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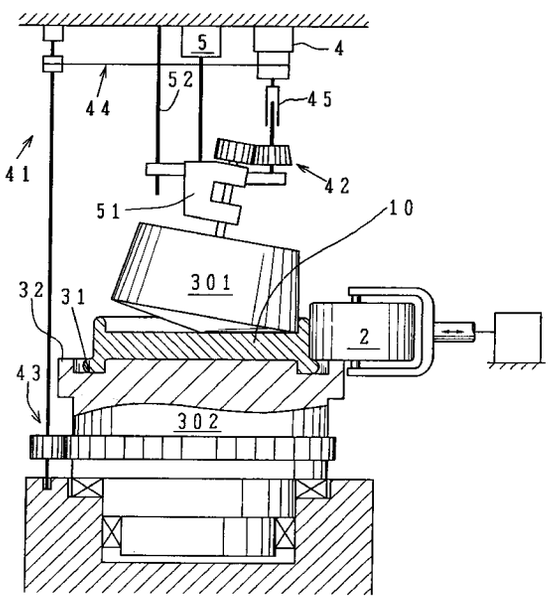
(54) Rotary forging apparatus.

(57) A rotary forging apparatus comprises a first rotary ram (301) having a conical pressing surface and a slanting rotary axis, a second rotary ram (302) facing the first ram (301) and having a vertical rotary axis, and a shaping roller (2) equipped beside the rams. The apparatus forges a product from a mass of material (workpiece 10) by sandwiching the workpiece (10) between the first ram (301) and the second ram (302), pressing the workpiece (10) with the rams which rotate synchronously, thinning the workpiece (10) into the disc part (1) of a product, pressing the excluded material out of the rams with the shaping roller and the rams and shaping into the rim part. This invention provides a rotary forging apparatus which can prevent a generation of cracks or flashes on the disc part (1) or the rim part (11) when the apparatus forges a wheel having a rim part (11) which consists of a small rim part and a large rim part. This invention provides a rim-shaping surface around the pressing surface of the second ram (302) for shaping a small rim and an annular wall (32) standind out toward the first ram (301) at a peripheral edge of the rim-shaping surface for restraining and shaping an end of the small rim. A bottom surface of the shaping roller (2) comes into touch with or comes very close to a top face of the annular wall (32).

FIG. 6



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This invention relates to a rotary forging apparatus, In particular it relates to an apparatus for forming a wheel with a disc part and a rim part which comprises of a large rim part and a small rim part formed around the disc part.

Japanese Patent Laying Open No.61-226132 proposed a rotary forging apparatus having two rams and a side roller. Fig.1 shows an example. A thick disc-like or shallow columnar initial mass of material (a workpiece 10) is placed between an upper ram (a first ram 301) and a lower ram (a second ram 302) which can rotate simultaneously. The disc part 1 is formed by pressing and thinning a central part of the workpiece between a bottom surface of the first ram 301 and a top surface of the second ram 302, and the rim part 11 is formed by pressing an extruded material out of the rams with a roller installed beside the boundary of the rams by a hot forging.

The top surface (a pressing surface) of the second ram 302 is shaped to form a bottom surface of the disc part 1 and an inner surface of the lower rim part. The first ram 301 has an umbrella-like bottom i.e. a cone with an obtuse top angle. A rotary axis of the first ram 301 is inclined slightly, e.g. at 2 to 5 degrees, from the perpendicular rotary axis of the second ram 302 so that a generating line of the conical bottom surface of the first ram 301 is horizontal at the roller side. A generating line is defined as a line of a section of a rotationally symmetric object taken along a plane including a central axis. A rotationally symmetric body has an infinite number of generating lines on its outer surface. However all the generating lines are geometrically identical because of the rotational symmetry. Since the upper ram 301 is inclined slightly from the perpendicular, only a small portion of the conical bottom surface touches the workpiece along a radius which is just included in the plumb symmetry plane.

The roller comprises a rough-shaping roller 21 and a final-shaping roller 22 which can be inserted alternately into the boundary of the rams.

In a first stage, the rough-shaping roller 21 is placed between the first ram 301 and the second ram 302. The forging apparatus synchronously rotates the first ram 301 and the second ram 302 sandwiching the workpiece 10. The first ram 301 is lowered towards the second ram 302 to its lowest position. The workpiece 10 is transformed into an intermediate product having a disc part 1 shaped after the bottom and top surfaces of the rams and a peripheral annular part 110 shaped with the rough-shaping roller 21, as shown in Fig.1.

In a second stage, the disc part 1 and the peripheral annular part 110 are held between the first ram 301 and the second ram 302, but not pressed with the rams. The rams are rotated synchronously and the final-shaping roller 22 presses the peripheral annular part 110. Thus, the peripheral annular part 110 is transformed into a final shape of the rim part 11 of a product by the final shaping roller 22.

The prior forging apparatus is capable of increasing the productivity of the product having the disc part 1 and the rim part 2 formed around the disc part since the workpiece 10 can be kept between the two rams during a forging process that the workpiece 10 is transformed into the final shape of the product.

If the section of the rim part 11 is symmetric with regard to the central plane of the disc part 1 similar to a rope pulley and the like, the apparatus is capable of satisfactorily finishing the section of the rim part 11 of the product. However, it is impossible to make a product with the rim part having an asymmetric section to the disc part, as shown in Fig.3. Because a central portion of the disc part 1 and the vicinity thereof are cracked while the peripheral annular part 110 is shaped with the rough-shaping roller at the first stage.

The reasons for the occurrence of the cracks is now explained.

When the first ram 301 moves towards the second ram 302, the worKpiece 10 is pressed and thinned between the rams. The peripheral outer surface of the workpiece 10 is shaped after an outer surface of the rough-shaping roller 21. The pressing surface of the first ram 301 presses only a fan-shaped area 101 of the workpiece 10, as shown in Fig.4. And a part of a curved side surface of the fan-shaped area 101 is pressed by the side surface of the rough-shaping roller 21. In proportion as the first ram 301 is depressed, extra material of the workpiece 10 shows a tendency to be extruded outwardly in a radial direction. An outward flow of the extra material is partially obstructed by pressing of the rough-shaping roller 21. But the flow of the workpiece 10 is not obstructed at both sides of the roller 21. Thus, the peripheral part of the workpiece 10 swells at the both sides of the roller 21, as shown in Fig.4. Namely, a compression force caused by the pressing of the rough-shaping roller 21 in the radial direction and a spreading force caused by an extrusion of the material act on an inner part of the fan-shaped area 101 of the workpiece 10 alternately while the outer peripheral surface of the workpiece 10 is pressed with the rough-shaping roller 21. Accordingly, cracks are generated in the inner part of the fun-shaped area 101 and its vicinity.

In the prior method, when the first ram 301 moves toward the second ram 302, the material sandwiched between the rams is thinned and spread outwardly. The peripheral portion of the workpiece 10 is extruded out of the pressing surfaces of the rams. Protruding material reaches the side roller 21. Thereafter, the protruding material is divided into two parts evenly. A space surrounded by the first ram 301, the second ram 302 and the rough-shaping roller 21 is filled with the protruding material.

In the case of Fig.3, however, the protruding matrial is charged into the space between the first ram

301 and the roller 21 at the first half stage of the thinning. At this time, the material has not fully occupied the space between the second ram 302 and the roller. The first ram 301 presses and thins the workpiece 10 till the space between the ram 302 and the roller 21 is filled with the protruding material. Thus, extruded material is formed into the peripheral annular part 110. When the space between the second ram 302 and the side roller 21 is filled with the material, the extruding material is forced into the space between the first ram 301 and the roller 21 where has already been full of the material more and more. An abnormal pressure causes in the space between the ram 301 and the roller 21. Therefore, extra material protrudes from a small opening between the ram 301 and the roller 21. This is a cause that flashes are generated at an end of the rim part.

One purpose of the present invention is to provide an improvement capable of shaping a product with a rim part having an asymmetric section to the disc part, e.g. having a large rim part and a small rim part, without cracks being formed at a center and the vicinity of the disc part, and without flashes at an end of the rim part in a rotary forging apparatus which has a rotary first ram 301, a rotary second ram 302, a shaping roller 2 installed beside the rams, and forges a wheel from a workpiece 10 by forming the disc part 1 with the rams and by shaping the rim part with the roller and the side surfaces of the rams.

In order to solve the difficulty, this invention proposes a rotary forging apparatus having a first rotary ram 301 with a conical pressing surface which rotates around an inclined axis, a second rotary ram 302 which faces the first ram 301 and rotates around a substantially vertical axis, a rim-shaping surface provided externally to the pressing surface of the second ram 302 for forming a small rim part, an annular wall 32 standing out toward the first ram 301 at the peripheral edge of the rim-shaping surface for shaping an end of the small rim part, and a shaping roller 2 supported rotatably so that it can come into contact with or come very close to a top face of the annular wall 32.

The function of the rotary forging apparatus of this invention is explained by taking an example of making a wheel having a rim part with a small rim part and a large rim part. The apparatus forges an object wheel from a workpiece 10 (starting material) by sandwiching the workpiece between the first ram 301 and the second ram 302, pressing and thinning the workpiece 10 with the rams 302 and 301, extruding a peripheral portion of the material from between the pressing surfaces of the rams, pressing the protruding material with the shaping roller 2, bending or extending the protruding material in the axial direction with the side surfaces of the rams and the roller. Thus, the extruded material is formed into the rim part 11.

The pressing surface of the second ram 302 is surrounded by the rim-shaping surface for forming the small rim part. The annular wall 32 is formed at the peripheral edge of the rim-shaping surface. The shaping roller 2 is supported rotatably and a bottom surface of the shaping roller 2 comes into touch with or comes very close to the top face of the annular wall 32. Therefore, at an early stage of forging, a part of the extruded material is charged into a space beleaguered by the rim-shaping surface, the annular wall 32 and the bottom surface of the shaping roller 2.

Thereafter, as the workpiece 10 is further pressed by the rams, the amount of the extruded material increases more and more. The protruding material flowing toward the rim-shaping surface is intercepted by the anuular wall 32. Therefore, the material flows into an another space between the first ram 301 and the shaping roller 2 by a rolling process with the rams and roller.

At the final stage of lowering of the first ram 301, both outer and inner surfaces of the disc part 1 are formed by the pressing surfaces of the rams and the rim part 11 is formed into the asymmetric section having the large rim part and the small rim part.

If a product with the rim part 11 having such a complicated section as an automobile wheel must be forged, a shape of the side surface of the first ram 301 and a shape of the side surface of the shaping roller 2 may be decided so as to suitable to the shape of the rim part.

The advantage of the invention is explained.

When the small rim part has been formed at the early stage, the end of the small rim part will be restricted by the peripheral annular wall 32. In other words, only part of the material of the workpiece where is near the second ram 302 is restrained. When the following rotary forging process proceeds with the end of the small rim part restricted, only part of the material which is near the first ram 301 in the workpiece 10 is spread. Accordingly, after the restriction of the end of the small rim part, the problem that the inner part of the fun-shaped area 101 and its vicinity are cracked by altering between compression and spreading in the radial direction.

At the latter half stage of the forging process, the pressure for shaping the small rim part at the rim-shaping surface of the second ram 302 rises substantially. The extruded material at the rim-shaping surface, however, is confined by the wall surrounding the rim-shaping surface. Accordingly, the restriction of the material suppresses the occurrence of a flash.

[VERSIONS OF THE INVENTION]

This invention has other versions besides the fundamental structure abovementioned. Four typical improvements of this invention will be further explained.

A first version (claim 2) proposes a rotary forging

apparatus in which the shaping roller 2 with a truncated conical part is installed beside a boundary between the first ran 301 and the second ram 302 rams, the truncated conical part tapers off to the first ram 301.

In this version the workpiece 10 is pressed between the first ram 301 and the second ram 302 and the extra material protrudes from the pressing surfaces of the rams. The extruded material reaches the truncated conical part of the roller 2. Since the truncated conical part tapers to the first ram 301, at the early step of depressing, there is much space between the outer peripheral edge of the pressig surface of the first ram 301 and the side surface of the roller 2. With an advance of the lowering of the first ram 301, the space becomes smaller gradually. Therefore, the thickness of the peripheral annular part 110 formed by spread of the extruded material with the first ram 301 and the roller 2 becomes thinner gradually toward the disc part 1. That is to say, it is possible to thicken the open end of the annular portion extending from the peripheral part of the disc part 1.

A second version (claim 3) aims at forming the automobile wheel by using the rotary forging apparatus claimed in claim 1.

The second version therefore proposes a rotary forging apparatus wherein the pressing surface and the rim-shaping surface of the second ram 302 are shaped after an outer surface of the disc part 1, an inner surface of the outer rim 12 and an outer surface of a rim flange 121 of the automobile wheel, the pressing surface and the side surface of the first ram 301 are shaped after an inner surface of the disc part 1, a part of an inner surface of the inner rim 13 where is vicinage of the disc part, an outer rim-shaping surface 25 is provided at the side surface of the shaping roller 2, and the outer rim-shaping surface 25 is shaped after an outer surface of the outer rim 12 and an inner surface of the rim flange 121.

The second version has an advantage of forming the both side surfaces of the disc part 1, all of the outer rim part 12 and at least a part of the inner rim 13 which is near the disc part 1 of the automovile wheel at one process.

A third version (claim 4) aims at adjusting the thickness of the rim part by enabling controls of a horizontal transference and a vertical transference of the shaping roller 2 whilst maintaining a substantially vertical orientation.

This version enables the shaping roller to move both in the horizontal and vertical directions to the first ram 301 and the second ram 302. Therefore this version succeeds in regulating the thickness of the rim part by controling the position of the roller 2 is a vertical and horizontal direction.

A fourth version (claim 5) aims at shaping the disc part 1 having concave or convex patterns. The fourth version further requires that a certain area of the pressing surfaces of the second ram 302 has negative patterns similar to the concave or convex patterns of the disc part 1 of the object product. When the rim flange 121 has been formed at the early step of forging, an edge of the rim flange 121 is confined by the annular wall 32. Therefore the material of the workpiece 10 is surely charged inot the concave or convex patterns of the pressing surface of the second ram 302 by the following thinning to the workpiece 10. Accordingly, the outer surfaces of the disc part 1 can be shaped after the concave or convex patterns of the pressing surface of the second ram 302 correctly. Namely the accuracy of shaping increases.

The invention will be described now by way of example only with reference to the accompanying drawings in which,

Fig.1 is a partially sectioned view of a prior rotary forging apparatus during formation of a rim part with a rectangular section by a rough-shaping roller.

Fig.2 is a partial section of a prior rotary forging apparatus during formation of a rim part by using a final shaping roller.

Fig.3 is a partial section of the prior rotary forging apparatus during the formation of a rim part with an asymmetric section to the disc part.

Fig.4 is an enlarged transverse sectional view of Fig.3 showing a relation of a fun-shaped area of the workpiece to the shaping roller.

Fig. 5 is a partial sectional view of the whole forging apparatus of a first embodiment of this invention showing the relation of a rams, a shaping roller and a workpiece at an initial step of the rotary forging.

Fig.6 is a partial sectional view of a part of the first embodiment demonstrating the relation of the rams, the shaping roller and the workpiece at an intermediate step of the forging.

Fig.7 is a sectional view of a part of the first embodiment designating the relation of the rams, the shaping roller and the workpiece at a final step of the forging.

Fig.8 is a sectional view of a disc part with rim part of a finished product.

Fig.9 is a partially sectional view of a part of a second embodiment demonstrating the relation of the workpiece, rams and a roller at an initial step.

Fig. 10 is a partially sectional view of the workpiece, the rams and the roller of the second embodiment at an intermediate step.

Fig.11 is a partially sectional view of a part of the workpiece, the rams and the roller of the second embodiment at a final step.

Fig. 12 is a partially sectional view of a part of the workpiece, the rams and the roller of a variation of the second embodiment.

Fig. 13 is a partially sectional view of the workpiece, the rams and the roller of a third embodiment.

Fig. 14 is a partially sectional view of the work-

piece, the rams and the roller of the third embodiment at an intermediate step.

Fig.15 is an explanatory sectional view of spinning .

Fig. 16 is a sectional view of a part of a finished automobile wheel forged by the third embodiment.

Fig. 17 is a partially sectional view of the rams, the workpiece and the roller which can move in a vertical direction and a horizontal direction.

Fig. 18 is a sectional view of the second ram and the workpiece which is roughly formed by an usual forging.

Fig.19 is a partially sectional view of the rams, the roller and the workpiece which is roughly formed by an usual forging.

As clearly shown by Fig.5 to Fig.8, a rotary forging apparatus of a first embodiment has an upper first ram 301 and a lower second ram 302 and a shaping roller 2 equipped beside a boundary of the rams. This apparatus aims at shaping a wheel having a disc part 1 and a cylindrical rim part 11 formed around the disc part 1, as shown in Fig.8. The rim part 11 comprises a flange 14 and a main rim part 111. The flange 14 is provided near the disc part 1. The main rim part 111 extends from an inner end of the flange in an axial direction.

The second ram 302 is rotatably supported along an upright axis. The ram 302 has a top surface designed to coincide in a negative with a section of the disc part 1 of a product and surrounded by an annular groove 31 which opens upwardly. The shape of the groove 31 just coincides with the a section of the flange 14.

The first ram 301 rotates around an axis which is inclined at two degrees to five degrees to a plumb line and is suspended so as to rise and fall in the inclined posture. The bottom surface of the first ram 301 is a cone with a wide obtuse top angle. The drum part of the upper ram 301 is a truncated cone with a narrower upper diameter and a wider lower diameter. A generating line of the conical pressing surface of the first ram 301 becomes almost horizontal at an inclined side of the tilted ram. A generating line of the drum part of the ram 301 becomes almost vertical at the same side. The apex of the conical pressing surface of the first ram 301 coincides with the rotary axis of the second ram 302. When the pressing surface of the first ram 301 approaches the nearest to the pressing surface of the second ram 302, a columnar shaping roller 2 is suspended rotatably outside the boundary between the rams. The shaping roller 2 can move in the radial direction of the second ram 302. There is a small space (e.g. 0.2 mm to 1 mm) between a bottom surface of the shaping roller 2 and the top surface of the annular wall 32.

The first ram 301 and the second ram 302 are driven by a driving device 4 via a transference system 41. The rams rotate synchronously in the same direction by transmitting rotation torque with a transference system 41. The second ram 302 rotates at a certain position and the first ram 301 is suspended and lifted up or down with a ram-rotating device 5 at a settled timing. An output shaft of the ram-rotating device 5 supports an intermediate bracket 51 which rotatably maintains the first ram 301 in a slanting posture. The intermediate bracket 51 has a guide shaft 52 which extends through a hole vertically perforated on a yoke. Since the guide shaft 52 is always kept in parallel with the output shaft of the ram-rotating device 5, the intermediate bracket 51 is raised or lowered by the progress or the recession of an output shaft of the ram-rotating device 5,whilst keeping the same orientation.

The transfarence system 41 comprises a first gear device 42 for transmitting rotation torque from the output shaft of the driving device 4 to the rotary axis of the first ram 301, a second gear device 43 for rotating the second ram 302, and a transference device 44 for transmitting rotation torque from the output shaft of the driving device 4 to an input shaft of the second gear device 43. A pulley transference device or a chain transference device can be adopted as the transference device 44. Speeds and directions of rotation of each of the devices are controled for rotating both rams 301 and 302 at the same speed in the same direction synchronously.

The driving device 4 has two output shafts connected in series. The output shafts expand and contract by a spline coupling 45. Therefore, the first ram 301 can rise and fall, keeping the transference condition to the driving device 4.

A shaping process to form the product shown in Fig.8 is now explained.

A thick disc-like or a columnar workpiece 10 is laid on the top surface of the second ram 302. At the moment, the bottom of the first ram 301 lies on the top surface of the workpiece 10, as shown in Fig.5. The shaping roller 2 is moved inwardly and fixed at a settled position where the side surface of the roller 2 coincides with a outer surface of the main rim part 111.

In this condition the driving device 4 rotates the first and second rams synchronously and lowers the ram-rotating device 5. Thus, the first ram 301 falls toward the second ram 302 and the workpiece 10 is pressed and thinned between the pressing surfaces of the rams. As the workpiece is gradually expanded by the rams, the peripheral part of the workpiece 10 is being excluded from the end surfaces of the rams. This extruded material is formed into an annular part extending upwardly and downwardly by the shaping roller 2.

With the advance of the thinning of the workpiece 10, as shown in Fig.6, the annular part further grows up. The downward annular part penetrates into the peripheral annular groove 31 and fills a space made by the annular groove 31 and the bottom surface of

the shaping roller 2. Thereby, the flange 14 is formed in the annular groove 31. The upward annular part further grows up upwardly and becomes a cylindrical part.

When the thinnning of the workpiece proceeds more and more, the upward cylindrical part alone grows up upwardly in the axial direction with the flange 14 finished in the groove 31. Namely, the periphery of the flange 14 is restricted by the peripheral annular wall 32. Thereby, there is a small difference between a compression and a spreading acting to the material at a fan-shaped area 101 which is pressed between the pressing surface of the first ram 301 and the pressing surface of the second ram 302. Accordingly, cracks are not caused in an inner part of the fun-shaped area 101.

When the first ram 301 is brought down on the workpiece 10 to the final, lowest position, the material sandwiched between the pressing surfaces of the rams is formed into a disc part 1 of the product with a predetermined thickness. And the cylindrical part formed around the disc part 1 becomes the main rim part 111. In the state, the workpiece is transformed into the final shape of the product as shown in Fig.8.

As shown by Fig.9 to Fig.11, a rotary forging apparatus of a second embodiment has the same first ram 301 and the second ram 302 as the first embodiment. This apparatus aims at shaping the main rim part 111 with a thick open end and a thin base end.

The shape of the shaping roller 2 in this embodiment is a truncated cone. The bottom surface of the shaping roller 2 and the top surface of the peripheral annular wall 32 of the second ram 302 face each other and are spaced apart slightly respectively. When the workpiece 10 is placed between the first ram 301 and the second ram 302 at the initial stage of forging, the pressing surface of the first ram 301 is positioned higher than a middle portion of the side surface of the shaping roller 2.

In the initial step, the workpiece 10 is pressed between the rams and the periphery of the material protrudes from the peripheral end of the rams. When the extruded material contacts the side surface of the rollwe 2, an interval α between the periphery of the pressing surface of the first ram 301 and the side surface of the shaping roller 2 coincides with the thickness of the open end of the main rim part 111. (See Fig.9)

With the advance of the thining, a part of the extruded material fills the space made by the annular groove 31 and the bottom surface of the shaping roller 2. Thereby, the flange 14 is formed in the annular groove 31. The other part of the material extends in the opposite direction from the flange 14 and grows up to form a cylindrical part. (See Fig. 10)

At this time, since the position of the pressing surface of the first ram 301 falls to the lower ram 302, the interval between the periphery of the pressing surface of the first ram 301 and the side roller 2 gradually becomes smaller. Accordingly, the thickness of the base end of the cylindrical part becomes thinner by degrees. And as shown in Fig.11, when the first ram 301 sinks to its lowest position, there is the smallest space between the pressing surface of the first ram 301 and the side surface of the shaping roller 2. Therefore, the cylindrical part is formed into the main rim part 111 with an inverse triangular-shaped section.

Fig.12 demonstrates another shape of the shaping roller 2 with a truncated conical part 23 and a columner part 24 formed below the truncated conical part 23. The first ram 301 is lowered and the pressing surface of the first ram 301 is placed beside the columnar part 24 of the roller 2. Thereafter, the extending portion passing through between the side sirfaces of the first ram 301 and the columnar part 24 becomes a cylindrical part of the main rim part 111 with substantially constant thickness. Namely, the apparatus in the second embodiment forms a product with the main rim part 111 comprising a lower cylindrical part with a constant thickness and an upper cylindrical part with a thickness which thickens gradually, upwardly.

Embodiment 3 aims at forging of the automobile wheel having a rim part 11 asymmetric to the disc part 1, as shown in Fig. 16. A drop center 15 is formed around the disc part 1. The rim part 11 consisits of a small outer ram 12 and the large inner ram 13. The outer rim side of the drop center 15 is formed into an circular part 122 which is almost plumb to an axis of the wheel. The disc part 1 is located near the circular part 122. The inner rim side of the drop center 15 is formed into a slanting wall 151. A pair of sealing portions 132 are provided at both sides of the drop center 15.

An intermediate shape of a product is formed with the apparatus in embodiment 3 before the final shape of the product is finished. The inclined first ram 301, the second ram 302 and the shaping roller 2 are illustrated in Fig.13.

The pressing surface of the second ram 302 is made after the pattern of the outer surface of the disc part 1. A patterned area 16 of the pressing surface of the second ram 302 has negative patterns which coincide with concave or convex patterns of the disc part 1 of the product. A peripheral surface of the pressing surface of the second ram 302 is shaped after a peripheral portion of the disc part 1, an inner surface of the outer rim 12 and an outer surface of a rim flange 121 of the automobile wheel. The peripheral surface of the pressing surface of the second ram 302 is surrounded by the annular wall 32. The height of the wall 32 corresponds with a thickness of the rim flange 121.

The first ram 301 has the same conical pressing surface which is formed after the inner surface of the

disc part as the embodiment 1. The first ram 301 consists of a small diameter upper portion and a large diameter lower portion. An outer surface of the large diameter lower portion corresponds to an inner rim-shaping surface for shaping a bottom wall 152 and the slanting wall 151 of the drop center 15 in the inner rim side. The large diameter lower portion has a lower tapered surface and an upper tapered surface 33. A generating line of the lower tapered surface is perpendicular at the shaping roller side. The slanting wall 151 of the inner rim 13 is formed after the upper tapered surface 33.

The shaping roller 2 comprises an upper columnar portion and a lower strange truncated conical portion having a curved surface 25 for shaping the outer surface of the puter rim 12 and an inner surface of the rim flange 121.

The shaping roller 2 is rotatably mounted at a position where the bottom surface of the shaping roller 2 is close to the top surface of the peripheral annular wall 32 of the second ram 302 and the side surface of the roller 2 corresponds to the outer surface of the rim part 11. The disc-like workpiece 10 is located between the first ram 301 and the second ram 302. The disc part 1 and the outer rim 12 including the rim flange 121 can be formed with the curved surface 25 and the second ram 302 into the final shape of the product at the initial stage of forging. With the following process, the peripheral material extruded from the peripheral ends of the rams flows upwardly and is transformed into a tapered cylindrical portion 130 which will be formed into the inner rim 13. (See Fig.14)

Before the tapered cylindrical portion 130 is shaped, the extruded material protruding from the boundary of the rams is formed into the cylindrical portion with the columner portion of the roller 2 and a vicinity of the lower end of the first ram 301. As the thinning of the workpiece 10 advances, the cylindrical portion grows upwardly. However, when the cylindrical portion extends upwardly in the axial direction, the cylindrical portion is flared with the upper slanting surface 33 of the first ram 301.

When the first ram 301 sinks at its final, lowest position, the workpiece 10 is pressed and thinned the most and the disc part 1 and the outer rim 12 of the rim part 11 are shaped into the final shape of the product, as shown in Fig. 14. And the drop center 15 and the slanting wall 151 are also formed into the final shape of the product. In this time, the end portion following from the slanting wall 151 has not been formed yet.

When the forging process is finished, the outer surface of the disc part 1 with a final design having concave or convex patterns has been completed by the patterned area 16 of the second ram 302. The end poriton of the rim flange which continues to the disc part 1 has been confined by the peripheral annular wall 32 while the designed outer surface of the disc part 1 is being formed. Therefore, the concave or convex patterns of the outer sirface of the disc part 1 can be finished correctly.

The intermediate wheel as mentioned above can be formed with the apparatus of embodiment 3. And then the end portion of the tapered cylindrical portion 130 is formed into the sealing porion 132 of the inner rim 13 by a spinning process, as shown in Fig. 15. Thereby, the inner rim 13 is shaped into the final shape of the product. That is to say, the final shape of the automobile wheel can be finished.

Needless to say, the length and thickness of the tapered cylindrical part 130 at the final stage of thinning is set to be sufficient to finish the inner rim 13 into the final shape. The thickness of the cylindrical portion 130 may be thicker than that of the inner rim 13 if the thickness of the tapered cylindrical portion 130 coincides with that of the inner rim 13 at the time of spinning process.

Above mentioned rotary forging apparatus can be make a product from a workpiece 10, for example aluminium, aluminium alloy and magnesium alloy, etc. by hot forging.

In the above mentioned embodiments. the shaping roller 2 has a perpendicular rotary axis and is rotatably fixed at a certain position. If a roller-driving device 6 which makes the shaping roller 2 move in the horizontal direction and in the vertical direction, maintaining the vertical posture of the roller 2 is installed as shown in Fig. 17, the thickness of the rim part can be changed optionally by contoroling of the roller-driving device 6. In this embodiment, if the shaping roller 2 has a trancated conical part, a complicated change of the thickness of the rim part is practicable.

A rough-formed workpiece that the cancave or convex patterns of the outer surface of the disc part and the outer rim part next to the outer surface of the disc part have been formed beforehand, as shown in Fig.18, can be adopted as the workpiece 10. The rough-formed workpiece is lain on the second ram 302 so that the outer rim part can be fitted into the annular groove 31. The outer rim 12 and the cylindrical part 130, as shown in Fig.19, can be formed by the same rotary forging as above mentioned embodimants. In this embodiment since the rough-formed wark 10 is prepared, it is possible to make a product shaped precisely. Besides, the periphery of the one rim part which is near the disc part 1 is confined by the annular wall 32 as soon as the rotary forging begins. Therefore, the disc part becomes hard to break easily.

In the above mentioned cases, the outer rim is provided at the outside from the outer surface of the disc part 1, however, it is possible to provide the outer rim at the same line of the outer surface of the disc part 1 or at the inside of the outer surface of the disc part 1, as shown in Fig.17.

Claims

1. A rotary forging apparatus for forming from a workpiece produced with a disc part (1) and a rim part (11) extending around the disc part (1) of which the rim part has a section asymmetrical to the disc part (1), or comprises a large rim part and a small rim part, said apparatus comprising:

   a rotary first ram (301) with a generally conical pressing surface which is rotated about an inclines axis,

   a rotary second ram (302) with a pressing surface which faces the pressing surface of the first ram and is rotatable about a generally upright axis at a certain height, and

   a shaping roller (2) supported rotatably beside the rams,

   wherein the second ram (302) and the first ram (301), in use, sandwich the workpiece (10), the rams rotate synchronously and press and thin the workpiece (10) into a disc part (1) of a product, a portion of the workpiece (10) extrudes from between the rams to the periphery of the rams, the extruded portion is pressed and formed into the rim part (11) by the shaping roller (2) and the rams, a rim-shaping surface is provided around the pressing surface of the second ram (302) for shaping the small rim part, an annular wall (32) stands out toward the first ram (301) at a peripheral edge of the rim-shaping surface for forming an end portion of the small rim part, and a bottom surface of the shaping roller (2) comes into contact with or comes very close to a top face of the annular wall 32.

2. A rotary forging apparatus as claimed in claim 1, wherein the shaping roller has a truncated conical part tapering off to the first ram side, and the truncated conical part is positioned outside a boundary between the first ram 301 and the second ram 302.

3. A rotary forging apparatus as claimed in claim 1, wherein the pressing surface and the rim-shaping surface of the second ram 302 have been shaped to form an outer surface of the disc part 1, an inner surface of an outer rim 12 and an outer surface of a rim flange 121 of an automobile wheel of a product, the pressing surface and a side surface of the first ram 301 have been shaped to form an inner surface of the disc part 1 and a part of an inner surface of an inner rim 13 where is near the disc part 1 of the product, and an outer rim-shaping surface 25 is provided at a side surface of the shaping roller 2 for shaping an outer surface of the outer rim 12 and an inner surface of the rim flange 121 of the product.

4. A rotary forging apparatus as claimed in claim 3, wherein the shaping roller 2 can move in a horizontal direction and a vertical direction whilst maintaining its generally vertical orientation.

5. A rotary forging apparatus as claimed in claim 4, wherein the pressing surface of the second ram 302 has a patterned area with negative patterns similar to concave or convex patterns of the disc part 1 of the product.

FIG. 1
(PRIOR ART)

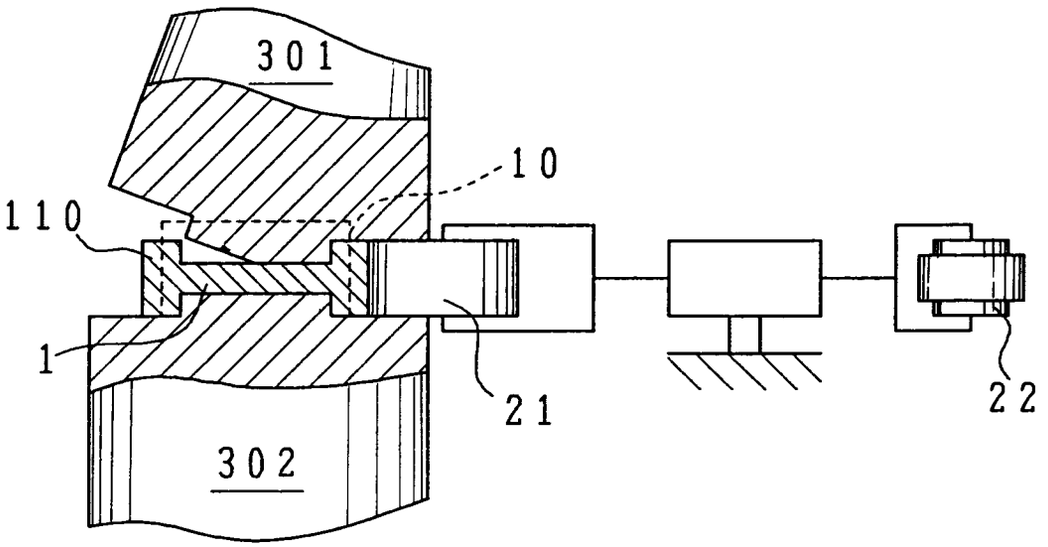


FIG. 2
(PRIOR ART)

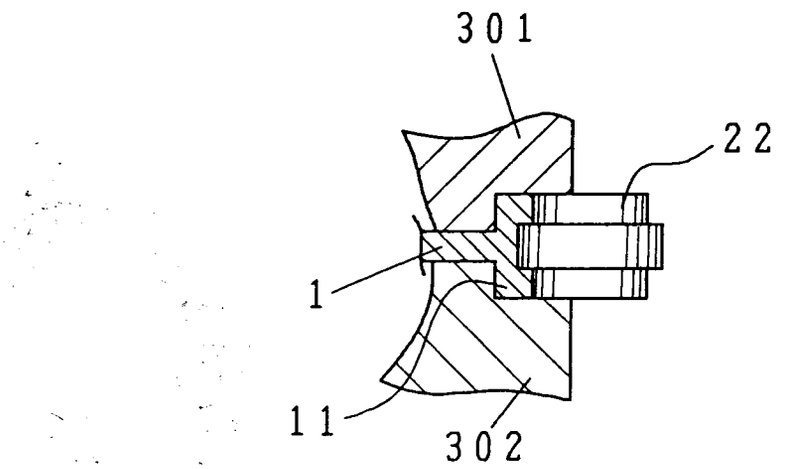


FIG. 3
(PRIOR ART)

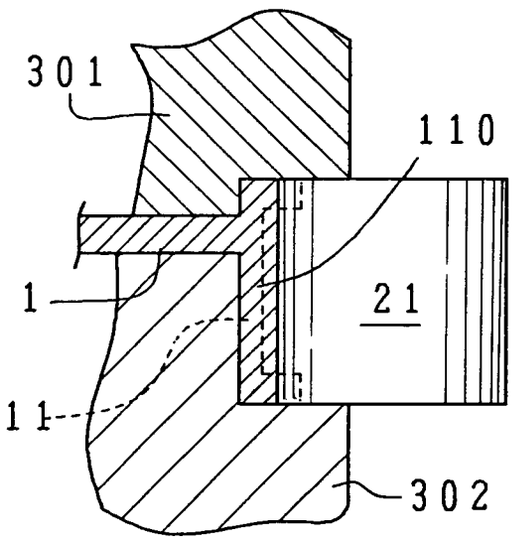


FIG. 4
(PRIOR ART)

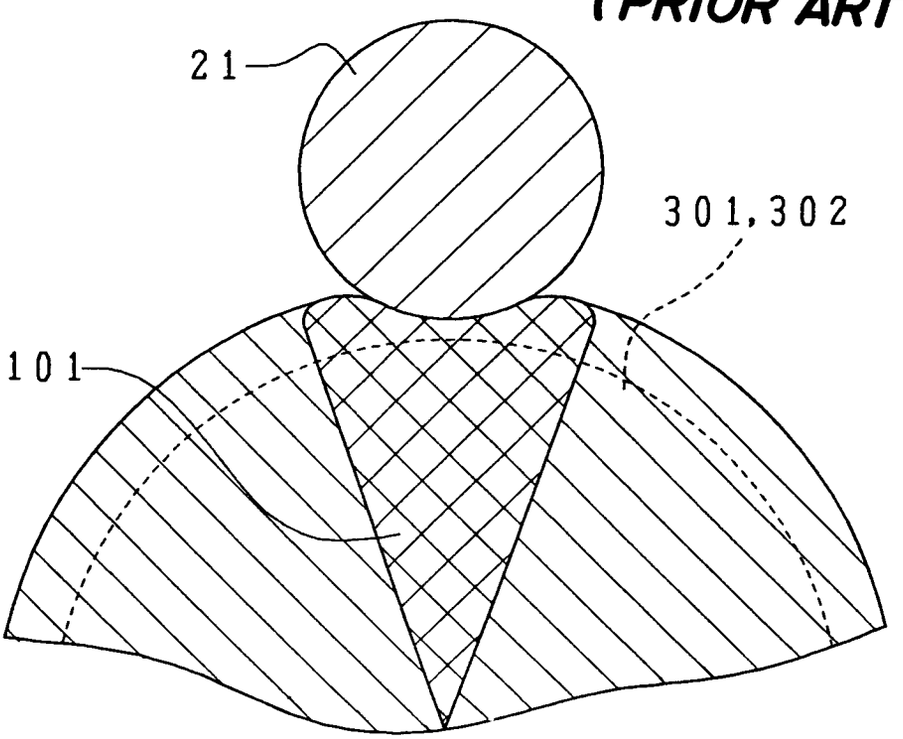


FIG. 5

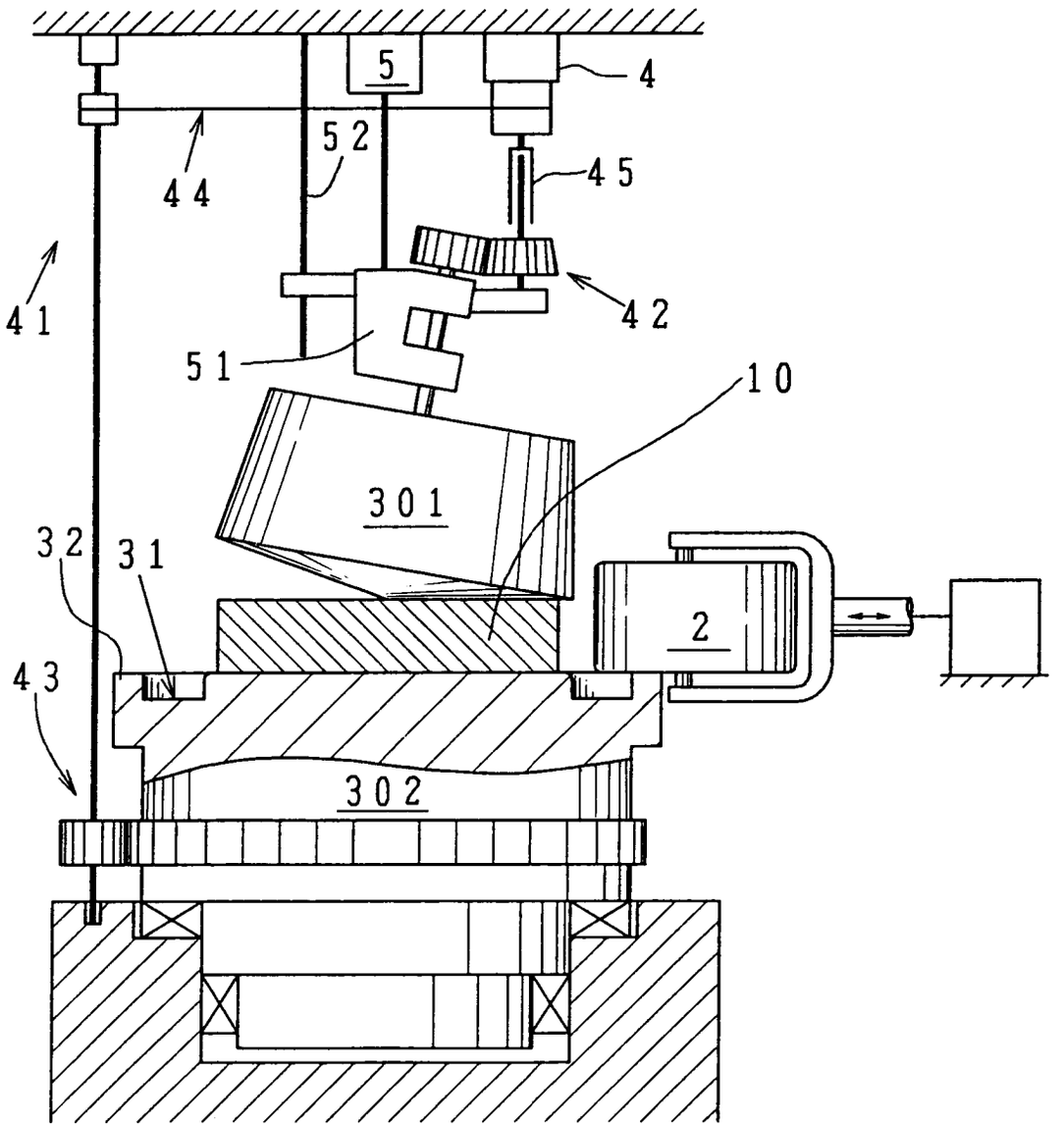


FIG. 6

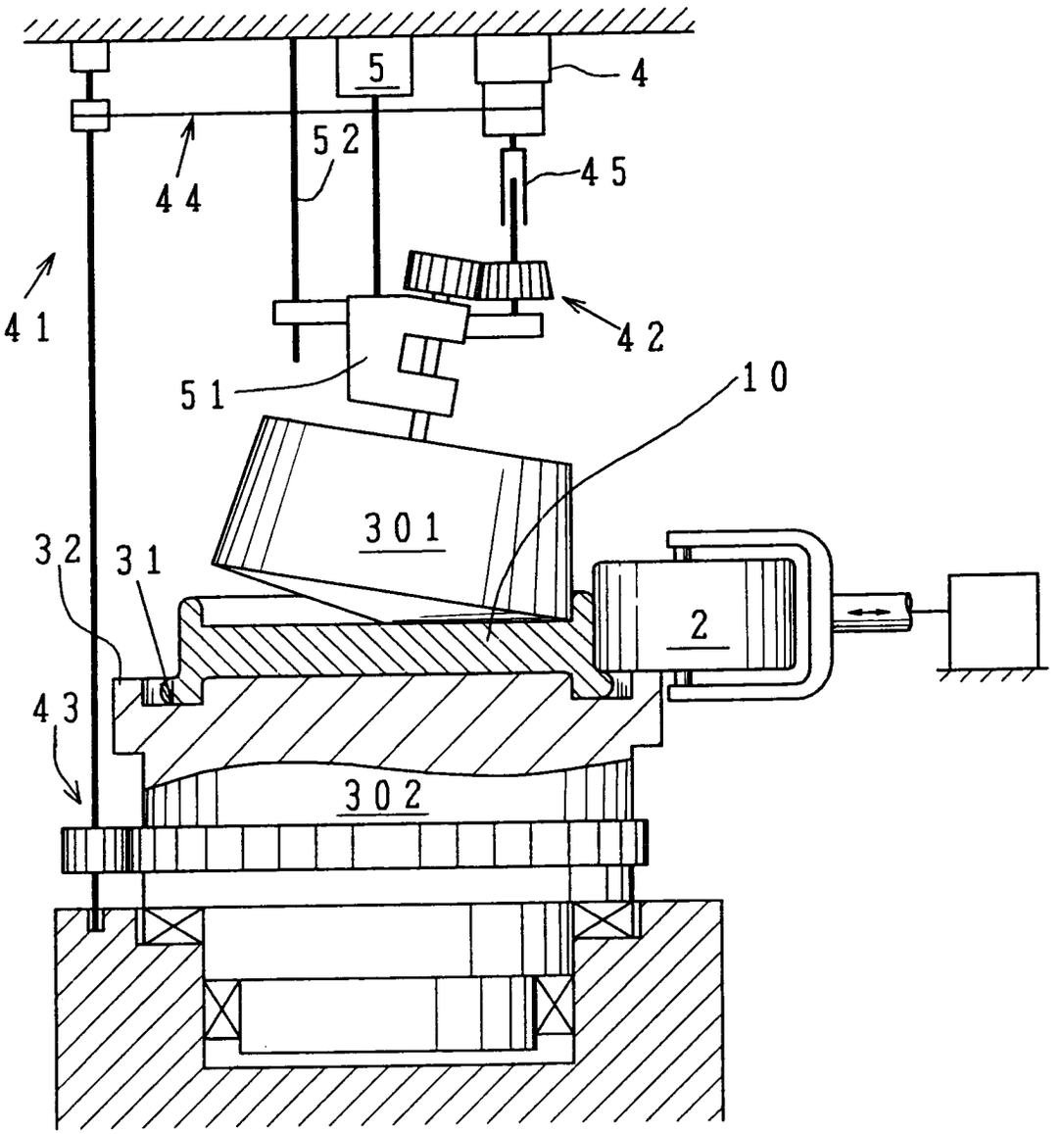


FIG. 7

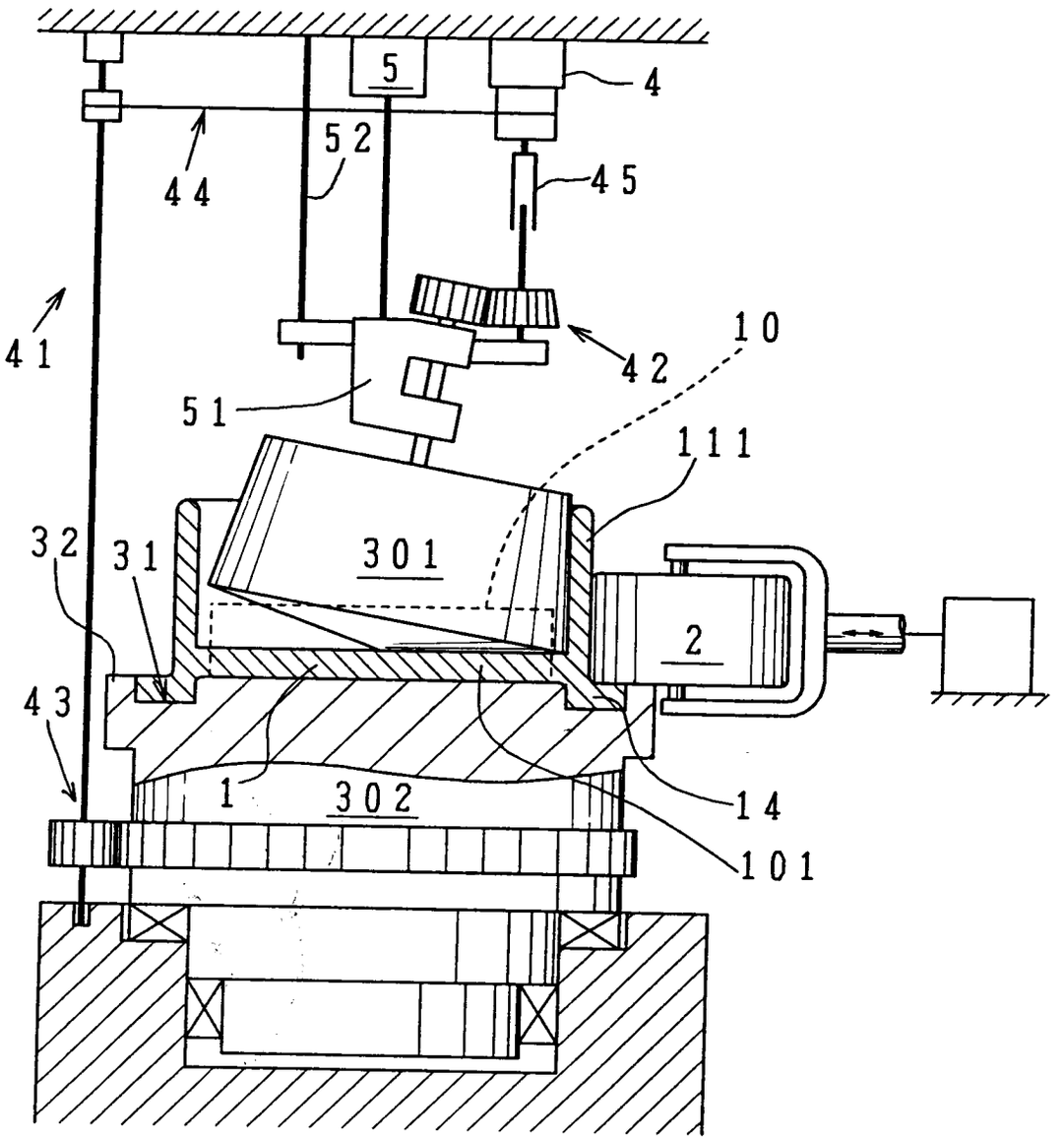


FIG. 8

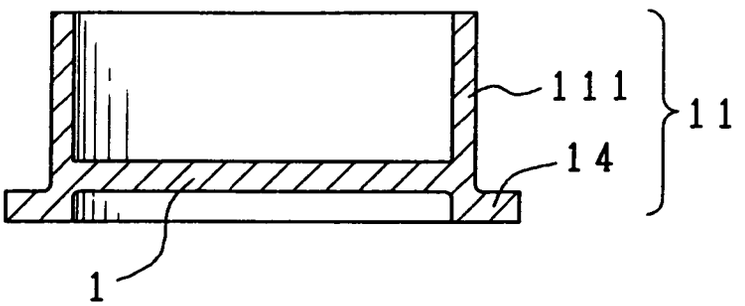


FIG. 9

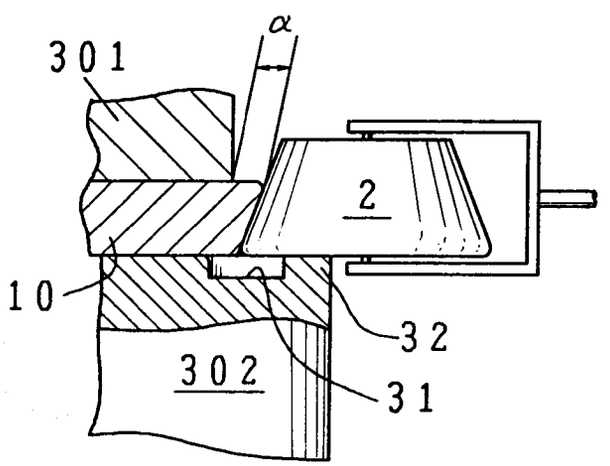


FIG. 10

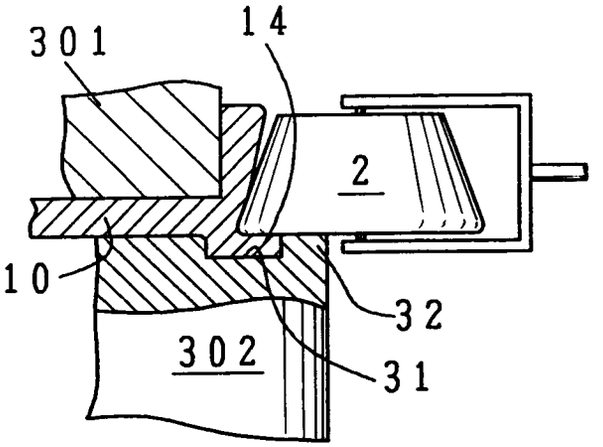


FIG. 11

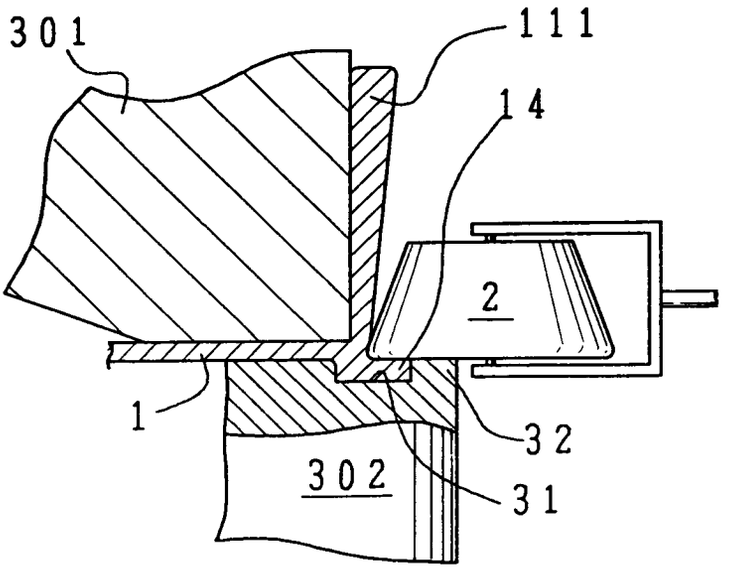


FIG. 12

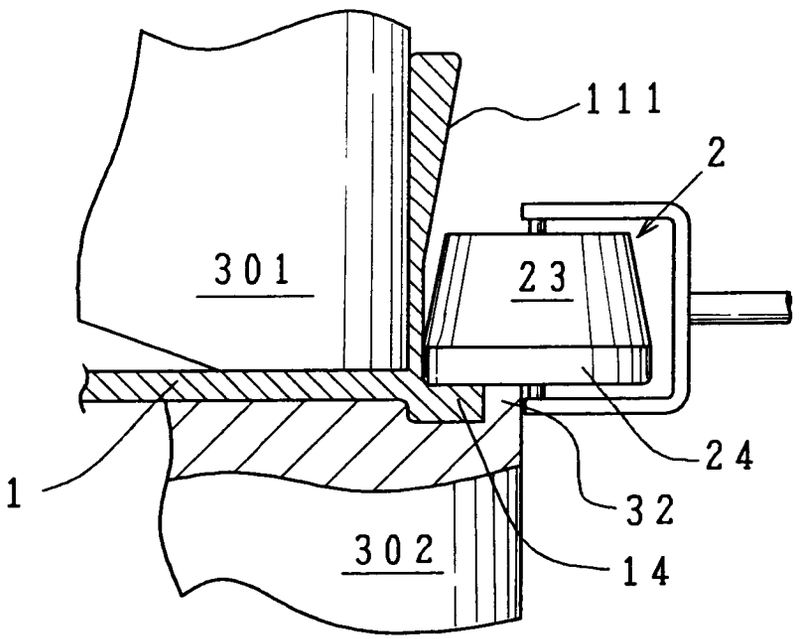


FIG. 13

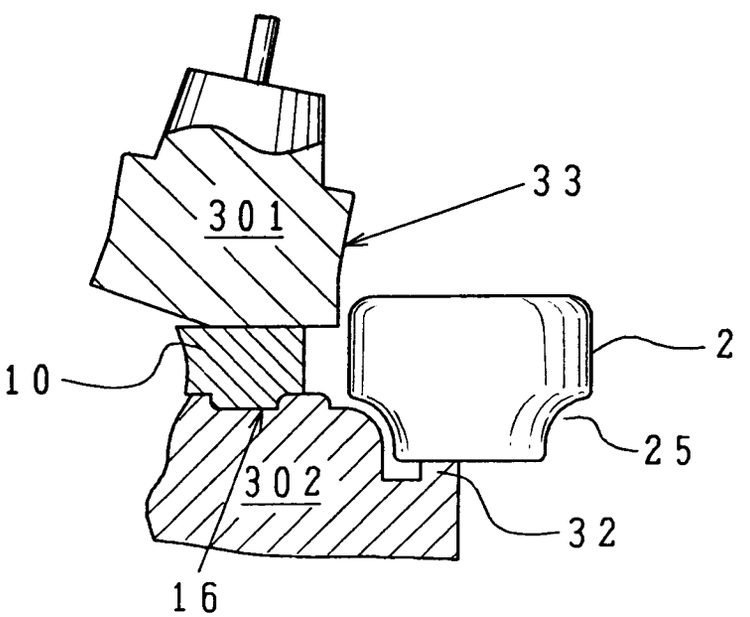


FIG. 14

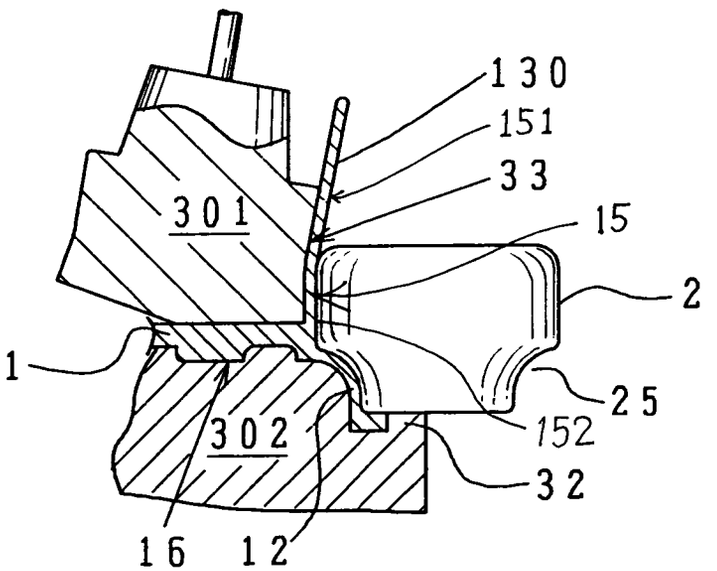


FIG. 15

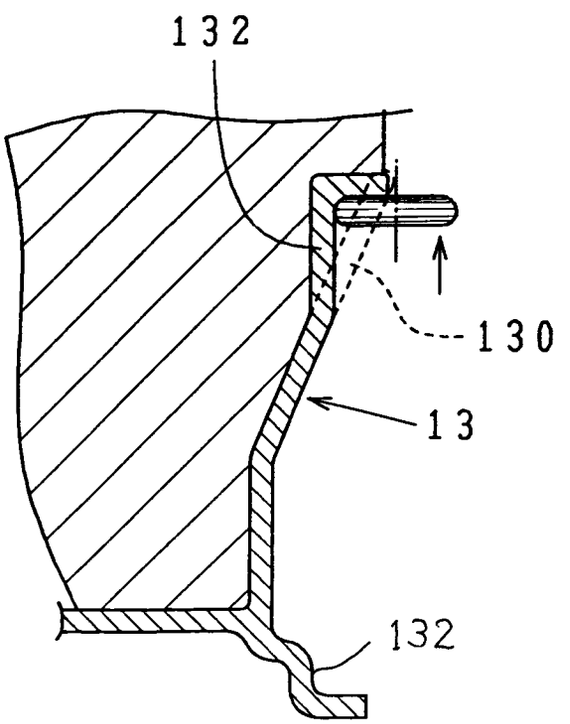


FIG. 16

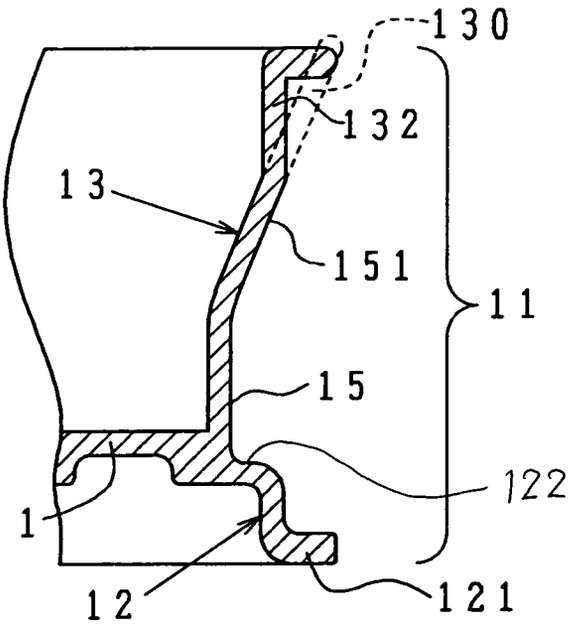


FIG. 17

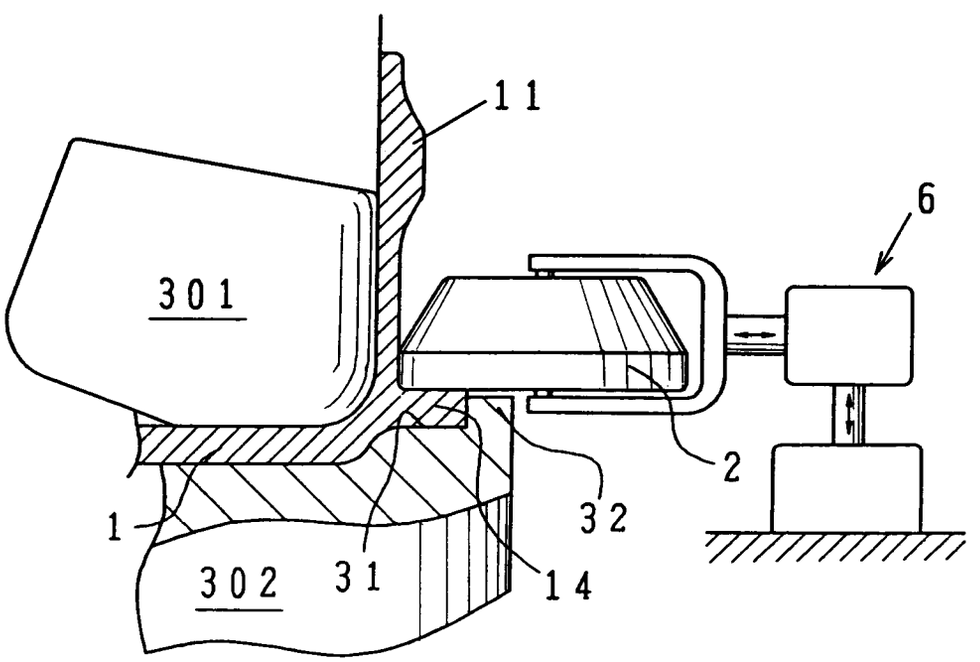


FIG. 18

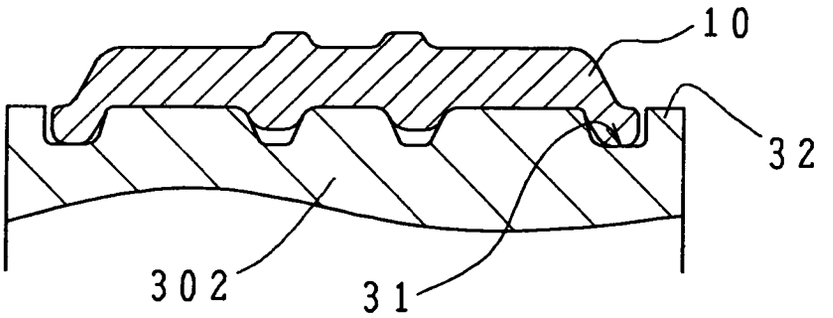
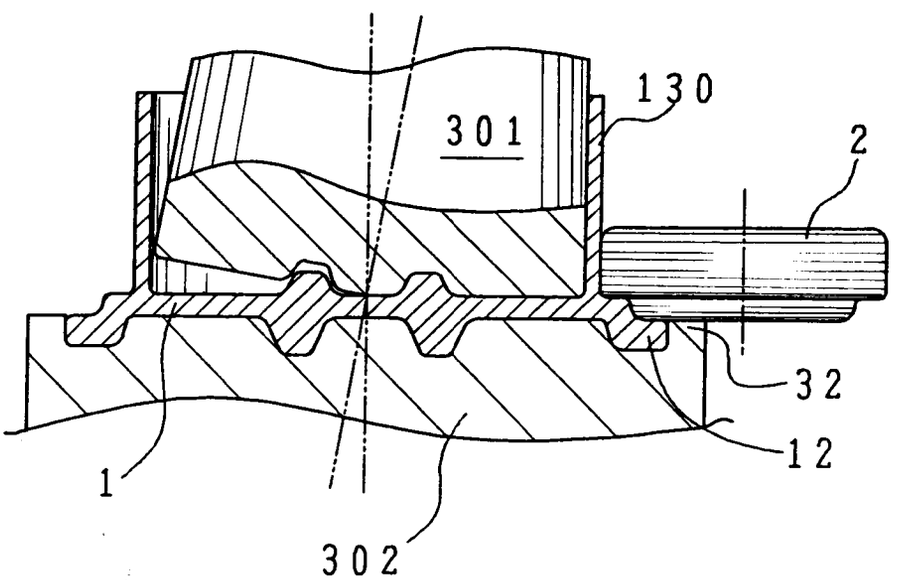


FIG. 19



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 95 30 1513

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
P,A	PATENT ABSTRACTS OF JAPAN vol. 18, no. 472 (M-1667) 2 September 1994 & JP-A-06 154 932 (REIZU ENG) 3 June 1994 * abstract *	1-5	B21J9/02 B21K1/28 B21H1/04
T	EP-A-0 652 061 (RAYS ENGINEERING) * column 1 - column 2; figures 1-3 *	1-5	
D,A	PATENT ABSTRACTS OF JAPAN vol. 11, no. 67 (M-566) 28 February 1987 & JP-A-61 226 132 (SUMITOMO METAL IND) 8 October 1986 * abstract *	1,2,4,5	
A	SOVIET INVENTIONS ILLUSTRATED Section PQ, Week 9337, 3 November 1994 Derwent Publications Ltd., London, GB; Class P52, AN 93-294101/37 & SU-A-1 761 349 (METAL TECHN INST) 15 September 1992 * abstract *	1,2,5	
A	SOVIET INVENTIONS ILLUSTRATED Section PQ, Week 9146, 8 January 1992 Derwent Publications Ltd., London, GB; Class P52, AN 91-337581/46 & SU-A-1 613 221 (GRIGOREV) 15 December 1990 * abstract *	1,4	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
B21D
B21H
B21J
B21K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 June 1995	Rosenbaum, H

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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P : intermediate document

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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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