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(71) Applicants:
• **ASAHI TEC CORPORATION**
Ogasa-gun Shizuoka 439-8651 (JP)
• **Hoei Industries Co., Ltd.**
Nagoya City, Aichi Pref, 466-0015 (JP)

(72) Inventors:
• **Matsumoto, Masaharu, Asahi Tec Corporation**
Ogasa-gun, Shizuoka-prefecture 439-8651 (JP)
• **Watanabe, Masatoshi**
Inabe-gun, Mie-prefecture 511-0205 (JP)
• **Machino, Daisuke**
Inabe-gun, Mie-prefecture 511-0203 (JP)

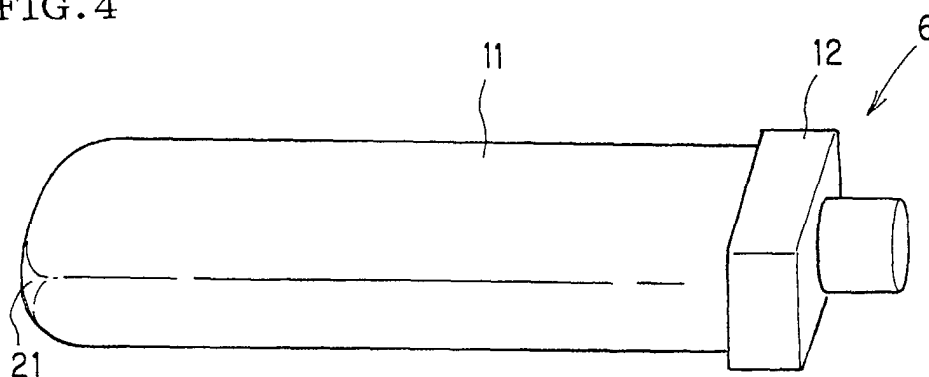
(74) Representative: **Paget, Hugh Charles Edward et al**
MEWBURN ELLIS
York House
23 Kingsway
London WC2B 6HP (GB)

(54) **Method for manufacturing forged product, and apparatus for manufacturing forged product**

(57) This invention is directed to a method for manufacturing metal which includes a step of melting a forged material, and a step of casting a molten forged material to obtain a preform (51-53) made of forged material, and a step of forging the preform (51-53) made of forged material, and an apparatus therefor. The preform (51-53) made of forged material comprises one or more

of standardized preforms made of forged material having an approximately cylindrical form with the same cross sectional shape, but a different length. According to the present method and the present apparatus, one may produce metal products to which excellent mechanical properties are impaired by subjecting standardized preforms (51-53) to the forging treatment with an improved productivity and reduced production cost.

FIG. 4



Description

[0001] The present invention relates to a method for manufacturing a forged product capable of producing for various forged products having different sizes and shapes from a preform made of forged material obtained by casting a molten forged material, an apparatus for forged product manufacturing therefor, and relates to a preform made of forged material therefor. More particularly, the present invention relates to a method for manufacturing a forged product and an apparatus for manufacturing a forged product having a big variation in size and shape, for example, vehicle suspension parts for an automobile or the like, by using one or a very few standardized preform made of forged materials and forging it, thereby the productivity is improved even in a method for manufacturing metal products such complicated shapes with various sizes, and relates to the standardized preform made of forged material.

[0002] To prevent global warming that is one of global environmental problems, reduction in fuel consumption of an automobile is required on a global scale. To reduce the fuel consumption, weight reduction techniques of an automobile are considered to be the most significant. It is because an automobile having reduced weight causes reduced load on a power source to allow reduction in fuel consumption of not only a gasoline engine, but also of any power source. A most approachable weight reduction technique is to change a material to be used to a weight reduction material.

Typically, using an aluminum alloy material, many automobile parts such as an engine cylinder head or an engine cylinder block have been manufactured and used.

[0003] However, most of the parts are what is called cast products. The cast products are easy to manufacture, but there is a limit of improvement in mechanical strength. Thus, it is difficult to use the cast products for automobile parts such as suspension parts that need to be less corrosive, have a sufficient strength and a good extending property, and have fewer defects, and that significantly relate to safety.

Instead, forged products or squeeze cast products (low speed injection molded products) have been manufactured and used.

[0004] However, the forged products or the squeeze cast products have a problem to be solved of high cost, and applications thereof are extremely limited. The reason why an aluminum forged product that uses a conventional A6061 alloy or the like and is preferably used for the suspension part for the automobile is high in cost is mainly that the forged material per se is high in cost, and also that the number of manufacturing steps is large. Further, for example, a squeeze cast product using an AC4CH alloy needs a large number of manufacturing steps and is low in injection speed, thus preventing an increase in productivity and cost reduction.

[0005] On the other hand, it is clearly difficult to apply general cast products to the suspension parts used in

hostile environments, because of the limited improvement of mechanical properties even if cleaning molten metal and the like causes reduction in occurrence of defects.

[0006] Thus, there have been increasing needs for reviewing a manufacturing process of the forged product having high mechanical strength to reduce costs. Usually, when an aluminum forged product is manufactured, a forged material of a wrought material in the form of a round bar is bought, cut into a length according to a metal product to be produced, and then, forged with a die, and separated into the product and burrs to obtain the product. Generally, the burrs are picked up by a collection service and recycled for use in miscellaneous cast products. The burrs separated from the product account for appropriately 30% of a starting material before the die forging. That is, only 70% of the forged material is used for the product, causing a big waste in terms of availability of the starting material. Thus, it is considered that reducing this waste reduces costs.

[0007] Specifically, melting unnecessary burrs generated by forging together with a new forged material such as of a wrought material, casting, molding, and then forging obtained molten metal to obtain a forged product, and performing post treatment such as heat treatment to produce a metal product causes the burrs to be recycled, and allows the availability of the starting material to reach appropriately 100%. This achieves cost reduction compared to the conventional forged products, since starting material costs form a large proportion of total costs for a forged metal product. Thus, the forged metal product having good mechanical properties can be provided at low cost to meet market needs.

[0008] However, though the starting material costs are reduced by the manufacturing process of melting, casting, and molding the forged material, a new equipment cost for a smelter or a casting apparatus is required to cause the necessity for depreciation of an initial cost. Thus, cost reduction is achieved compared to the conventional forged product, but is not achieved compared to the cast product or the squeeze cast product, so that there has been a continuing need for studying to achieve further cost reduction.

[0009] Thus, a metal product lower in cost has been required as a forged metal product that needs good mechanical properties like strength and extension, such as a vehicle suspension part for an automobile or the like used on a strict condition, but no appropriate metal product has been proposed.

[0010] The present invention has been completed, in view of the above described problems, and its preferred object is to improve productivity and allow to produce metal products at lower cost, with reviewing a process for manufacturing metal products having good mechanical properties provided by forging. Further, another preferred object is to use, for example, an aluminum alloy as metal to provide a light and strong vehicle suspension part for an automobile or the like at lower cost, thus re-

ducing fuel cost of the automobile to reduce discharged carbon dioxide and to contribute to environmental protection measures such as preventing global warming.

[0011] To address the above described problems, the inventors have studied conventional forging processes and related processing thereof. They have found, as a result of trials and errors, that the above described preferred objects can be achieved by manufacturing metal products, in case of manufacturing such metal products by a forging treatment, through a process comprising the step of obtaining a preform made of a forged material with melting the forged material once, and the step of casting thus obtained preform made of a forged material. And even if the metal products have different sizes and shapes, one produces metal products by using one type if possible, and few types, even plural types are required, of standardized preform made of forged materials without casting the preform made of forged material corresponding to the sizes or shapes of the metal products, and forging the preform made of forged material.

[0012] Specifically, according to one aspect of the present invention, there is provided a method for manufacturing forged products having different sizes and shapes from a forged material which includes a step of melting a forged material to obtain a molten metal, a step of casting the molten metal to obtain a preform made of forged material, and a step of forging the preform made of forged material to obtain a forged product, characterized in that the preform made of forged material has one standardized outer shape substantially of a cylinder or a predetermined number of standard outer shapes with the same sectional shape and different length.

[0013] In the present invention, the sectional shape of the preform made of forged material is preferably extremely simple and substantially cylindrical.

[0014] According to the method for manufacturing a forged product of the present invention, a vehicle suspension part can be preferably manufactured as a metal product having more desirable mechanical properties by post treatment, for example, heat treatment of the forged product. An aluminum alloy can be preferably used as the forged material.

In another aspect, the present invention provides a preform made of forged material for use in the above described method for manufacturing a forged product, and has one standard outer shape substantially of a cylinder or a predetermined number of standard outer shapes with the same sectional shape but different length.

[0015] According to another aspect of the present invention, there is provided an apparatus for manufacturing forged products having different sizes and shapes from a forged material, which includes at least: melting means for melting the forged material to obtain molten metal; casting means for casting the molten metal to obtain a preform made of forged material; and forging means for forging the preform made of forged material

to obtain a forged product, characterized in that the preform made of forged material has one standard outer shape substantially of a cylinder or a predetermined number of standard outer shapes with the same sectional shape but different length.

Fig. 1 shows a schematic block flow of an embodiment of a method for manufacturing a forged product according to an embodiment of the present invention.

Fig. 2 shows a schematic block flow of an example of a known method for manufacturing a forged product.

Fig. 3 is a perspective view of an embodiment of standard outer shapes of preform made of forged materials used in the method for manufacturing a forged product according to an embodiment of the present invention.

Fig. 4 is a perspective view of an embodiment of a preform made of forged material used in the method for manufacturing a forged product according to an embodiment of the present invention.

Fig. 5 is a perspective view of an embodiment of a forged product having different sizes and shapes obtained by the method for manufacturing a forged product according to an embodiment of the present invention.

Fig. 6 is a top view of another embodiment of a forged product having different sizes and shapes obtained by the method for manufacturing a forged product according to an embodiment of the present invention.

Fig. 7 is a top view of a further embodiment of a forged product having different sizes and shapes obtained by the method for manufacturing a forged product according to an embodiment of the present invention.

[0016] Now, embodiments of a method for manufacturing a forged product, embodiments of an apparatus for manufacturing a forged product, and embodiment of a preform made of forged material, according to the present invention, will be described in detail. The present invention is not limited to the embodiments, but various changes, modifications, and improvements may be made based on knowledge of those skilled in the art without departing the scope of the present invention.

[0017] For example, a metal product that is produced by forging an aluminum alloy will be described as a typical metal product in the detailed description. However, the present invention is preferably directed to an invention by which the productivity has been improved by standardizing a preform made of forged material so as to reduce the number of a preform made of forged material required to produce even metal products have different sizes and shapes; said invention preferably being directed to a method for manufacturing a forged product through the steps of melting and casting a forged mate-

rial as a starting material to obtain a preform made of forged material, and forging thus prepared preform made of forged material to obtain a metal product having good mechanical properties, and an apparatus for manufacturing a forged product thereof. Herein, the term "metal as the forged material" means a forged material having high plasticity appropriate for forging, and being formed by forging to be a metal product, but it is not considered to be limitative. For example, the metal may include carbon steel (such as S40C) or special steel (such as chrome molybdenum steel) as an iron based alloy, or a magnesium alloy, other than the aluminum alloy (A6061).

[0018] The preform made of forged material refers to a forged material that is cast and previously cast by a casting apparatus for die forging in a forging apparatus, and means a cast forged material.

[0019] The present invention provides the method for manufacturing a forged product for melting and casting the forged material to obtain the preform made of forged material, and forging the preform made of forged material to obtain the forged product. The present invention has a feature of forging the preform made of forged material that has one standard outer shape substantially of a cylinder or a predetermined number of standard outer shapes with the same sectional shape and different lengths, even when producing various forged products having different sizes and shapes.

[0020] If the metal product is produced by forging through the manufacturing process of once melting and casting the starting material that is the forged material to obtain the preform made of forged material, and forging the preform made of forged material, scrap such as burrs can be recycled to reduce starting material costs. However, if the size or the shape of the preform made of forged material is changed according to the metal product to be produced in this manufacturing process as in pretreatment of conventional forging in which a round bar of the forged material is cut to match the size and the shape of the metal product, a casting mold for each metal product must be prepared to increase equipment costs, and to reduce productivity since the casting mold needs replacement for each time.

[0021] In the present invention, the preform made of forged material is standardized to preferably have one standard outer shape, thereby reducing the equipment costs and reducing manpower to maintain and control the casting mold. Thus, the casting mold needs no replacement during the manufacturing process to increase production speed and improve throughput.

[0022] The preform made of forged material can be, for example, forged with a die without being cut before forging. Cutting the round bar such as of a wrought material on the market to match the metal product and chamfering in the pretreatment of conventional forging is no longer necessary.

[0023] When a forging ratio of the preform made of forged material to the metal product is not large enough

to obtain good forging effects according to the size and the shape of the metal product, it is preferable to prepare a preform made of forged material matching the metal product in addition to one preform made of forged material. It is because the metal product having no desirable mechanical properties provided by forging does not meet market's needs even if the cost is low. However, to improve productivity and reduce costs, the number of the preform made of forged materials is desirably as small as possible. When manufacturing metal products to which the forged product is preferably applied, for example, vehicle suspension parts for an automobile or the like, one to three types of preform made of forged materials can constitute parts for the same automobile class.

[0024] In the method for manufacturing a forged product using the preform made of forged material preferably having one standard outer shape proposed in the present invention, the outer shape of the preform made of forged material is determined to match the largest metal product as long as sufficient forging effects can be obtained. Thus, compared to when many preform made of forged materials are prepared, burrs separated from the product after die forging may increase. However, in the present invention, the burrs can be melted and recycled, causing no waste.

[0025] Now, the present invention will be described in detailed with reference to the drawings. First, the method for manufacturing a forged product will be described compared to a conventional method with reference to a block flow. Fig. 2 shows a schematic block flow of an example of a conventional method for manufacturing a forged product. A forged material such as of a wrought material is bought as a new material 8, and, for example, forged with a die in a forging apparatus 63 to obtain a forged product 9, then heat treatment is preferably performed in a post treatment apparatus 64 to obtain a metal product 7 having more desirable mechanical properties. Burr materials 5 generated by the die forging in the forging apparatus 63 are discarded out of a system, and picked up by a collection service. The burr materials 5 account for 30% of the new material 8. The forged material on the market is in the form of a long round bar, and an outer surface thereof is coated with an oxide film, so that usually, before forging in the forging apparatus 63, the oxide film of the new material 8 is removed, the long new material 8 is cut into a length according to the metal product 7 (or the forged product 9), and edges of cut surfaces are chamfered to be smooth in a pretreatment apparatus 65.

[0026] Fig. 1 shows a schematic block flow of an embodiment of a method for manufacturing a forged product according to the present invention. As in the conventional method, a forged material is, for example, forged with a die in a forging apparatus 63 to obtain a forged product 9, and then heat treatment is preferably performed in a post treatment apparatus 64 to obtain a metal product 7 having more desirable mechanical proper-

ties. However, burr materials 5 generated after, for example, the die forging in the forging apparatus 63 are effectively recycled as a starting material and not discarded out of a system. The burr materials 5 are mixed with a new material 8 in a smelter 61 and melted to be molten metal, and molded into a preform made of forged material 6 in a casting apparatus 62. The preform made of forged material 6 is soon forged in the forging apparatus 63, so that there is no need for removing an oxide film.

[0027] In the present invention, the burr materials 5 are preferably not discarded and effectively used as the starting material of the forged product 9. Thus, there is no need for molding the preform made of forged material 6 obtained by casting to match a size and a shape of a metal product 7 (or the forged product 9) in order to reduce generation of the burr materials 5, and the preform made of forged material 6 can be standardized to preferably have one standard outer shape and forged.

[0028] When manufacturing the metal products 7 having different shapes and sizes, there are no needs for changing a casting mold of the casting apparatus 62 during a manufacturing process, and cutting the preform made of forged material 6 and chamfering, thus improving productivity. When preferable forging effects cannot be obtained according to the size and the shape of the metal product 7, a plurality of preform made of forged materials 6 may be prepared, but for higher productivity, it is preferable to design a size and a shape of the preform made of forged material 6 to match the metal product 7 (or the forged product 9) to be manufactured such that the number of types of the preform made of forged materials 6 is as small as possible.

[0029] As shown in the schematic block flow in Fig. 1, the preform made of forged material 6 is standardized to preferably have one standard outer shape. Thus, even if the burr materials 5 more than 30% of the preform made of forged material 6, which is a higher percentage than a conventional one, are generated, the burr materials 5 are returned to the smelter 61 and entirely used in the system effectively. Thus, a volume of the new materials 8 to be added is constant, and the starting material costs can be sufficiently reduced regardless of a volume of the burr materials 5 that do not become the product. The costs for the new material 8 such as of the wrought material that is the starting material form a large proportion of total costs for the metal product 7 by expensive forging, so that even if the metal product 7 is manufactured through the process of melting and casting, the cost reduction can be achieved.

[0030] Generation of a large volume of burr materials 5 means that a ratio of the forged material that is forged with the die to effectively become the forged product 9 and also the metal product 7 to the preform made of forged material 6 is small. This also contributes to reduction in internal defects of the metal product 7.

[0031] The forged material originally has poor castability, and when the forged material is cast and molded

to obtain the preform made of forged material 6, it is preferable to cause directional solidification and bring shrinkage cavities or the like to an end of a riser of the preform made of forged material 6 to prevent the defects from remaining in a portion to be forged. It is because if the portion to be forged for the forged product 9 forms a small proportion of the entire preform made of forged material 6, the portion to be forged is likely to have desirable quality. However, to prevent the large volume of burr materials 5 from being unnecessarily generated and remelted, it is preferable as described above that the outer shape of the preform made of forged material 6 is basically determined to match the largest metal product in view of the forging ratio, and the burr materials 5 separated from the product account for approximately 30 to 50% of the preform made of forged material 6.

[0032] Next, the standard outer shape of the preform made of forged material will be described. The standard outer shape refers to a standard size and shape for use in the preferred method for manufacturing a forged product of the present invention. For example, three standard outer shapes refer to three types of standard outer shapes in which either of sizes or shapes are different, or both of sizes and shapes are different.

[0033] In the method for manufacturing a forged product of the present invention, the preform made of forged material preferably has one standard outer shape, and even if a plurality of standard outer shapes are needed, it is preferable to limit the number of the standard outer shapes as small as possible. The standard outer shape is preferably substantially cylindrical, and the plurality of standard outer shapes preferably have the same sectional shape and different lengths.

[0034] An example is shown in Fig. 3. Fig. 3 is a side view of an embodiment of standard outer shapes of preform made of forged materials used in the method for manufacturing a forged product according to the present invention. Preform made of forged materials 51 to 53 each include a forged portion 11 and a riser 12, and the forged portions 11 have circular sections with the same diameter D and different lengths L.

[0035] The three preform made of forged materials 51 to 53 having the forged portions 11 with the same diameter D and the different lengths L can be molded by one casting mold having a cavity matching the preform made of forged material 53 with the longest forged portion 11. When molding the preform made of forged materials 51, 52, the same casting mold as when molding the preform made of forged material 53 is used, and a smaller amount of molten metal is poured into the mold standing vertically to be solidified such that the forged portion 11 has a desired length L. This allows the casting apparatus to accommodate a larger number of types of metal products simply by adjusting the amount of molten metal without changing the casting mold, causing no reduction in productivity.

[0036] Next, the metal product manufactured by the

preferred method for manufacturing a forged product of the present invention will be described. According to the preferred method for manufacturing a forged product of the present invention, the vehicle suspension part for the automobile generally used can be preferably manufactured as a final metal product obtained by, for example, heat treatment of the forged product produced by forging the preform made of forged material. More specifically, the vehicle suspension part for the automobile such as a delivery pipe, a lower arm, or a knuckle steering can be manufactured.

[0037] Conventional metal products manufactured by forging have been too expensive to be widely used, though it has been understood that the products have good mechanical properties and are appropriate for the vehicle suspension parts requiring higher strength. However, the present invention improves productivity, achieves cost reduction, and facilitates wide use of the forged products with high performance.

[0038] A lighter vehicle suspension part for the automobile is preferable, and in the present invention, the aluminum alloy can be preferably used as the molten forged material that is the starting material, thus sufficiently achieving reduction in weight.

[0039] Figs. 4 to 7 show the preform made of forged materials of the present invention, and examples of shapes of the forged products obtained by forging the preform made of forged materials by the method for manufacturing a forged product of the present invention. The forged products are then subjected to heat treatment or the like to be the vehicle suspension parts for the automobile, and have significantly different sizes and shapes. Fig. 5 is a perspective view of a delivery pipe 2, Fig. 6 is a top view of a lower arm 3, and Fig. 7 is a top view of a knuckle steering 4. The preform made of forged material 6 alone shown in Fig. 4 can accommodate production of such forged products having different shapes and sizes.

[0040] Now, an example of a producing method of the vehicle suspension part for the automobile that is the forged product will be shown. For example, an aluminum alloy wrought material A6061 (hereinafter also simply referred to as an A6061 alloy) by the Japanese Industrial Standard can be used as the forged material. The new A6061 alloy that is a new material, and the burrs separated from the forged product by die forging in the forging apparatus, more specifically, by a trimming apparatus are mixed and melted in a smelter in which a temperature is kept within a range of approximately 680 to 780°C to obtain molten metal. It is preferable to remove inclusion or impure gas and clean the molten metal by degassing, deoxidizing, and filtering.

[0041] Then, in the casting apparatus, the molten metal is poured into the casting mold heated up to approximately 230 to 270°C and solidified to obtain molded preform made of forged material 6. The forged material has poor castability, so that it is preferable to cause directional solidification and use, for the casting mold, a

material having high thermal conductivity that is appropriate for directional solidification.

[0042] The preform made of forged material 6 is cooled down to approximately 380 to 520°C that are temperatures appropriate for forging, then subjected to rough forging and finish forging in the forging apparatus, more specifically, by a pressing machine of approximately 2000 to 4000 ton friction to be the forged product. The forged product is cooled and then separated into the product and the burr materials by the trimming apparatus, and the burr materials are mixed with the new A6061 alloy and reused as the starting material.

[0043] The size and the shape of the preform made of forged material 6 are preferably determined to secure a forging ratio of approximately 10:1 to 2:1 before and after the forging in order to obtain more preferable forging effects based on the sizes and the shapes of the delivery pipe 2, the lower arm 3, and the knuckle steering 4.

[0044] The preform made of forged material 6 preferably has a simpler shape such as a rectangle shown in Fig. 4. The forged material has poor fluidity, thus simpler shapes reduces internal defects. Further, to prevent splinters from remaining to cause the internal defects, it is preferable, as shown in Fig. 4, to chamfer corners between surfaces of the rectangle configuring the forged portion 11 in the preform made of forged material 6 to form a small curved surface 21.

[0045] When the preform made of forged material 6 in Fig. 4 is forged to obtain the delivery pipe 2 in Fig. 5, the forging ratio is approximately 5:1 to 2:1, and the burrs to be separated account for approximately 30% of the preform made of forged material 6. For the lower arm 3 in Fig. 6, the forging ratio is approximately 9:1 to 2:1, and the burrs to be separated account for 10 to 50% of the preform made of forged material 6. For the knuckle steering 4 in Fig. 7, the forging ratio is approximately 8:1 to 3:1, and the burrs to be separated account for approximately 40% of the preform made of forged material 6.

[0046] As described above, the method for manufacturing a forged product, the forged product manufacturing apparatus, and the preform made of forged material according to the present invention preferably improve productivity and reduce costs in manufacturing the metal product having good mechanical properties provided by forging. Further, using, for example, an aluminum alloy as metal to provide the light vehicle suspension part or the like at lower cost preferably achieves reduction in fuel cost of the automobile to reduce discharged carbon dioxide and to contribute to environmental protection measures such as preventing global warming. This may be a solution for the global problems.

Claims

1. A method for manufacturing forged products having

different sizes and shapes from a forged material, which includes:

a step of melting a forged material to obtain molten metal; 5
a step of casting said molten metal to obtain a preform made of forged material; and
a step of forging said preform made of forged material to obtain a forged product, 10

wherein said preform made of forged material has one standard outer shape substantially of a cylinder or a predetermined number of standard outer shapes with the same sectional shape and different lengths. 15

2. The method for manufacturing forged products having different sizes and shapes from a forged material according to claim 1, wherein the sectional shape of said preform made of forged material is substantially circular. 20

3. The method for manufacturing forged products having different sizes and shapes from a forged material according to claim 1 or 2, wherein a metal product obtained by heat treatment of said forged product is a vehicle suspension part. 25

4. The method for manufacturing forged products having different sizes and shapes from a forged material according to any one of claims 1 to 3, wherein said forged material is an aluminum alloy. 30

5. A preform made of forged material usable in a method for manufacturing a forged product according to any one of claims 1 to 4, wherein the preform made of forged material has one standard outer shape substantially of a cylinder or a predetermined number of standard outer shapes with the same sectional shape and different lengths. 35 40

6. An apparatus for manufacturing a forged product for producing forged products having different sized and shapes from a forged material, comprising at least: 45

melting means for melting a forged material to obtain molten metal;
casting means for casting a molten metal to obtain a preform made of forged material; and 50
forging means for forging a preform made of forged material to obtain a forged product,

wherein said preform made of forged material has one standard outer shape substantially of a cylinder or a predetermined number of standard outer shapes with the same sectional shape and different lengths. 55

FIG. 1

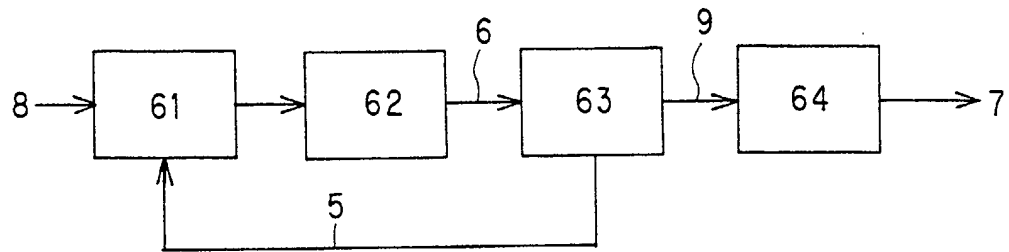


FIG. 2

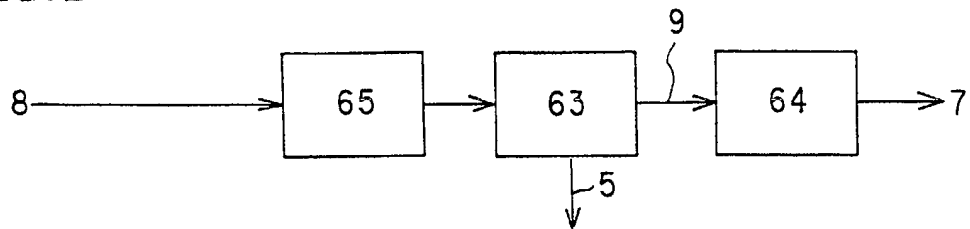


FIG. 3(a)

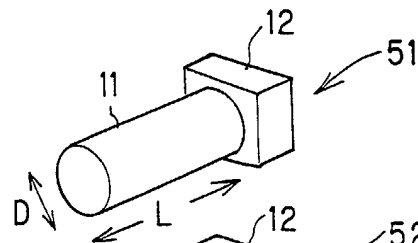


FIG. 3(b)

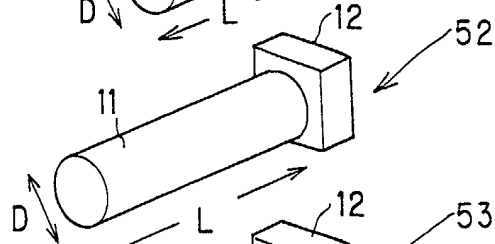


FIG. 3(c)

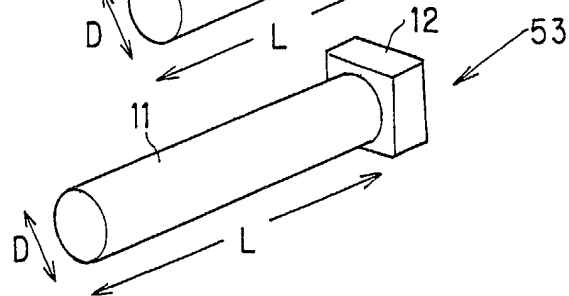


FIG. 4

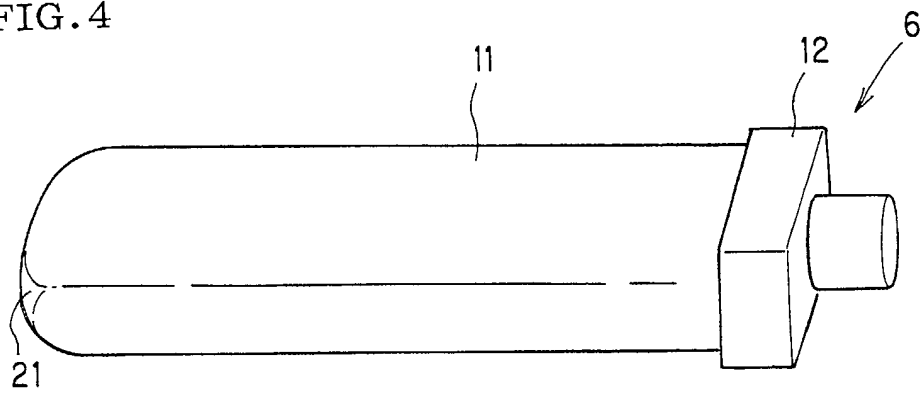


FIG. 5

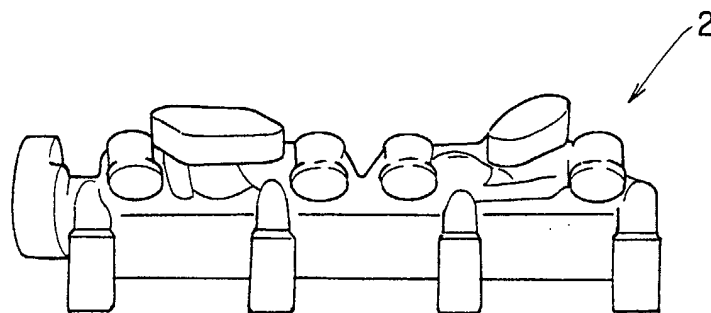


FIG. 6

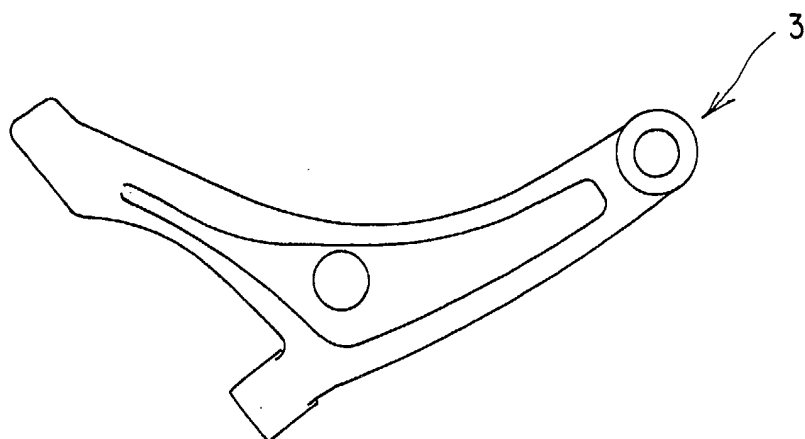
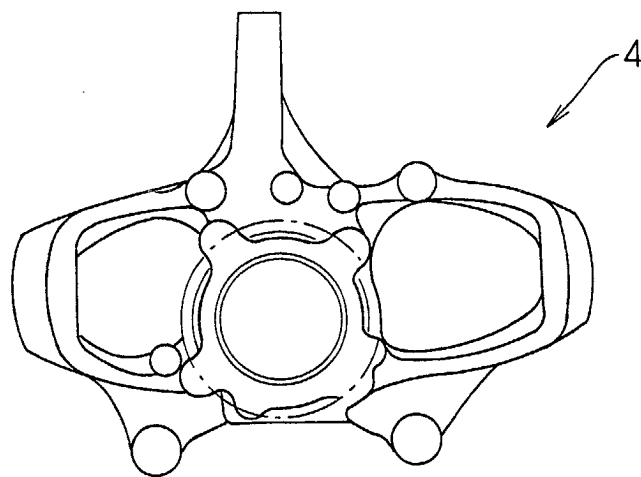


FIG. 7





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 25 6611

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (InCl.7)
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