a formed product and a punch for forming an recessed part of the formed product in combination from the same direction, and moving a die pin back under applying a back pressure thereto during the forging.

7. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

wherein forging is carried out by pressurizing the forging material using a plural number of punches for forming a plural number of recessed parts from a same direction, and moving a die pin back under applying a back pressure thereto during the forging.

8. The die forging method according to Claim 6, wherein forming is carried out by using the above-mentioned die and the punch at different timings

9. The die forging method according to Claim 7, wherein forming is carried out by using a plural number of punches at different timings.

10. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

wherein forging is carried out by driving a plural number of punches into the forging material from different directions simultaneously to carry out forming and by moving a die pin back under applying a back pressure thereto during the forging.

11. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a forging step by driving a punch into the forging material or by pressing a die to the forging material while a die pin is in touch with one end surface of said forging material and moving back under applying a back pressure thereto,
wherein a plural number of die pins are provided to form a plural number of holes.

12. The die forging method according to Claim 11, wherein the above-mentioned plural number of die pins are operated successively along a time difference and the above-mentioned plural number of holes are successively formed.

13. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a forging step in which forging is completed by advancing a punch or a die to a predetermined position by pressing the punch or the die to the forging material while a die pin is in touch with one end surface of the forging material and pressured thereto,
wherein, in this step, when a die inner pressure is a predetermined pressure or lower, the above-mentioned die pin is not moved back and, when a die inner pressure exceeds said predetermined pressure, the die pin is moved back.

14. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a hole-forming step by driving a punch into the forging material while a die pin is in touch with one end surface of the forging material and the die pin is moving back under applying a back pressure to the forging material,
wherein a recessed or protruded part is provided at the end surface of the above-mentioned die pin, which applies the back pressure, and a part of product shape is formed by using the recessed or protruded part.

15. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a pushing out step by forming an pushed out part by forging, and a forming step by forming the pushed out part to a predetermined shape by forging further,
wherein the above-mentioned both steps are carried out in an identical die.

16. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a pushing out step by forming an pushed out part by forging, and a forming step by forming the pushed out part to a predetermined shape by forging further,
wherein the above-mentioned pushing out part is pushed out to the same direction or the opposite direction with or to the forging in the above-mentioned pushing out step.

17. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a pushing out step by forming a pushed out part by forging, and a forming step by forming the pushed out part to a predetermined shape by forging further,
wherein a forging material is forged a plural number of times in the above-mentioned pushing out step.

18. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

wherein, while driving a first punch into the forging material, the forging material is processed by a second punch or a die without moving said first punch back.

19. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a first step by making a cavity at a side of one end part of the above-mentioned forging material,
a second step by pressing the above-mentioned forging material from the other side of the above-mentioned forging material to push out said one end part of the above-mentioned forging material and fill the above-mentioned cavity whereby forming an outer shape thereof, thereby obtaining a pushed out body, and
a third step by driving a punch into the above-mentioned pushed out body from said one end surface of the end part to an axis direction after the above-mentioned second step to form a recessed part in the above-mentioned pushed out body.

20. A die forging method in which a forging material is subjected to plastic fluidization in a forging die under pressure to form a predetermined shape;

which comprises a step A by forming an recessed part by driving a punch into the forging material from a end surface of one end part of the above-mentioned forging material to the axis direction, and thereafter,
a step B by forming a second recessed part with a larger diameter and shallower than the first recessed part at the above-mentioned end surface by using a second punch arranged at an outer peripheral of the punch,
wherein the die pin contacted to the other end of the above-mentioned forging material is moved back under applying a back pressure thereto.

21. A die forging method in which a forging material is formed by subjecting to plastic fluidization in a forging die under pressure to obtain a formed product which has a protruded part having an undercut;

wherein the method comprises a first step by pushing out an starting part of the above-mentioned protruded part at the tip of the above-mentioned forging material, and
after the above-mentioned first step, a second step by pushing out the above-mentioned protruded part to the side direction by pushing said original part from the opposite direction to the pushing out direction.

22. A die forging method in which a forging material is formed by subjecting to plastic fluidization in a forging die under pressure to obtain a formed product having a closed bottom cylindrical shape;

wherein the method comprises a step A by a back extrusion forming the cylindrical part by driving a punch into the center portion of the above-mentioned forging material while forming the outer surface of the cylindrical part by a die cavity surface and applying a back pressure to the end surface of the cylindrical part,
a step B by firstly drawing the above-mentioned punch used for forming the above-mentioned cylindrical part when removing the above-mentioned formed product, and
a step C by removing the above-mentioned formed product from the die used for forming the outer surface of the above-mentioned cylindrical part, after the above-mentioned step B.

23. The die forging method according to any one of Claims 1 to 23, wherein the above-mentioned formed product after forging and cooling is made of a brass material having the following crystal structure;

(a) a crystal structure wherein areal ratio of an $\alpha+\beta$ phase and a β phase is 20% or higher,
(b) a crystal structure wherein an average crystal grain size of an α phase and a β phase is 15 μm or smaller, and
(c) an Sn concentration in the β phase is 1.5 wt% or higher.

24. The die forging method according to any one of Claims 1 to 23, wherein the above-mentioned formed product after forging and cooling is made of a brass material having the following crystal structure;

(a) a crystal structure wherein areal ratio of an $\alpha+\gamma$ phase and a γ phase is 3 to 30%,
(b) an average crystal grain size of an α phase is 15 μm or smaller, and an average crystal grain size of a short axis of the γ phase is 8 μm or smaller,
(c) an Sn concentration in the γ phase is 8 wt% or higher, and
(d) the γ phase is distributed in the grain boundary of the α phase.

25. The die forging method according to any one of Claims 1 to 23, wherein the above-mentioned formed product after forging and cooling is made of a brass material having the following crystal structure;

(a) a crystal structure wherein areal ratio of an α+β+γ phase and an α phase is 40 to 94%, and areal ratio of a β phase and an α phase is 3 to 30% respectively ,
(b) an average crystal grain sizes of an α phase and a β phase are 15 μm or smaller, an average crystal grain size of a short axis of the γ phase is 8 μm or smaller,
(c) an Sn concentration in the γ phase is 8 wt% or higher and
(d) the γ phase surrounds the α phase.

26. The die forging method according to any one of Claims 1 to 25, wherein the above-mentioned forging material is a brass material, and comprises a step by forging while heating the above-mentioned forging material and the above-mentioned forging dies at 300 to 550°C.

27. The die forging method according to Claim 27, wherein the above-mentioned brass material has an apparent Zn content of 37 to 50% by weight and an Sn content of 1.7 to 2.2% by weight, and
contains a γ phase having an average crystal grain diameter of the short axis of 15 μm or smaller in the crystal structure at the above-mentioned temperature region.

FIG. 1

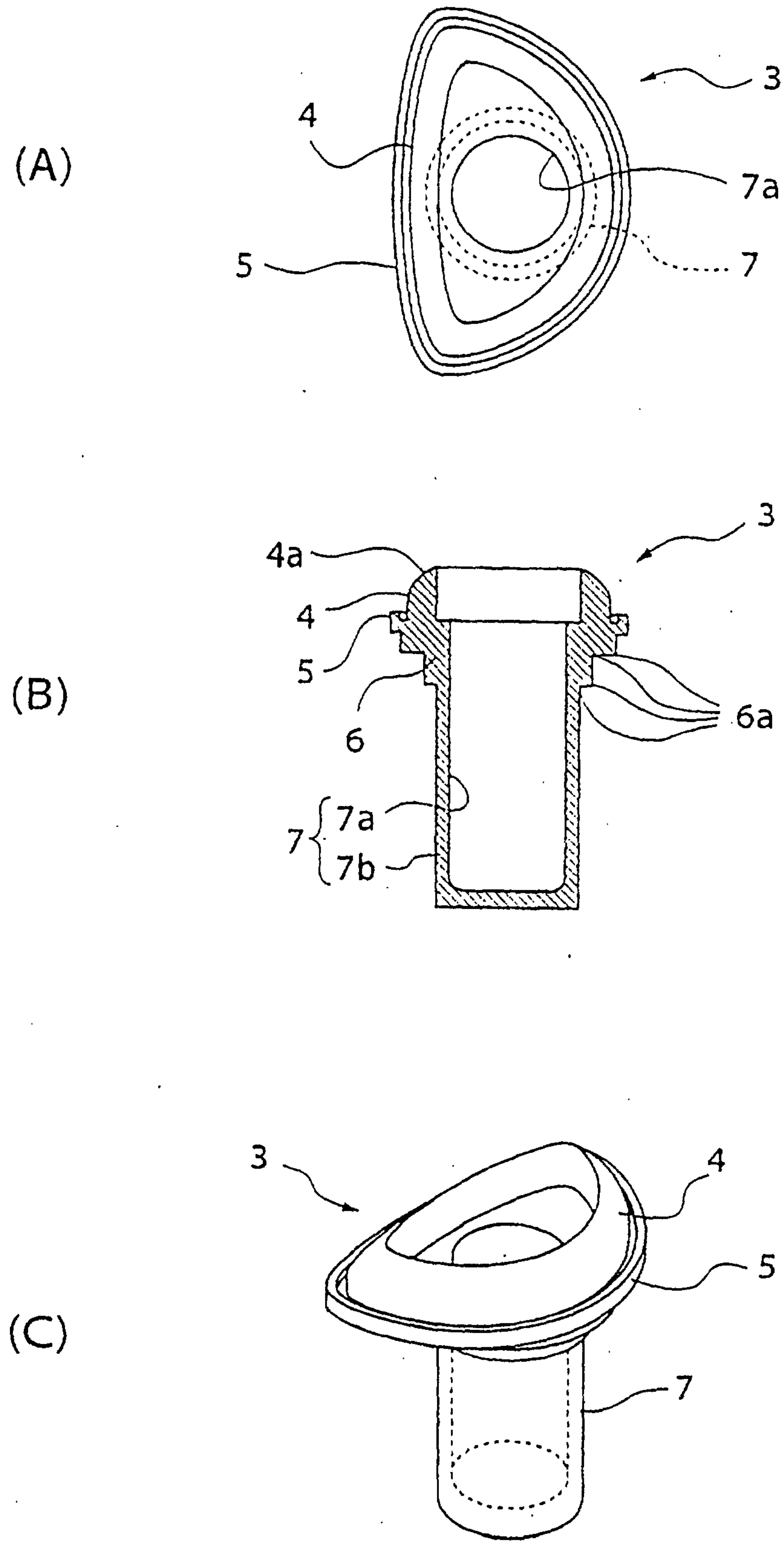


FIG. 2

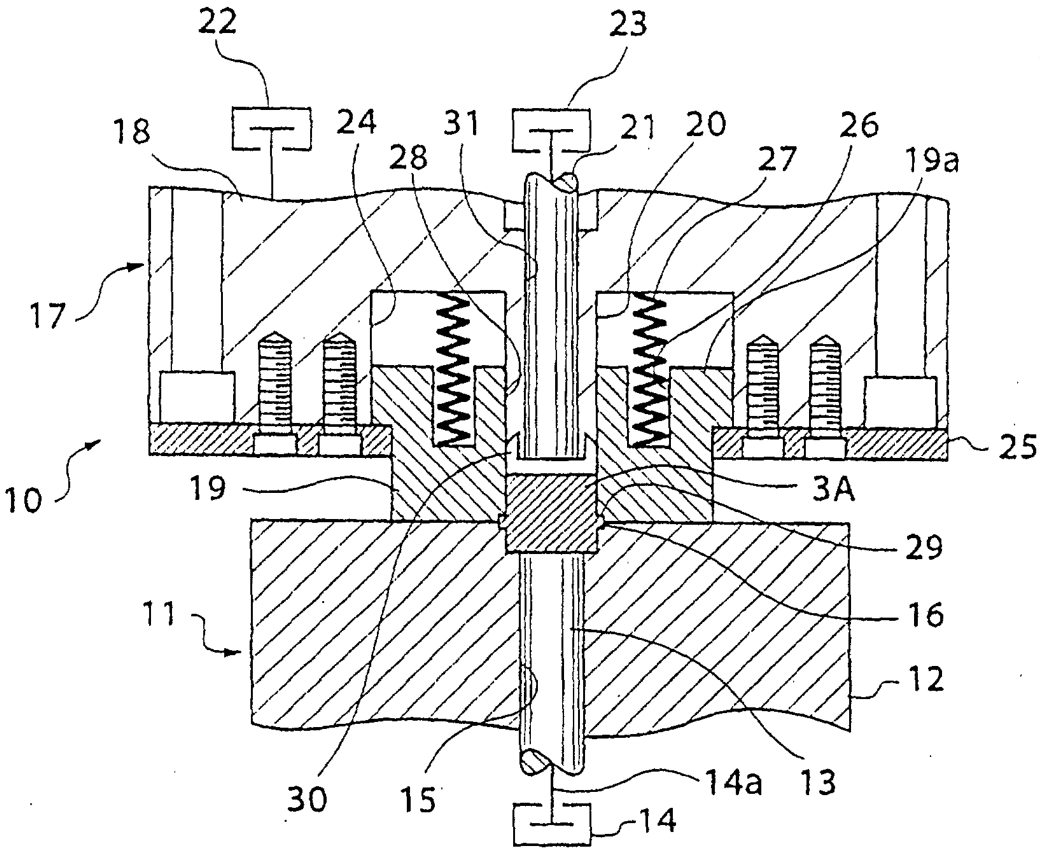

22
23
18
24
31
21
20
26
28
27
19a
17
25
10
19
3A
29
16
11
12
30
15
14a
13
14

FIG. 3

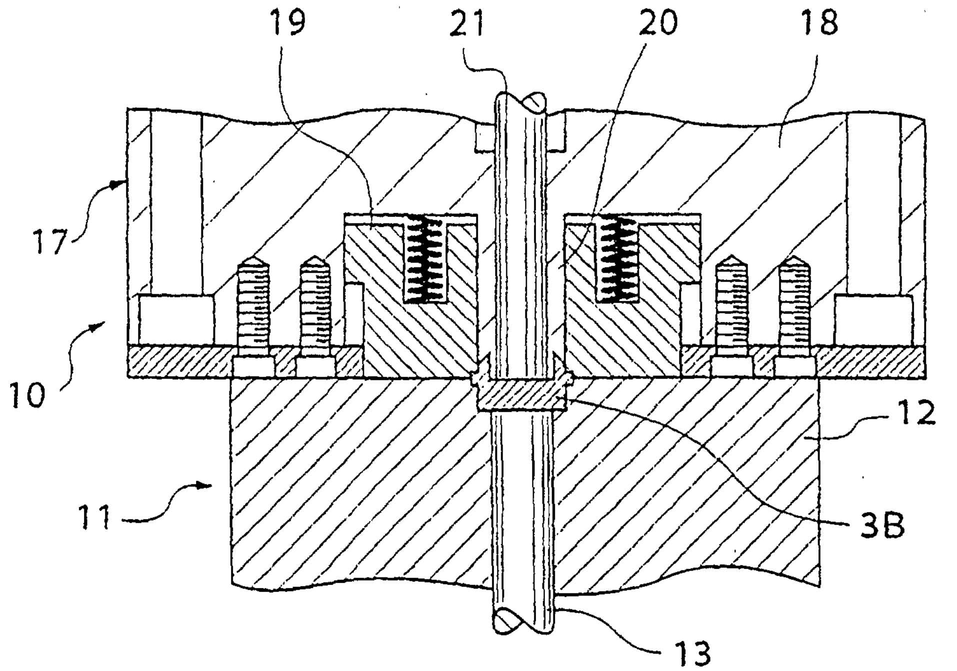


FIG. 4

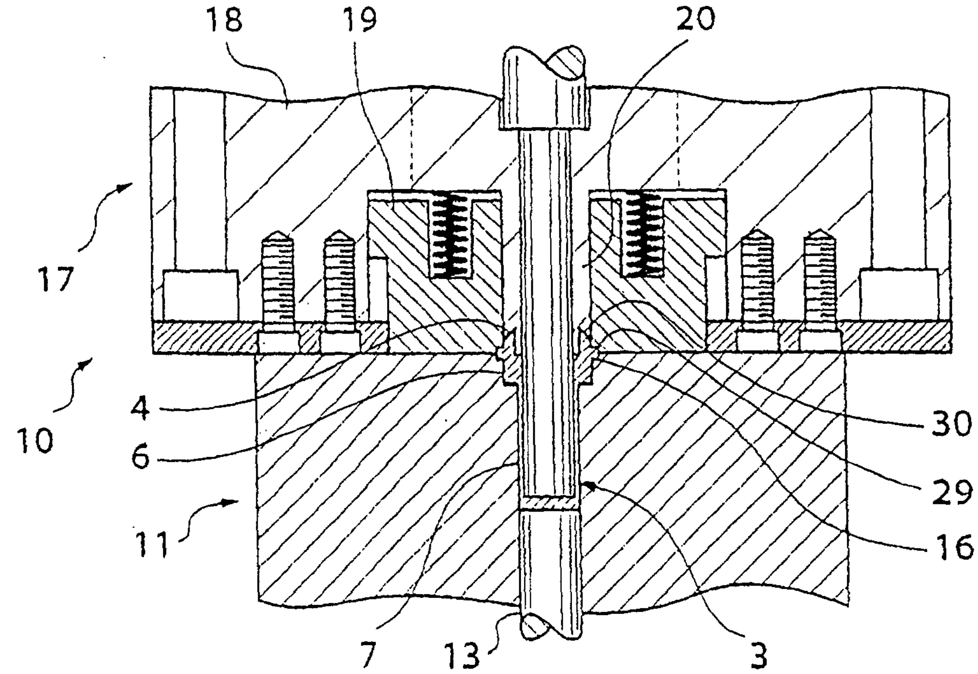


FIG. 5

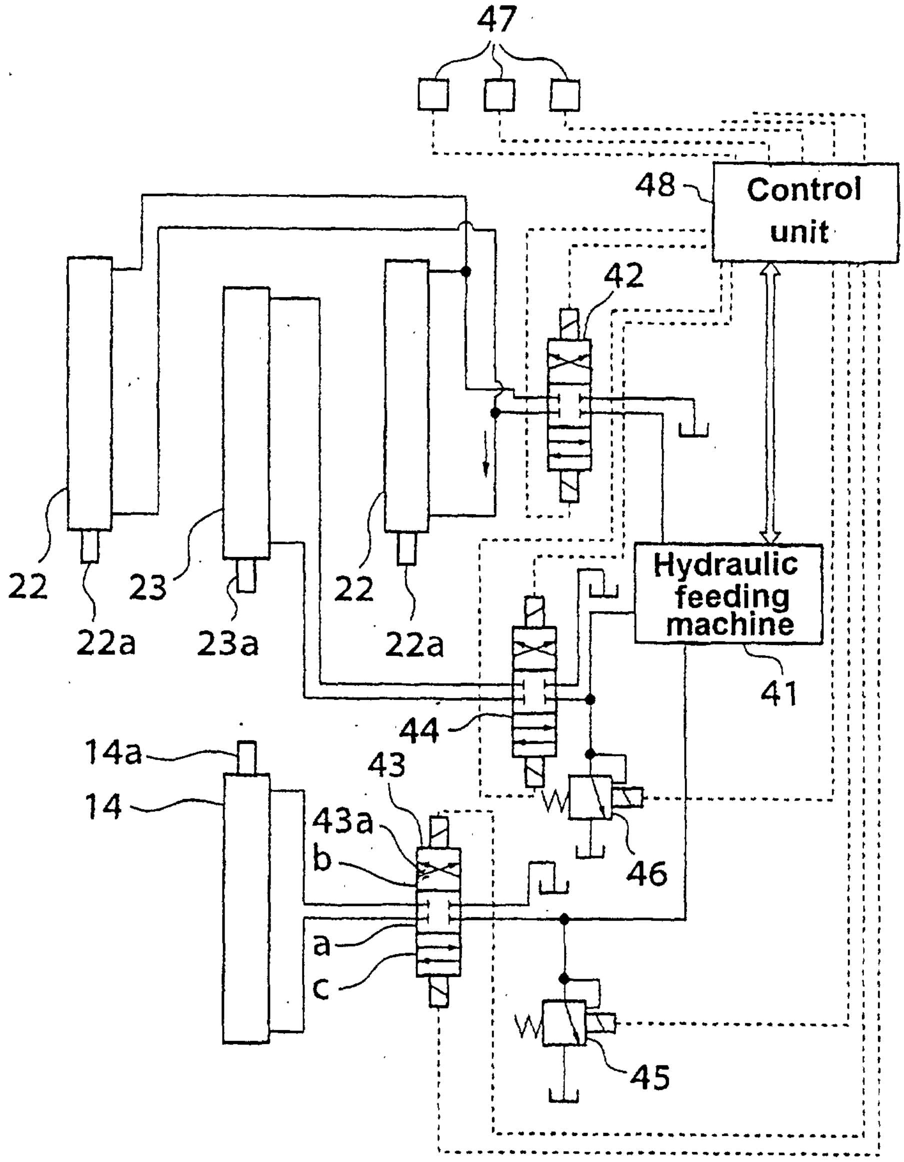

47
48
Control unit
42
22
22a
23
23a
22
22a
Hydraulic feeding machine
41
44
14a
14
43
43a
b
a
c
46
45

FIG. 6

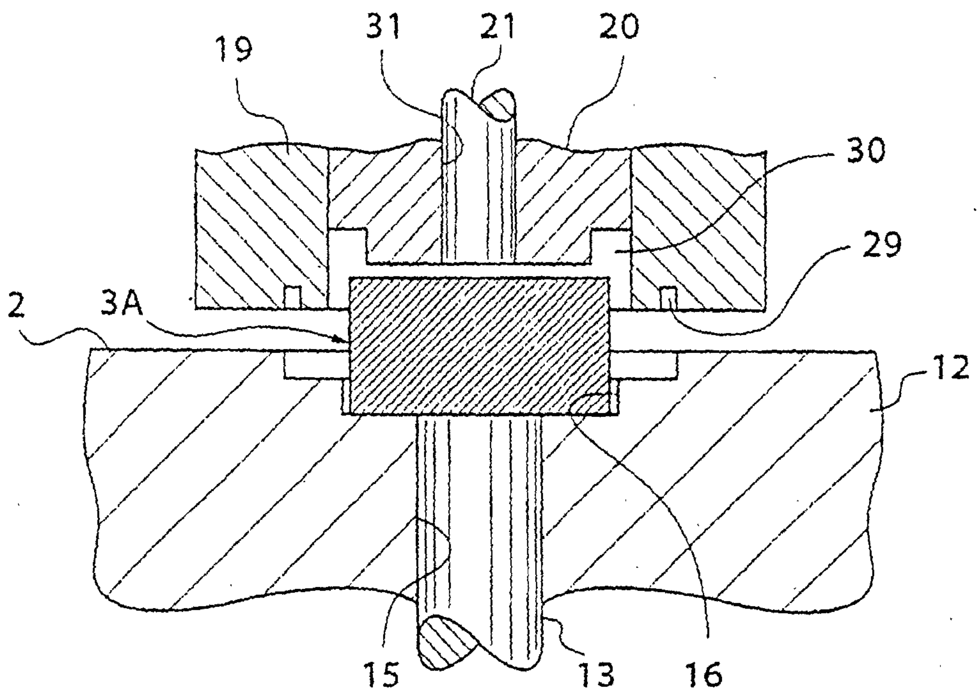


FIG. 7

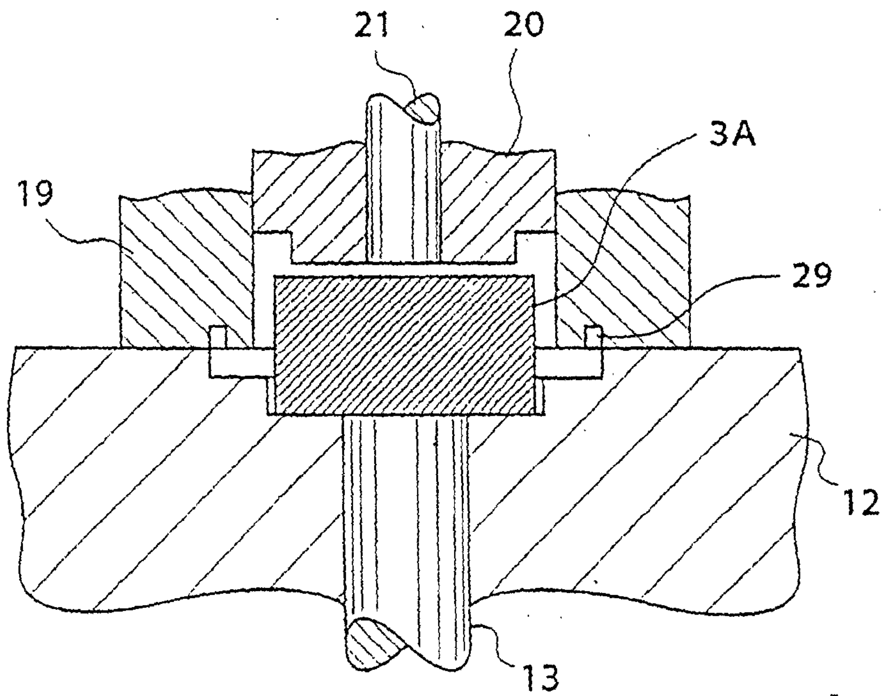


FIG. 8

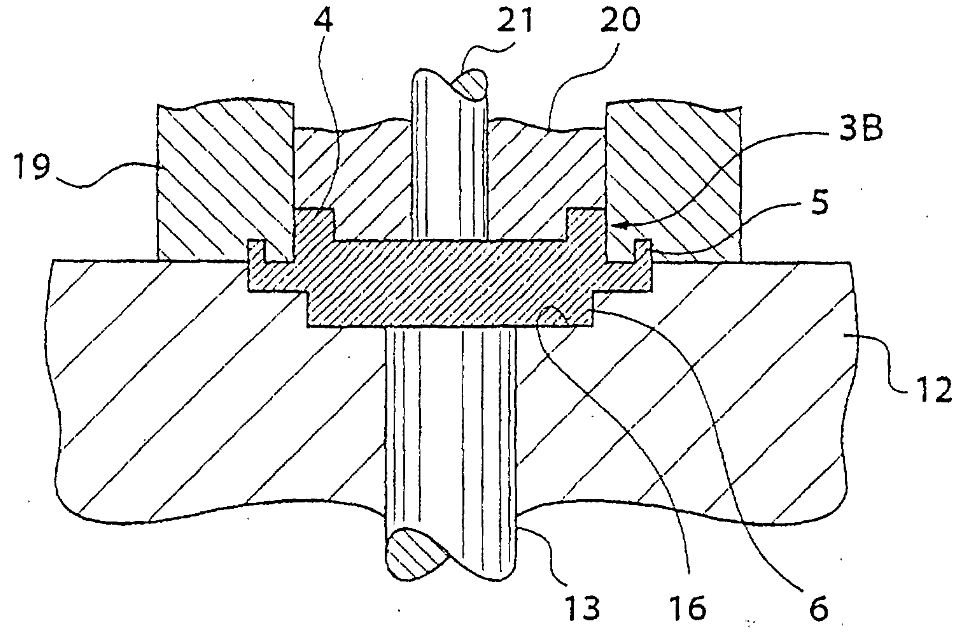


FIG. 9

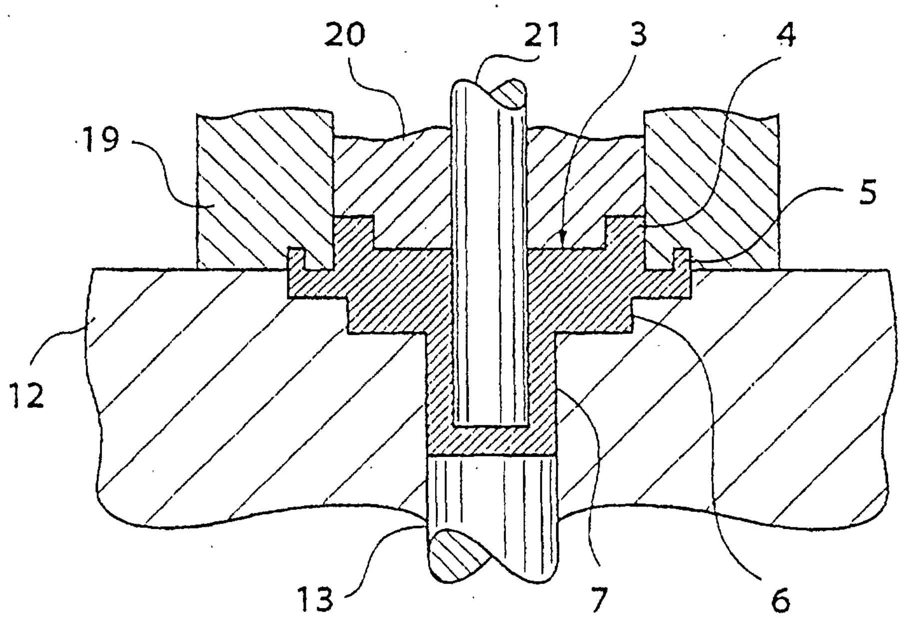


FIG. 10

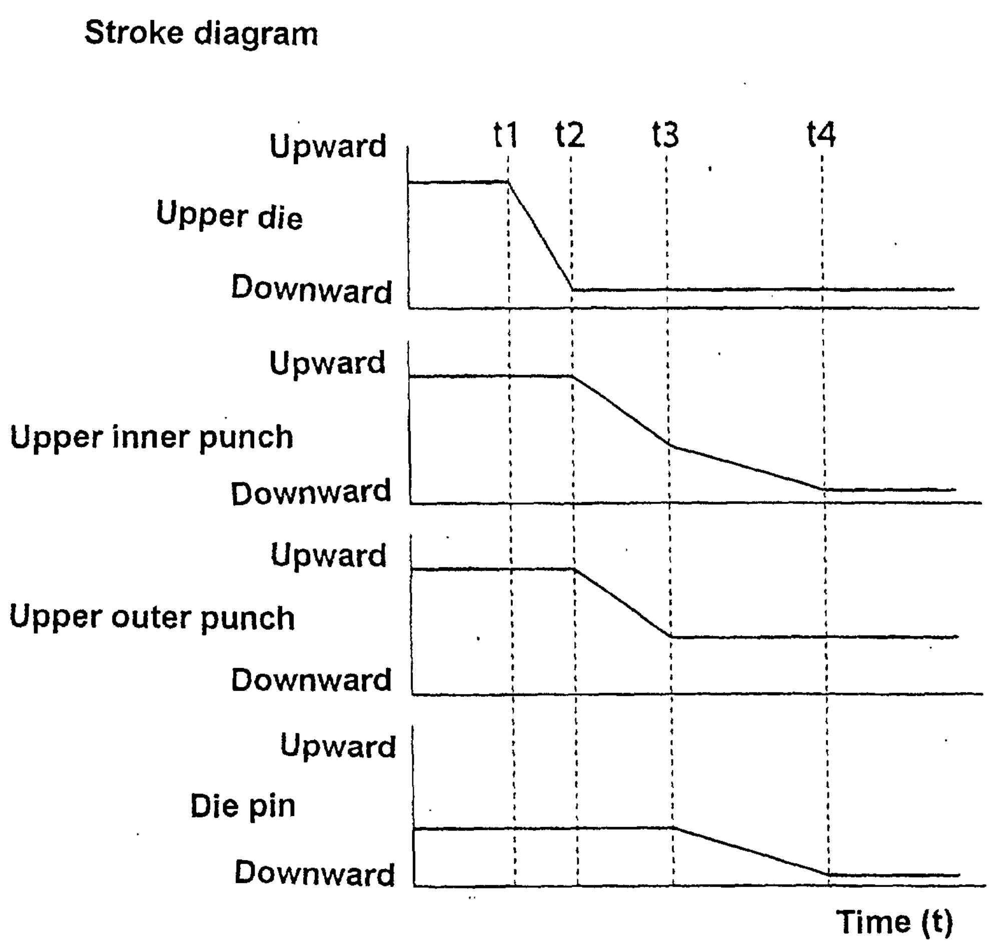

Stroke diagram
Upward
Upper die
Downward
Upward
Upper inner punch
Downward
Upward
Upper outer punch
Downward
Upward
Die pin
Downward
t1
t2
t3
t4
Time (t)

FIG. 11

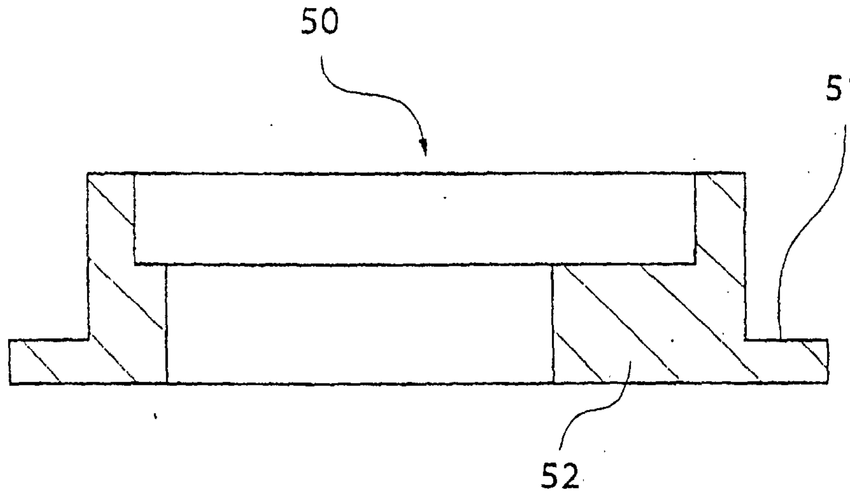


FIG. 12

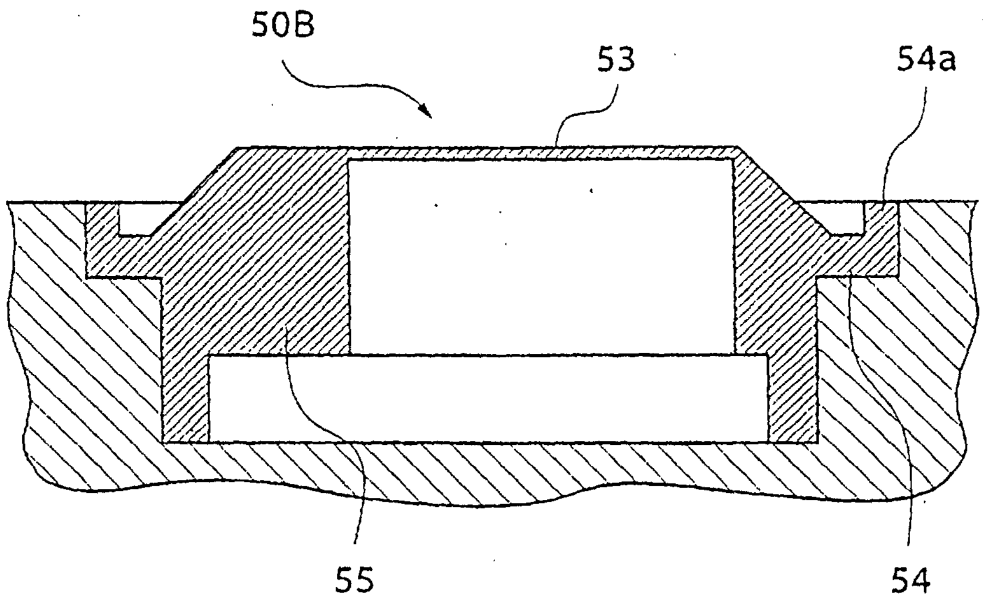


FIG. 13

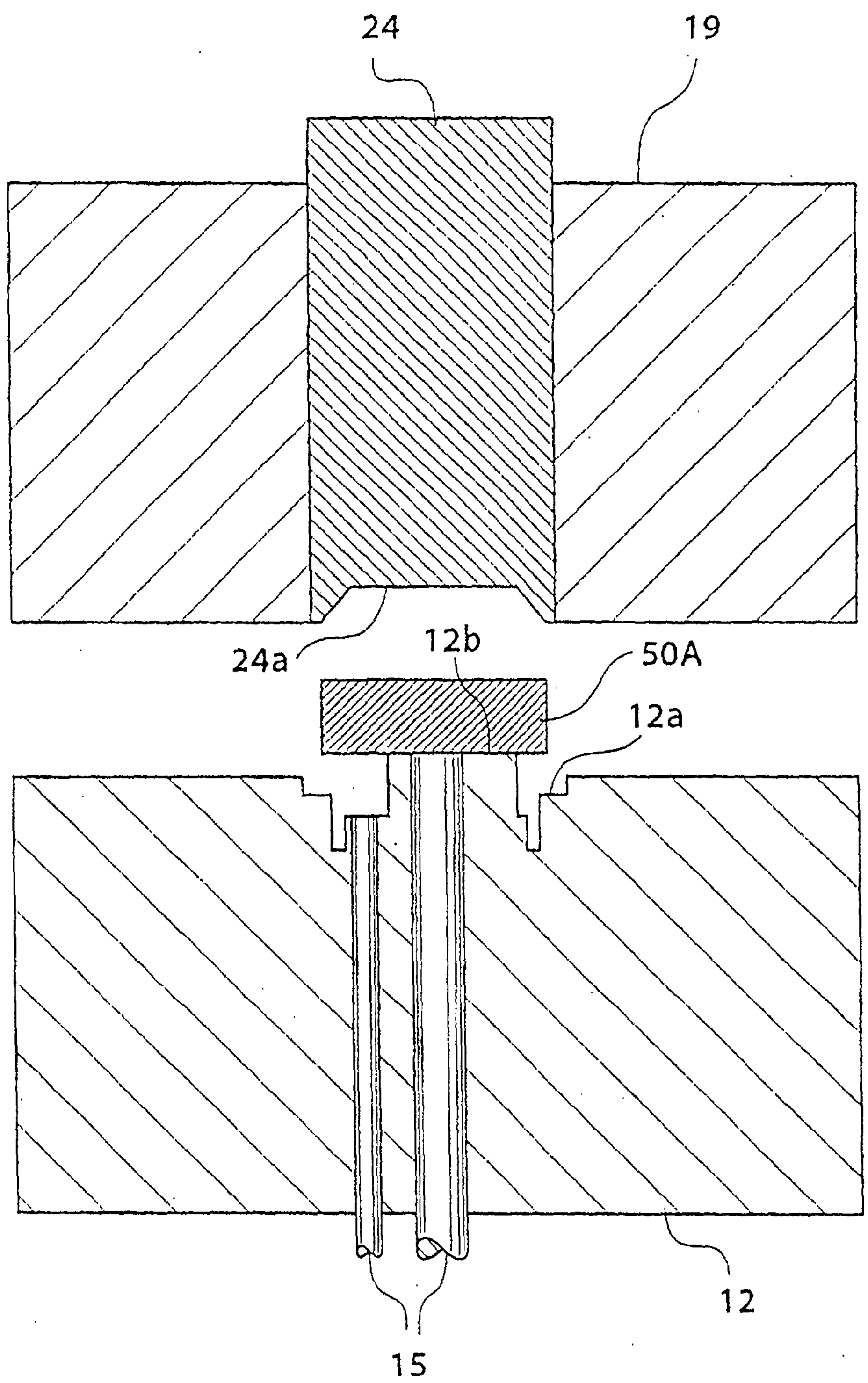


FIG. 14

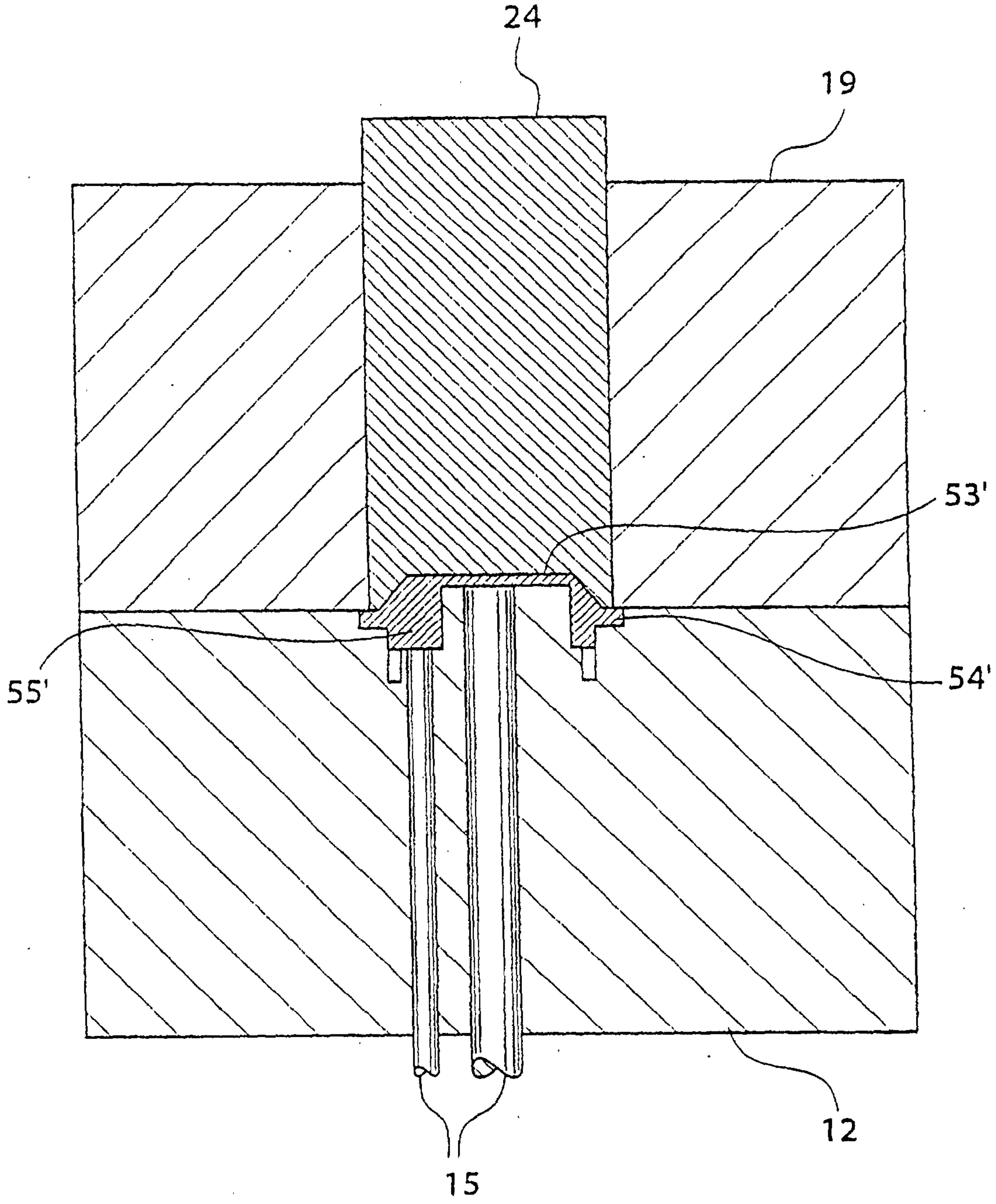


FIG. 15

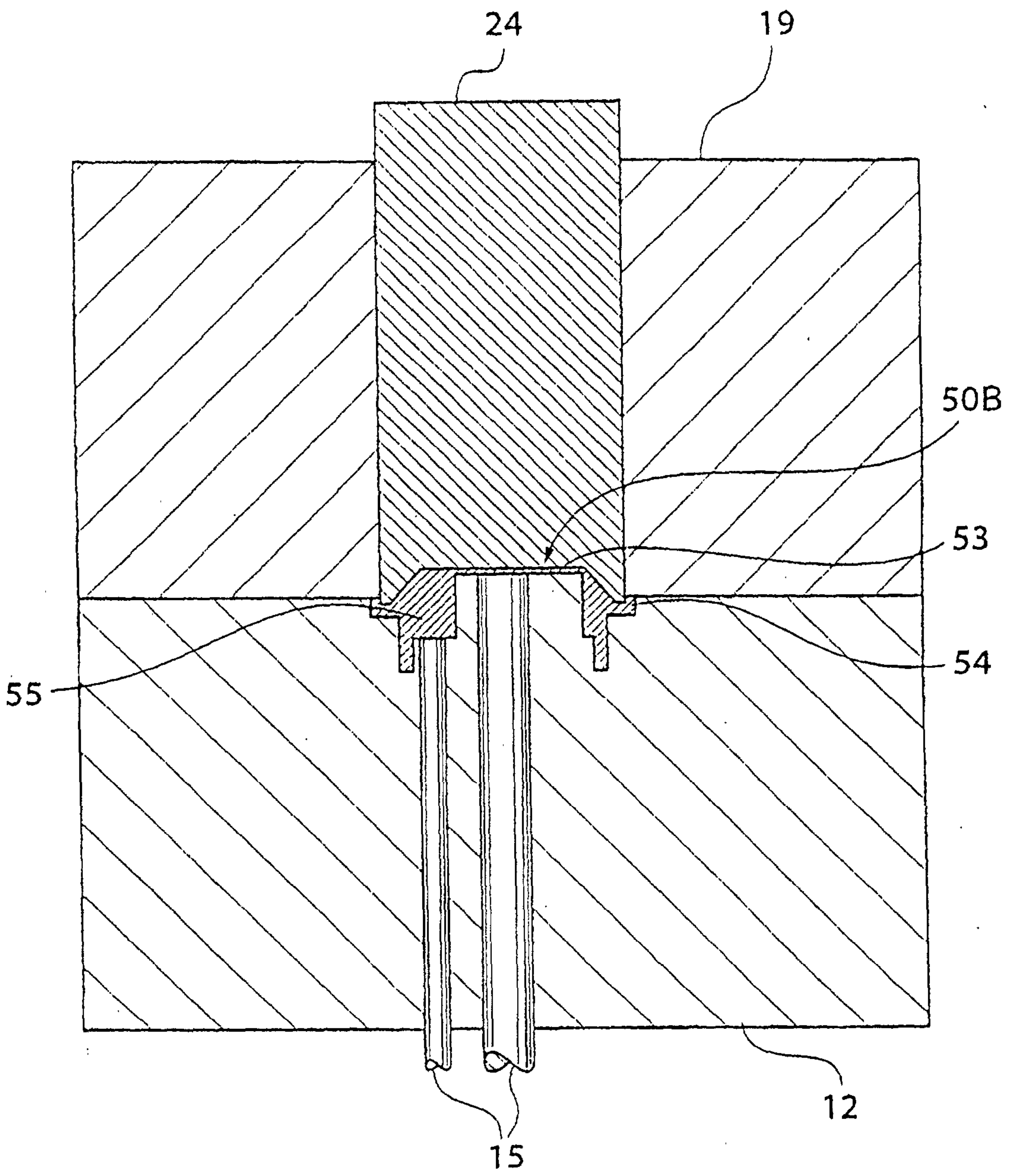


FIG. 16

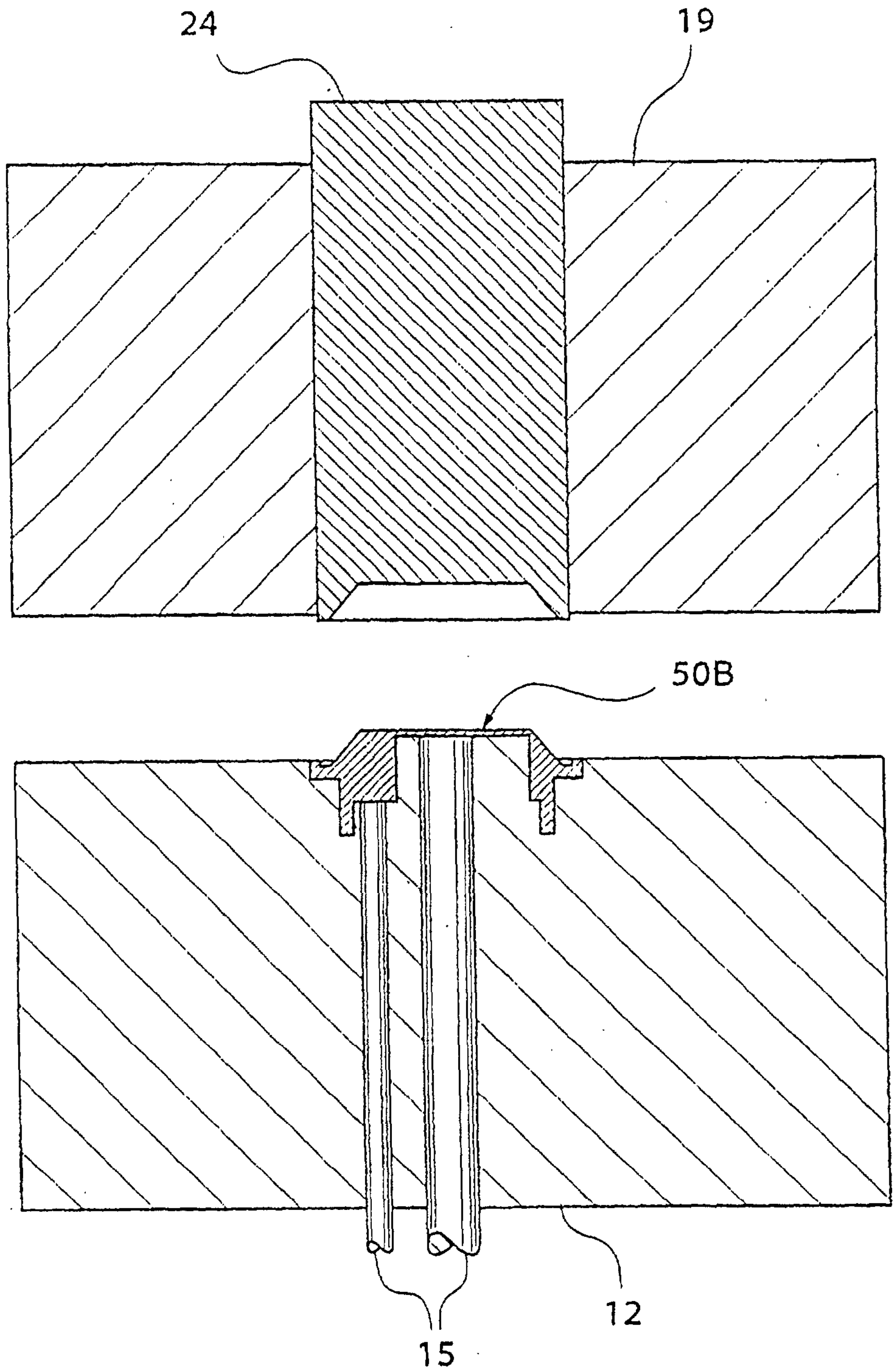


FIG. 17

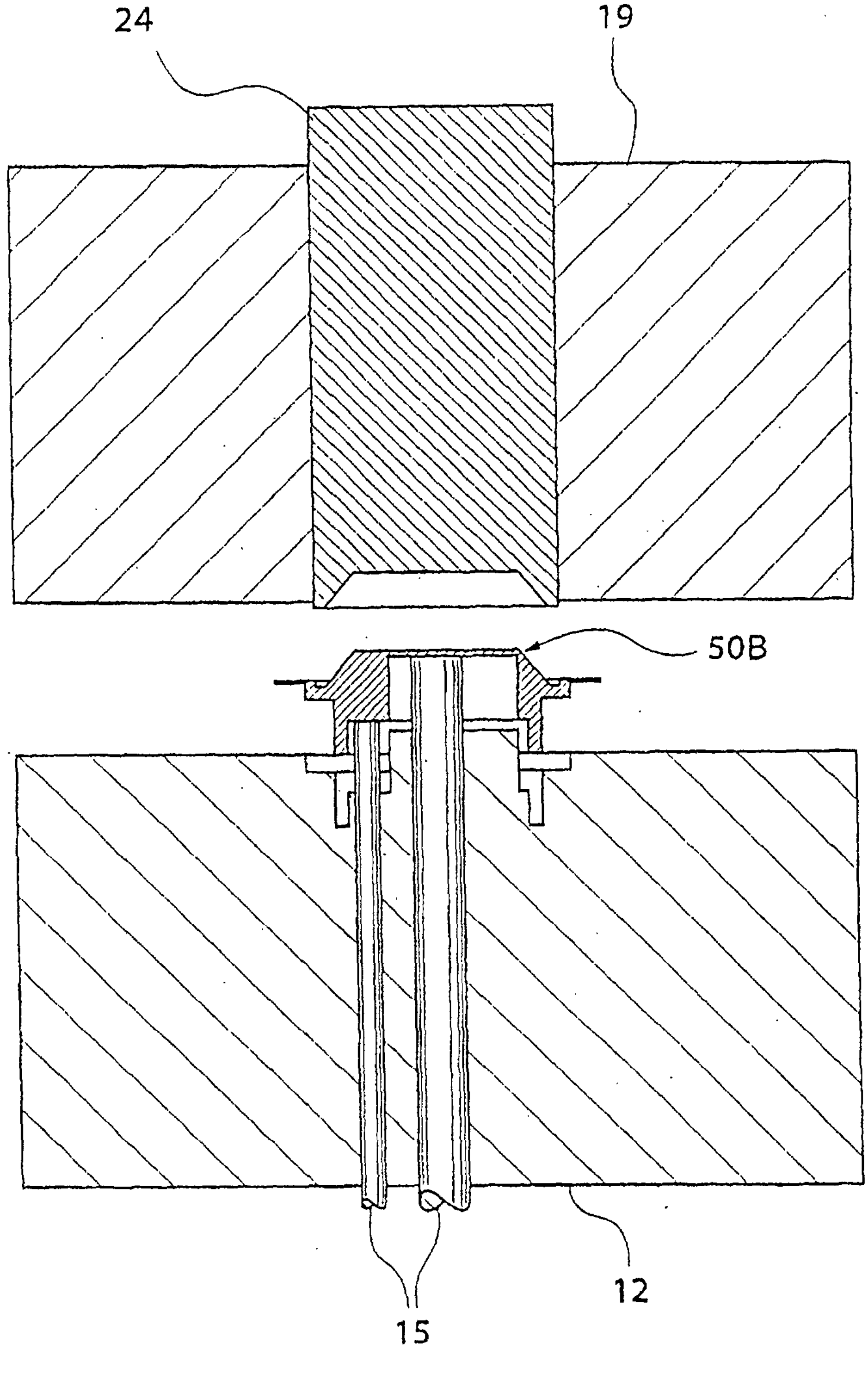
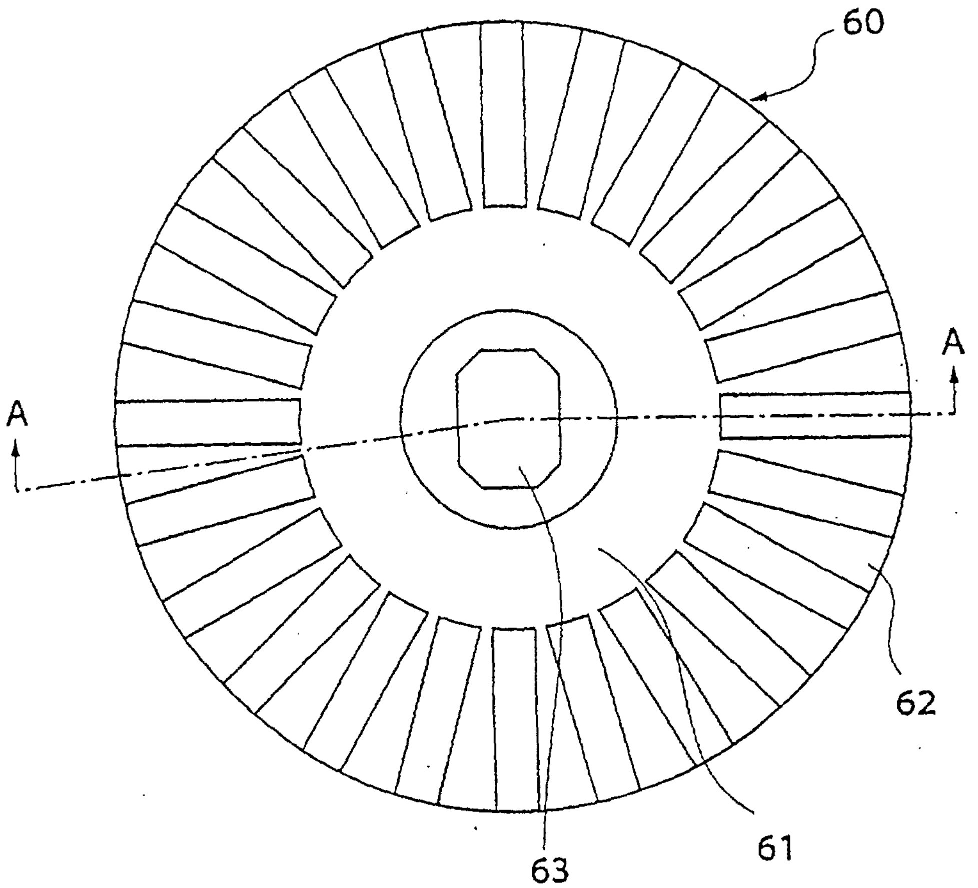


FIG. 18

(A)



(B)

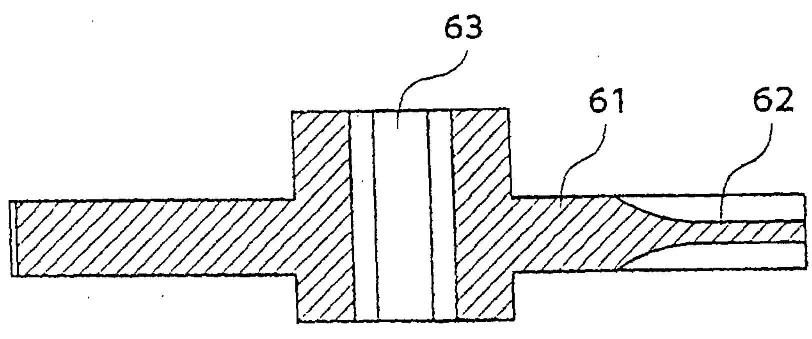
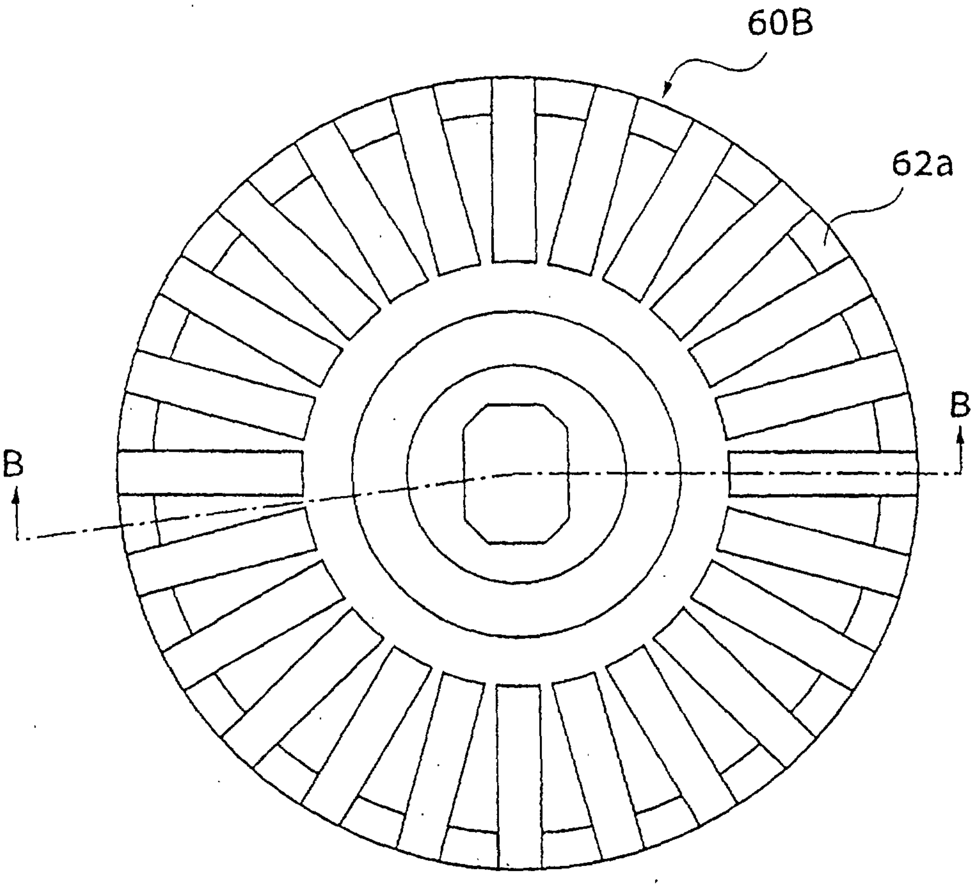


FIG. 19

(A)



(B)

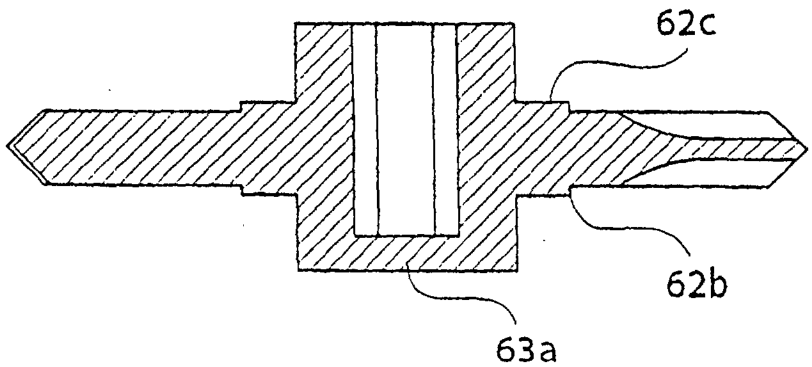


FIG. 20

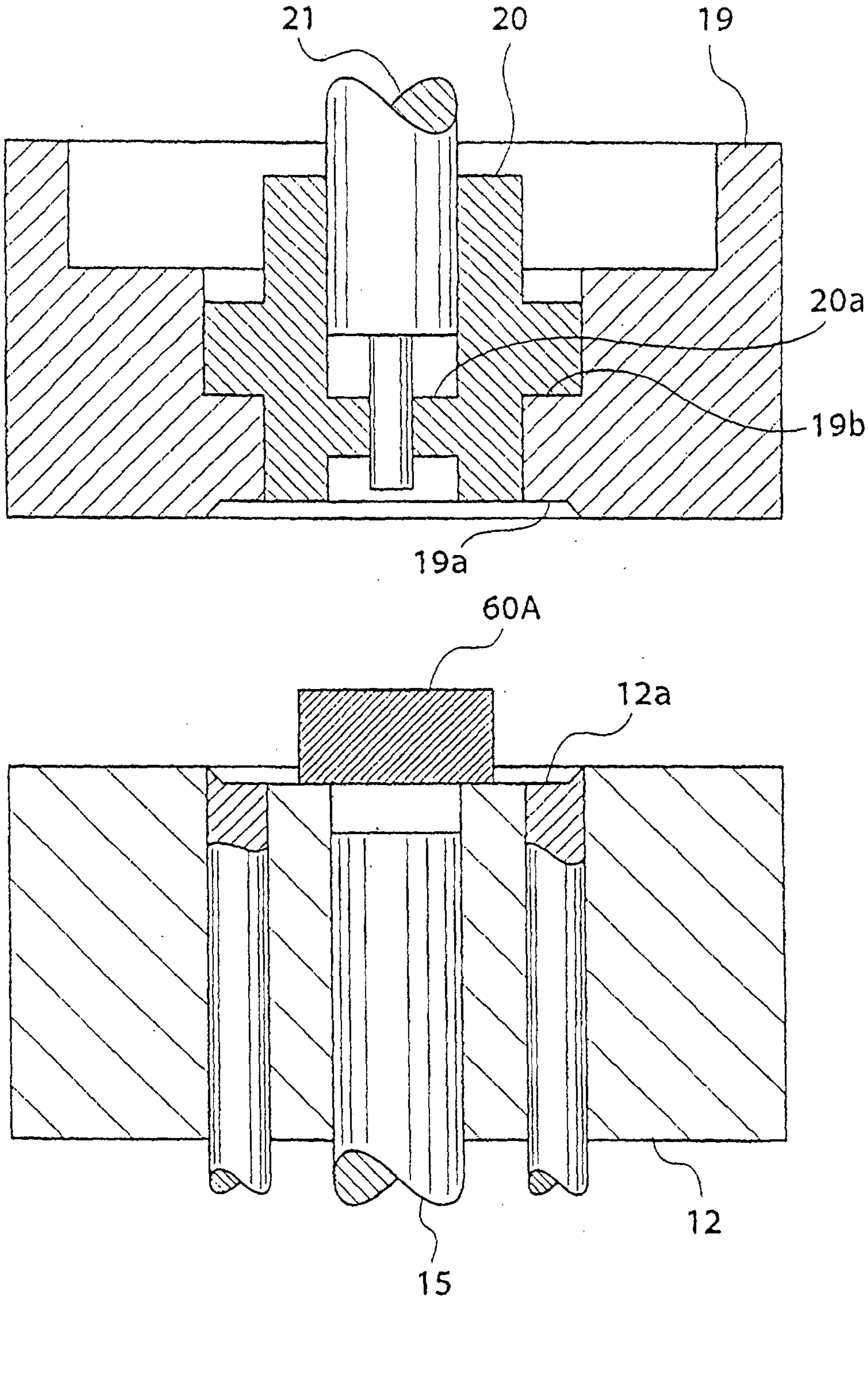


FIG. 21

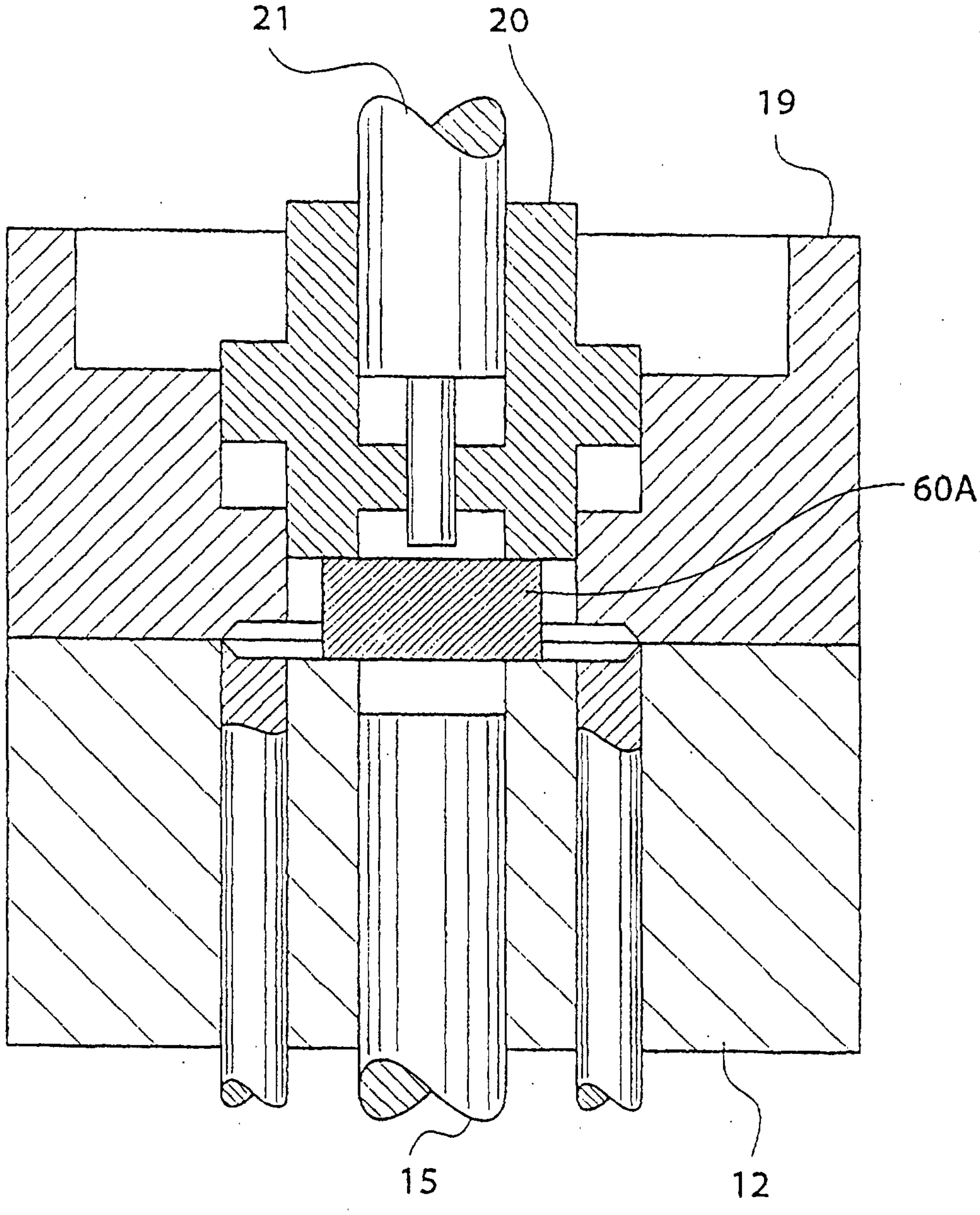


FIG. 22

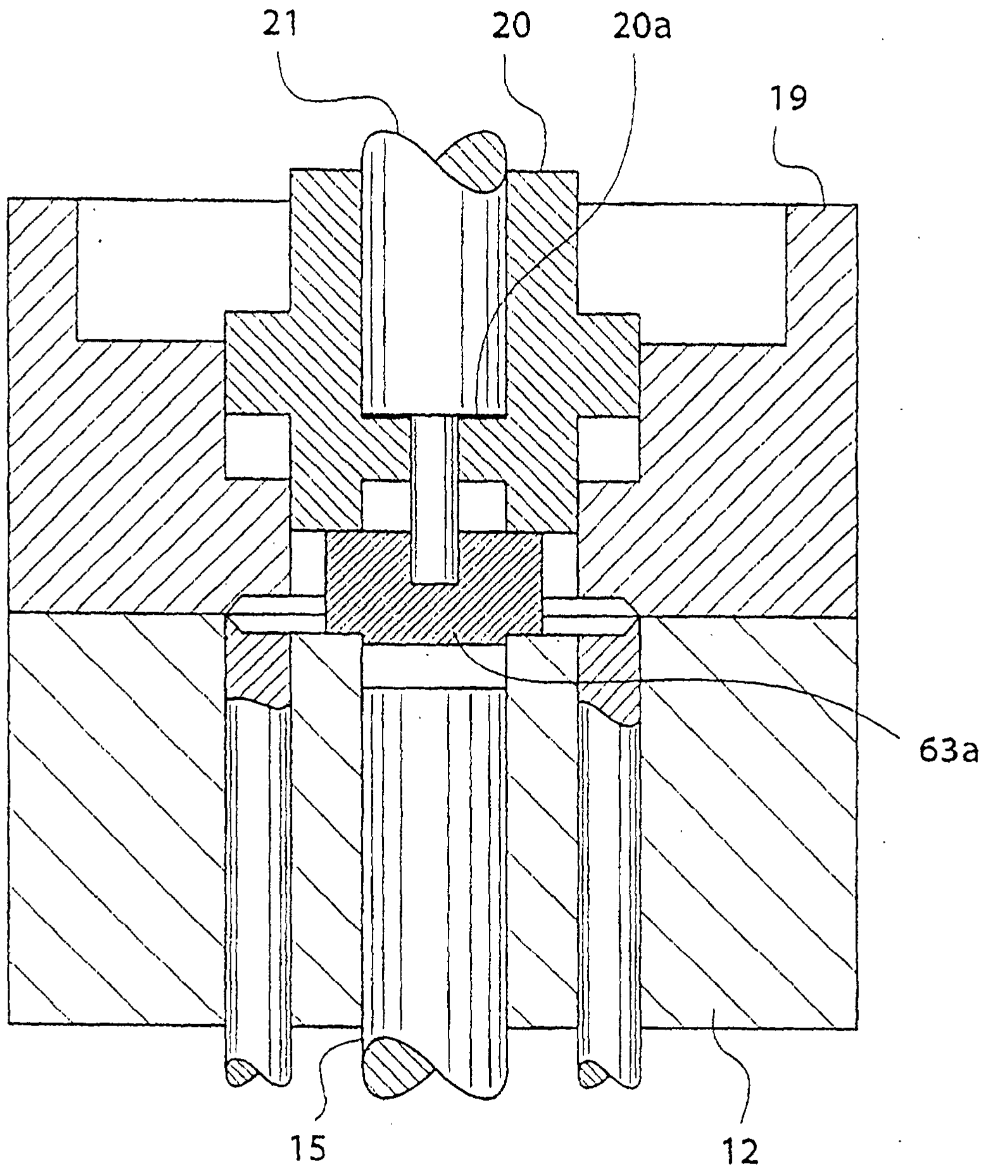


FIG. 23

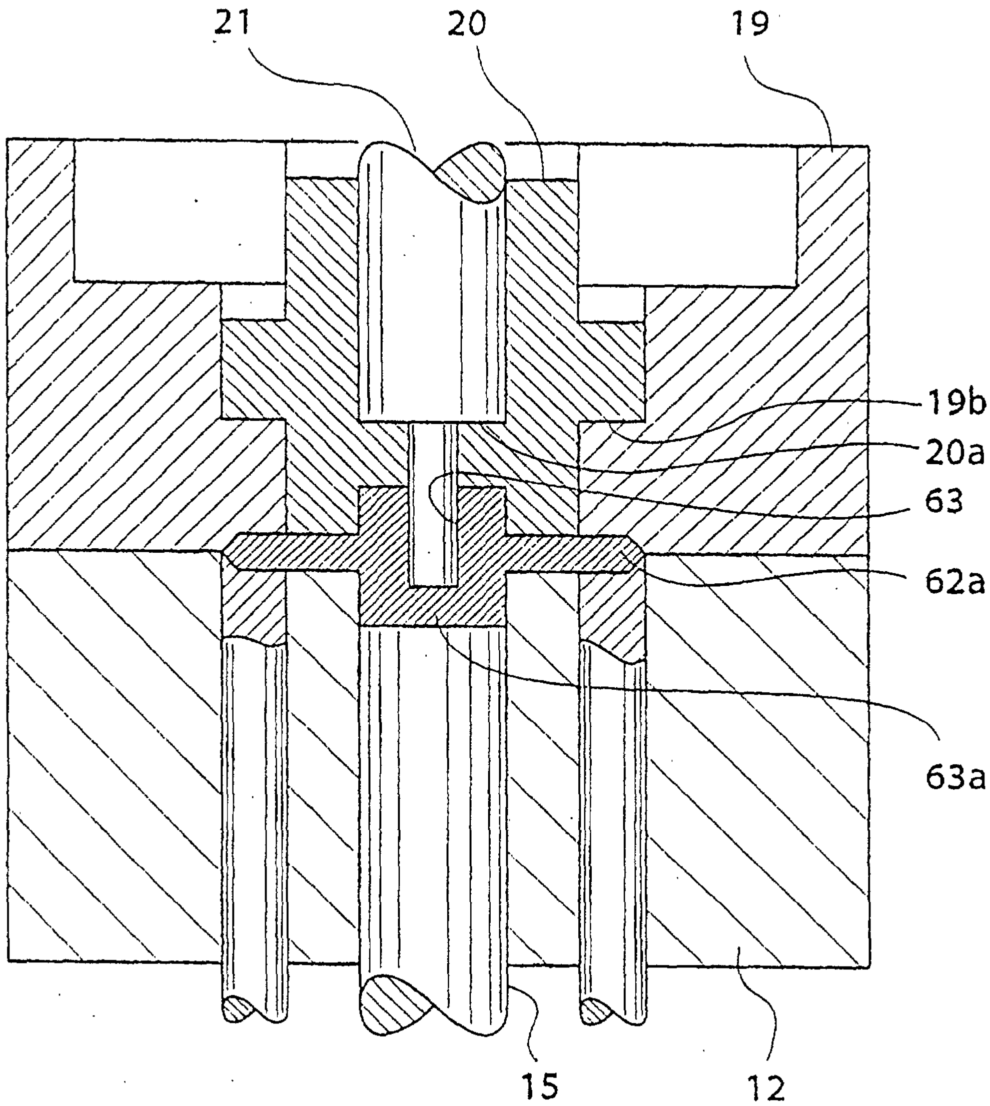


FIG. 24

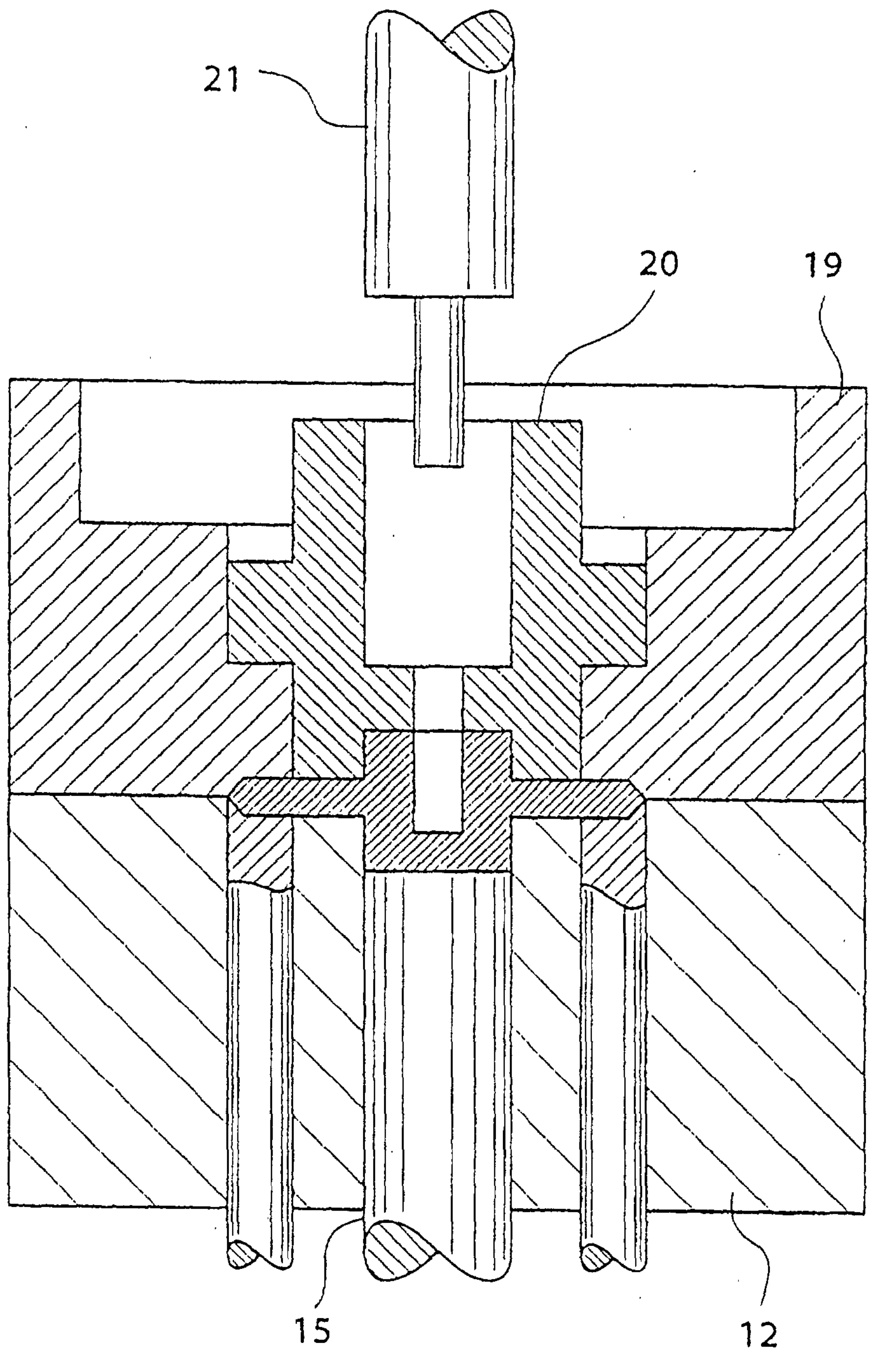


FIG. 25

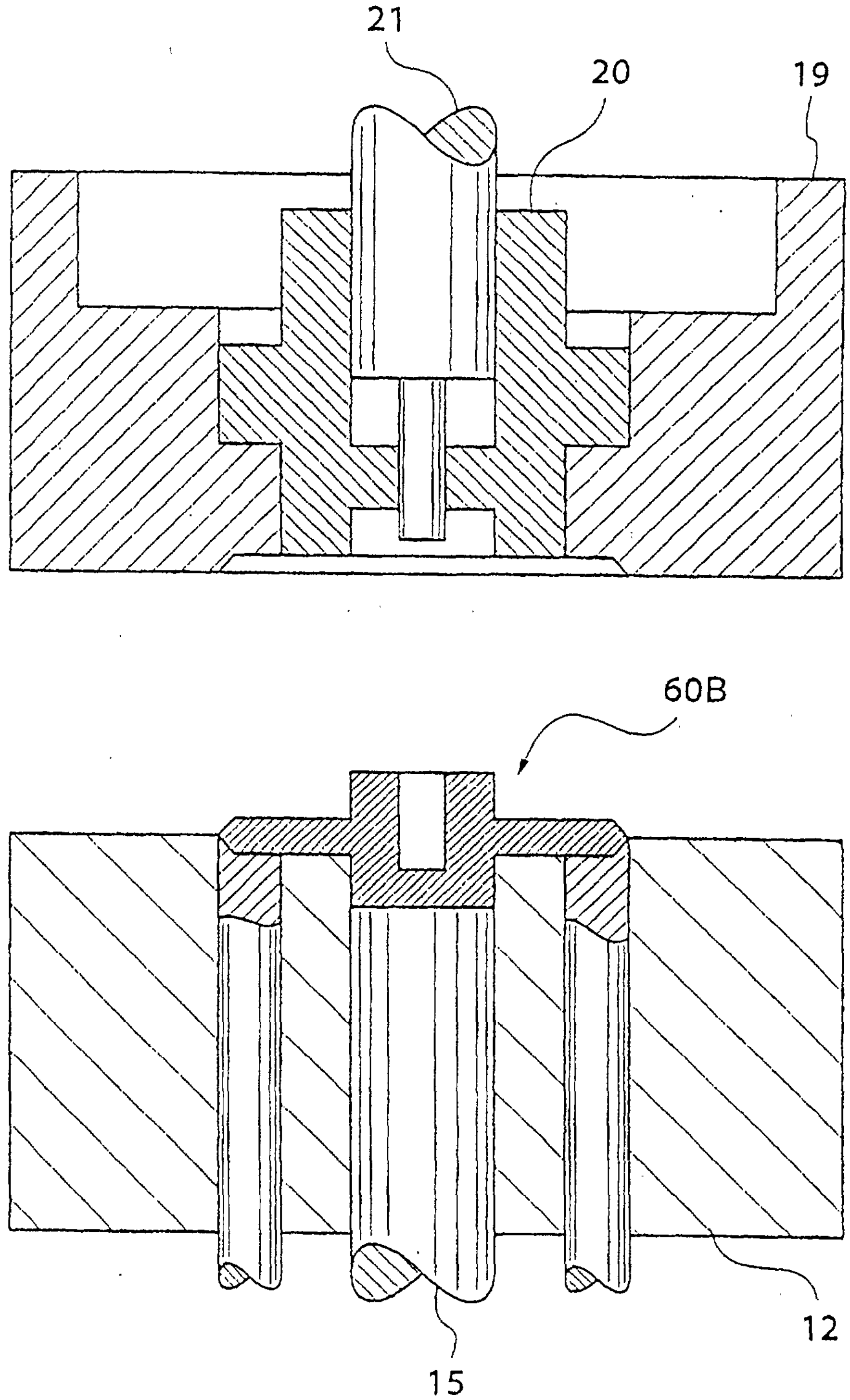


FIG. 26

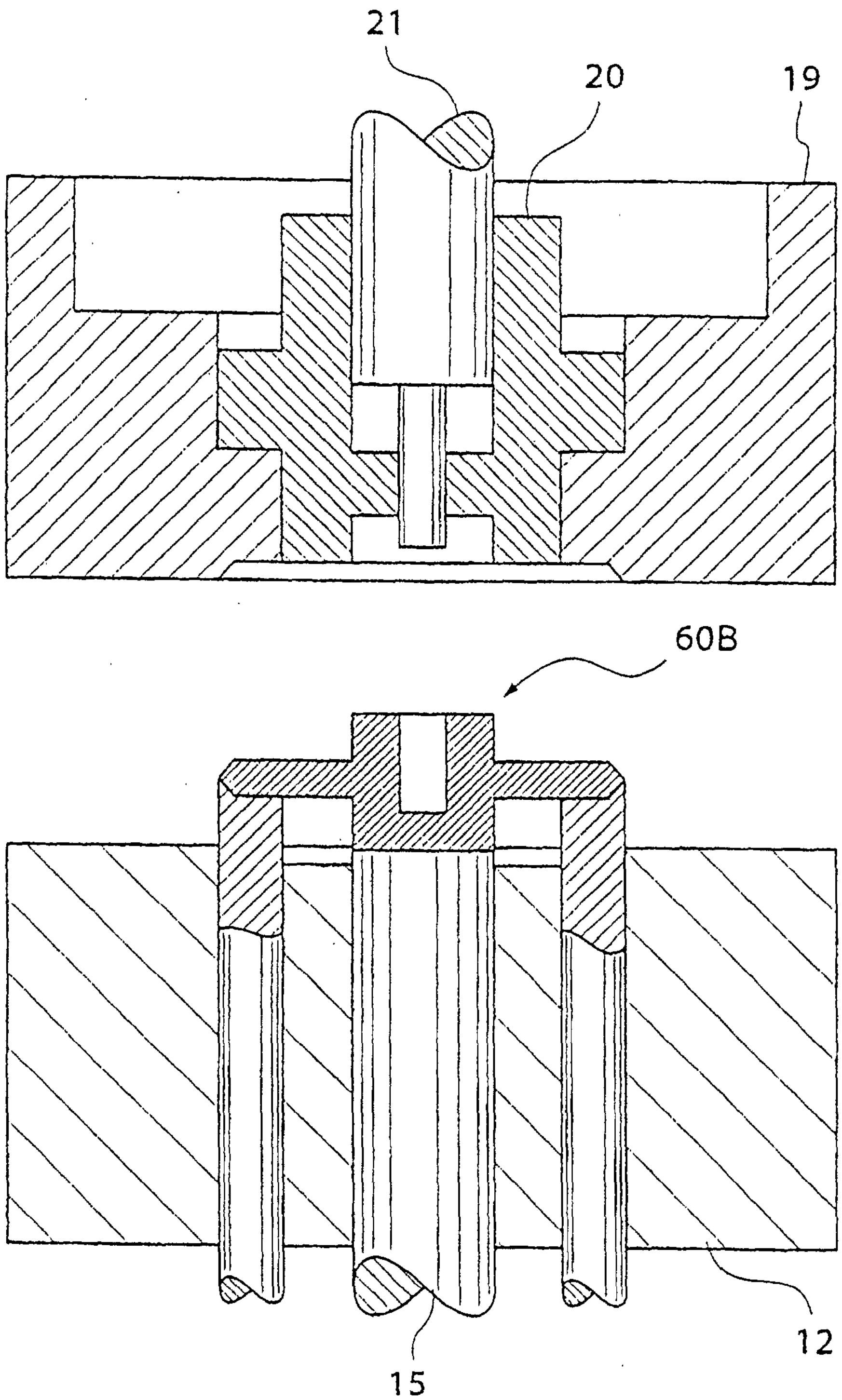


FIG. 27

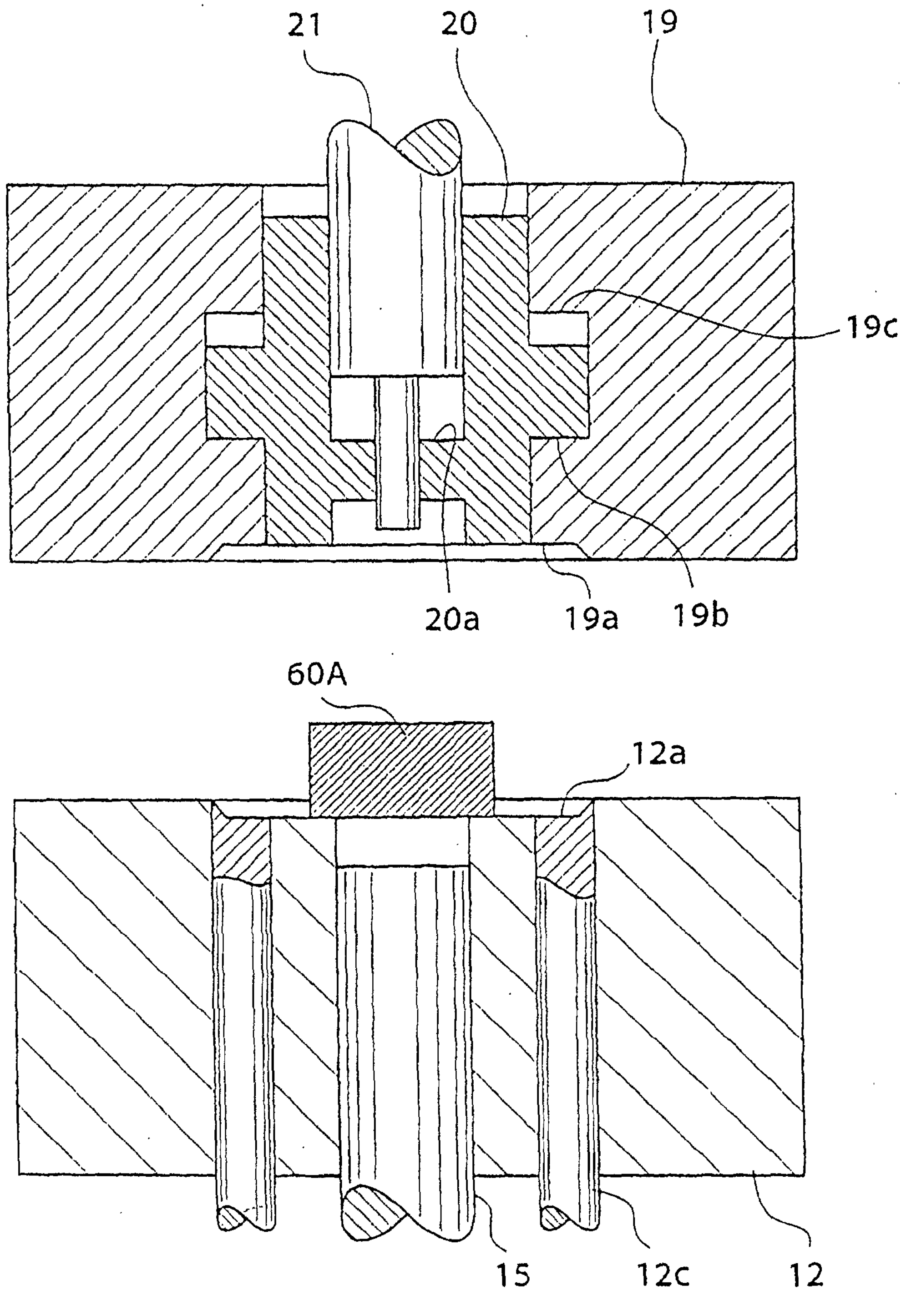


FIG. 28

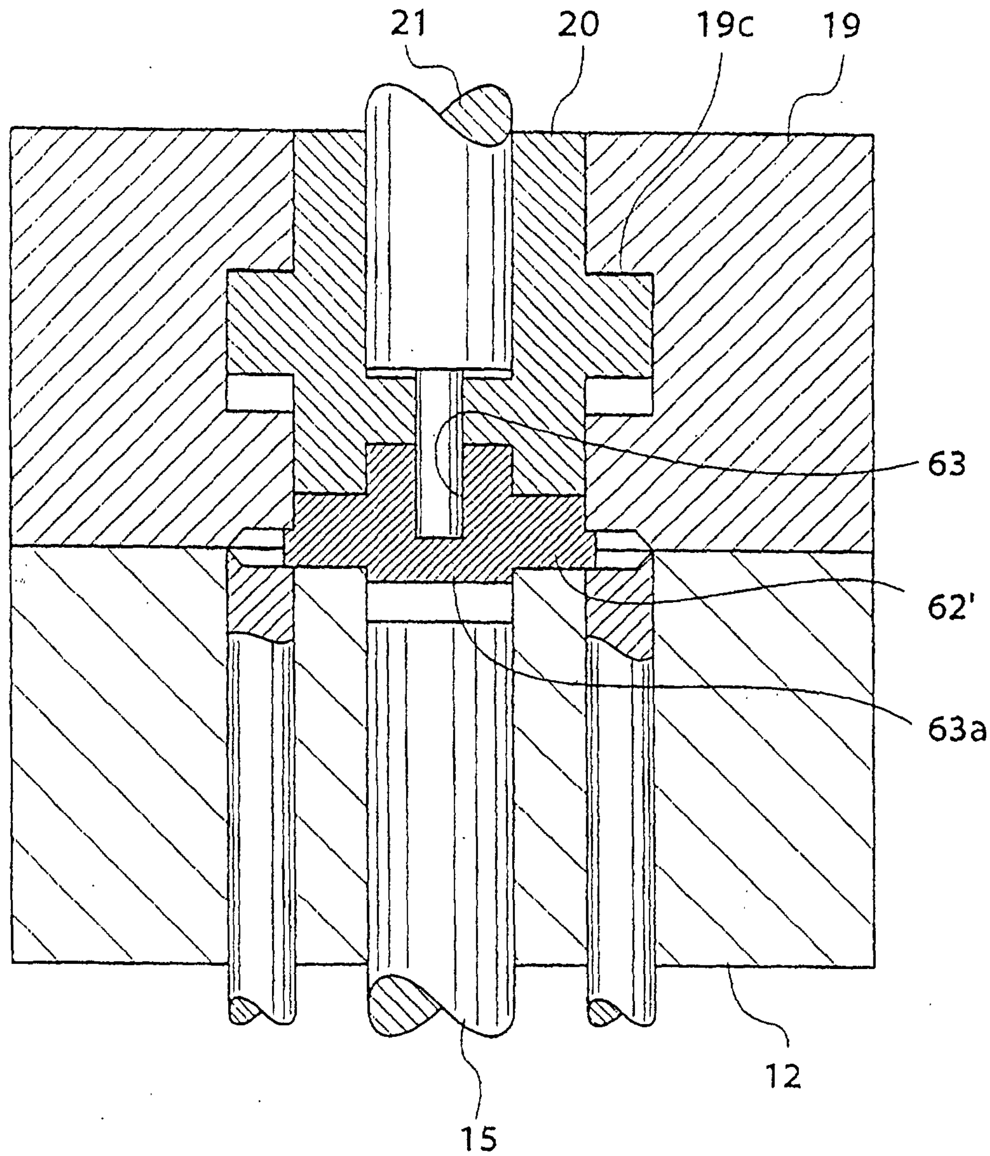


FIG. 29

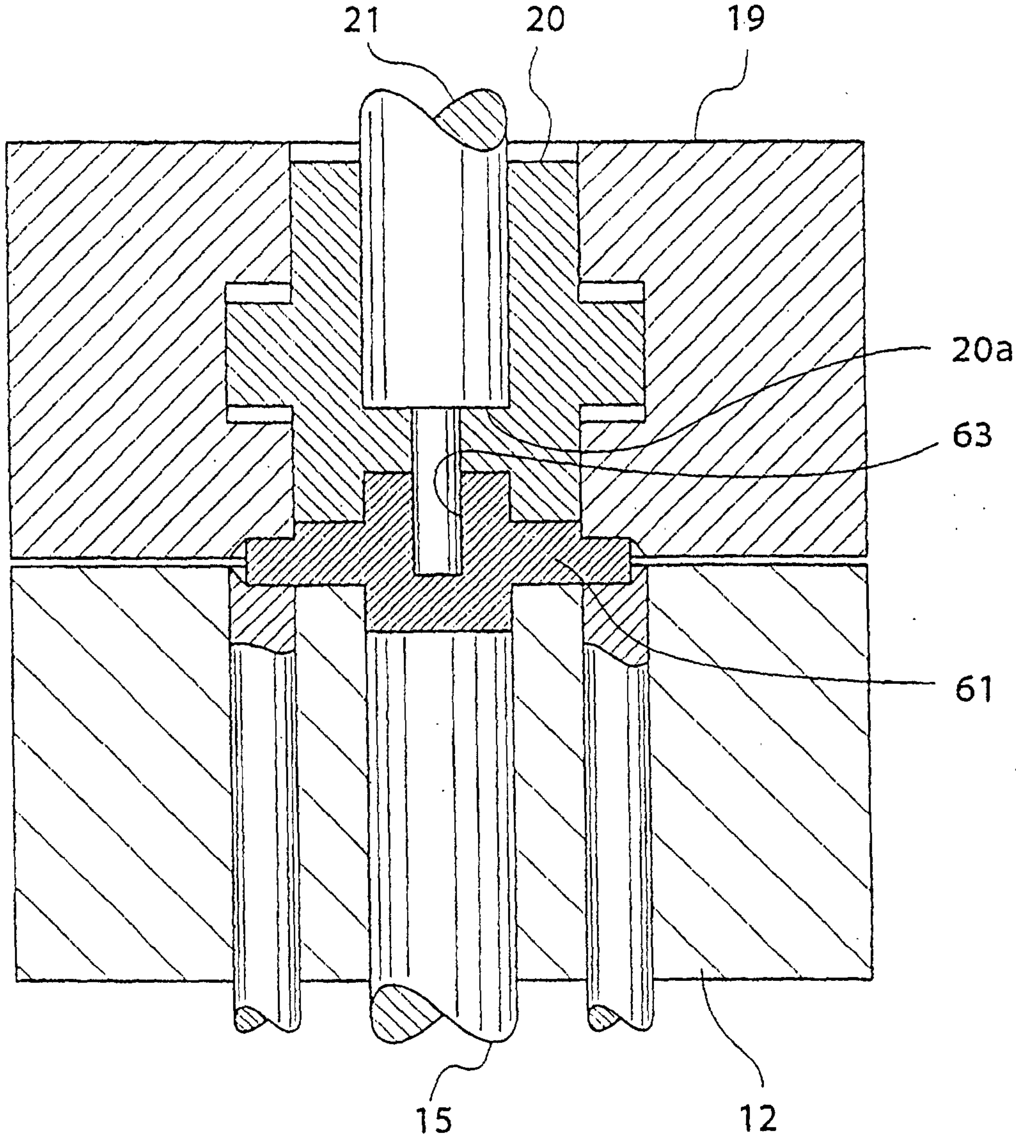


FIG. 30

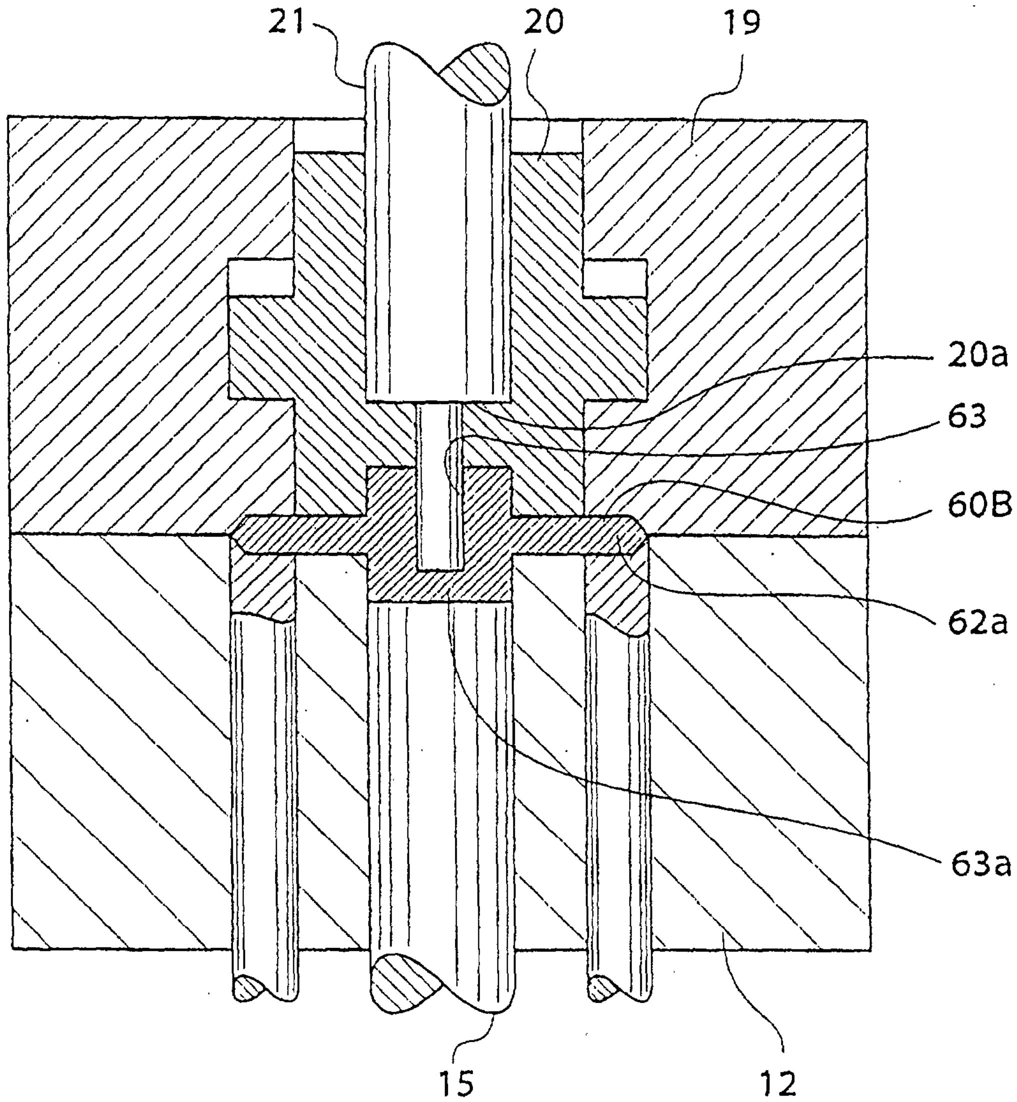


FIG. 31

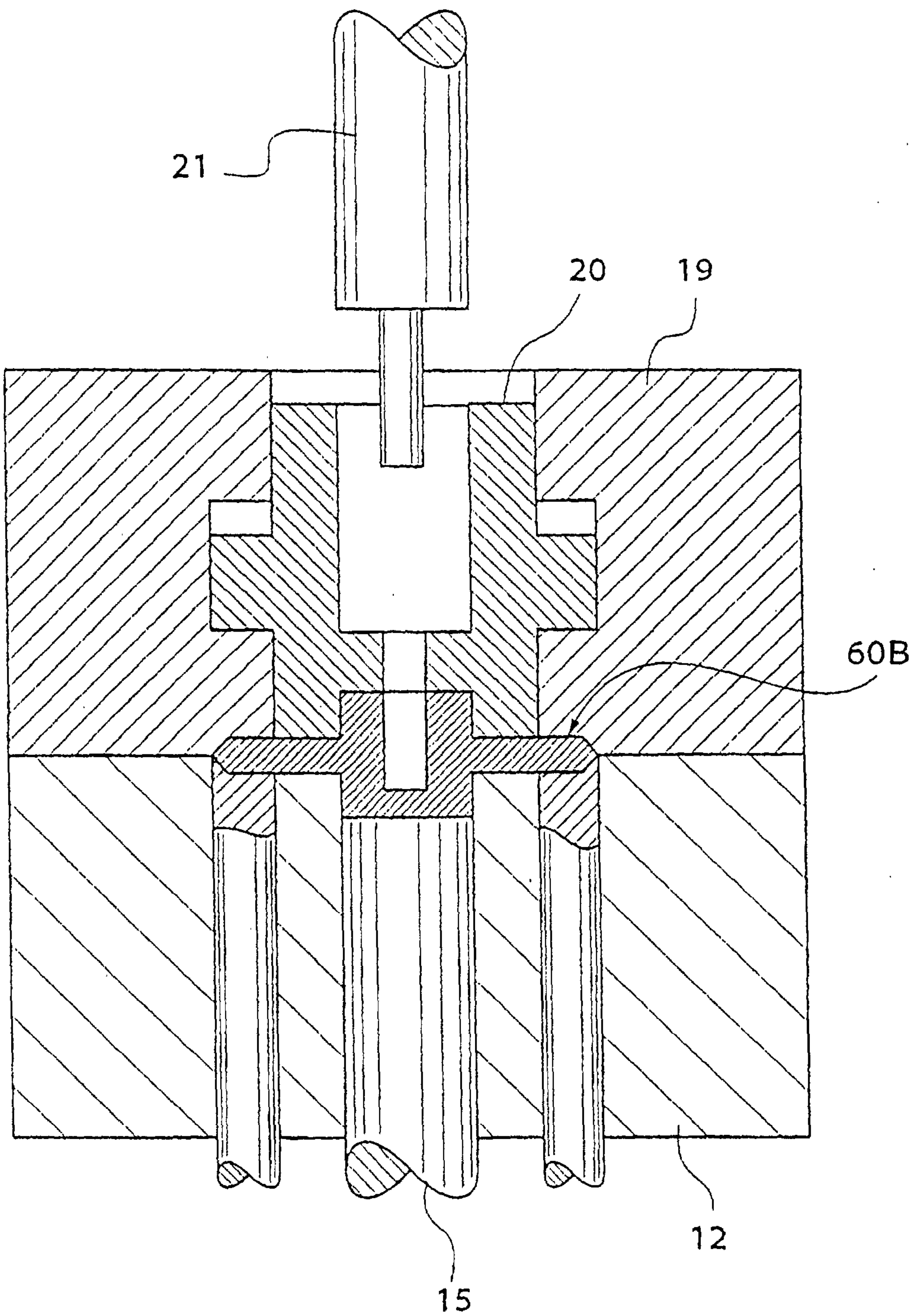


FIG. 32

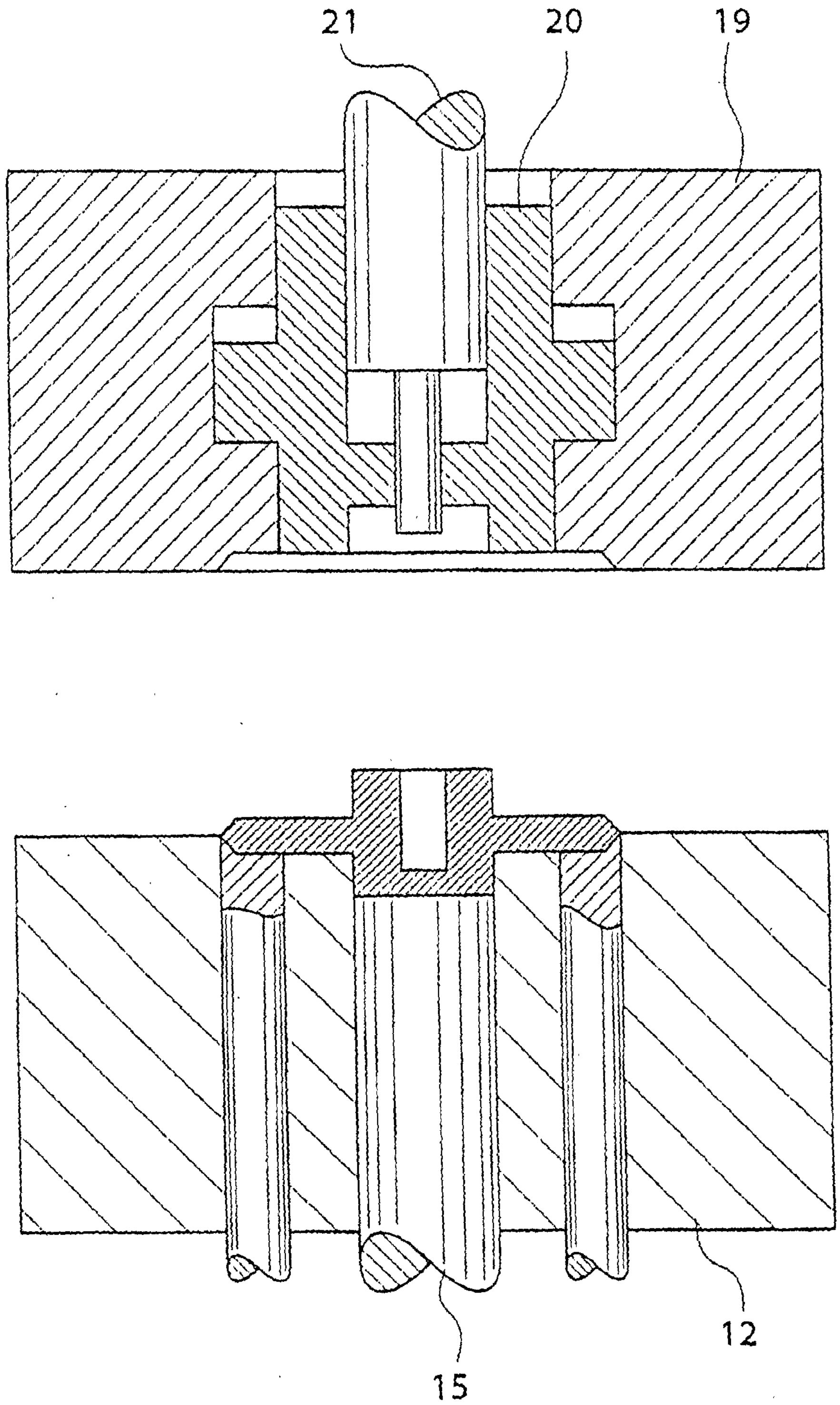


FIG. 33

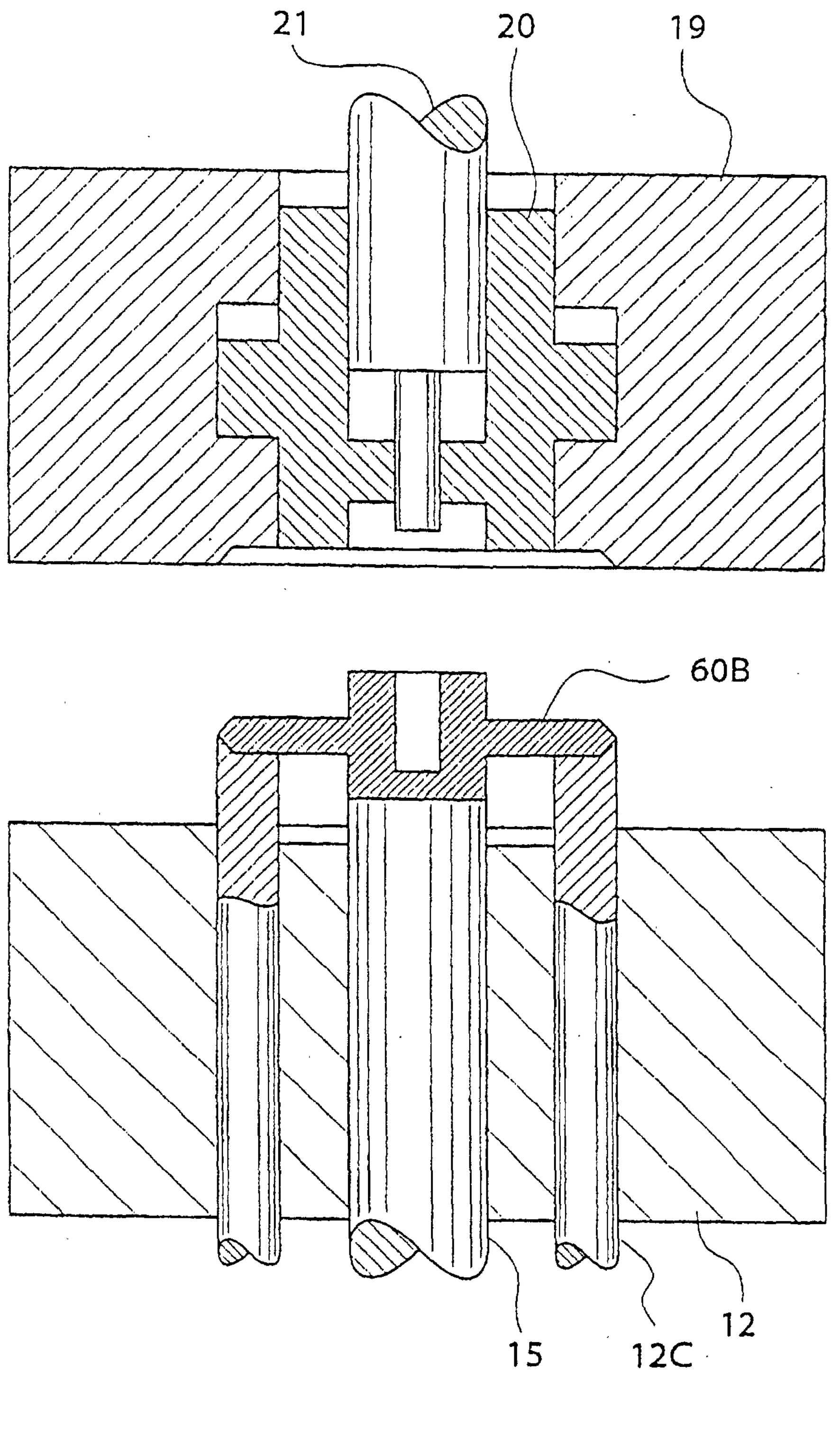


FIG. 34

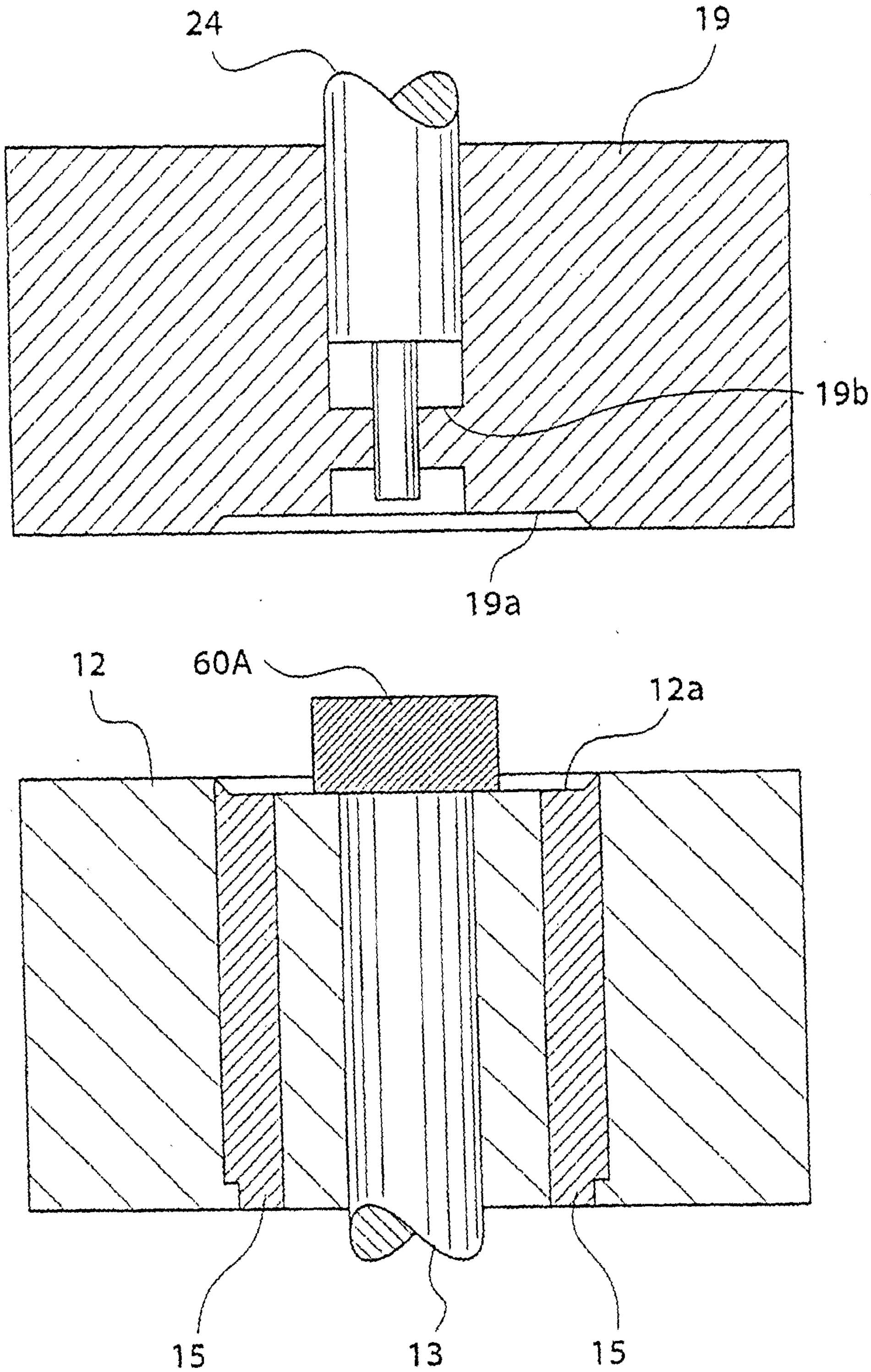


FIG. 35

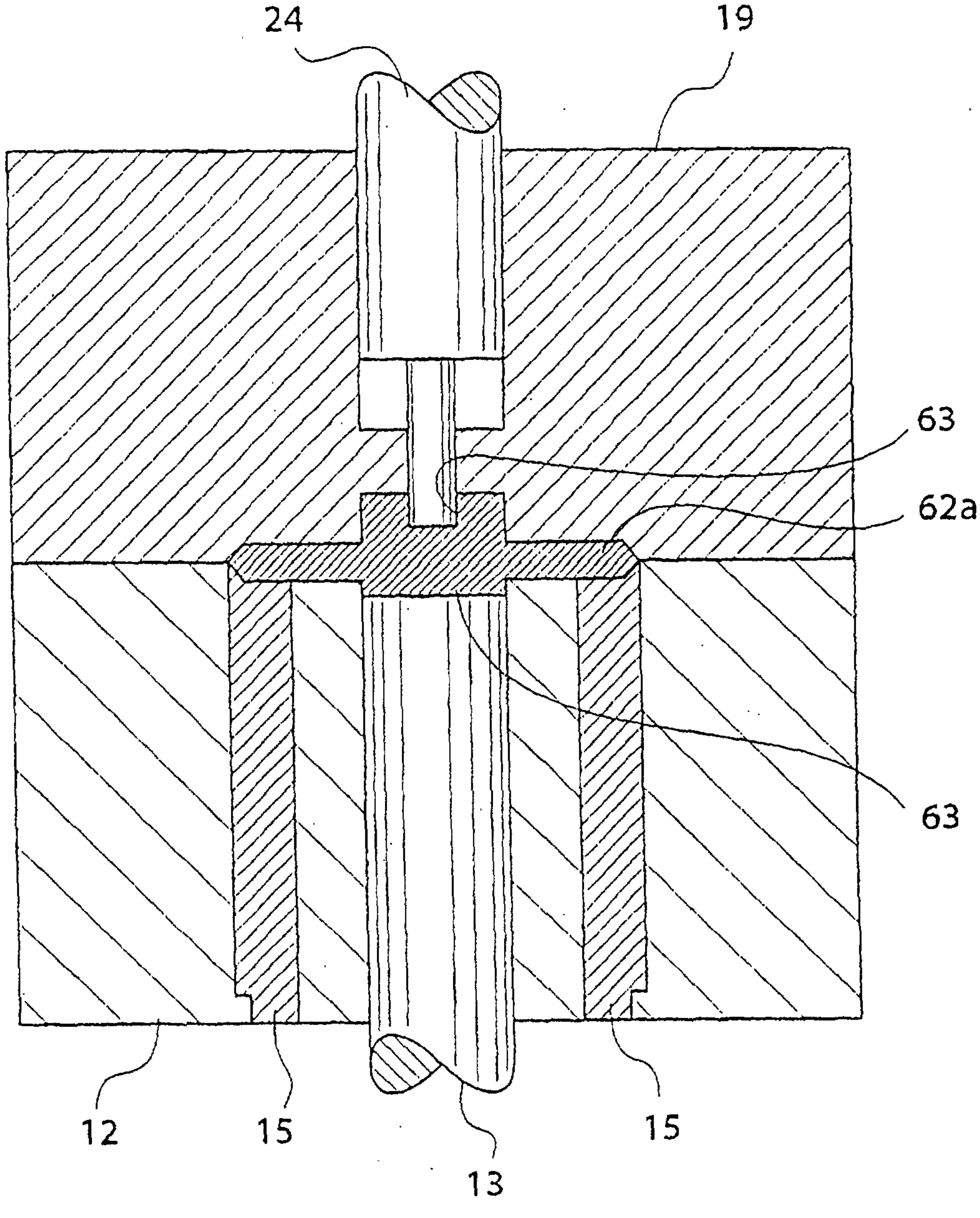


FIG. 36

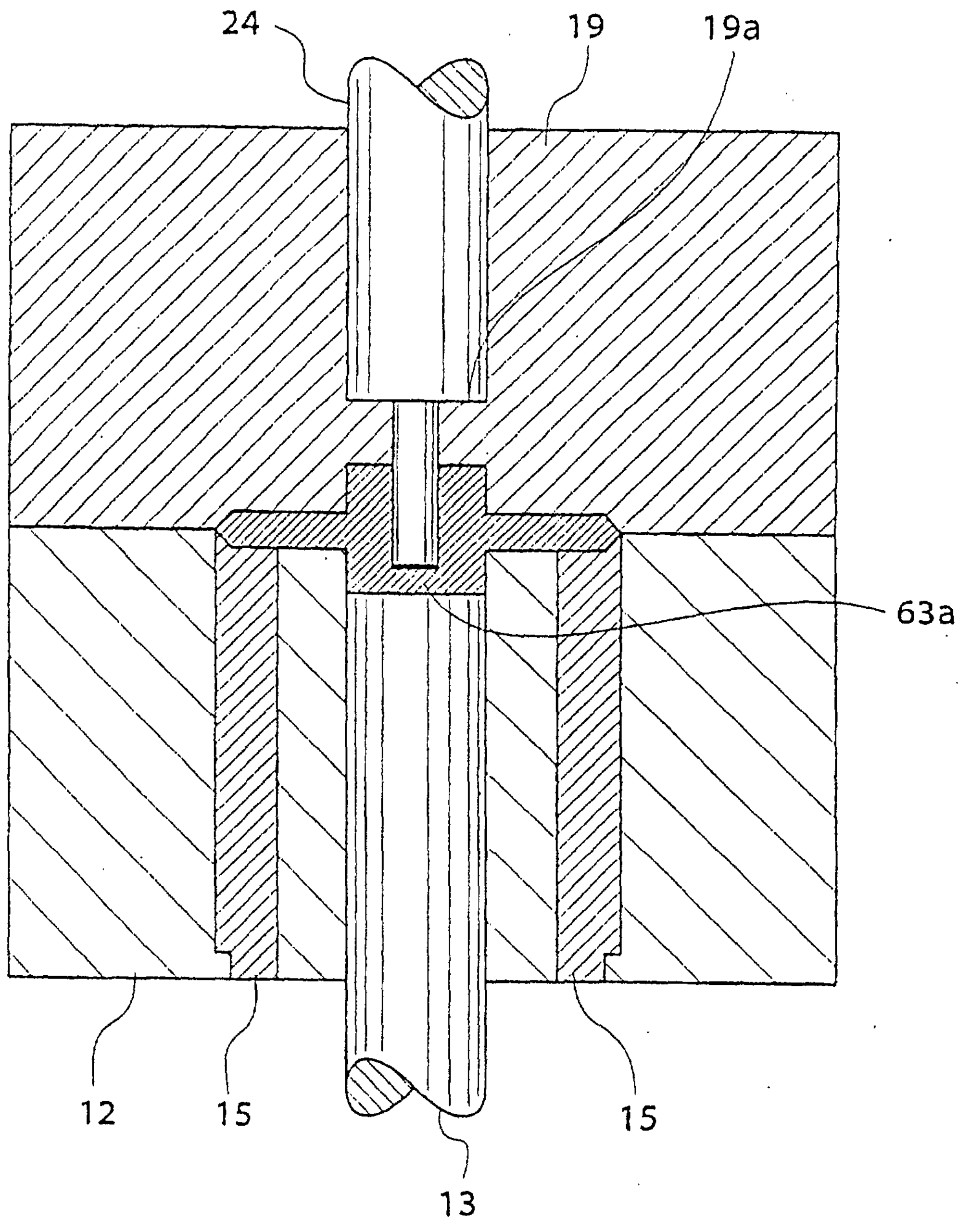


FIG. 37

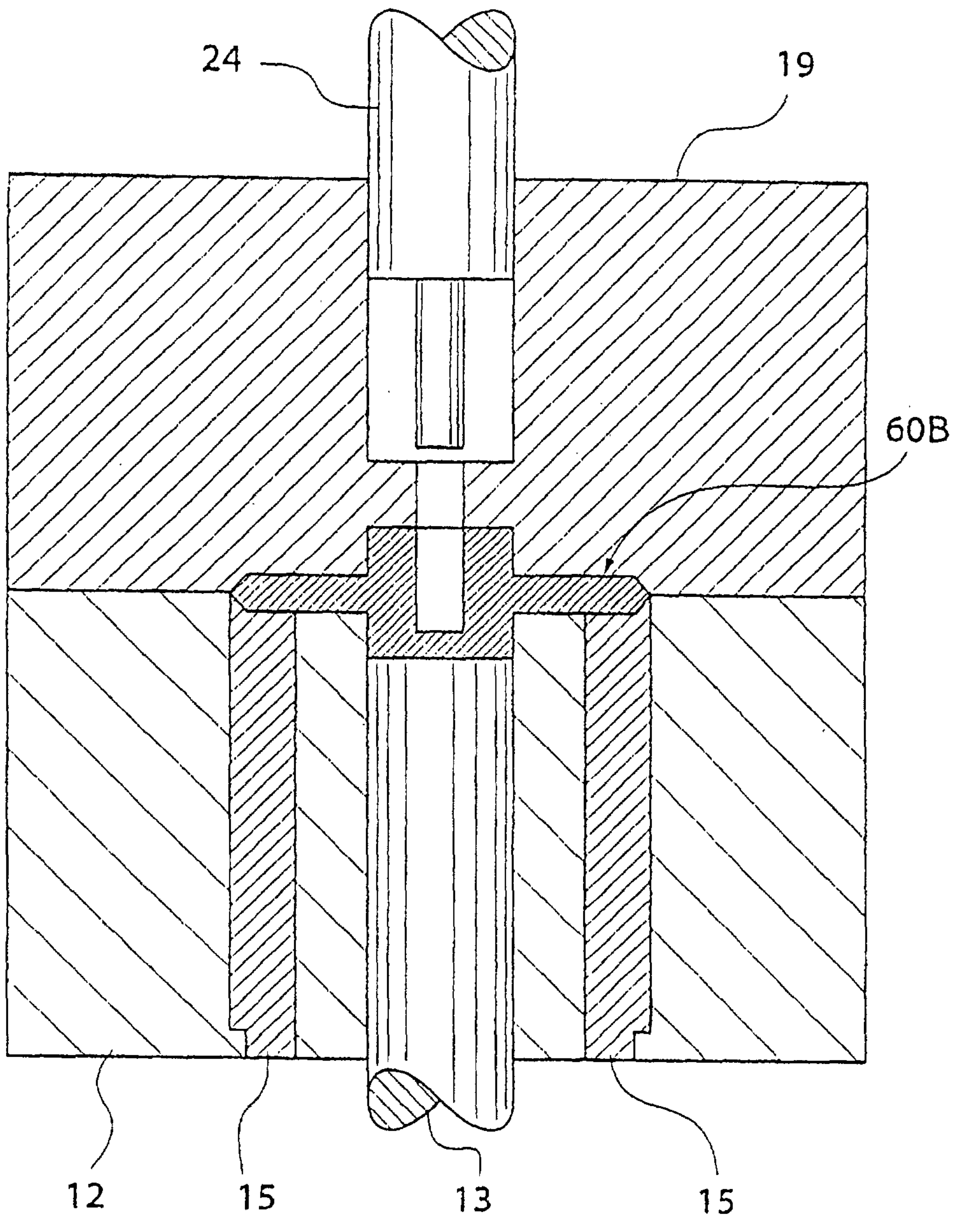


FIG. 38

(A)

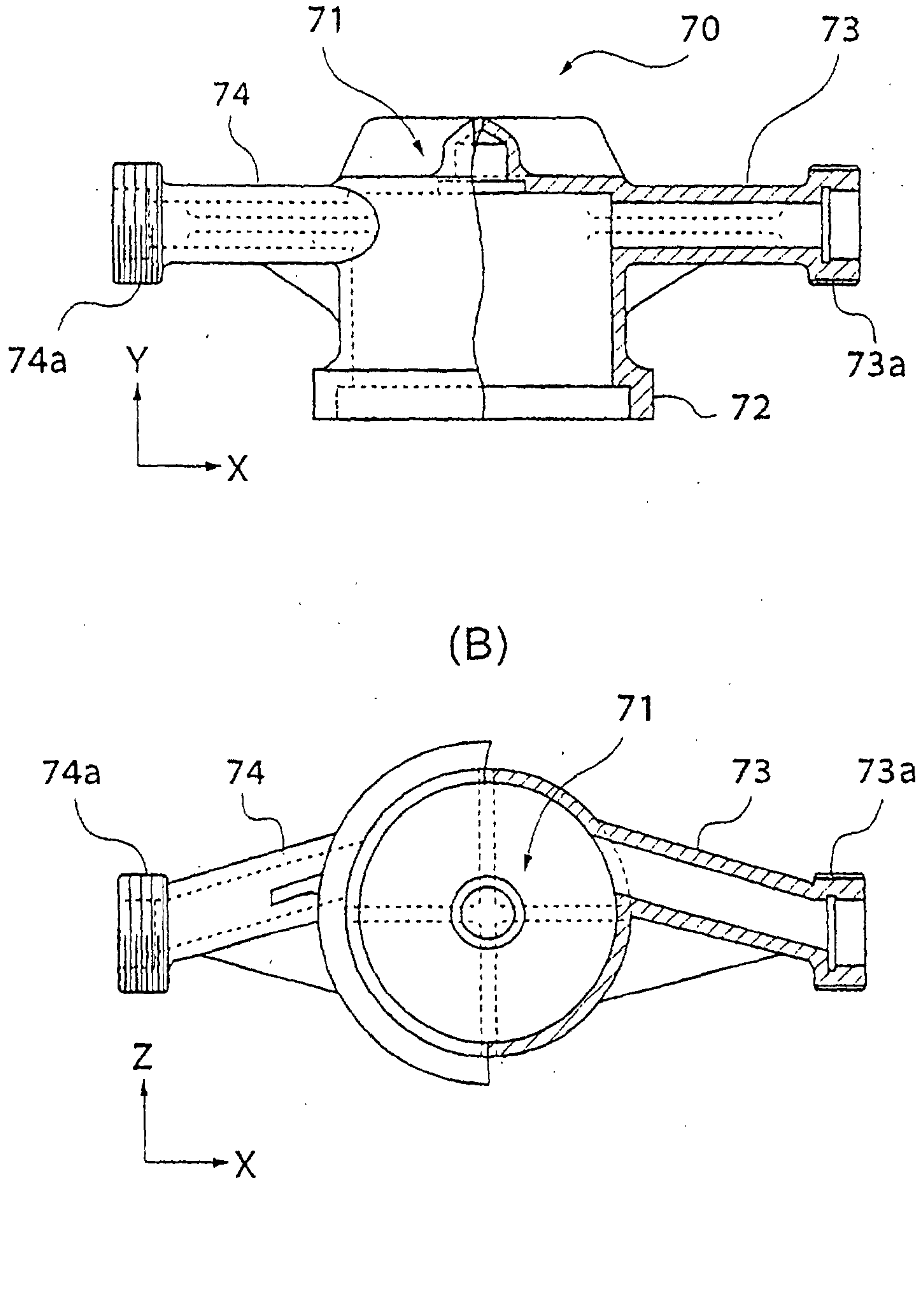


FIG. 39

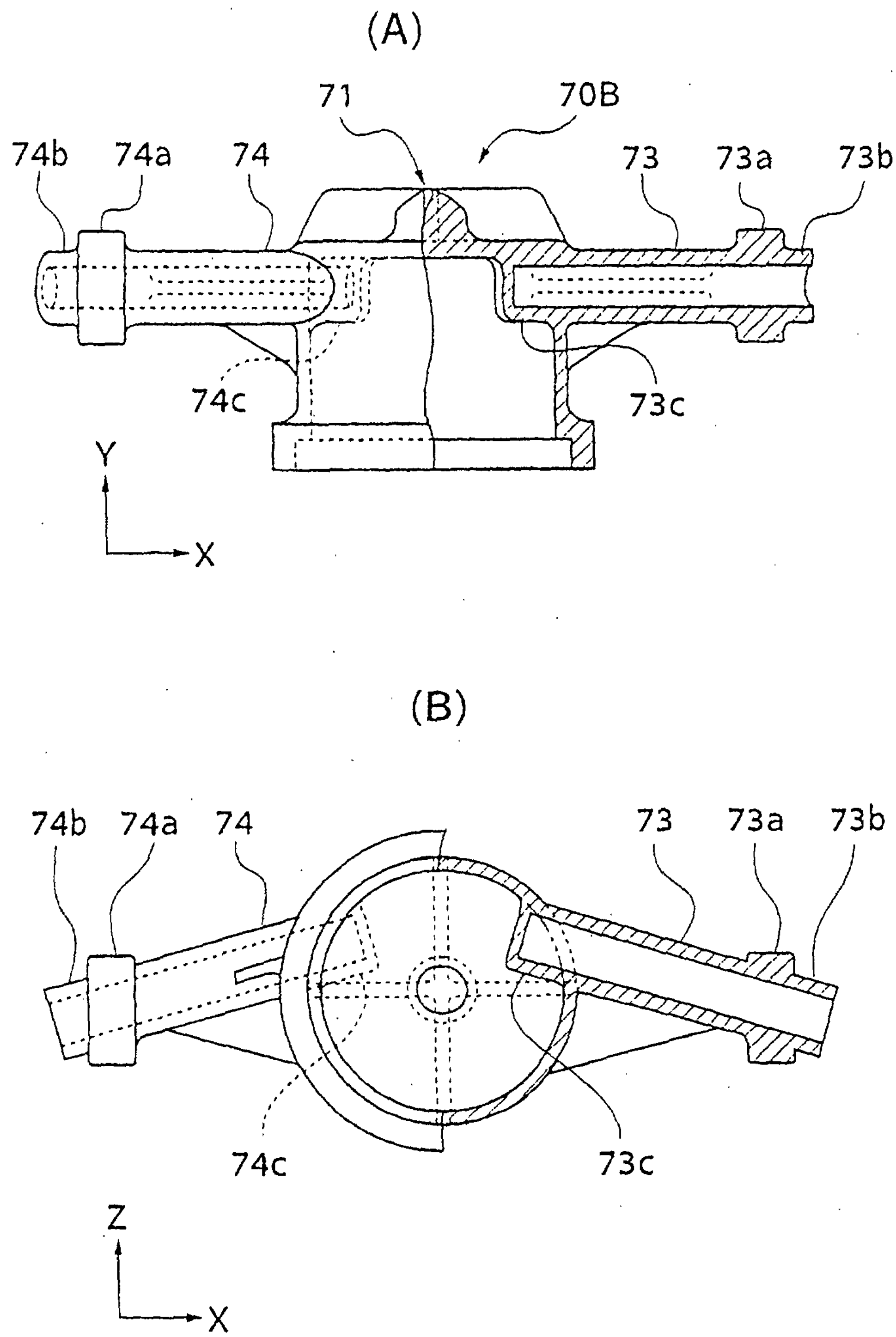

(A)
71
70B
74b
74a
74
73
73a
73b
74c
73c
Y
X
(B)
74b
74a
74
73
73a
73b
74c
73c
Z
X

FIG. 40

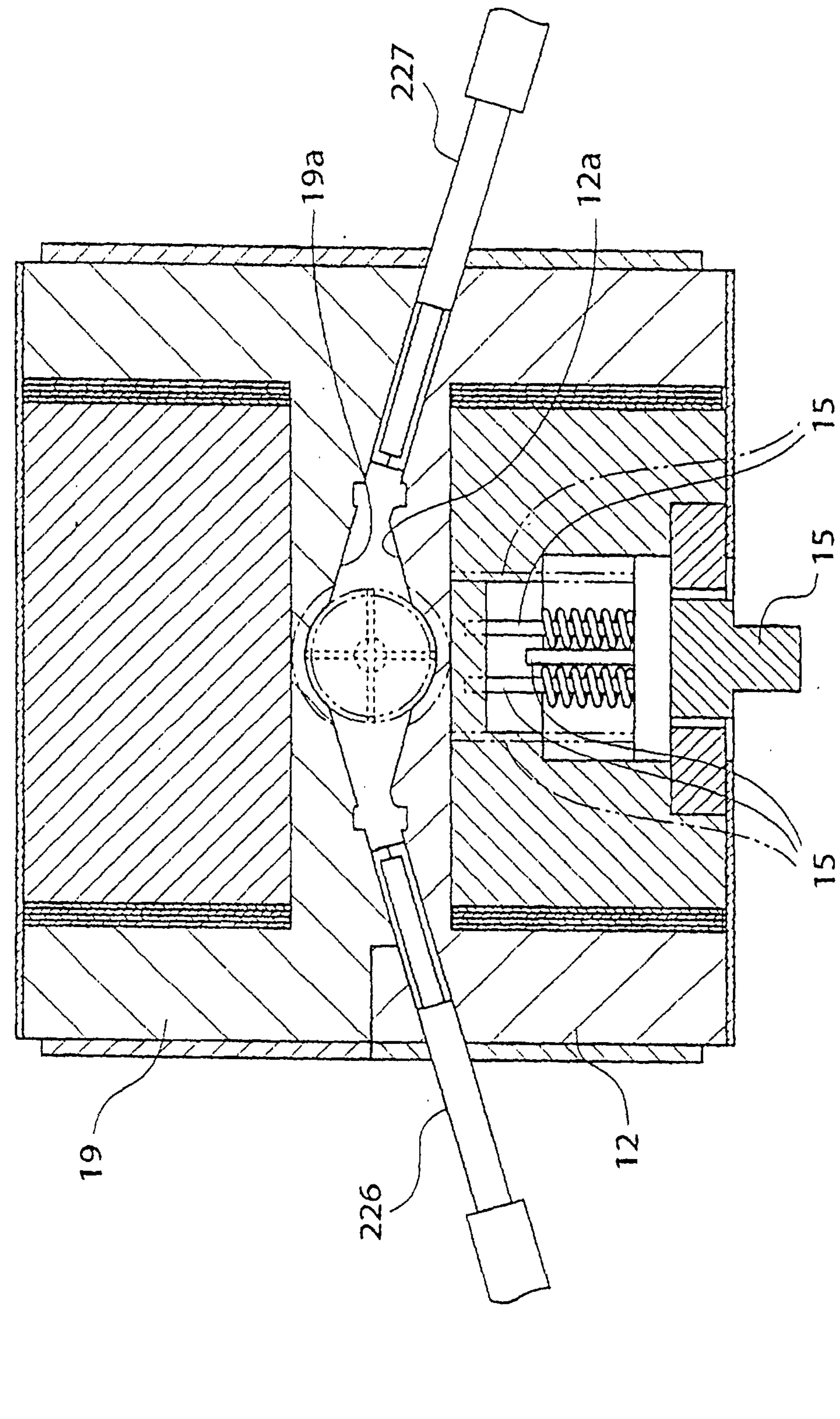


FIG. 41

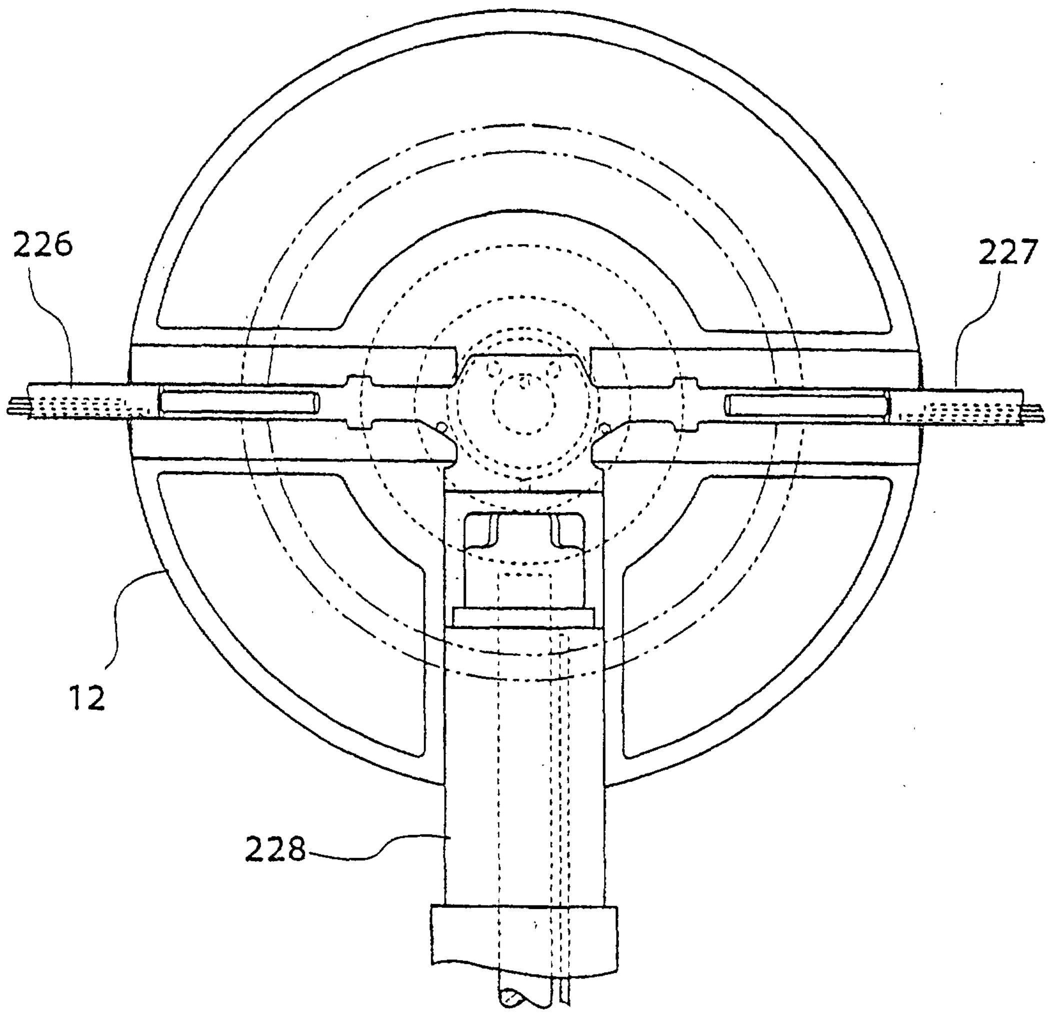


FIG. 42

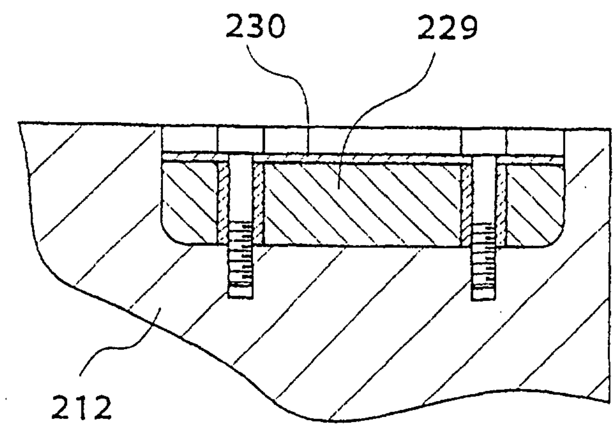


FIG. 43

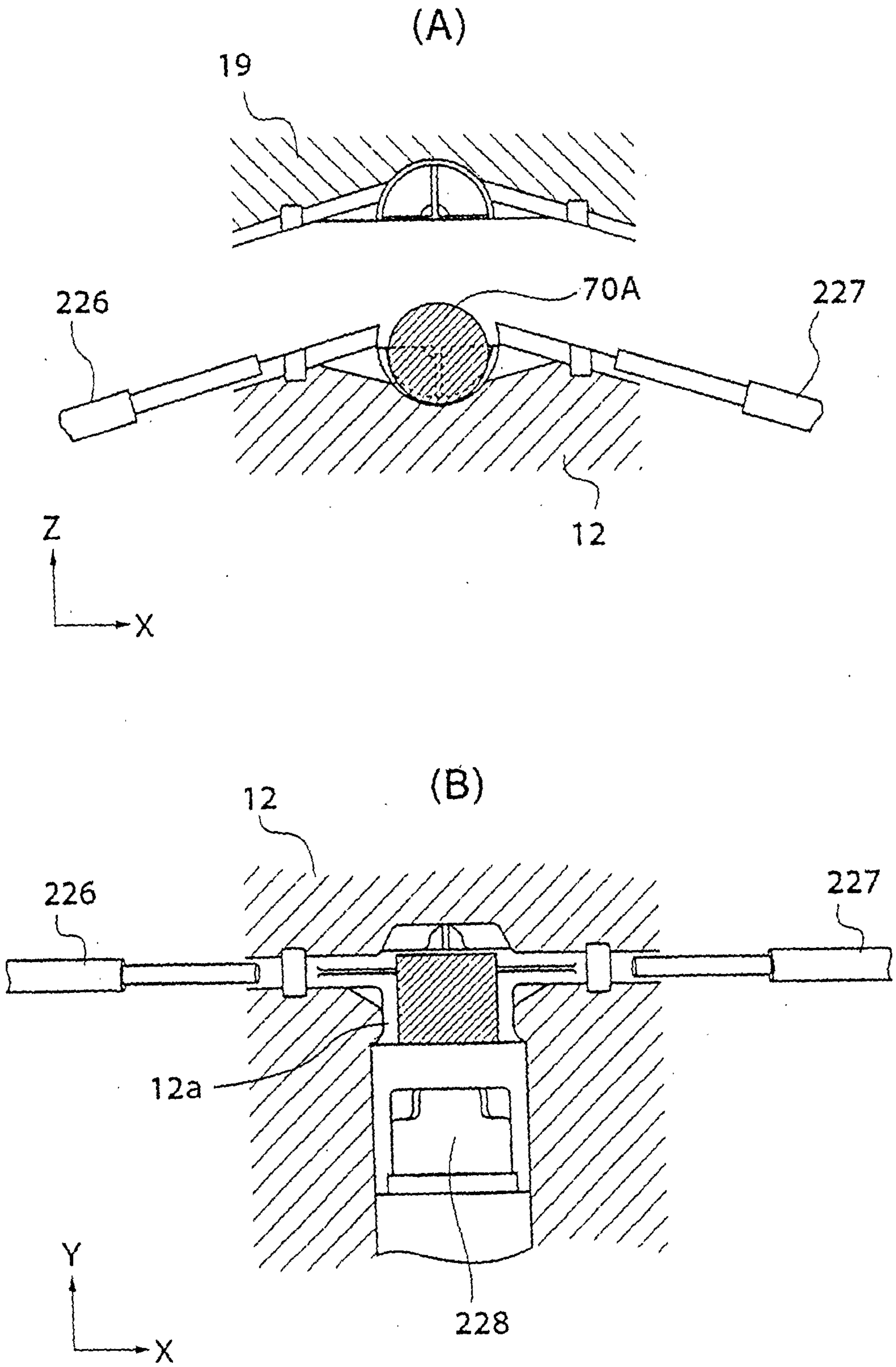
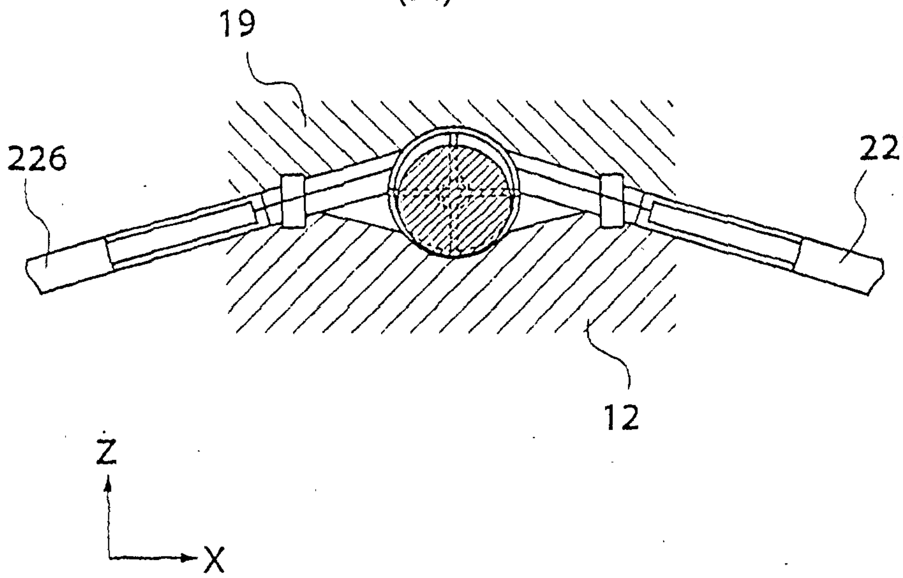


FIG. 44

(A)



(B)

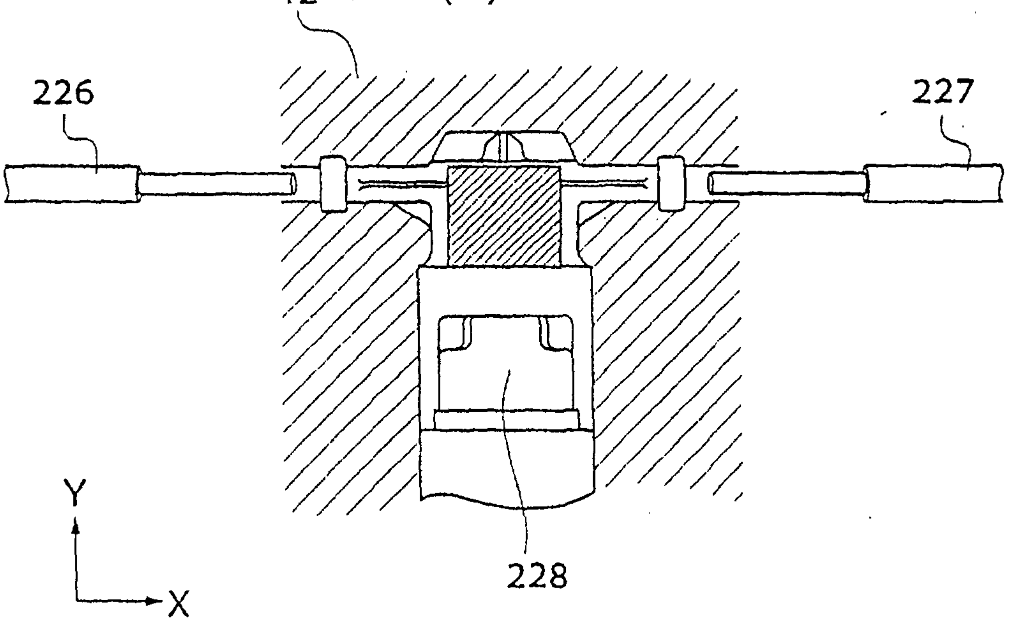


FIG. 45

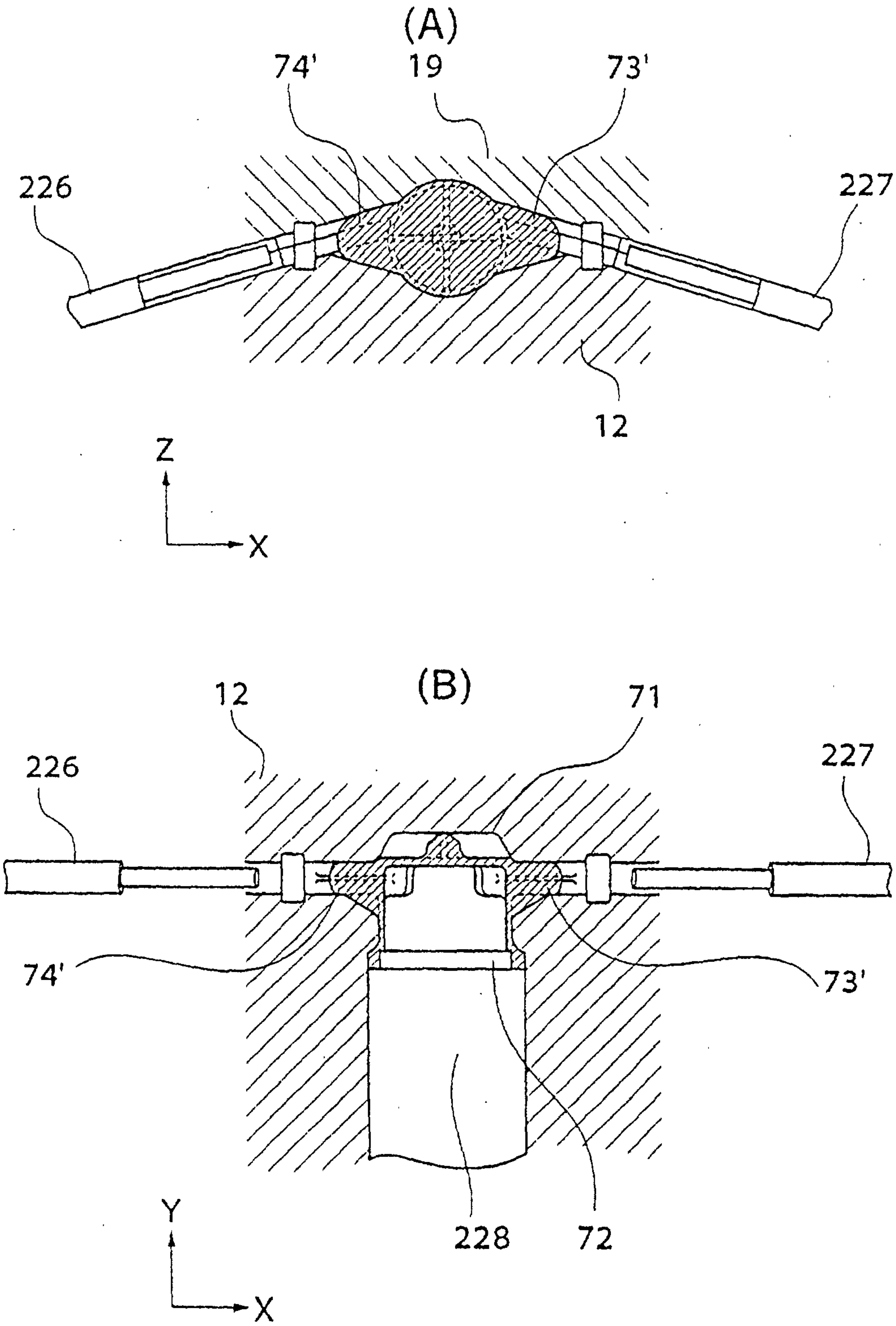


FIG. 46

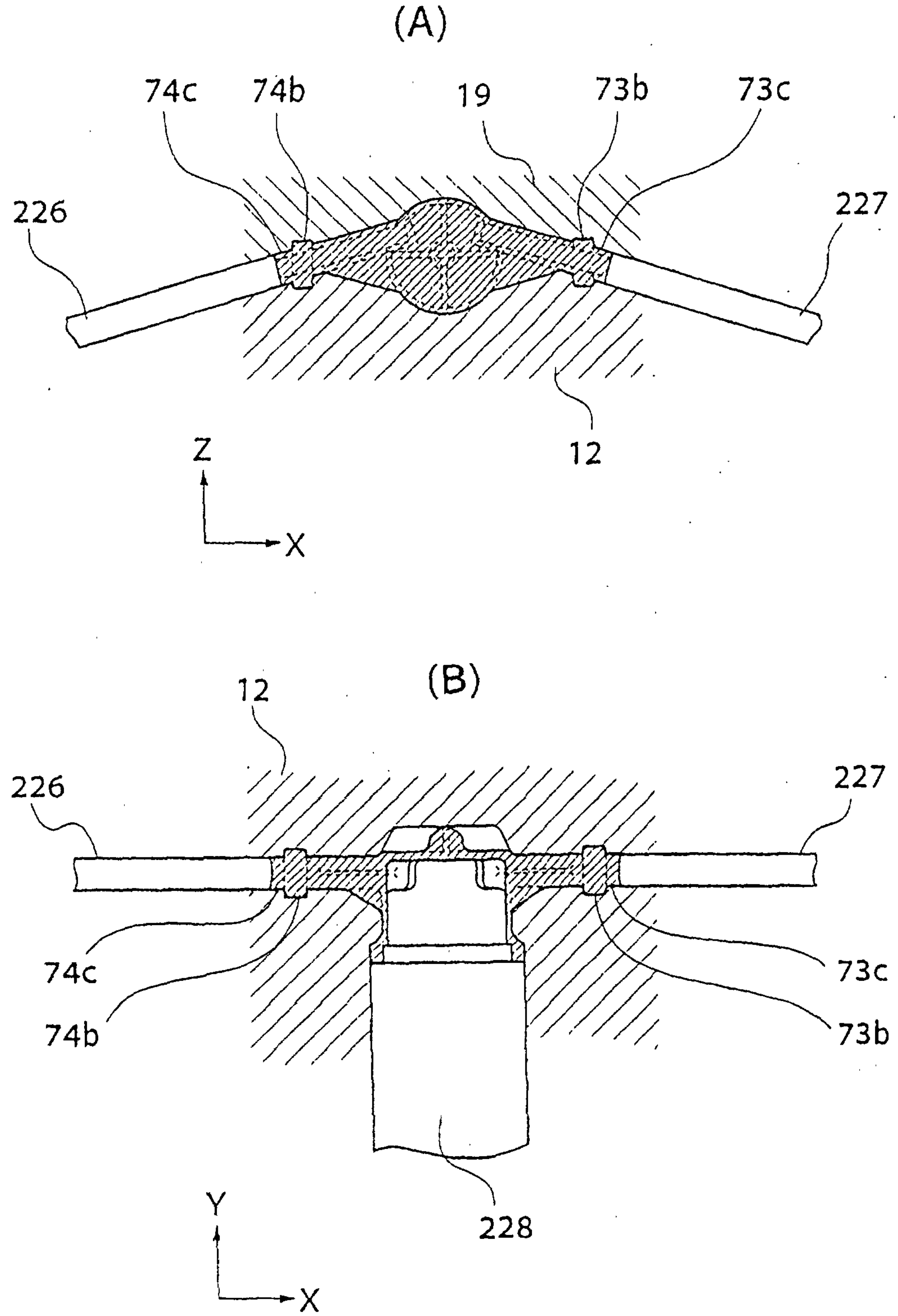
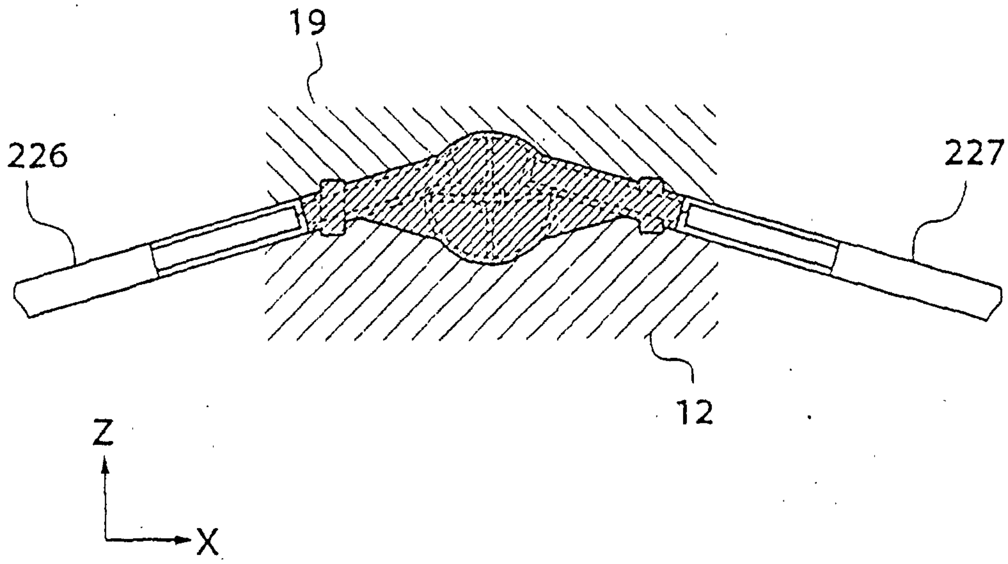

(A)
74c
74b
19
73b
73c
226
227
12
Z
X
(B)
12
226
227
74c
74b
73c
73b
228
Y
X

FIG. 47

(A)



(B)

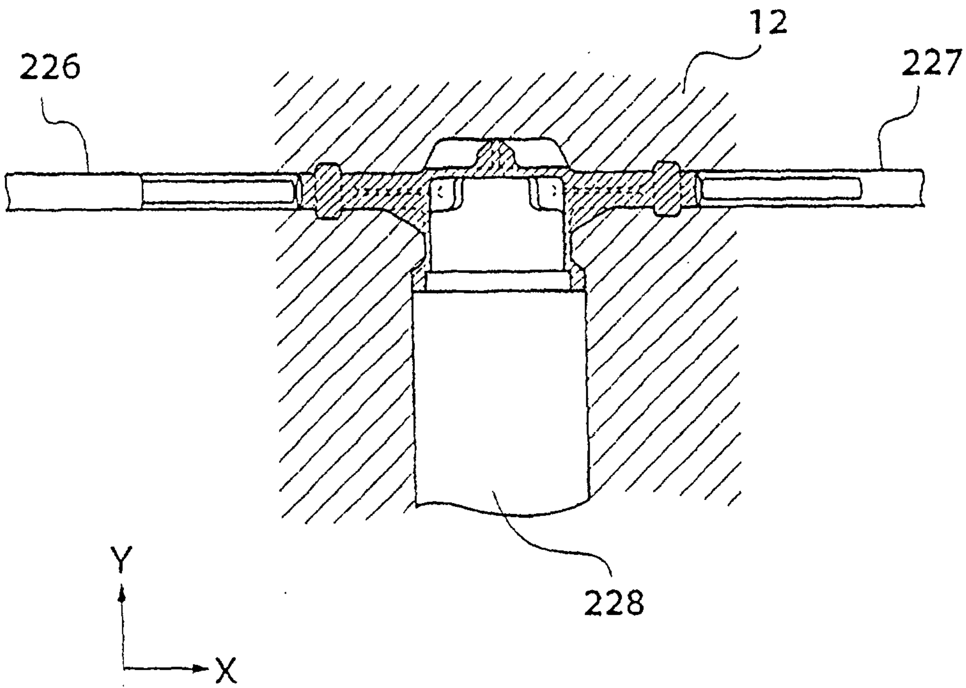
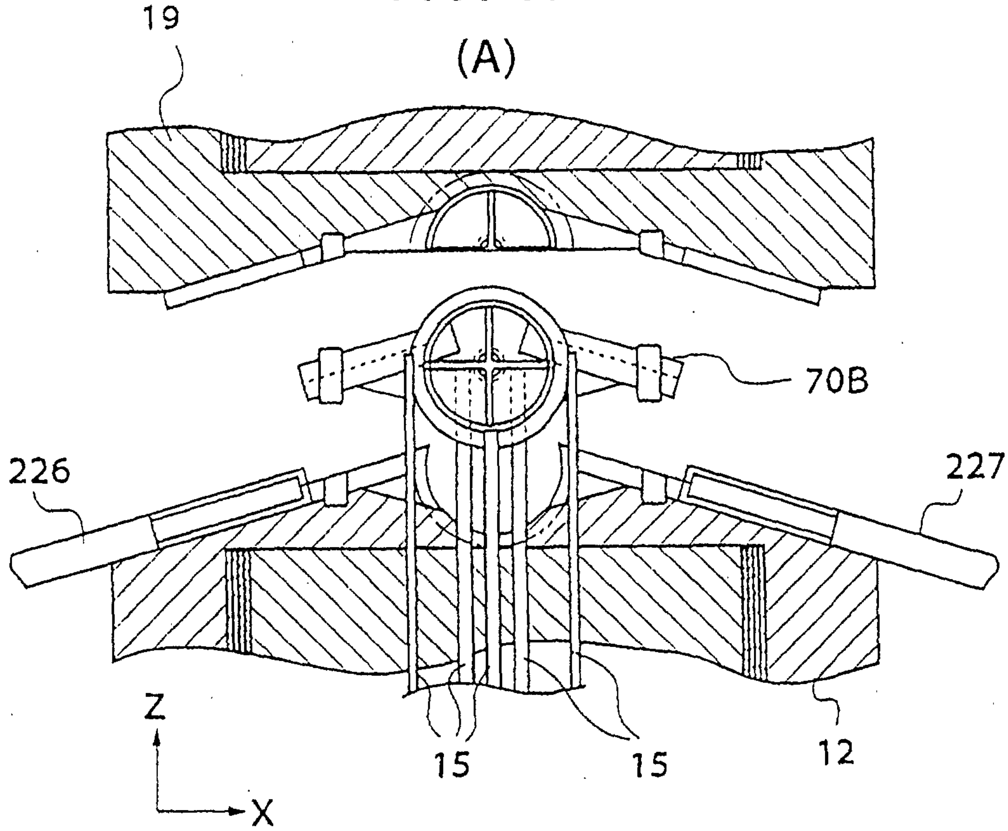


FIG. 48

(A)



(B)

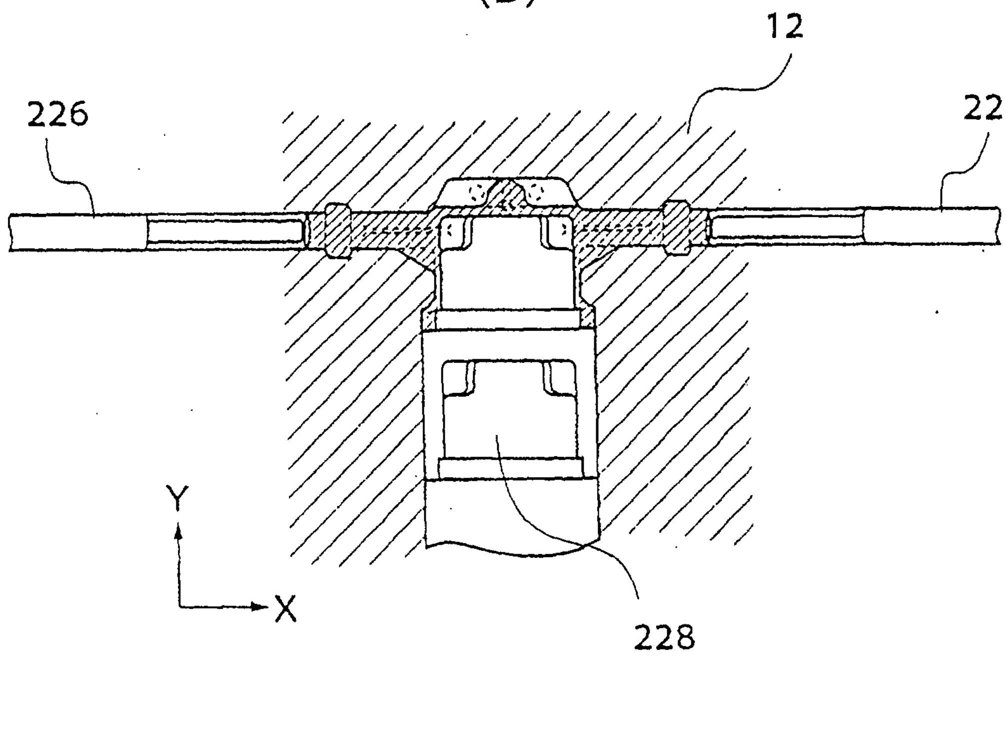


FIG. 49

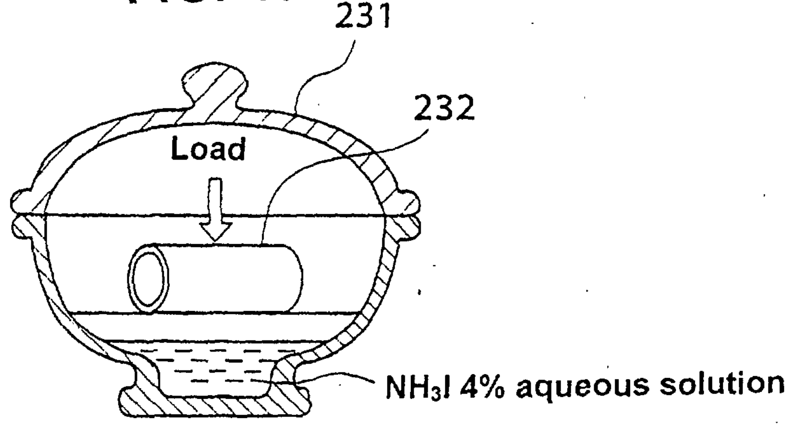

231
232
Load
NH3I 4% aqueous solution

FIG. 50

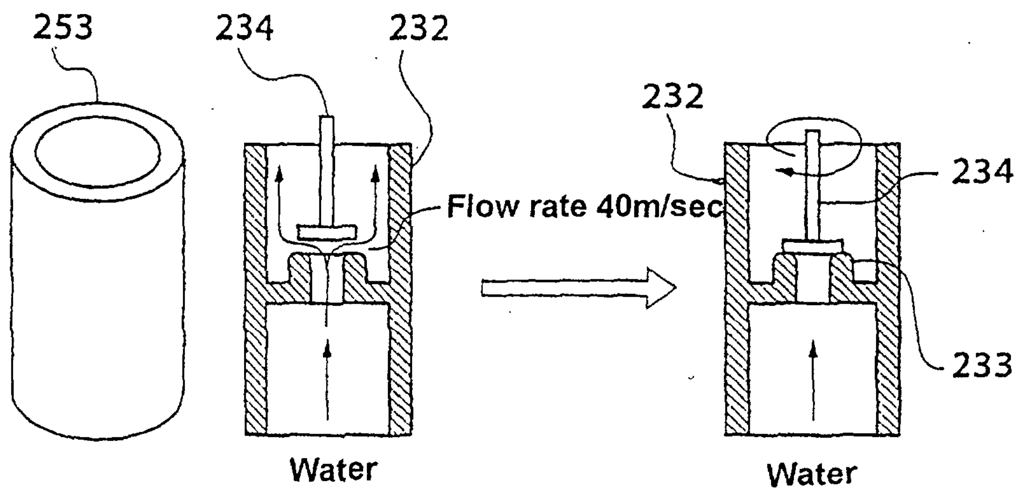

253
234
232
Flow rate 40m/sec
232
234
233
Water
Water

FIG. 51

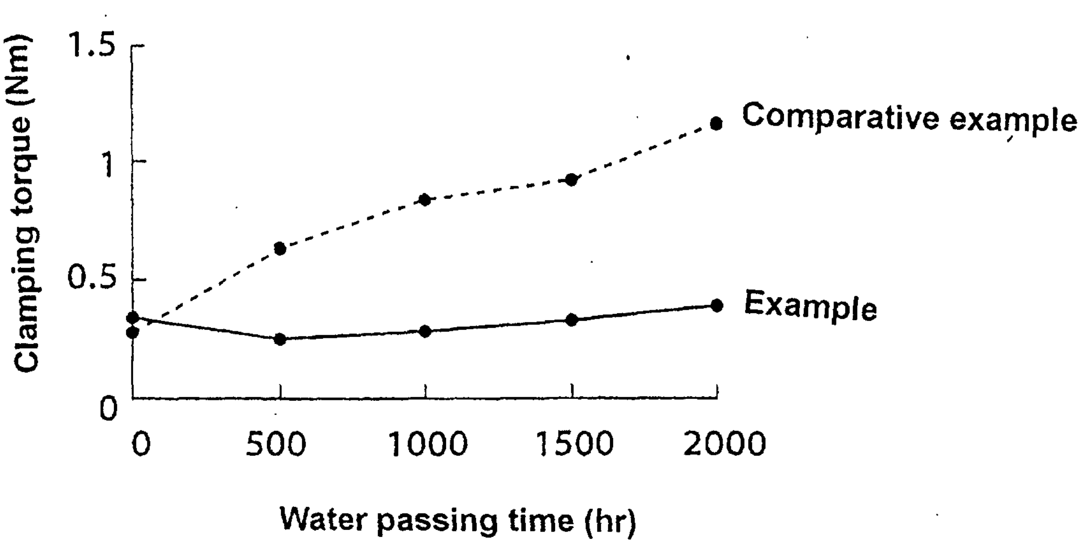

Clamping torque (Nm)
1.5
1
0.5
0
Comparative example
Example
0
500
1000
1500
2000
Water passing time (hr)

FIG. 52

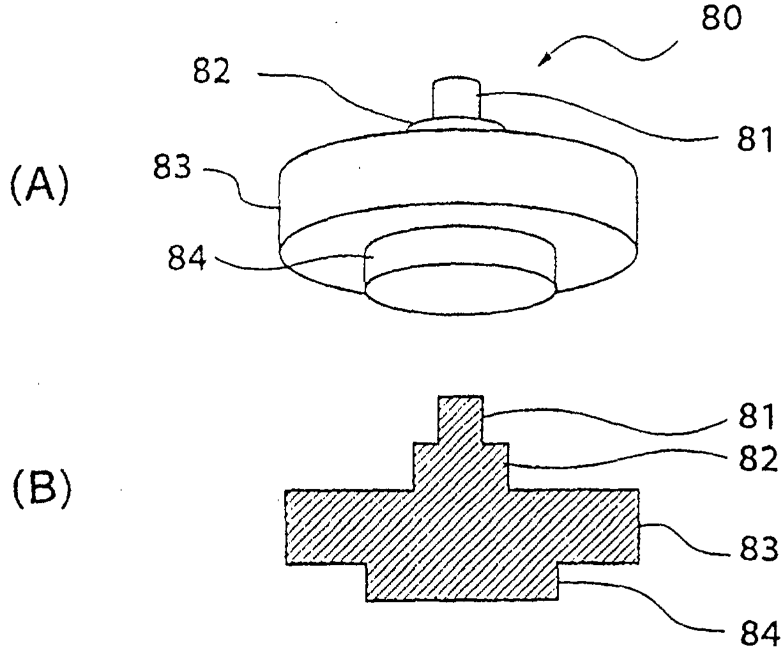


FIG. 53

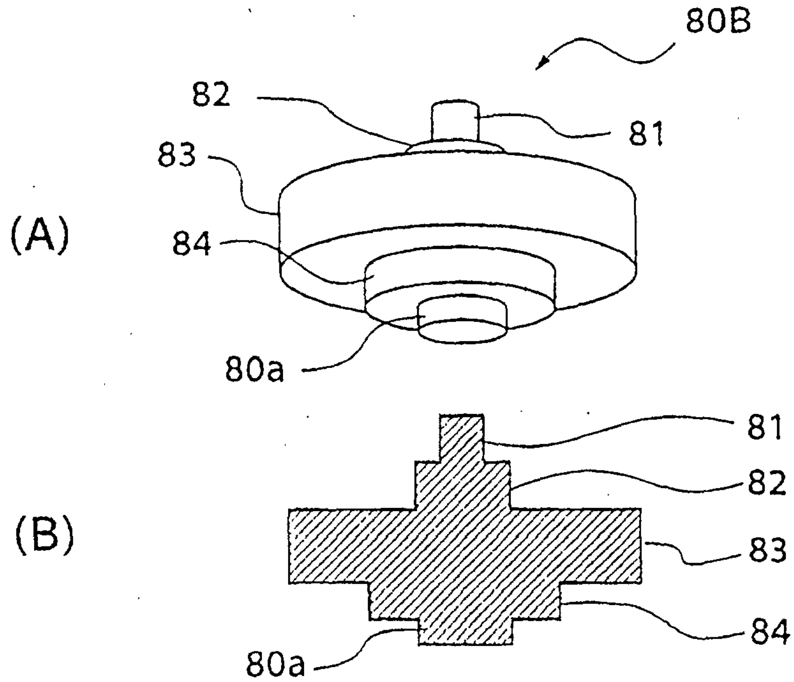


FIG. 54

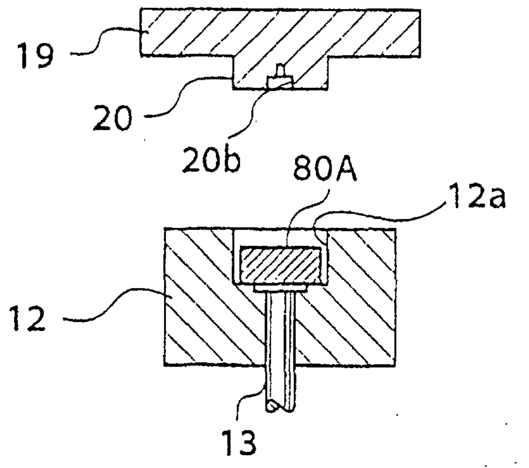


FIG. 55

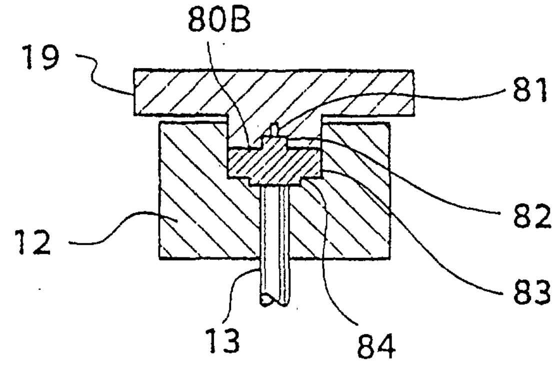


FIG. 56

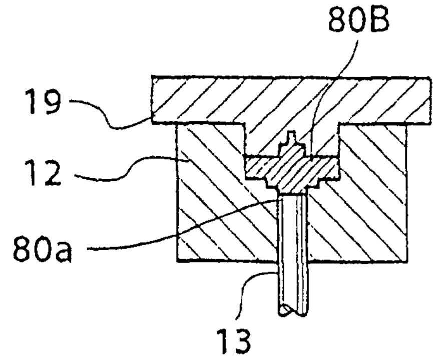


FIG. 57

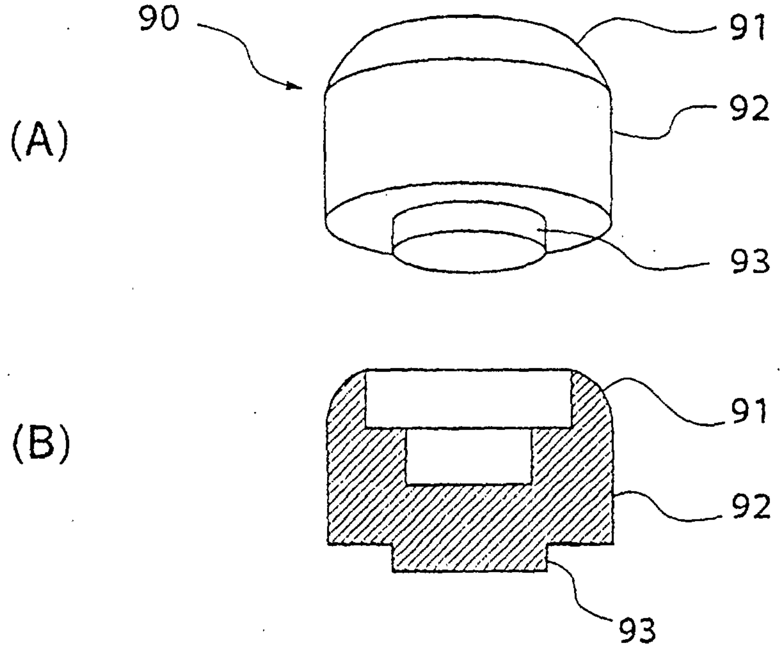


FIG. 58

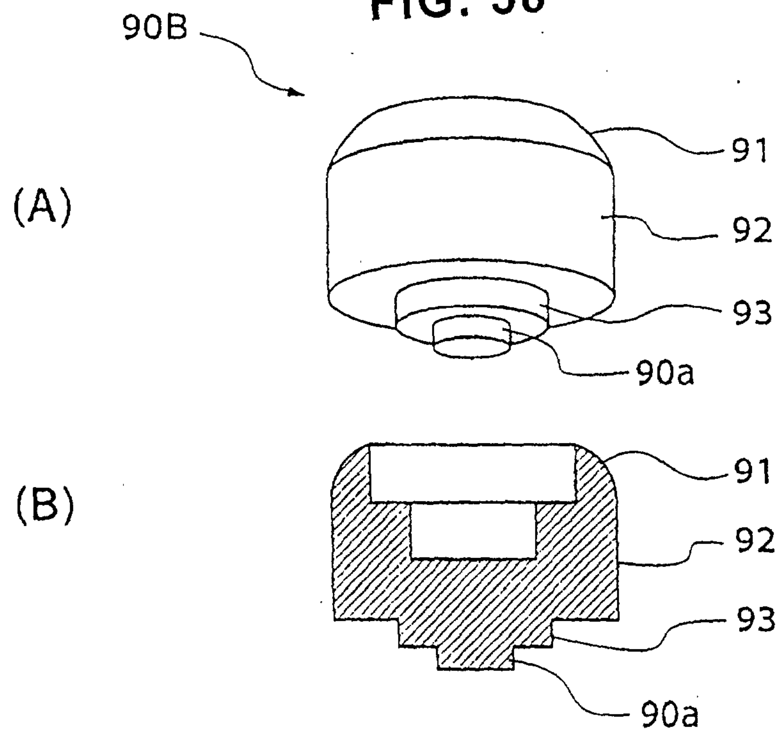


FIG. 59

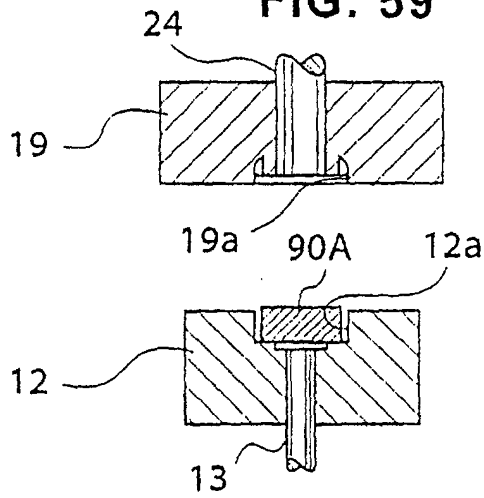


FIG. 60

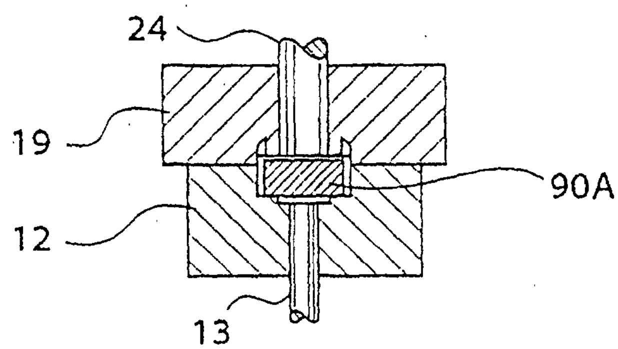


FIG. 61

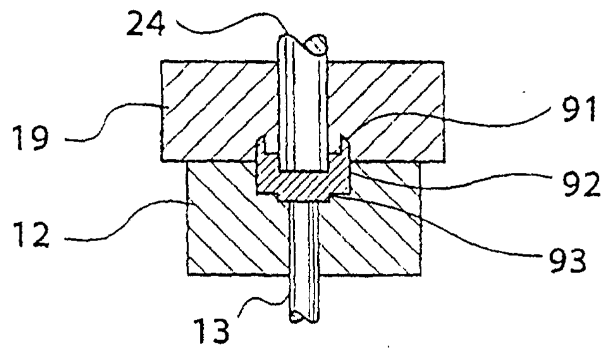


FIG. 62

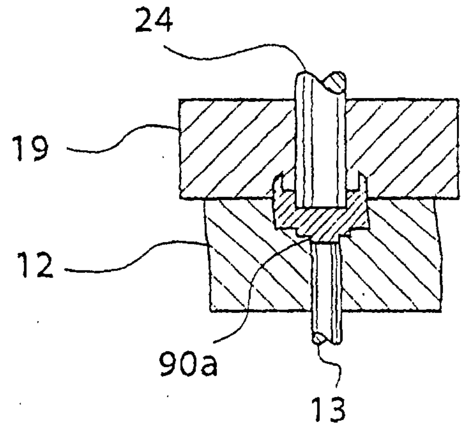


FIG. 63

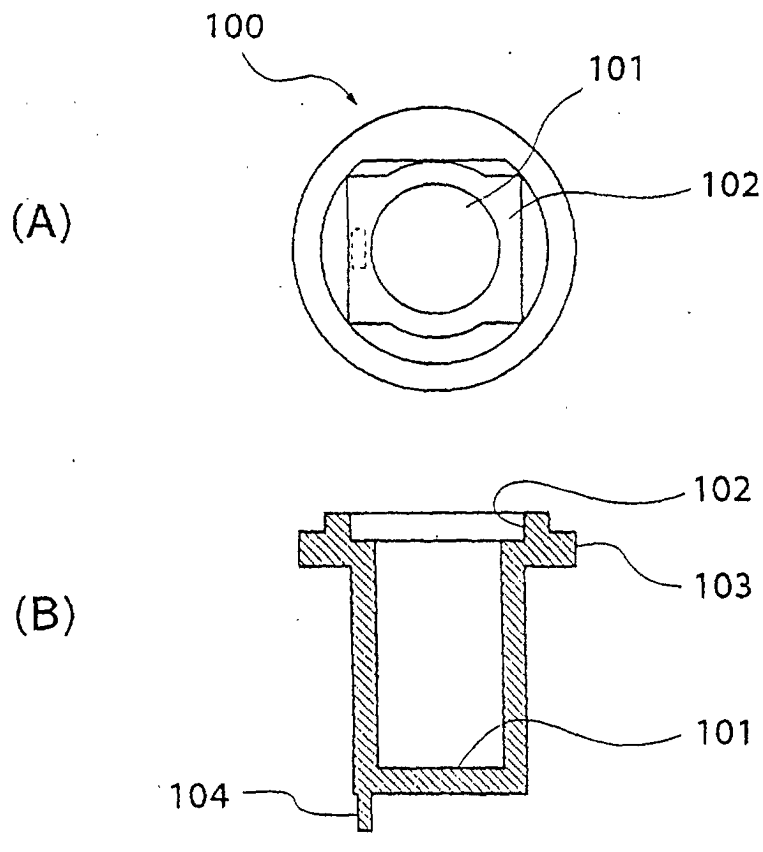


FIG. 64

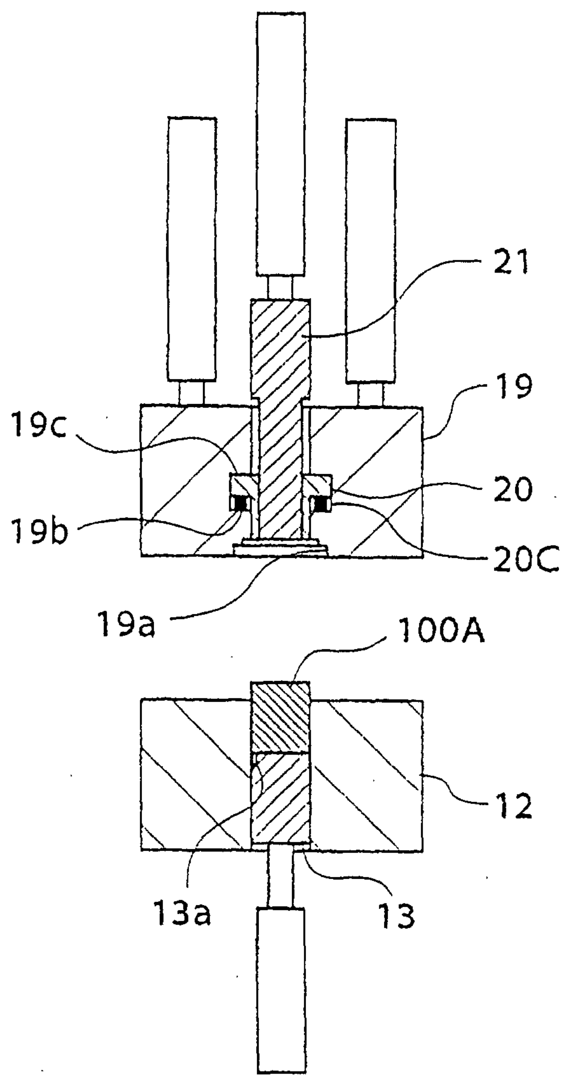


FIG. 65

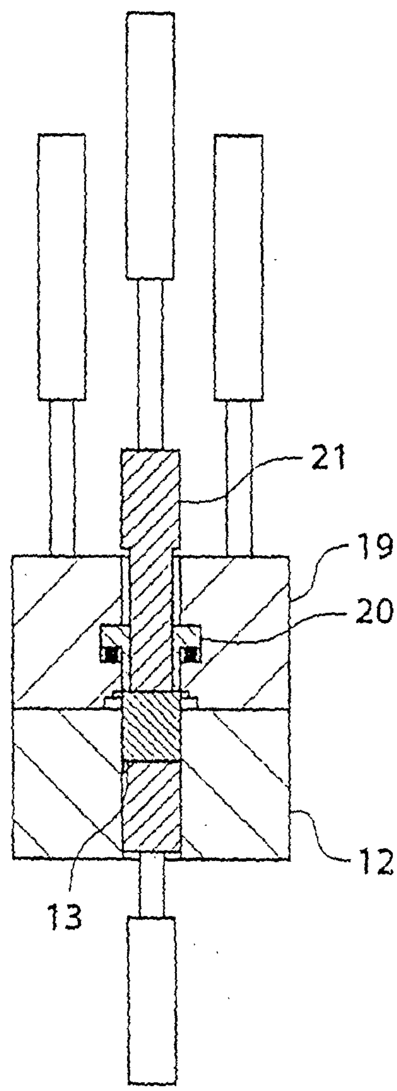


FIG. 66

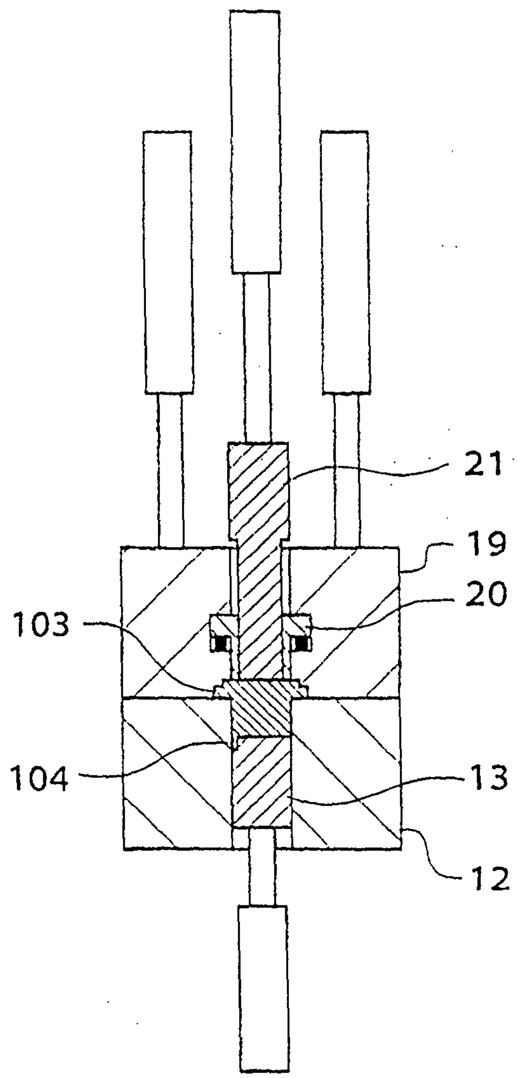


FIG. 67

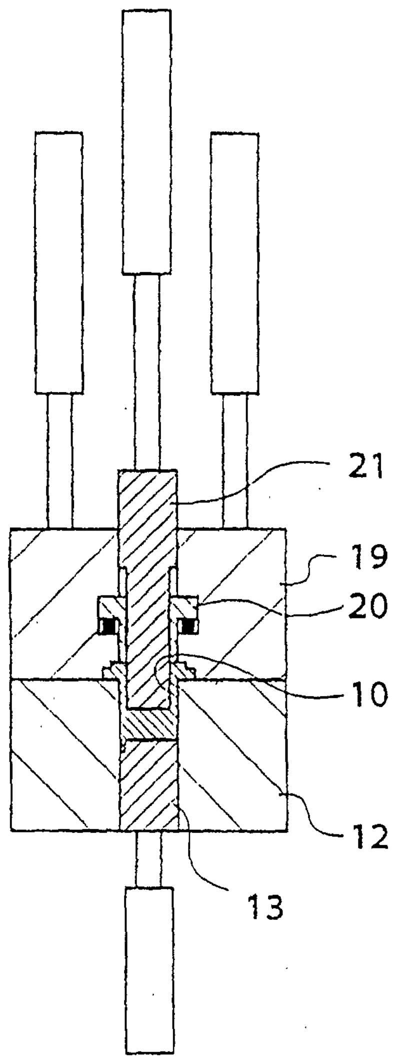


FIG. 68

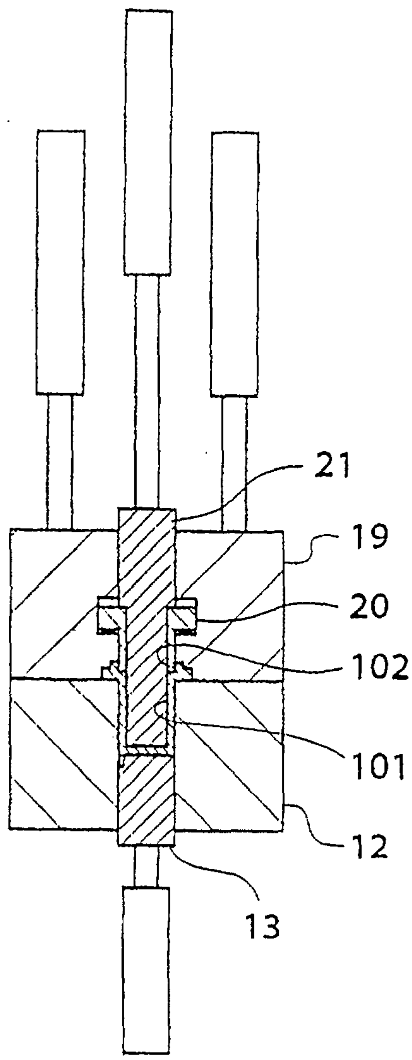


FIG. 69

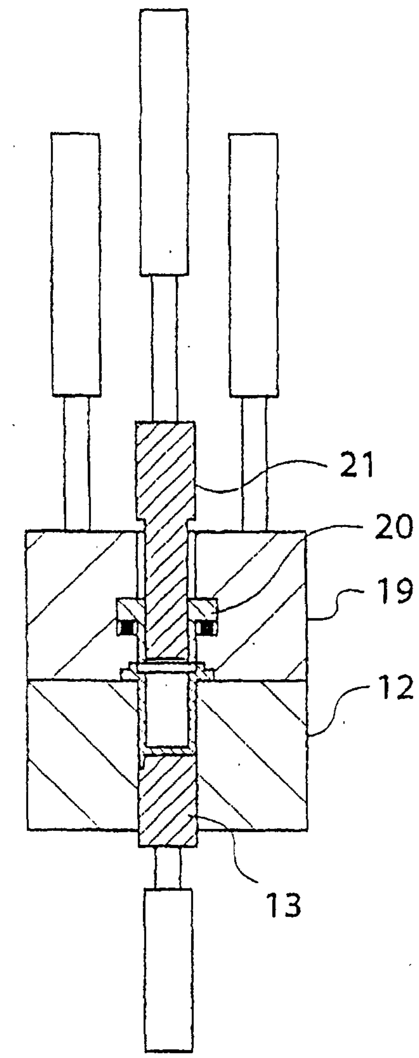


FIG. 70

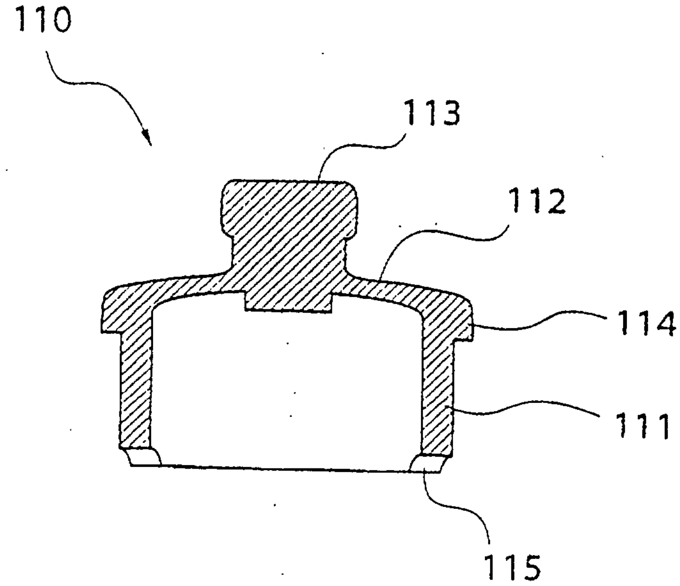


FIG. 71

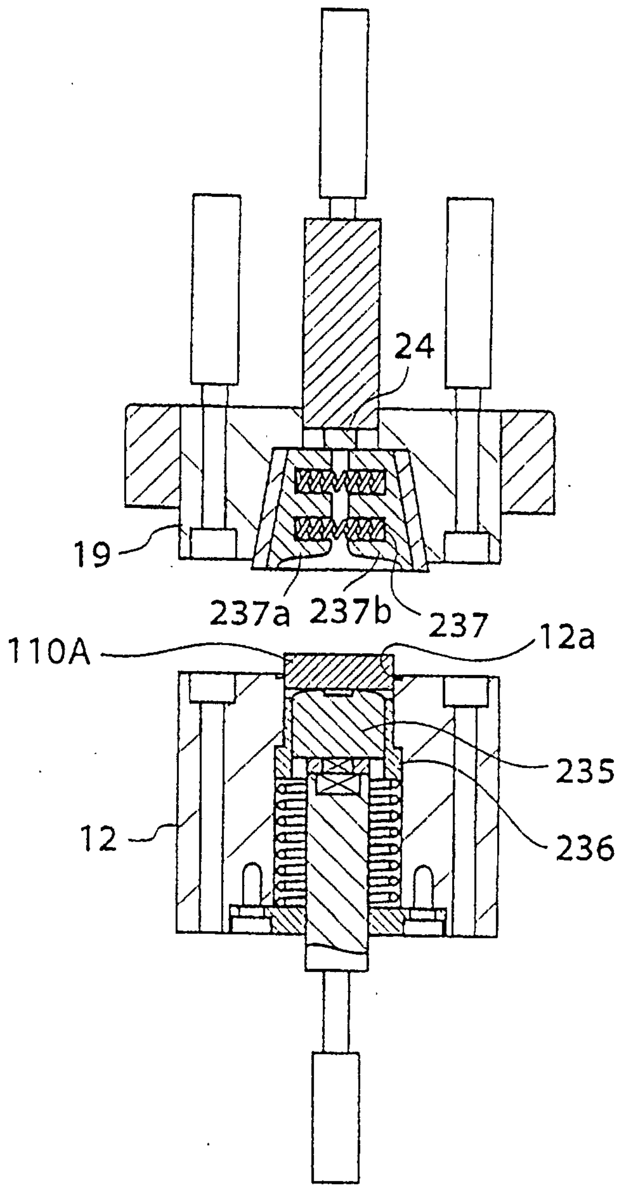


FIG. 72

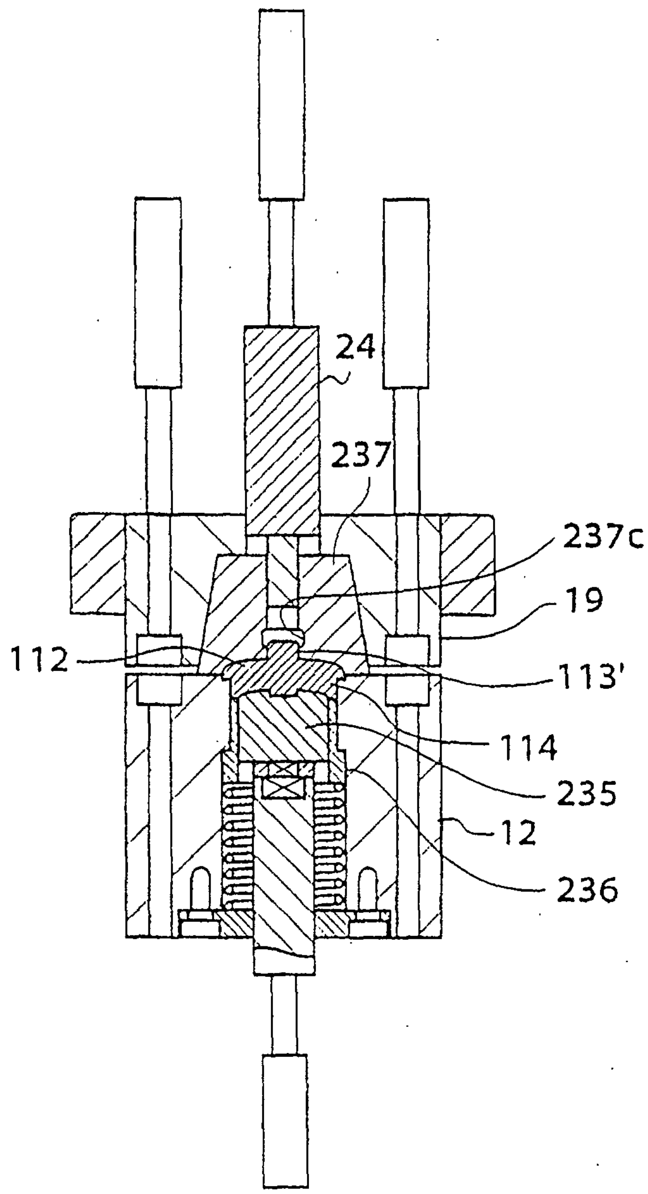


FIG. 73

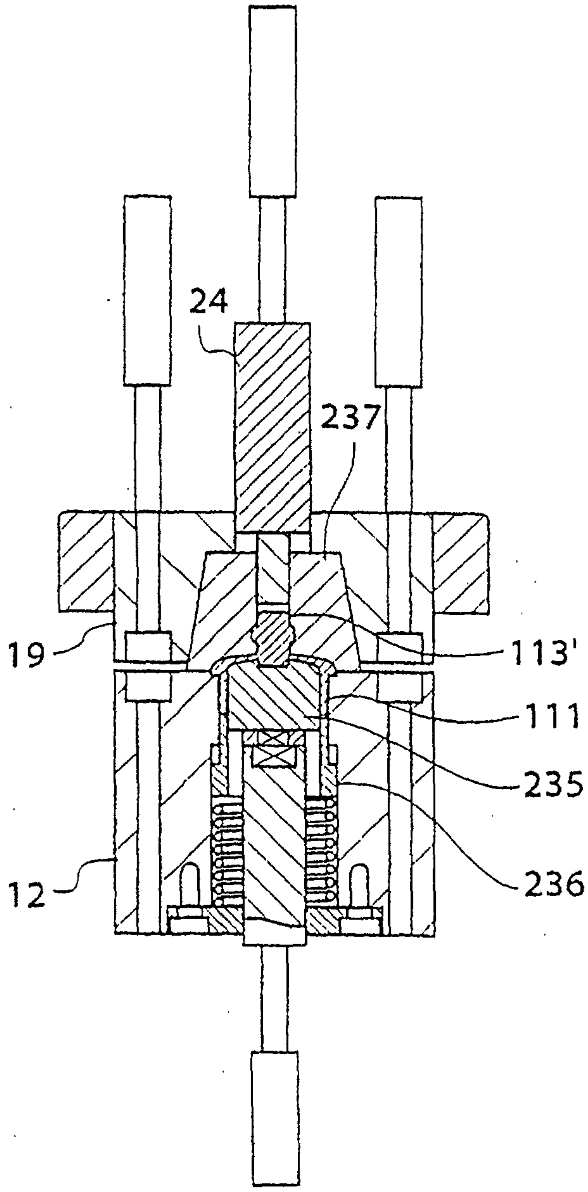


FIG. 74

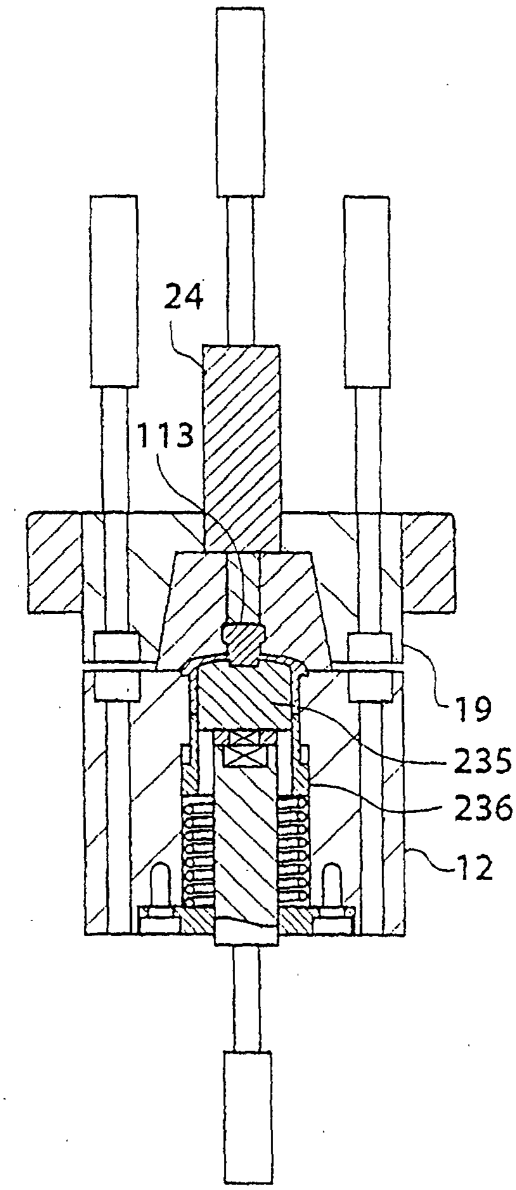


FIG. 75

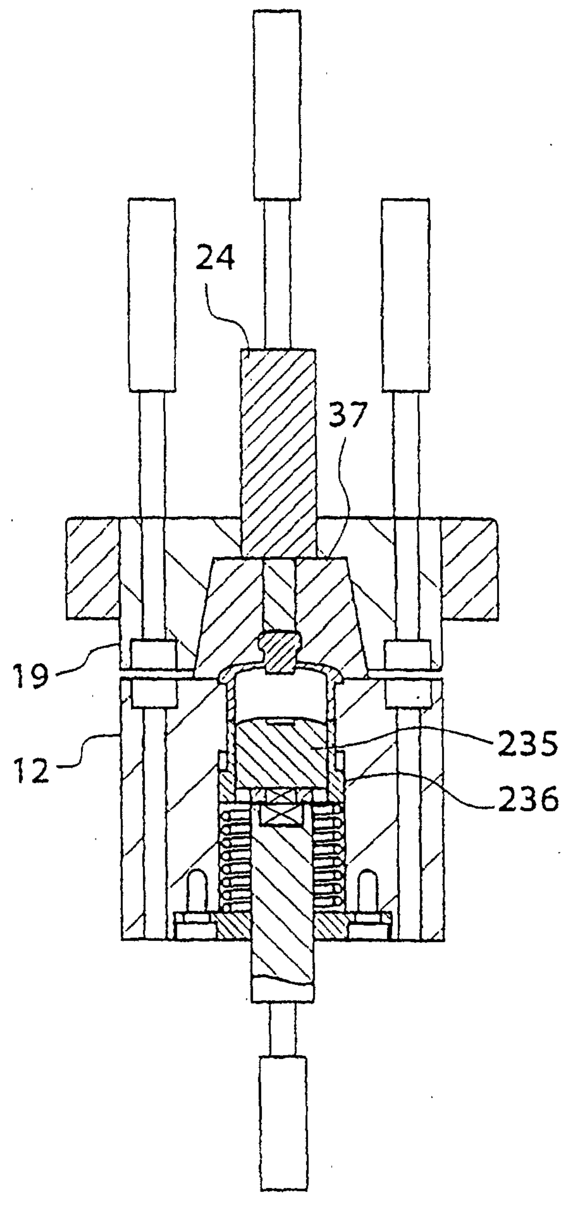


FIG. 76

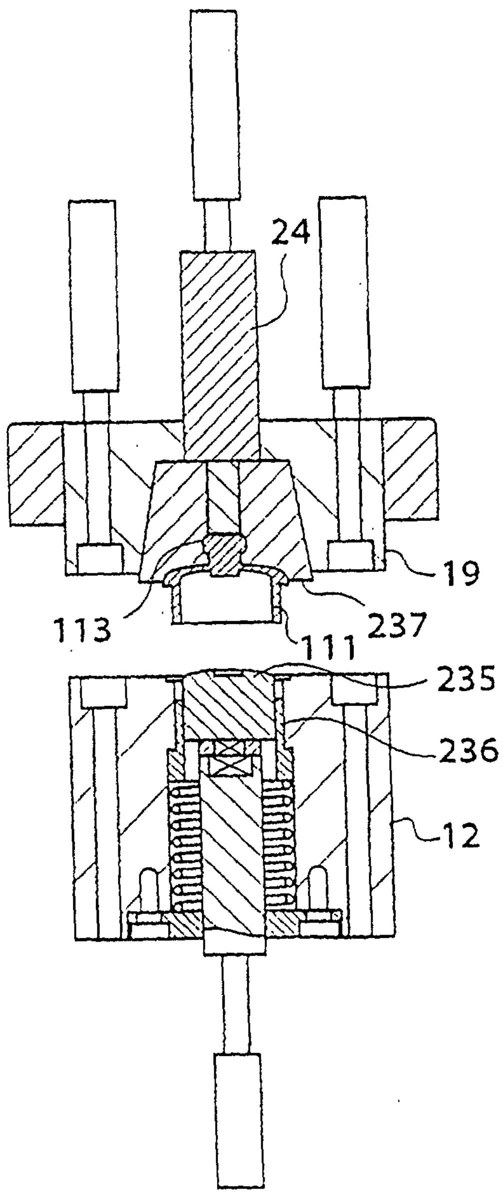


FIG. 77

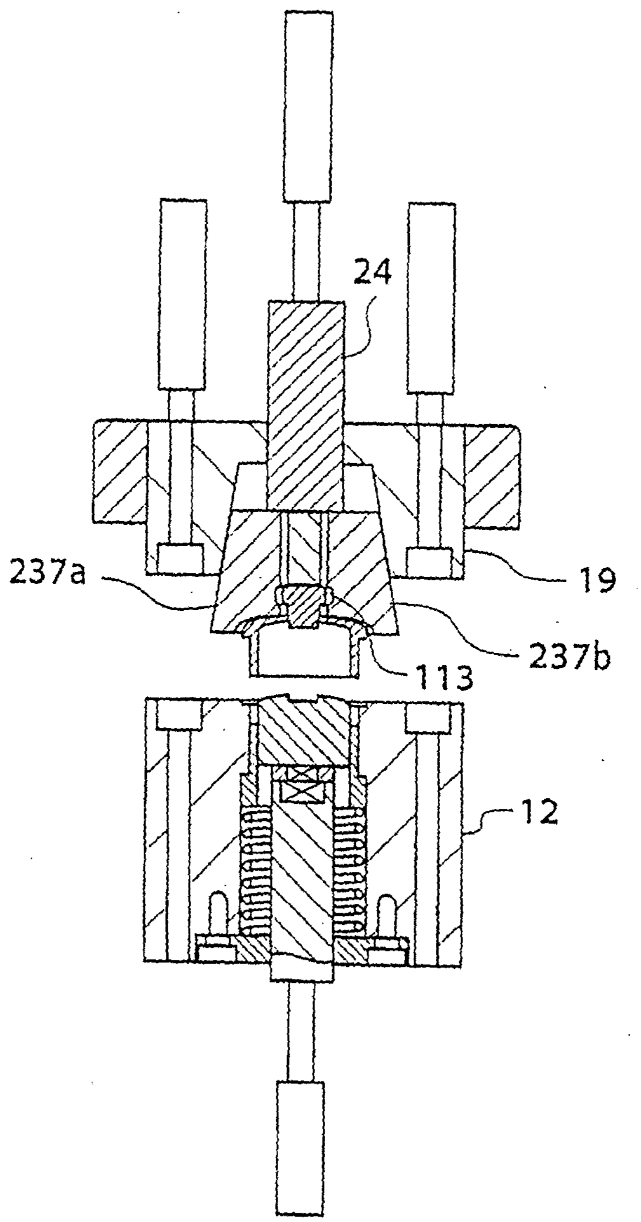


FIG. 78

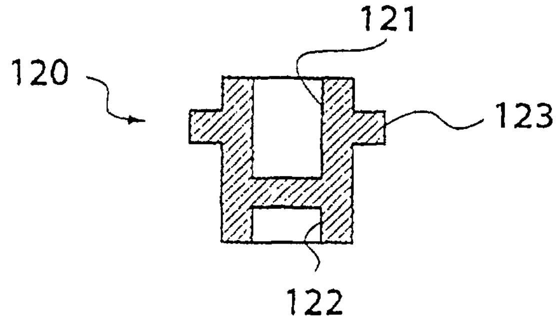


FIG. 79

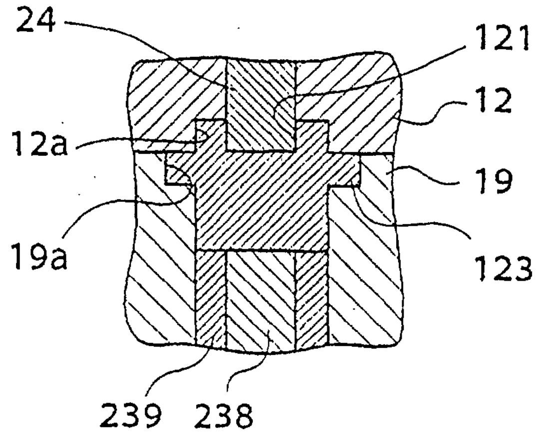


FIG. 80

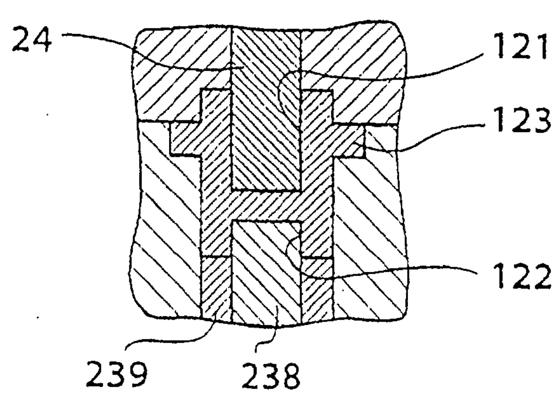


FIG. 81

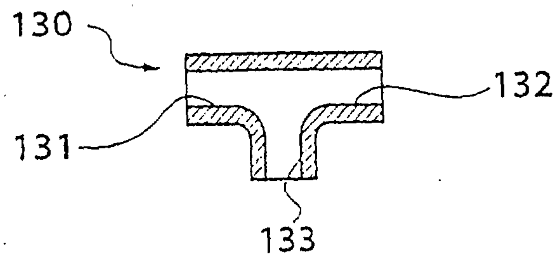


FIG. 82

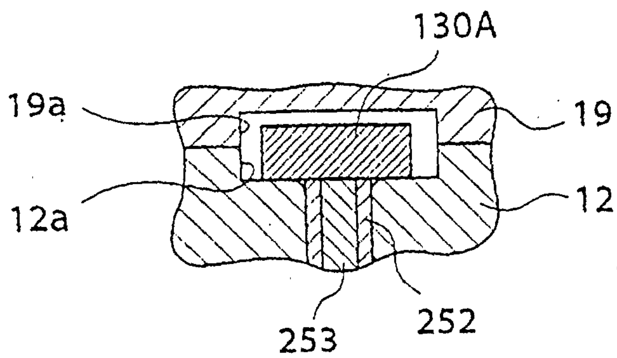


FIG. 83

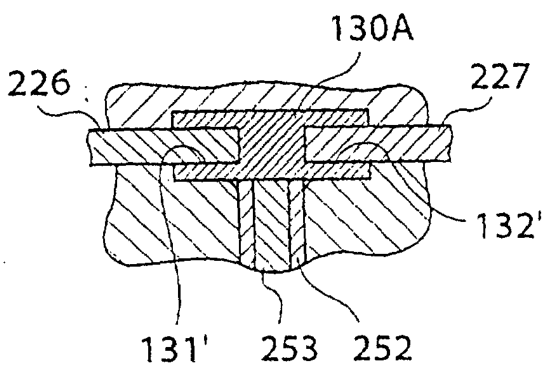


FIG. 84

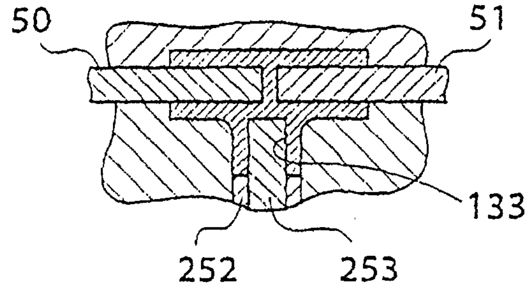


FIG. 85

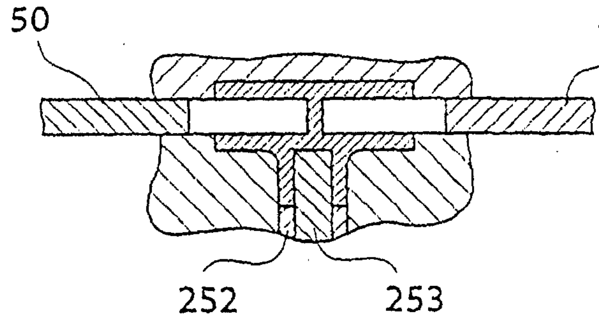


FIG. 86

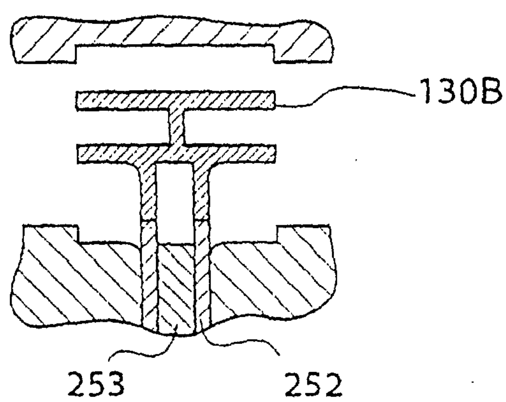


FIG. 87

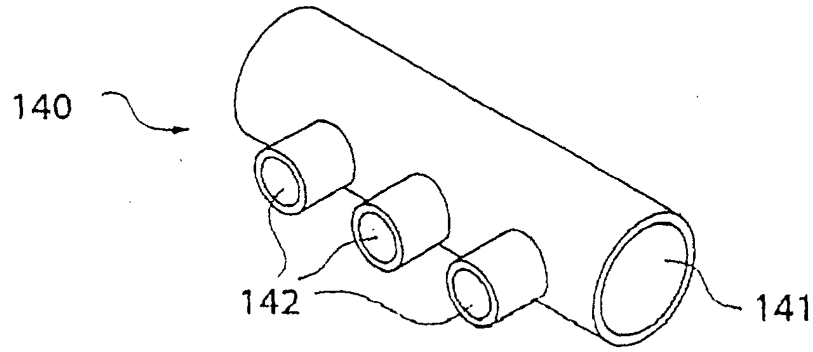


FIG. 88

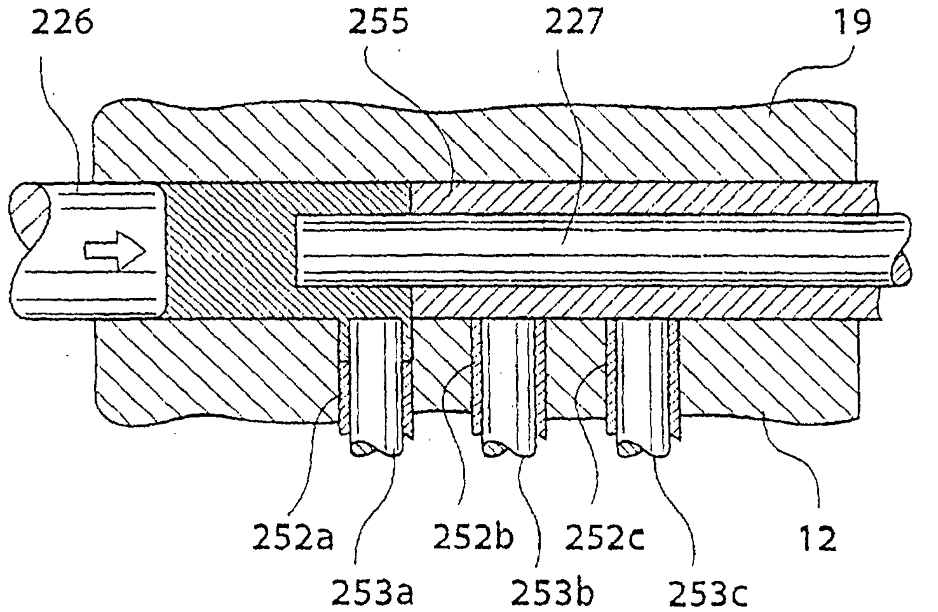


FIG. 89

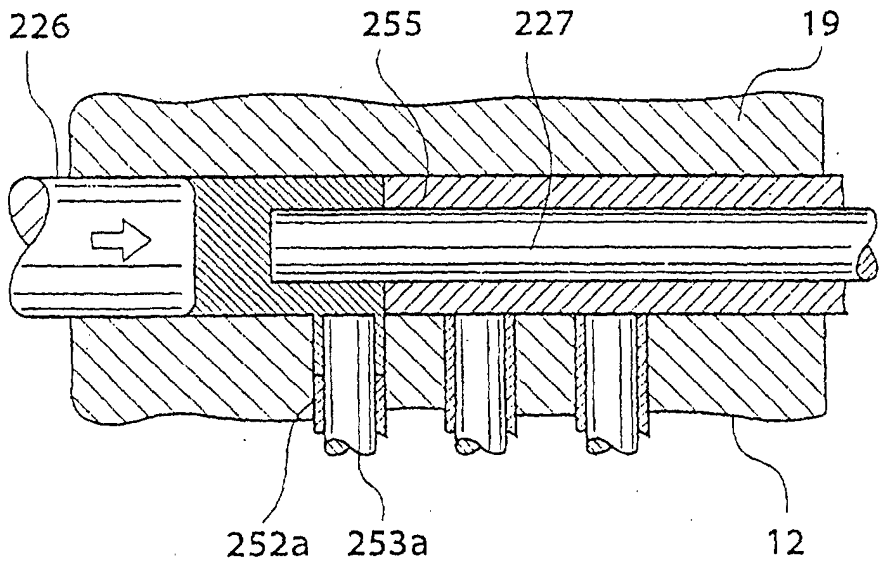


FIG. 90

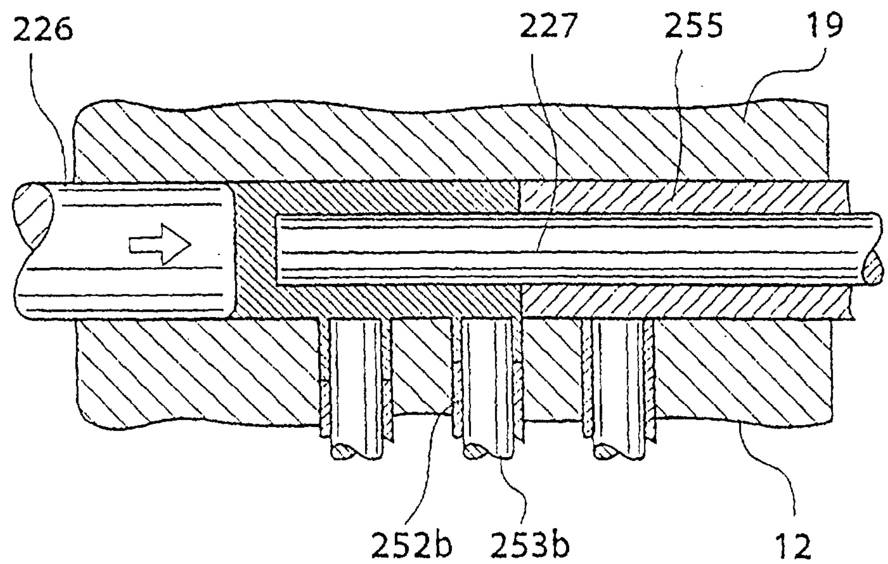


FIG. 91

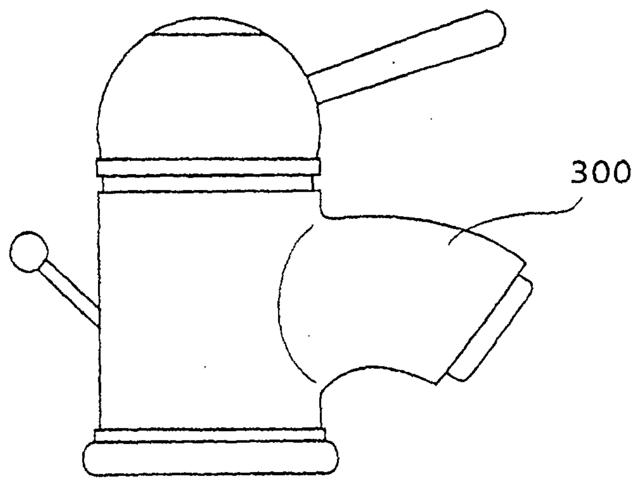


FIG. 92

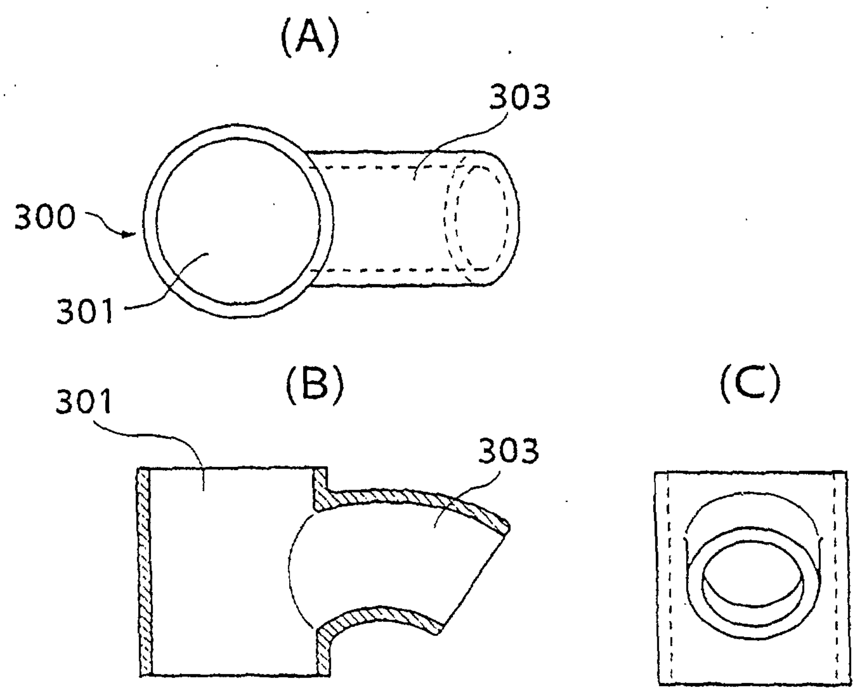


FIG. 93

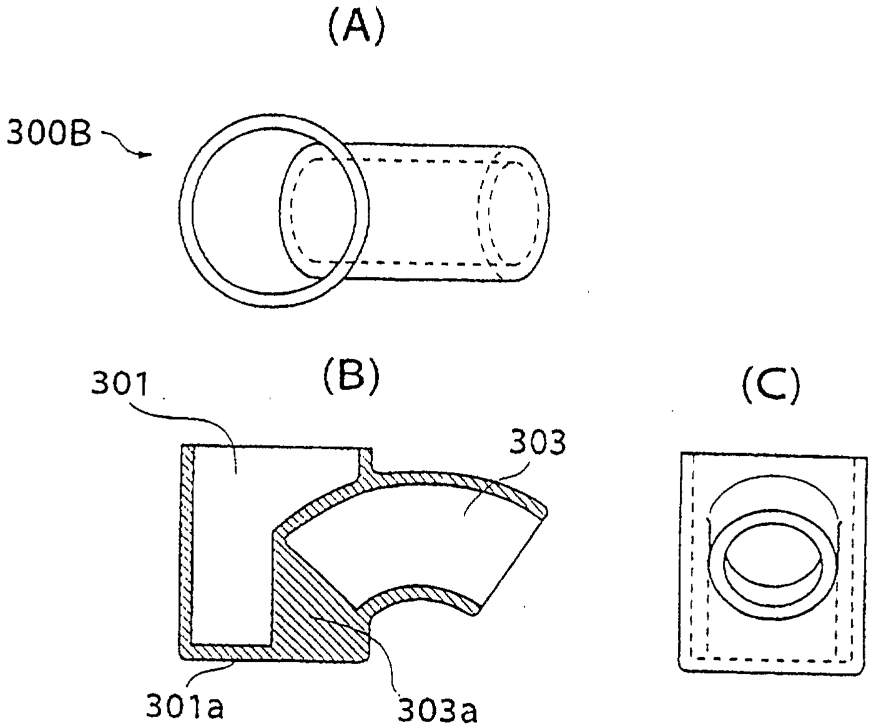

(A)
300B
(B)
301
303
301a
303a
(C)

FIG. 94

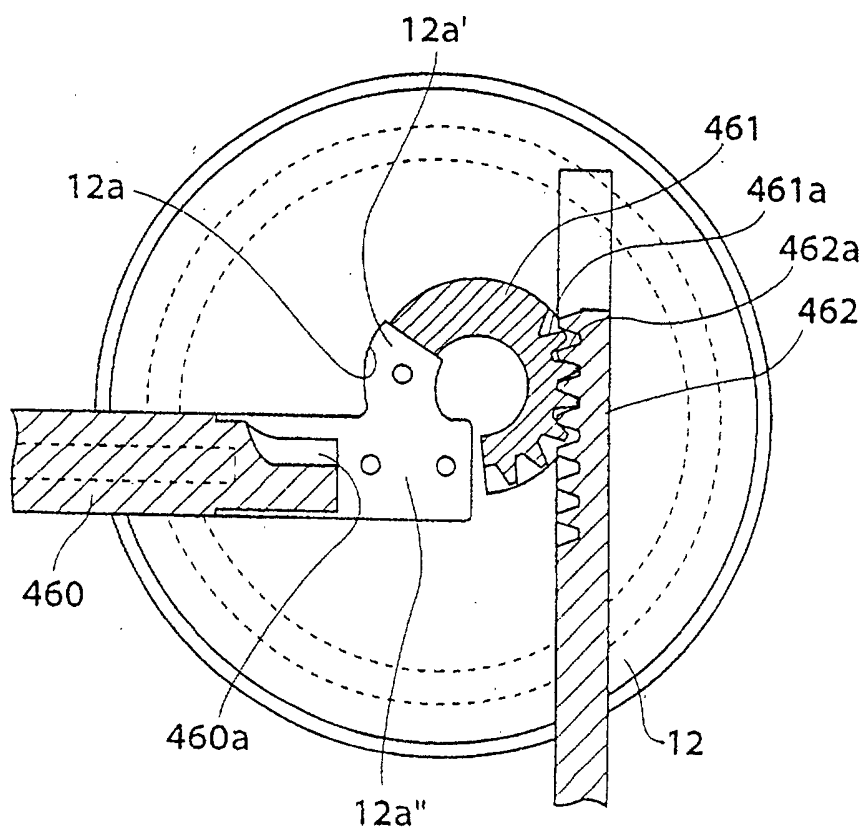

12a'
461
12a
461a
462a
462
460
460a
12a"
12

FIG. 95

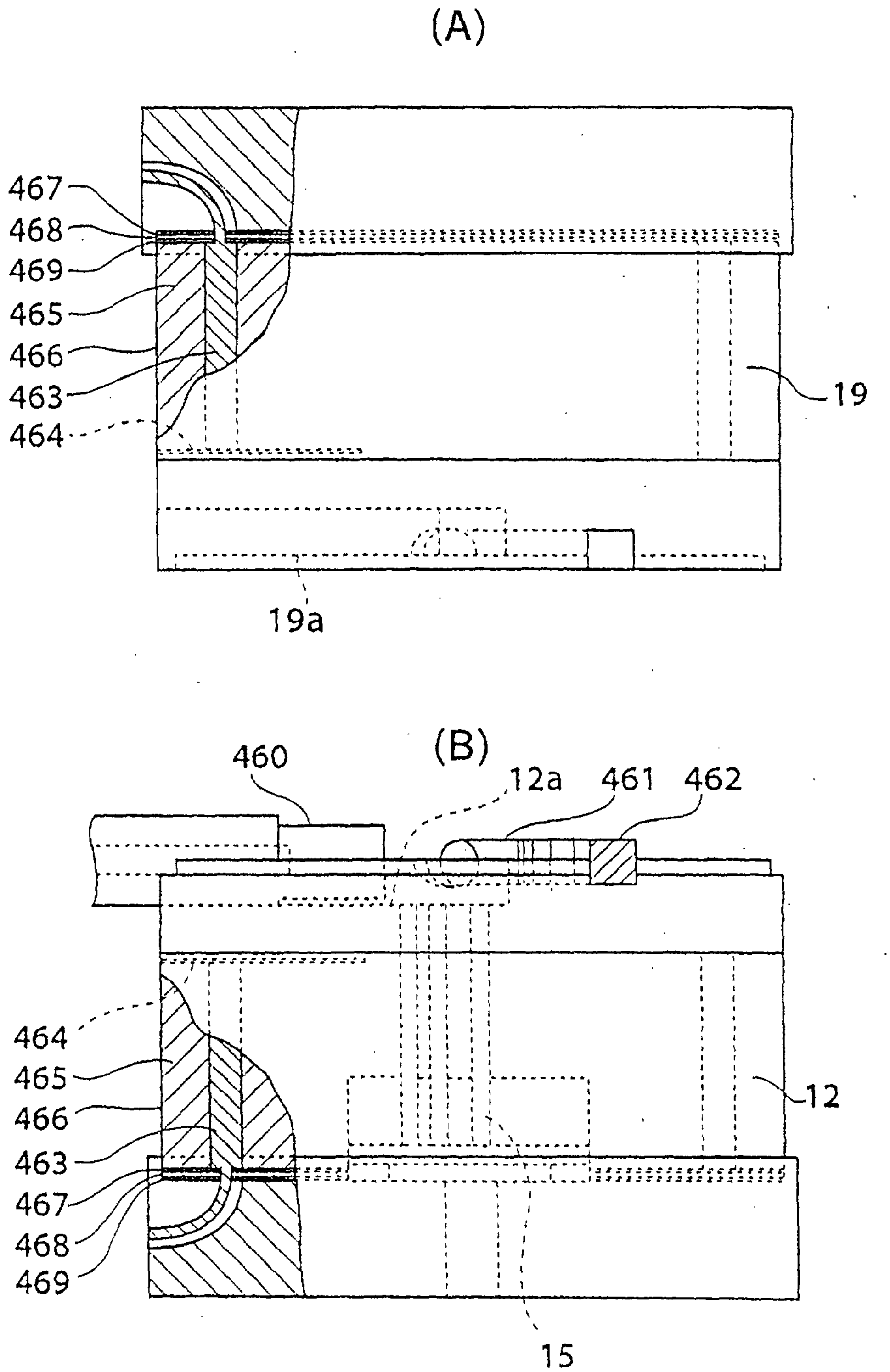

(A)
467
468
469
465
466
463
464
19
19a
(B)
460
12a
461
462
464
465
466
463
467
468
469
12
15

FIG. 96

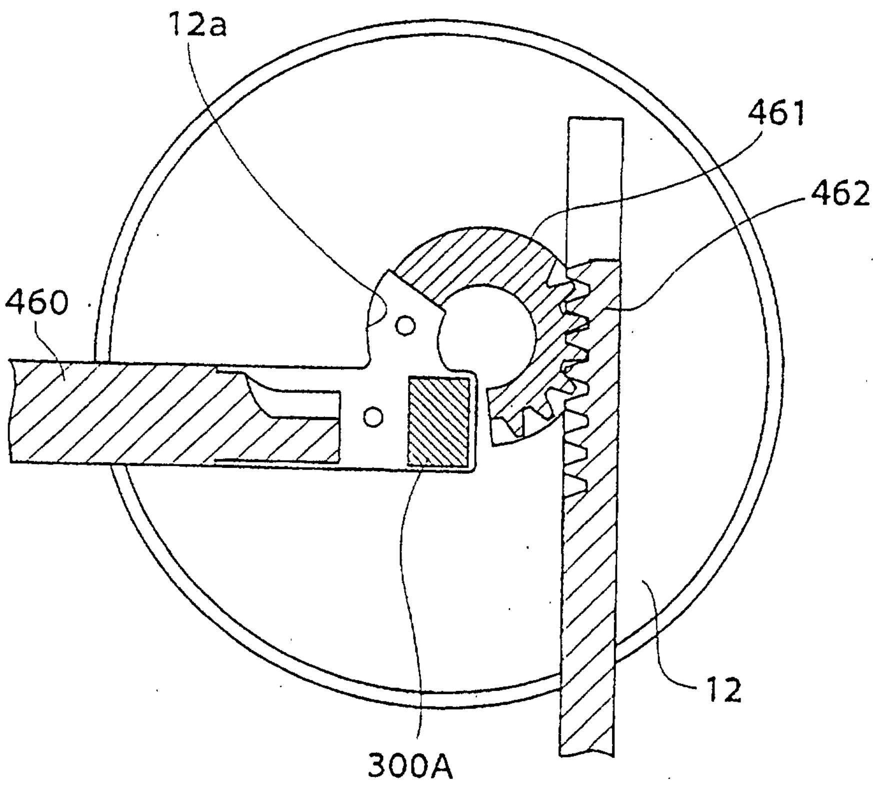


FIG. 97

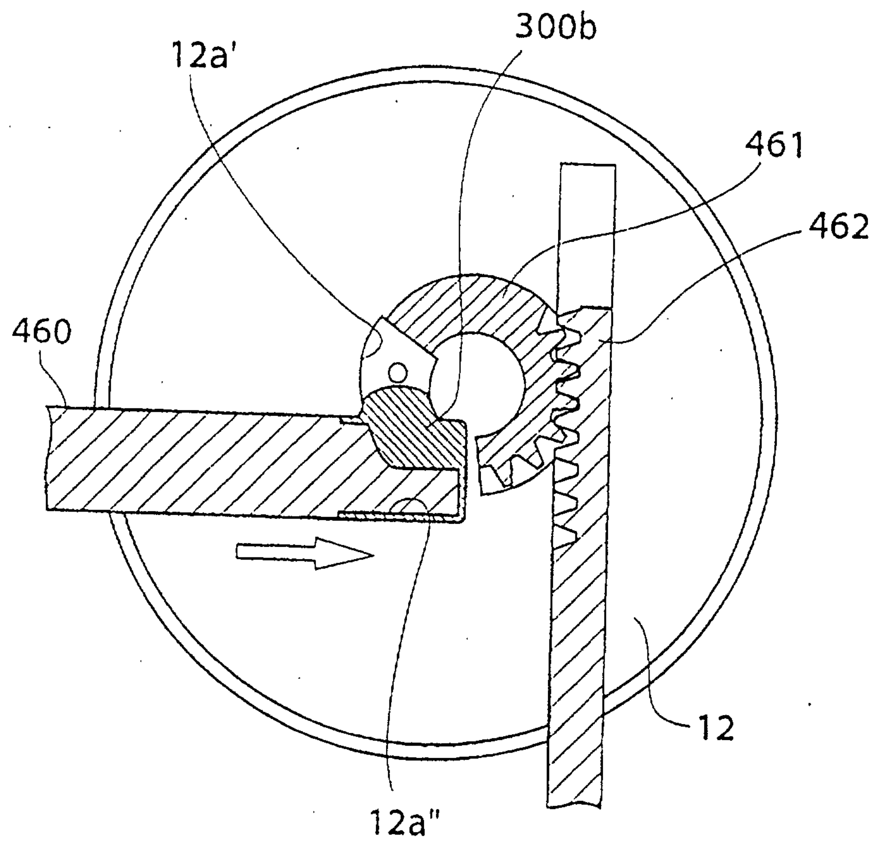


FIG. 98

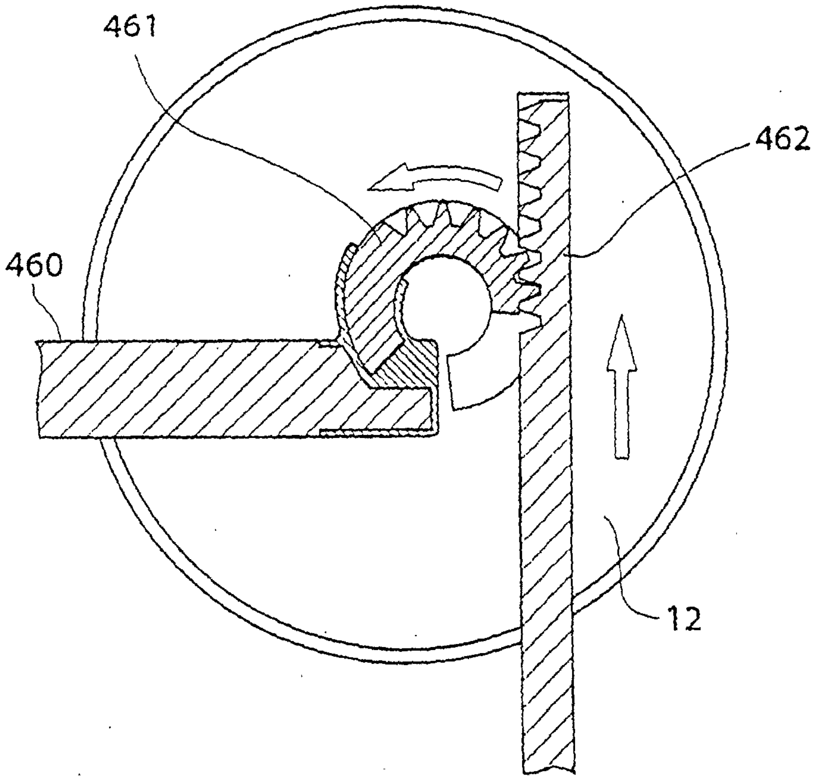


FIG. 99

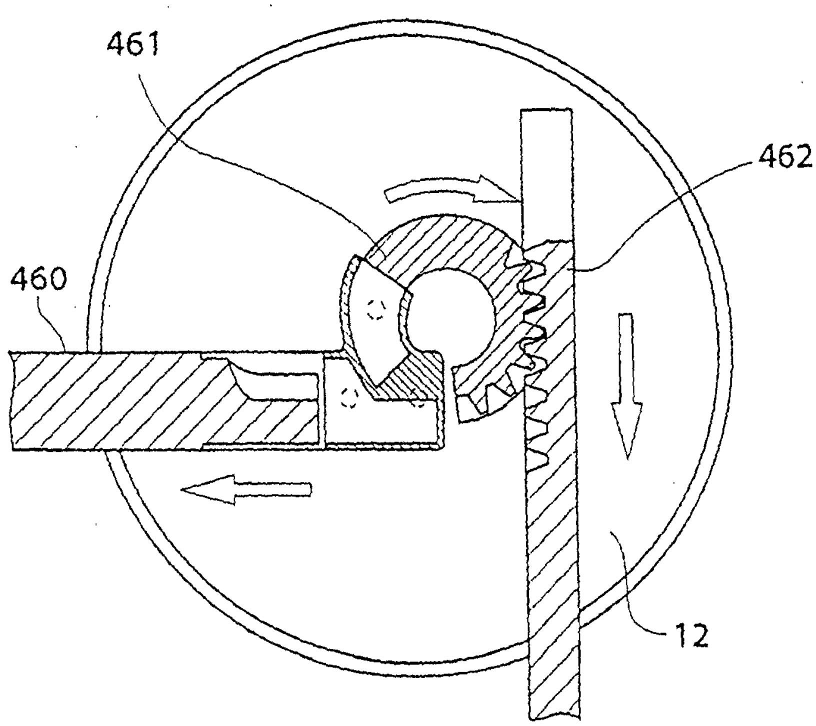


FIG. 100

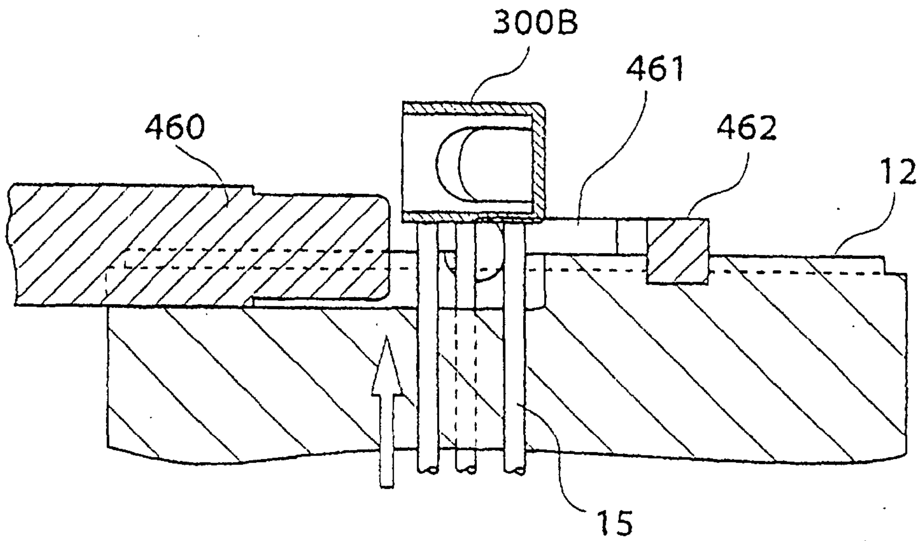


FIG. 101

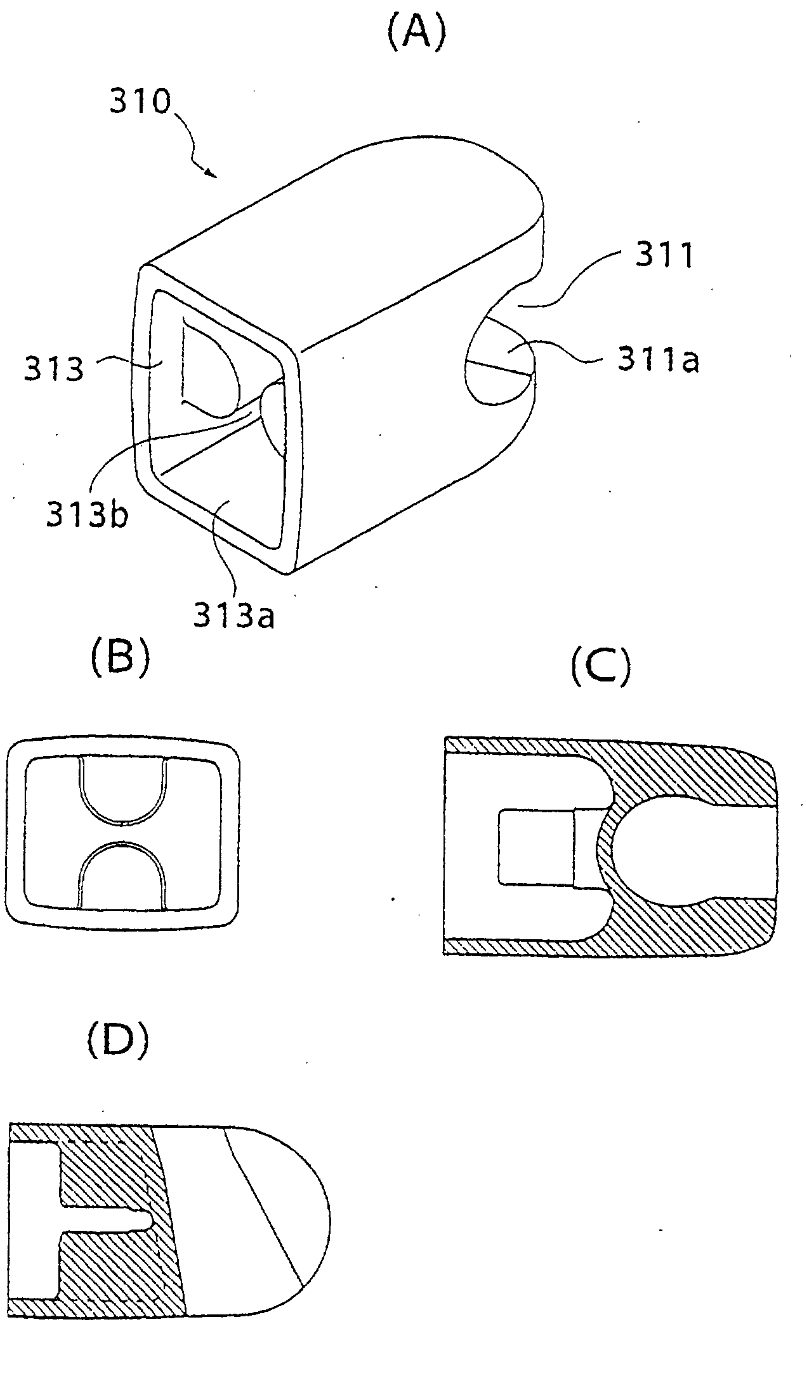


FIG. 102

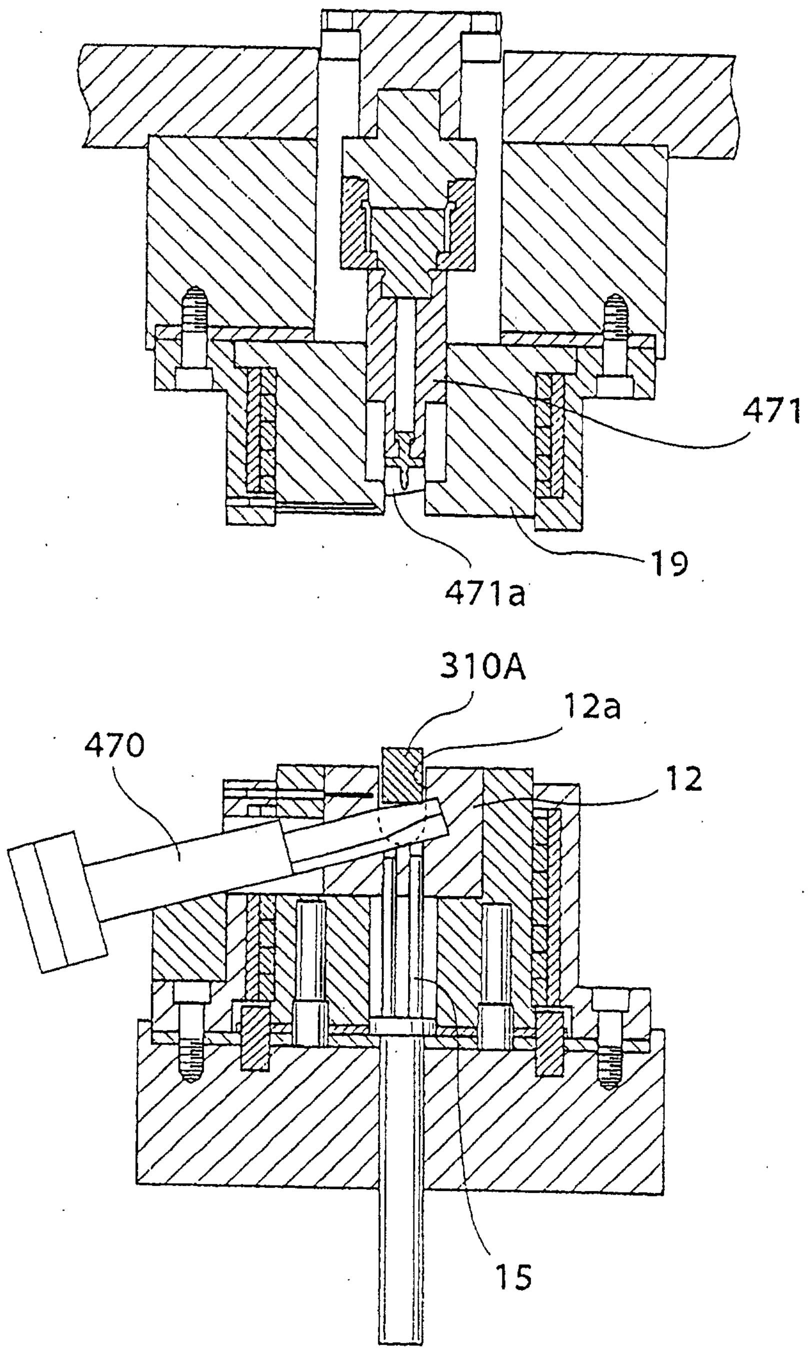


FIG. 103

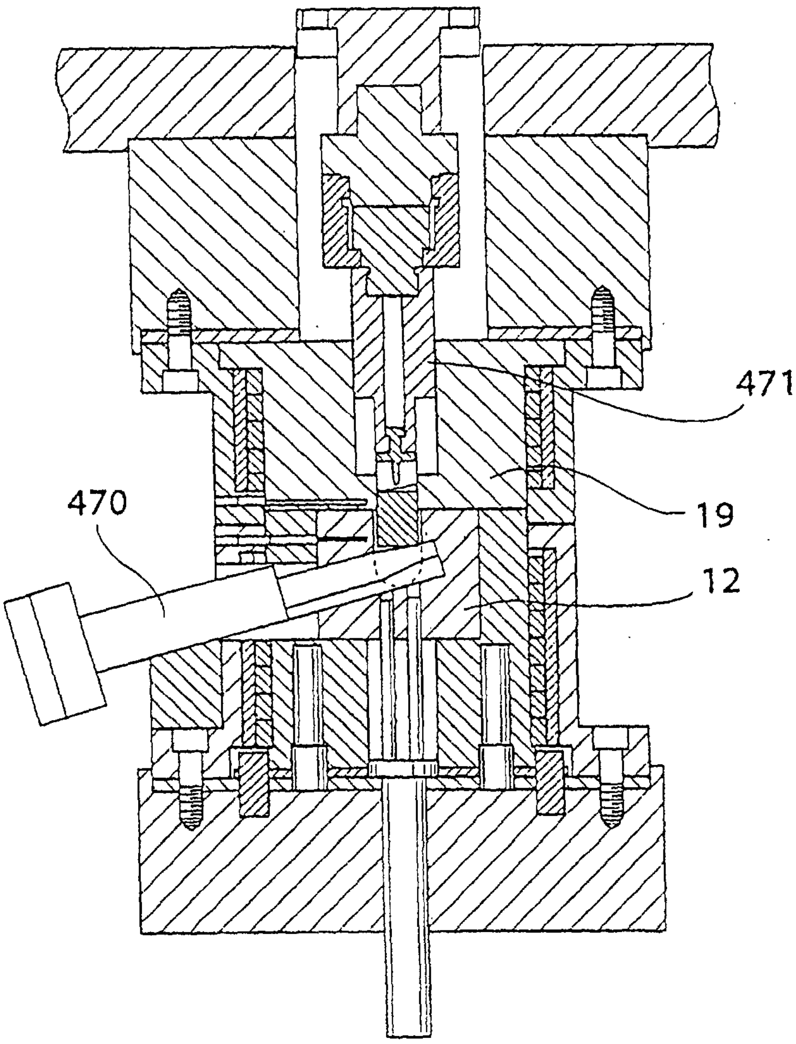


FIG. 104

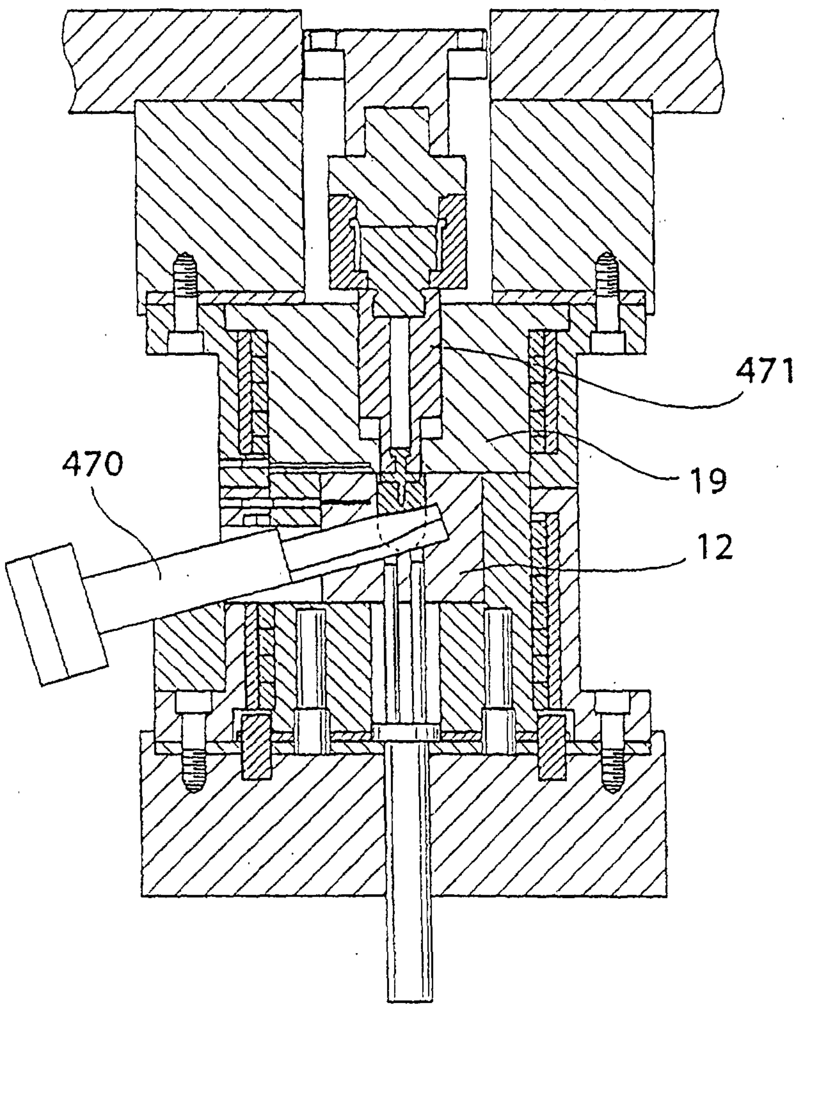


FIG. 105

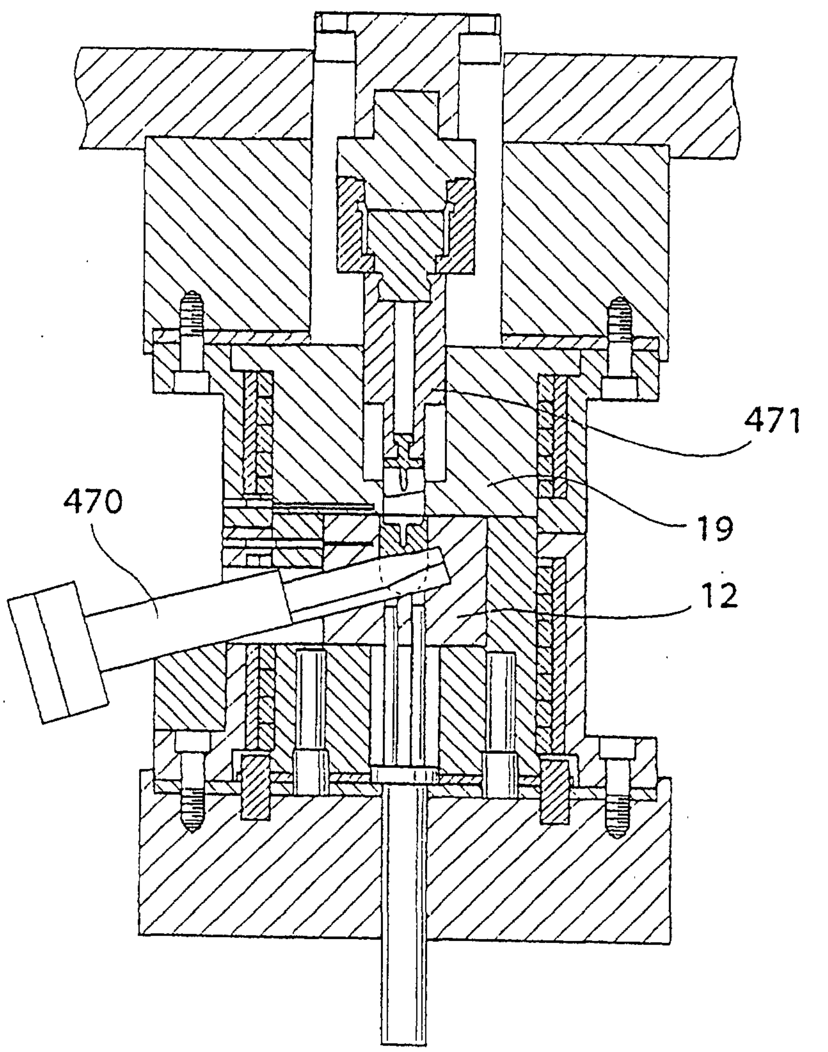


FIG. 106

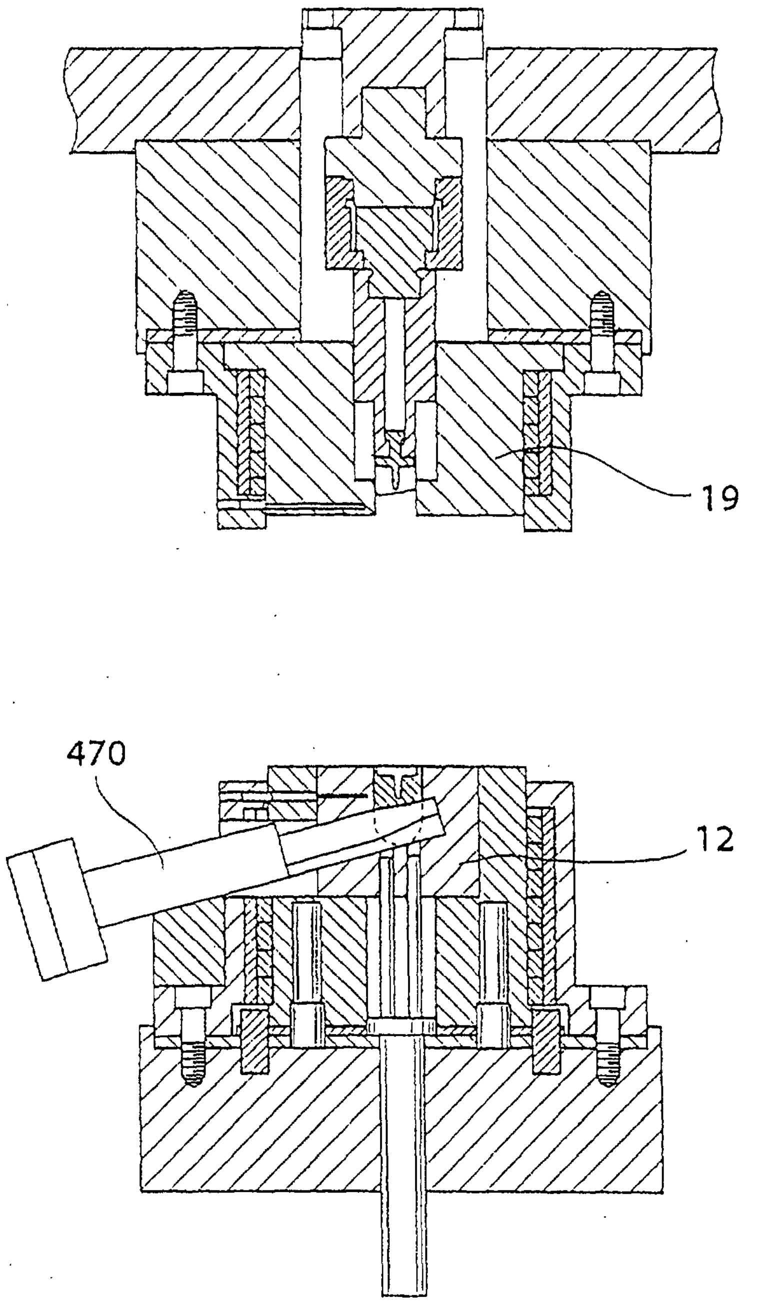


FIG. 107

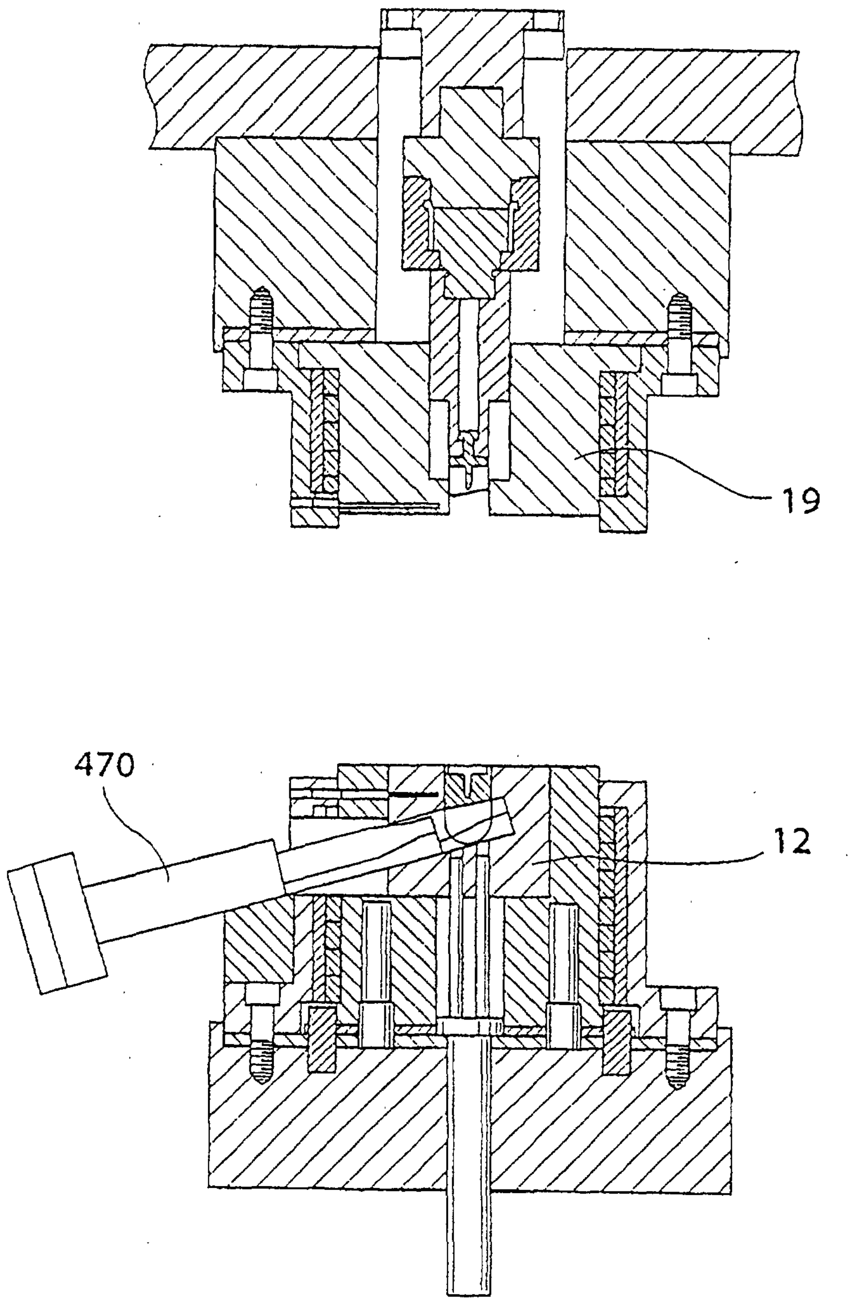


FIG. 108

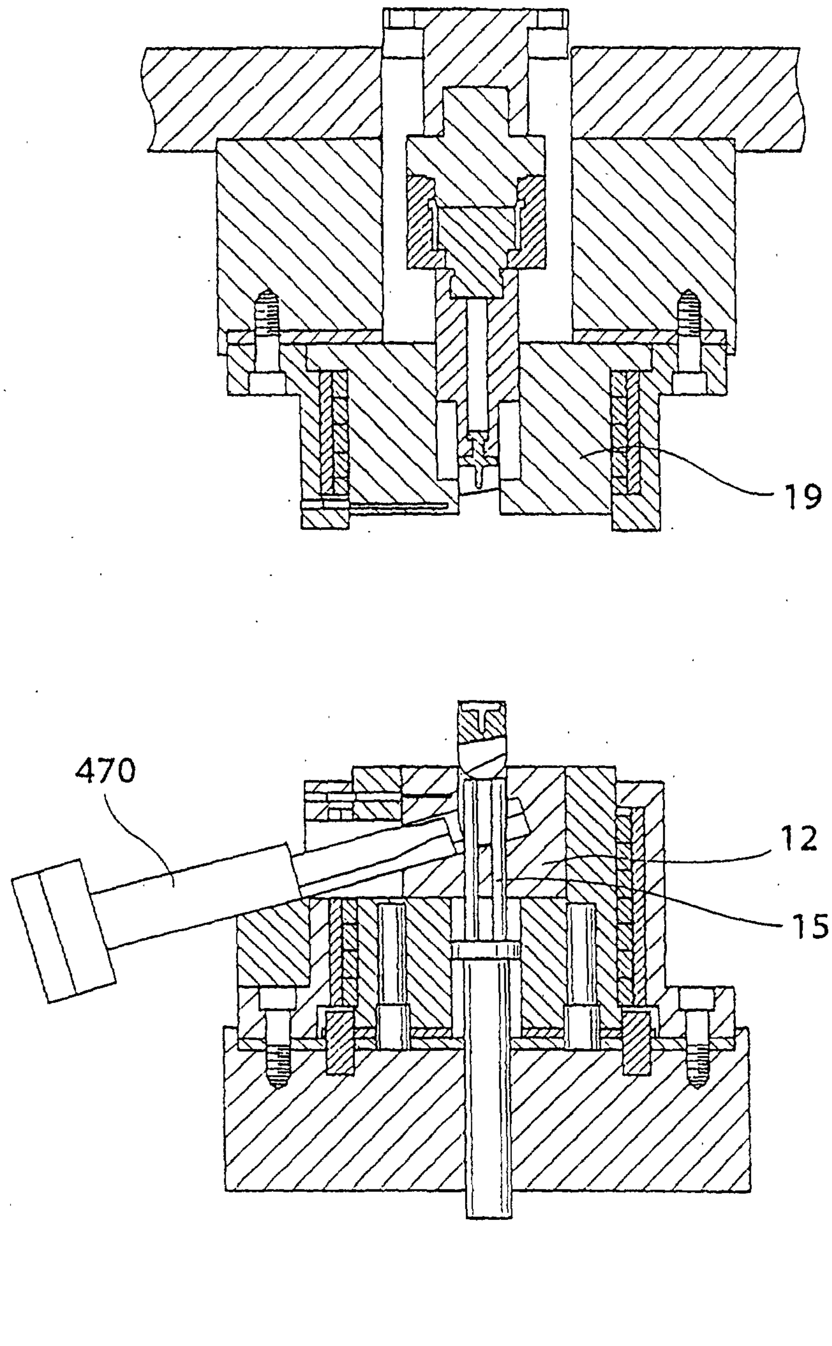


FIG. 109

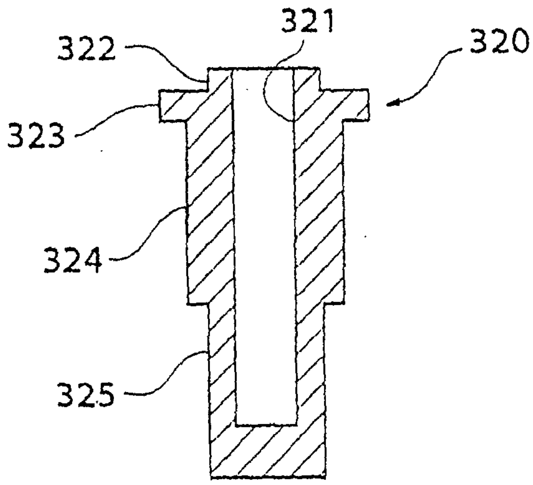


FIG. 110

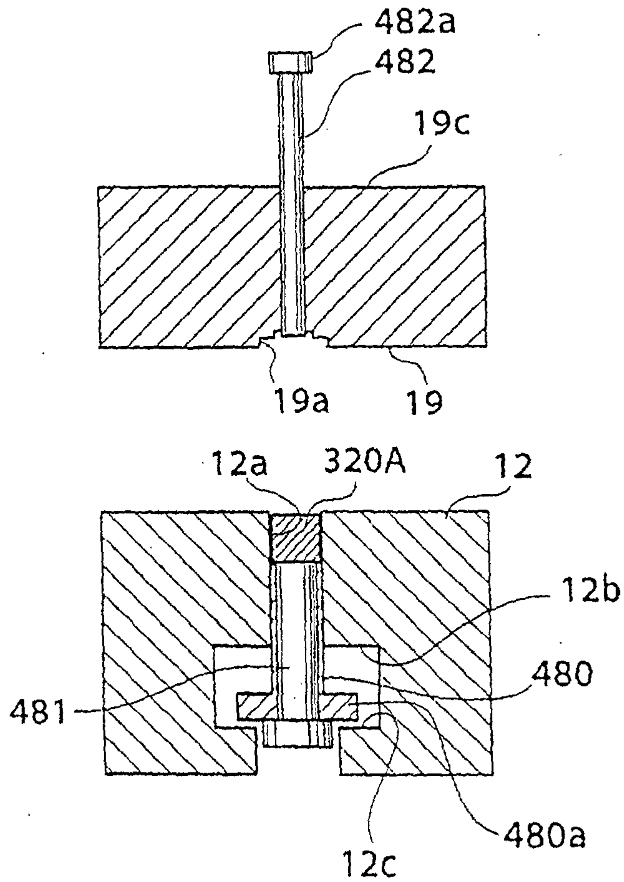


FIG. 111

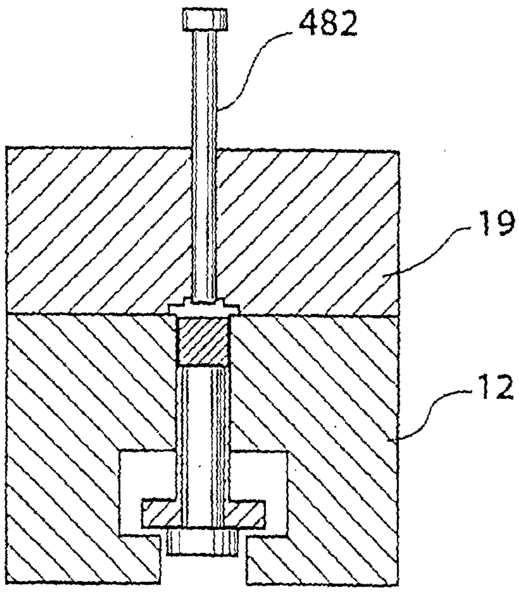


FIG. 112

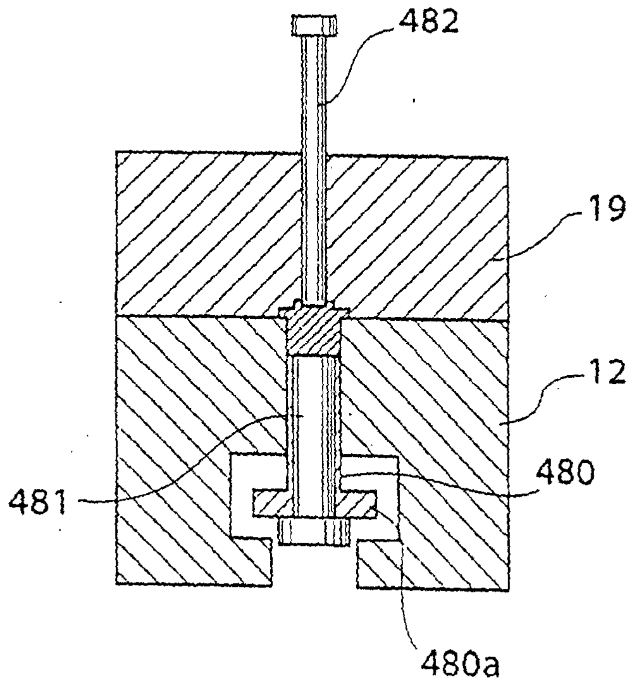


FIG. 113

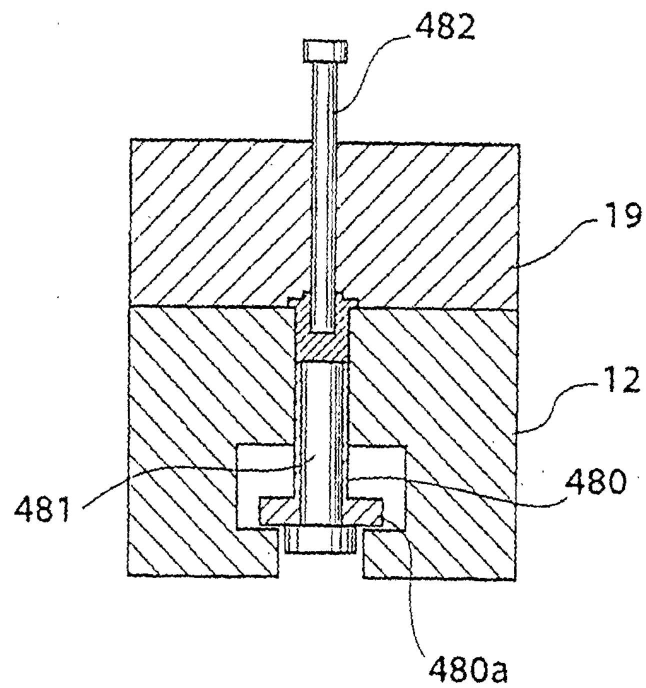


FIG. 114

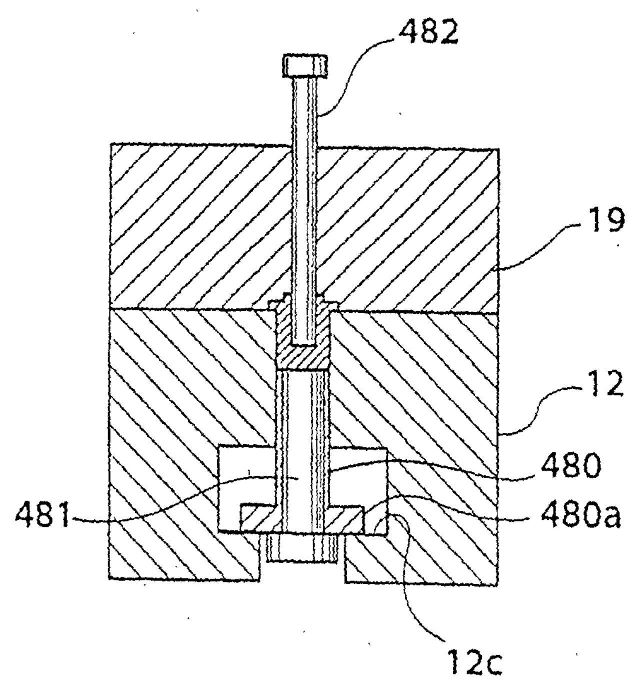


FIG. 115

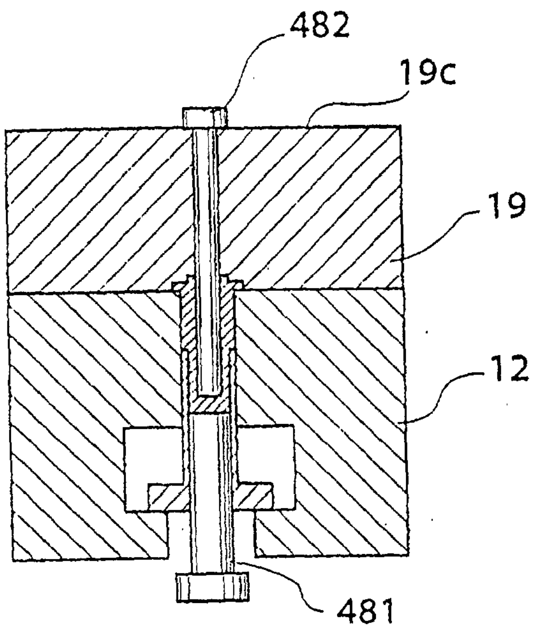


FIG. 116

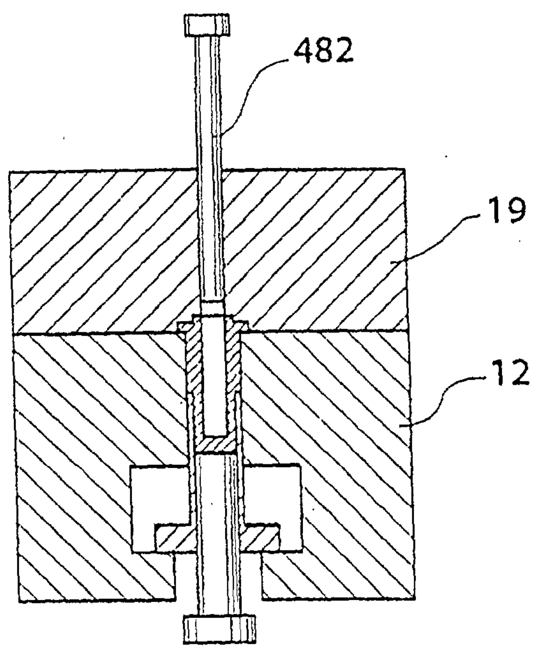


FIG.117

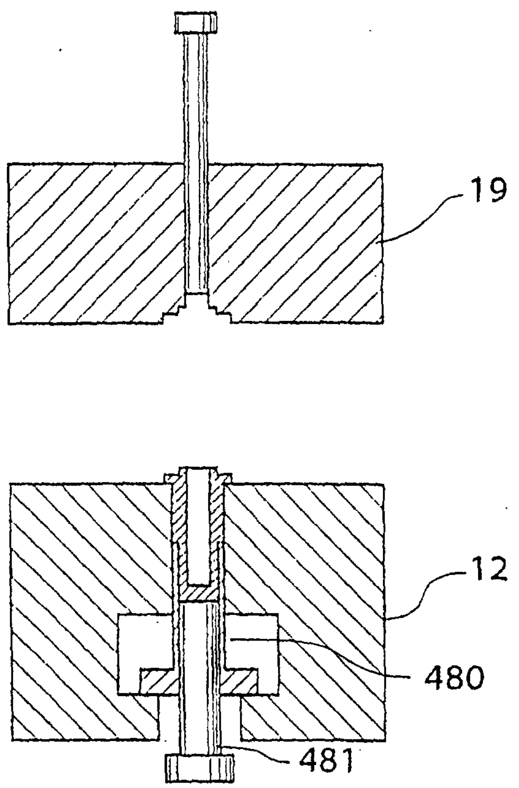


FIG. 118

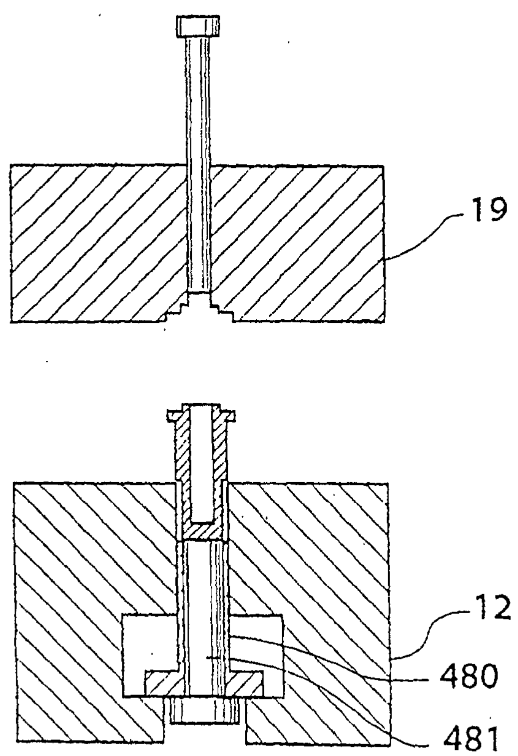


FIG. 119

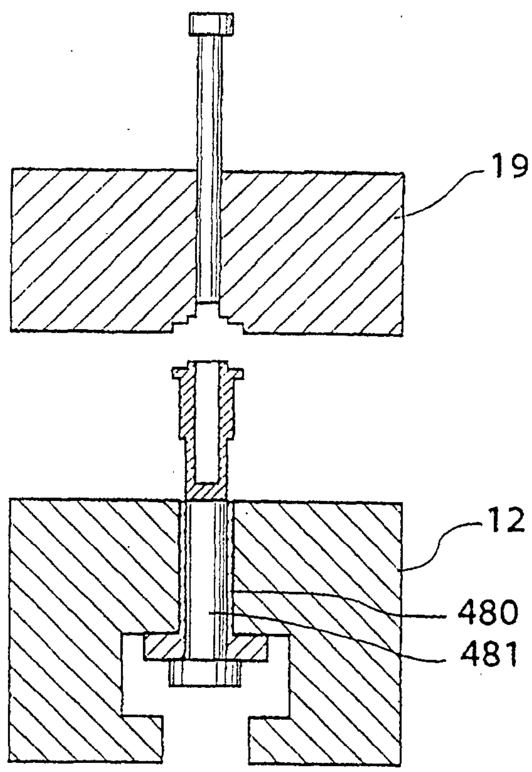


FIG. 120

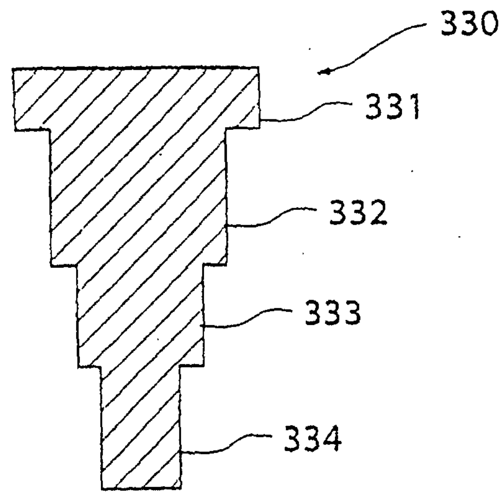
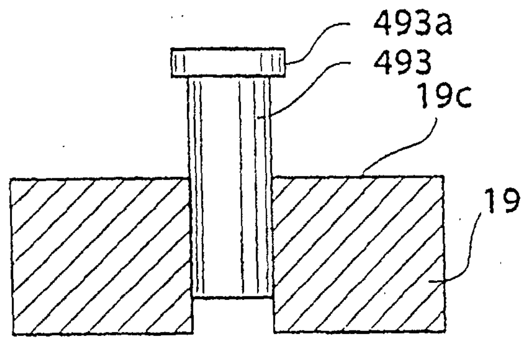


FIG. 121



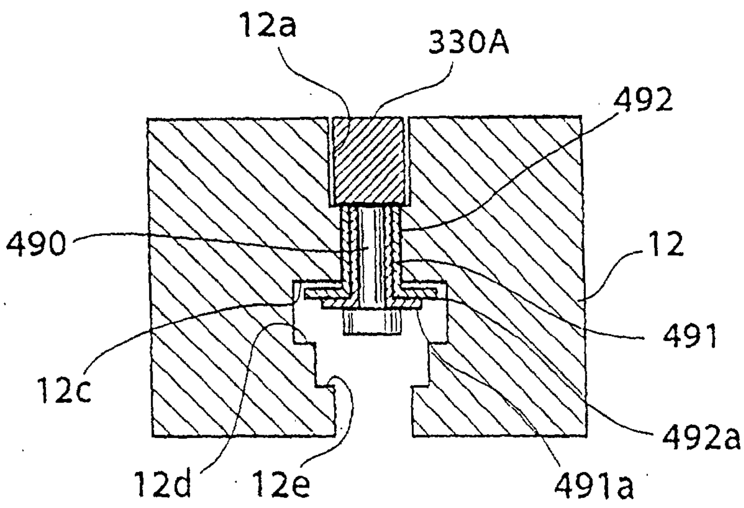


FIG. 122

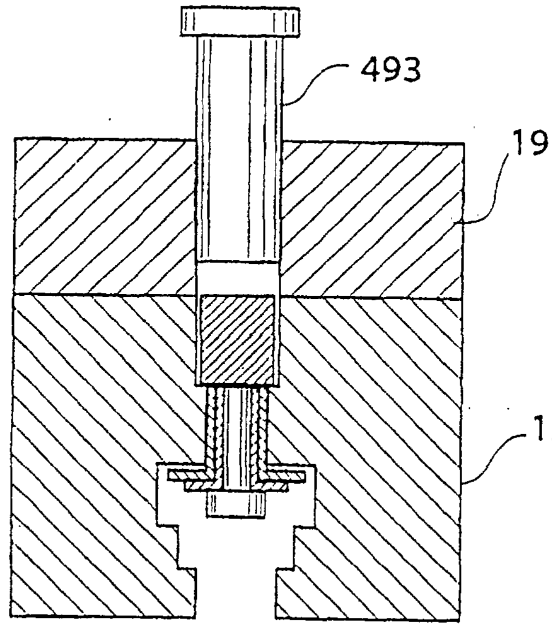


FIG. 123

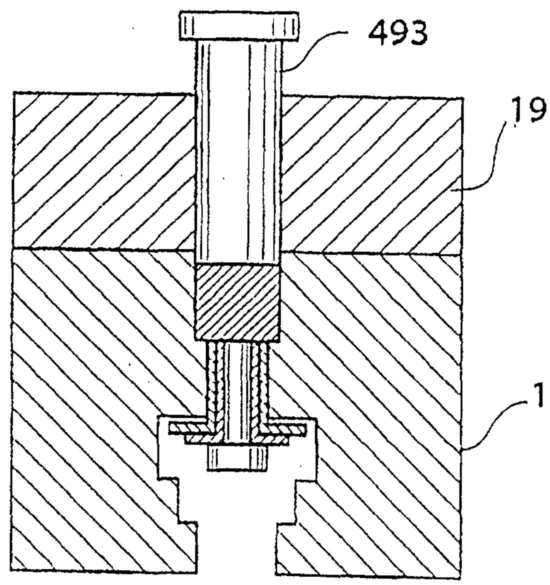


FIG. 124

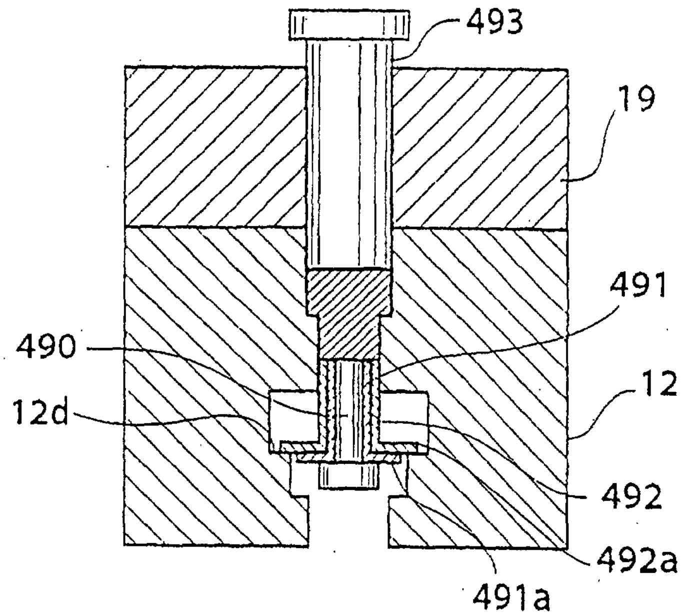


FIG. 125

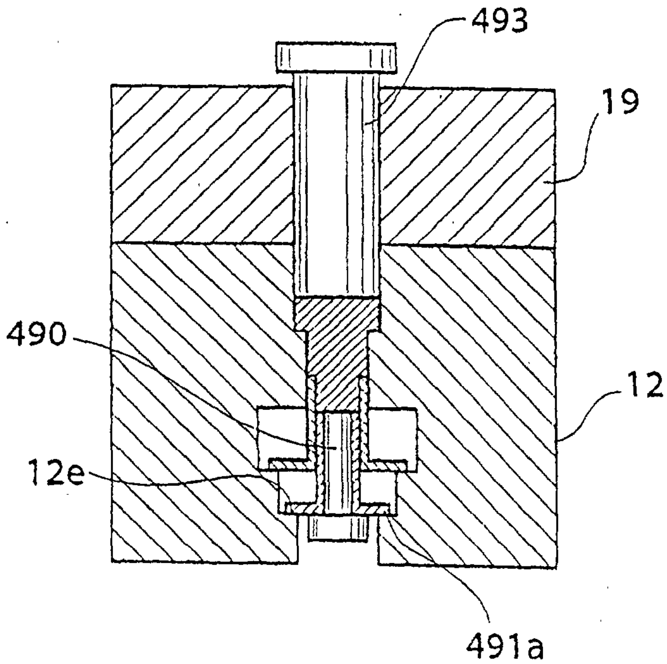


FIG. 126

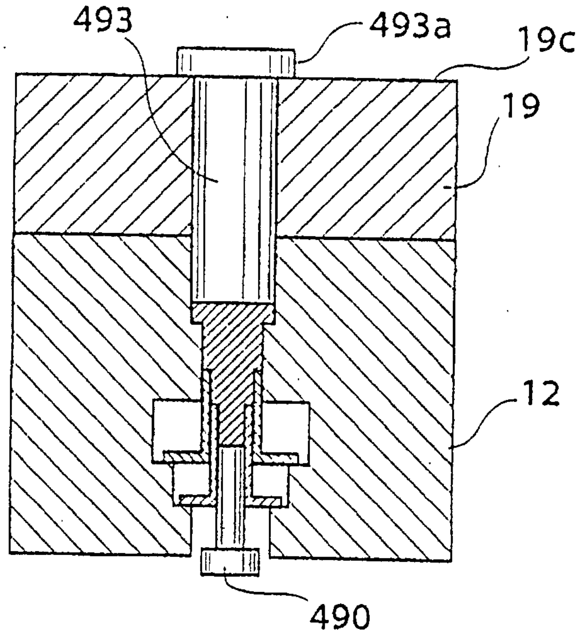


FIG. 127

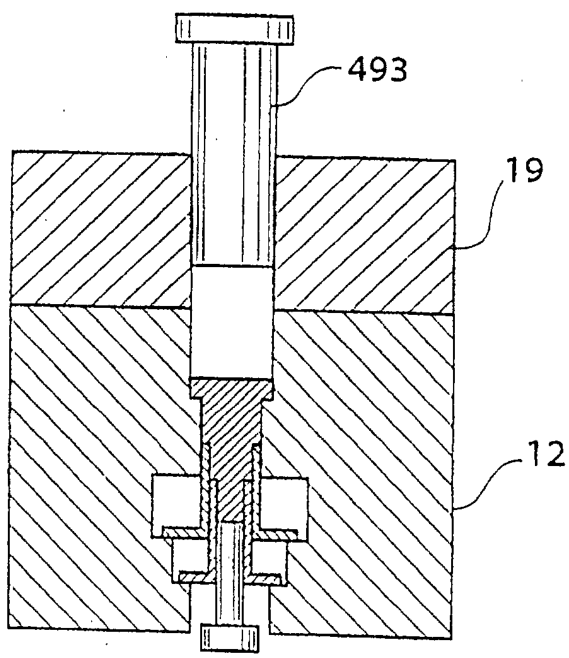


FIG. 128

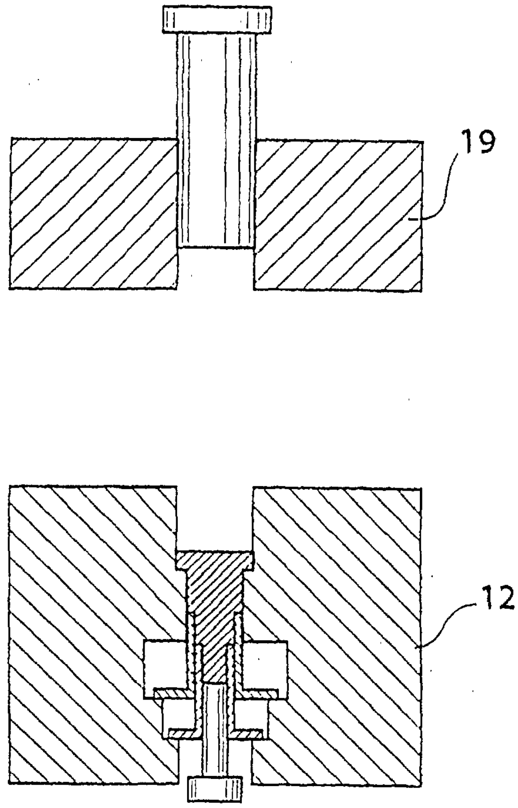


FIG. 129

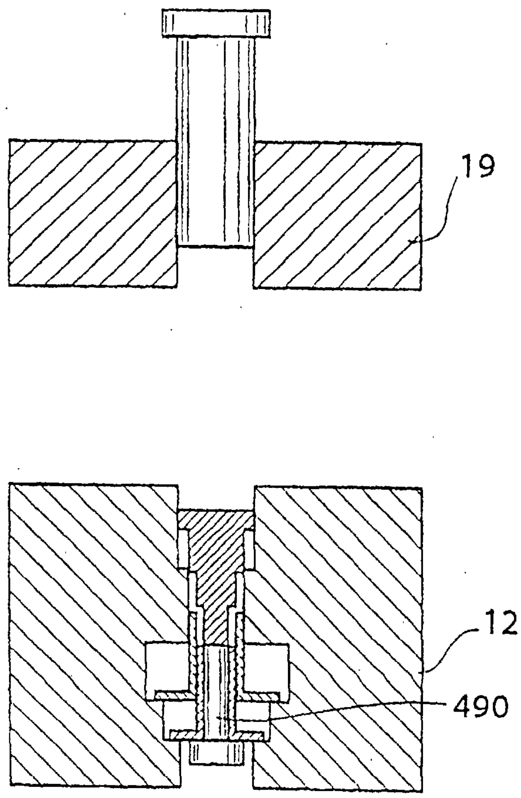


FIG. 130

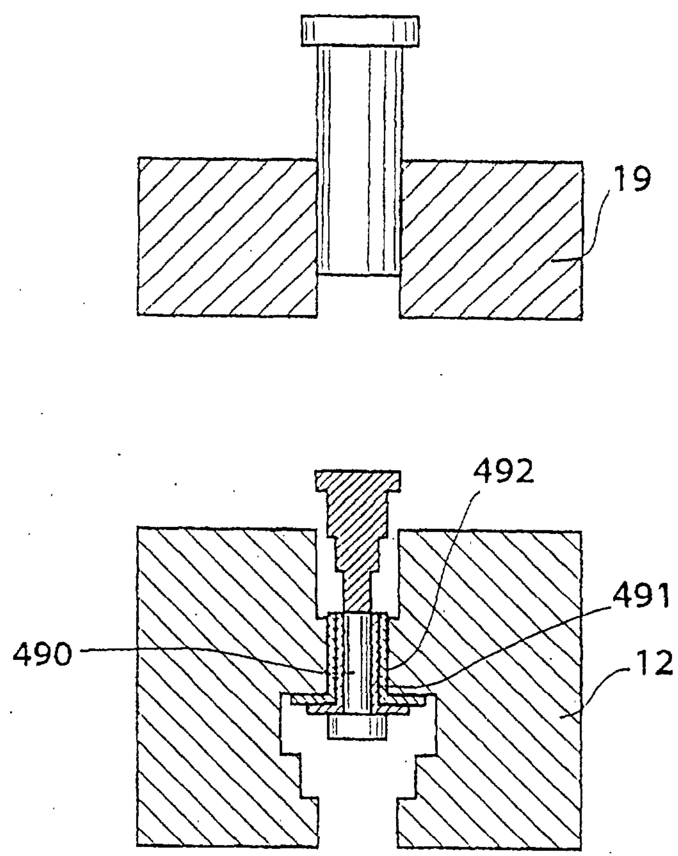


FIG. 131

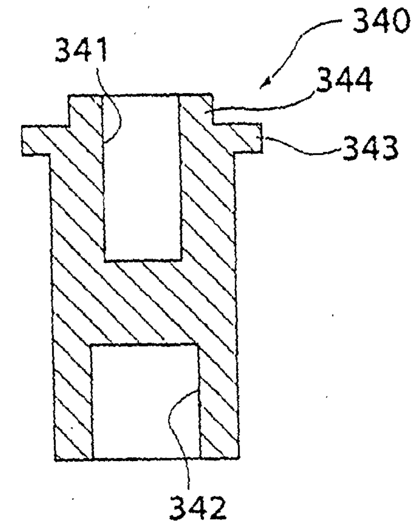


FIG. 132

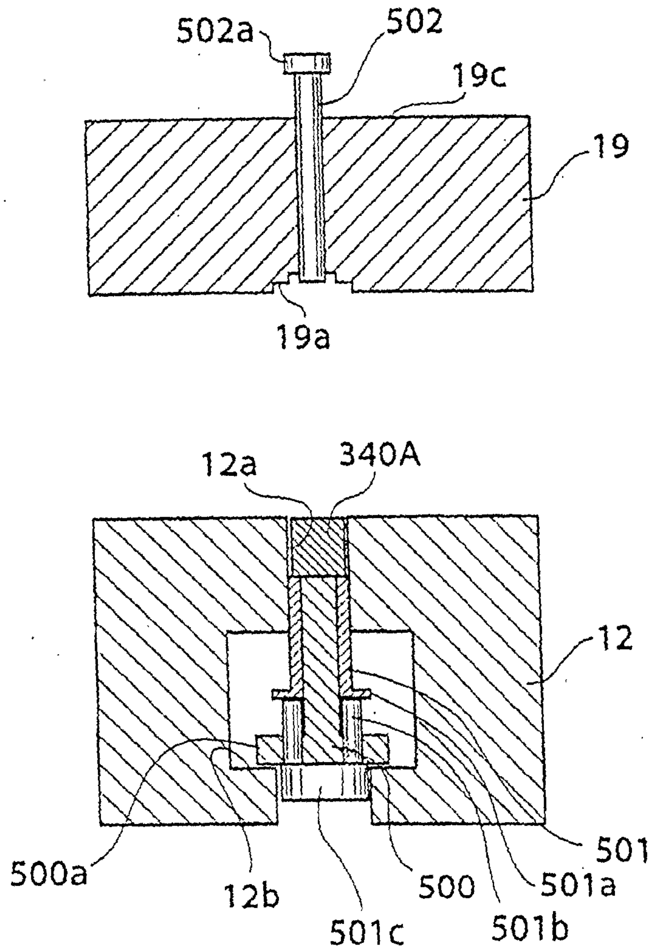


FIG. 133

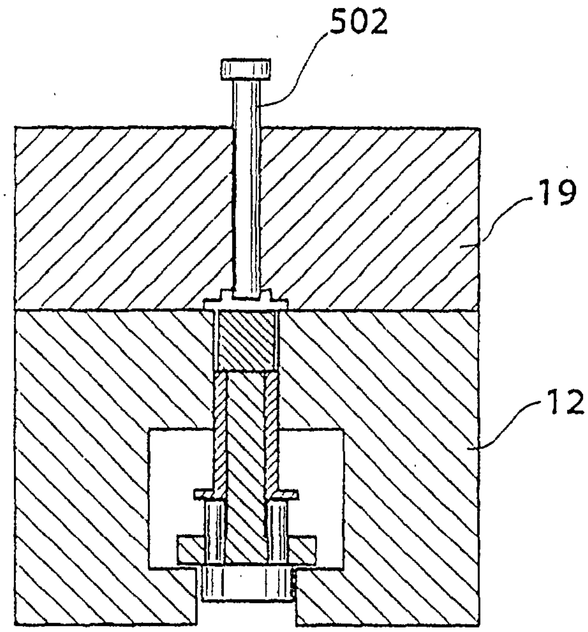


FIG. 134

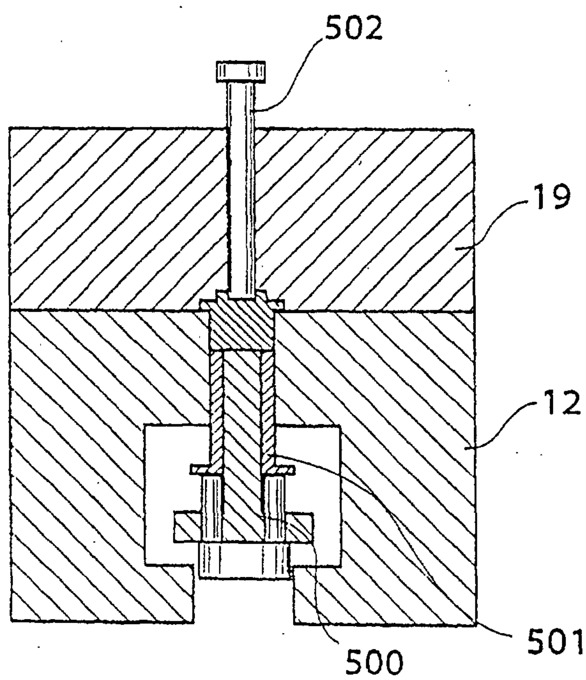


FIG. 135

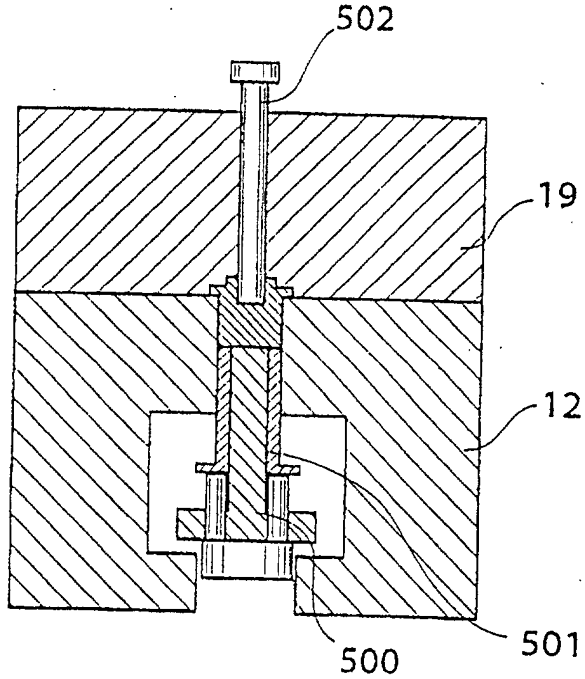


FIG. 136

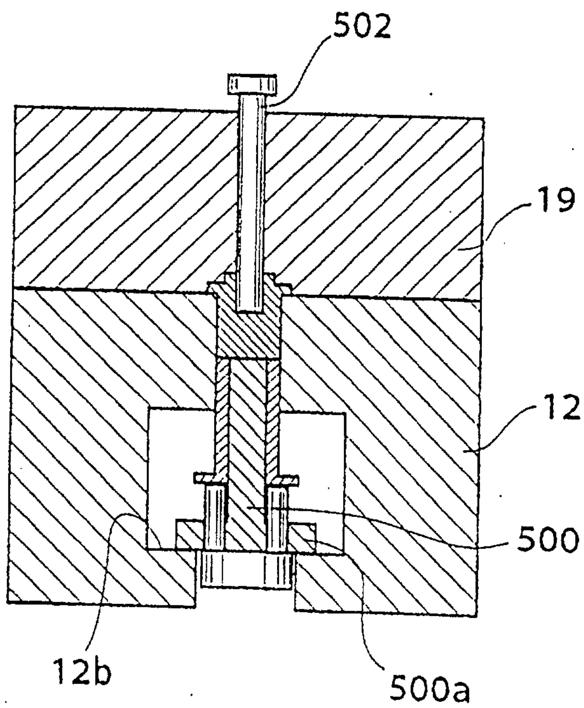


FIG. 137

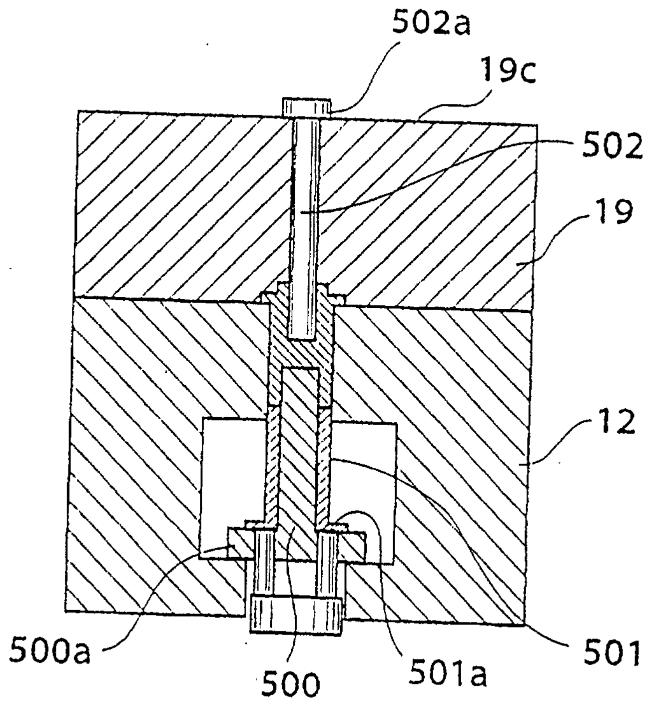


FIG. 138

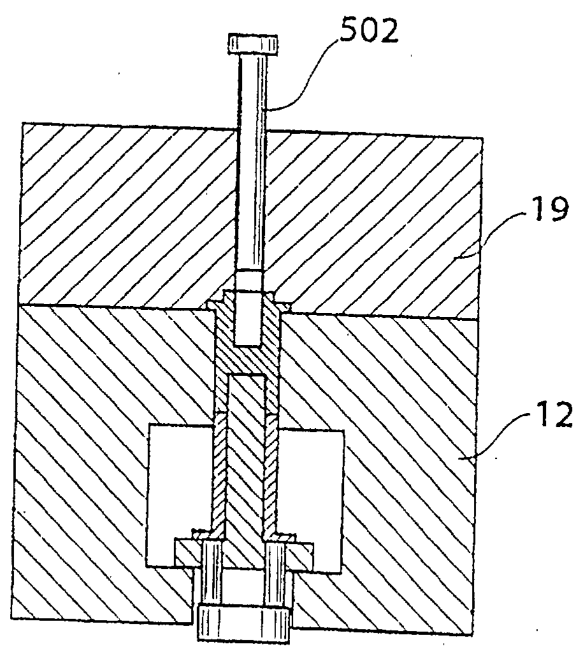


FIG. 139

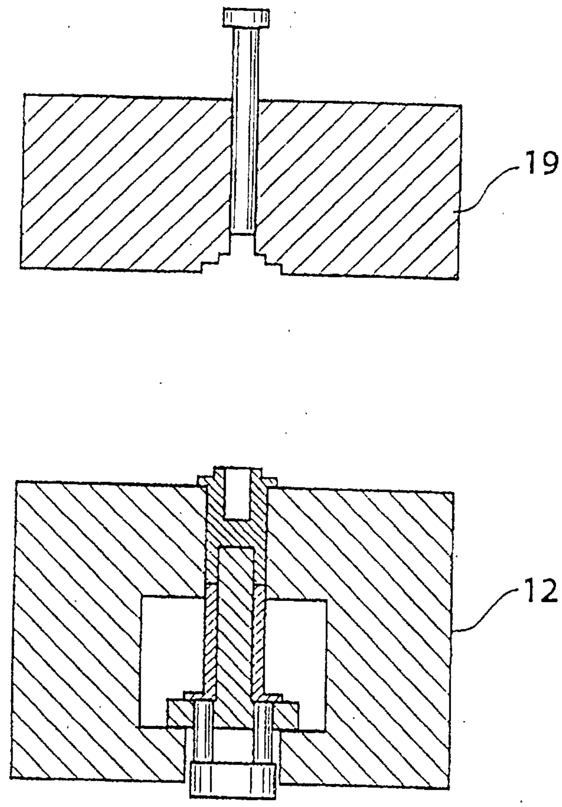


FIG. 140

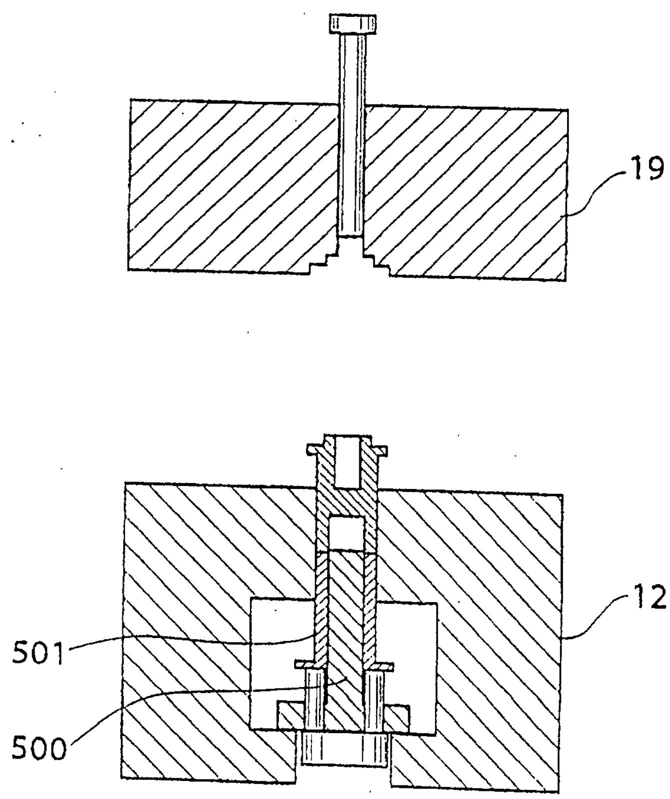
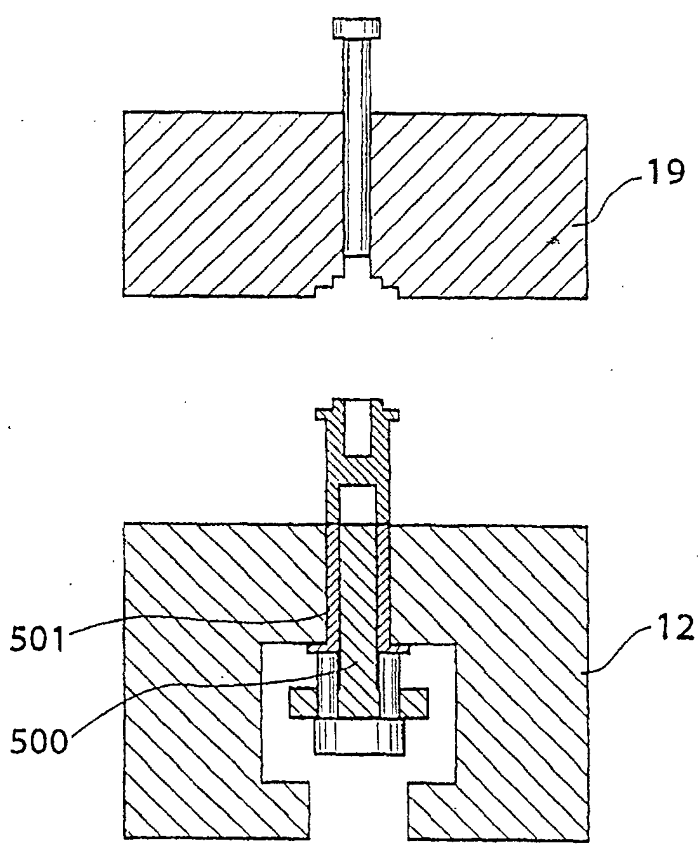


FIG. 141



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/03964

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[6] B21J5/02, B21K23/04, C22C9/04

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[6] B21J5/02, B21K23/04, C22C9/00-9/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1926-1996 Toroku Jitsuyo Shinan Koho 1994-1999
Kokai Jitsuyo Shinan Koho 1971-1999 Jitsuyo Shinan Toroku Koho 1996-1999

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, 55-156631, A (Mitsubishi Heavy Industries,Ltd., et al.), 5 December, 1980 (05. 12. 80), Page 2, upper right column, line 6 to page 3, upper right column, line 3 ; Figs. 10 to 12 & US, 4271655, A & GB, 2048814, B & DE, 2935894, A1 & CH, 640188, A	1, 2, 4, 7, 9, 10, 11, 15, 16, 18 6, 12, 17
X Y A	JP, 4-17934, A (TMT), 22 January, 1992 (22. 01. 92), Page 1, left column, line 5 to right column, line 8 ; page 3, upper right column, line 2 to page 4, upper left column, line 11 (Family: none)	6, 8 7, 9, 11 12

[X] 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
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"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	Date of mailing of the international search report
13 October, 1999 (13. 10. 99)	26 October, 1999 (26. 10. 99)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/03964

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP, 4-344845, A (Kubota Corp.), 1 December, 1992 (01. 12. 92), Claims 1, 2 ; Par. Nos. [0007], [0011] ; Figs. 1 to 6 (Family: none)	6 11, 13 26
X X A	JP, 7-236937, A (Mitsubishi Motors Corp., et al.), 12 September, 1995 (12. 09. 95), Claim 1 ; Par. No. [0012] ; Fig. 1 ; Par. Nos. [0015] to [0018] Par. Nos. [0019] to [0023] ; Figs. 3, 4 (Family: none)	15 17 16, 18, 19
Y	JP, 58-84632, A (Daini Seikosha K.K.), 20 May, 1983 (20. 05. 83), Page 1, left column, lines 5 to 9 ; page 1, right column, line 15 to page 2, upper right column, line 1 ; Figs. 1 to 4 (Family: none)	15-17
Y A	JP, 1-228638, A (Susumu Ito), 12 September, 1989 (12. 09. 89), Page 1, left column, line 5 to right column, line 8 ; page 3, upper right column, line 16 to page 4, upper left column, line 16 ; Fig. 4 (Family: none)	17 15, 16
A	JP, 2-274341, A (Komatsu Ltd.), 8 November, 1990 (08. 11. 90), Page 1, right column, lines 5 to 13 ; Figs. 2 to 4 (Family: none)	15-17
X Y	JP, 61-27137, A (Mitsubishi Heavy Industries, Ltd.), 6 February, 1986 (06. 02. 86), Page 1, left column, line 5 to right column, line 12 ; page 3, upper right column, line 9 to page 4, upper right column, line 4 ; Fig. 1 (Family: none)	1, 6, 8, 15 2, 4, 17
X	JP, 62-240129, A (Honda Motor Co., Ltd.), 20 October, 1987 (20. 10. 87), Page 1, left column, lines 5 to 18 ; page 3, lower left column, line 15 to page 4, upper left column, line 15 ; Figs. 1 to 4 (Family: none)	5, 10
X	JP, 63-101137, U (Nissan Motor Co., Ltd.), 1 July, 1988 (01. 07. 88), Page 1, lines 5 to 14 ; page 11, lines 12 to 19 (Family: none)	6
X Y	JP, 6-126369, A (Toyota Motor Corp.), 10 May, 1994 (10. 05. 94), Claim 1 ; Par. Nos. [0019], [0020] ; Fig. 1 (Family: none)	6 8

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP99/03964

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP, 6-114489, A (Mitsubishi Materials Corp.), 26 April, 1994 (26. 04. 94), Claim 1 ; Par. Nos. [0013] to [0023] ; Figs. 1 to 4 (Family: none)	11
Y		26
Y	JP, 6-39471, A (Mitsubishi Materials Corp.), 15 February, 1994 (15. 02. 94), Claim 1 ; Par. No. [0006] ; Figs. 1, 2 (Family: none)	10
X	JP, 7-166279, A (Kobe Steel,Ltd.), 27 June, 1995 (27. 06. 95), Abstract ; Claims ; Par. No. [0012] (Family: none)	23
Y	JP, 49-23970, B1 (The Furukawa Electric Co., Ltd.), 19 June, 1974 (19. 06. 74), Page 1, left column, lines 17 to 25 ; page 2, right column, lines 25 to 34 (Family: none)	23
Y	JP, 10-46364, A (TOTO Ltd.), 17 February, 1998 (17. 02. 98), Abstract ; Claims ; Par. Nos. [0038] to [0042] (Family: none)	23
A	JP, 1-272734, A (Kobe Steel,Ltd.), 31 October, 1989 (31. 10. 89), Page 1, left column, lines 5 to 11 (Family: none)	27
A	JP, 63-203735, A (Sumitomo Electric Industries,Ltd.), 23 August, 1988 (23. 08. 88), Page 1, left column, line 5 to right column, line 5 (Family: none)	23-27
A	JP, 6-158251, A (Sumitomo Metal Mining Co., Ltd.), 7 June, 1994 (07. 06. 94), Claims (Family: none)	23-27

Form PCT/ISA/210 (continuation of second sheet) (July 1992)