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(54) **ACETABULAR PROSTHESIS AND CORRESPONDING METHOD FOR PRODUCTION AND ASSEMBLY**

ACETABULUMPROTHESE SOWIE ENTSPRECHENDES VERFAHREN ZUR HERSTELLUNG UND MONTAGE

PROTHÈSE COTYLOÏDIENNE ET PROCÉDÉ DE PRODUCTION ET D'ASSEMBLAGE CORRESPONDANT

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## Description

### FIELD OF THE INVENTION

**[0001]** The present invention concerns an acetabular prosthesis associable to a natural acetabular seating of the hip to function as the positioning and rotation seating for the head of a femoral prosthesis.

**[0002]** The present invention also concerns the method to produce and assemble the acetabular prosthesis.

### BACKGROUND OF THE INVENTION

**[0003]** In the field of orthopedic hip prostheses, it is known to produce acetabular prostheses consisting of an insert with a semispherical cavity which acts as a positioning and rotation seating for the head of the femoral prosthesis.

**[0004]** The insert, in its turn, is normally disposed inside a mating shell, or acetabular cup, with an internal cavity, made of osteo-compatible metal material, for example with a titanium base or a cobalt base, attached in an acetabular seating of the hip.

**[0005]** In this context, resurfacing prostheses are known, suitable to be attached on the head of the femur, leaving it substantially intact.

**[0006]** Resurfacing systems have been used for many years in reconstruction surgery of the hip with the purpose of:

- preserving the neck and a portion of the head of the femur in active, young patients;
- using diameters of the head which are nearer to the anatomical diameter, compared with traditional implants, in order to restore the articular biomechanics and at the same time to guarantee a smaller risk of dislocation;
- facilitating possible future revisions with a traditional implant, since the proximal part of the femur is intact, instead of with revision implants.

**[0007]** The resurfacing systems on the market traditionally provide couplings of the metal-metal type.

**[0008]** Recently, some resurfacing systems have shown a higher failure rate than that of traditional implants. More generally, a possible drawback has emerged in the case of metal-metal couplings, due to the release of metal ions, which have developed following wear on the components in the human body. These ions have different side effects including deterioration in the tissues surrounding the implant, loss of the implant itself and in some cases effects at a systemic level (heart, nervous system, etc....). The development of these wear phenomena is more evident in cases where the acetabular implant is not perfectly positioned in terms of inclination and turning. Consequently, even though, by using metal-metal couplings, very limited thicknesses are obtained which adapt well to the production of resurfacing prostheses, it is better to avoid this type of coupling because of the drawbacks described above.

**[0009]** From the document DE-A-19616059 it is known to make a prosthesis which has a cylindrical coupling, in particular, which provides the possibility of an insert with a diameter larger than that of the cup. This technique is usually used in cylindrical forced couplings in mechanics. More specifically, the coupling provided achieves a congruency between the two spherical surfaces, in order to have a better distribution of the contact.

**[0010]** Document DE-A-19701536 describes an articulation prosthesis of the known type, which provides a conical coupling of inserts made of ceramic, but without providing a mechanical forcing in proximity to the coupling plane between acetabular cup and insert defined along the coupling axis.

**[0011]** Document EP-A-1.712.206 describes an acetabular prosthesis which provides a conical coupling similar to DE-A-19701536.

**[0012]** Document WO-A-2004/017870 describes an expandable cotyloid cavity, or acetabular cup, which is made elastic by means of radial sections and which provides a throat inside which a flange or tooth of the insert is coupled in snap-in manner, in order to prevent it from coming out. In substance, the coupling occurs by connecting the tooth into the throat and subsequent conical coupling.

**[0013]** Document WO-A-2006/125711 describes a prosthesis provided with recesses made only directly under the surface, which connect with the outside through transverse apertures.

**[0014]** Document US-A-2012/095569 describes a prosthetic joint which comprises a contact member made of metal or ceramic with an osteo-integrating resurfacing surface, such as trabecular metal, texturized metal, sintered or extruded integration textures, which is made only on the surface, not wholly throughout the component without a break in continuity.

**[0015]** One purpose of the present invention is therefore to produce an acetabular prosthesis which on the one hand can be made with reduced thicknesses and on the other hand is compatible and has good mechanical resistance, in particular to wear, and thus prevents the release of ions.

**[0016]** Another purpose of the present invention is to produce an acetabular prosthesis of a total prosthesis of the hip which can be configured as a resurfacing prosthesis, thus obtaining the typical advantages of this type of prosthesis, but without the drawbacks of the metal-metal coupling described above.

**[0017]** Another purpose of the present invention is to produce an acetabular prosthesis of a total prosthesis of the hip, the insert of which, once disposed inside the acetabular cup or shell, maintains, during normal use, the position determined during the operation of inserting the acetabular cup inside the acetabular seating and of the prosthesis of the femoral head, inside the insert, preventing rotation with respect to the common axis of sym-

metry.

**[0018]** Another purpose of the present invention is to perfect a production method which optimizes the assembly and installation of the acetabular prosthesis.

**[0019]** The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

## SUMMARY OF THE INVENTION

**[0020]** The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

**[0021]** In accordance with the above purposes, an acetabular prosthesis according to the present invention, which overcomes the limits of the state of the art and eliminates the defects therein, is insertable inside a natural acetabular seating of the hip to act as a positioning and rotation seating for the head of a femoral prosthesis.

**[0022]** The acetabular prosthesis comprises an acetabular cup, in turn comprising an internal surface defining a coupling cavity, and an insert able to be inserted inside the coupling cavity and in turn comprising an external surface.

**[0023]** The acetabular cup and the insert have a common coupling axis and comprise corresponding clamping means for their reciprocal clamping in an assembled condition.

**[0024]** According to the present invention, in a disassembled condition the coupling cavity of the acetabular cup has an internal diameter which is less than the largest external diameter of the insert; moreover, in the assembled condition the largest external diameter of the insert is equal to the internal diameter of the coupling cavity of the acetabular cup. In some forms of embodiment, the internal diameter of the coupling cavity of the acetabular cup is considered in correspondence to a coupling plane between the acetabular cup and the insert, defined along the coupling axis.

**[0025]** The clamping means comprise a first clamping surface, made on the internal surface of the acetabular cup, and a second clamping surface, made on the external surface of the insert and cooperating with the first clamping surface.

**[0026]** The first and the second clamping surface have a truncated cone shape with a different inclination between them with respect to the coupling axis.

**[0027]** A conical coupling is made between the insert and the acetabular cup, with an imposed interference, variable along the axis of symmetry.

**[0028]** In particular, unlike in the state of the art, the insert can be coupled to the acetabular cup by means of forced conical coupling.

**[0029]** Indeed the present invention achieves a conical coupling with forcing of the insert and the acetabular cup, in particular obtaining said forcing in proximity to the coupling plane defined above.

**[0030]** According to another possible feature of the present invention, the variable interference during use is maximum in proximity to the maximum diameters of the cones and minimum in proximity to the minimum diameters of the cones defining the first and the second clamping surfaces.

**[0031]** The variable interference is able to compensate the deformations that the insert undergoes during the assembly steps of the acetabular prosthesis.

**[0032]** In this way, we maintain that the present invention is suitable to preserve the advantages deriving from the production of resurfacing prostheses, but also provides greater primary stability to the prosthesis itself.

**[0033]** In variant embodiments, the first clamping surface has a smaller inclination compared to the inclination of the second clamping surface.

**[0034]** According to another feature of the present invention, at least one of either the acetabular cup or the insert is made of ceramic material.

**[0035]** In example embodiments, the insert is made of ceramic material.

**[0036]** The choice of ceramic material allows to adopt relatively thin thicknesses and, at the same time, to obtain optimum mechanical and anti-wear characteristics, preventing the release of metal ions. Ceramic material is also bio-compatible.

**[0037]** Ceramic-ceramic couplings have a reduced rate of wear, they do not release metal ions and they are less sensitive to the positioning of the implant compared with metal-metal systems. In particular, with the present invention it is possible to obtain reduced thicknesses of the acetabular prosthesis, to maintain the necessary mechanical properties, and, what is more, to prevent the problem of wear and release of ions.

**[0038]** The acetabular cup is shaped so as to comprise a through aperture, in correspondence to its polar region.

**[0039]** The insert is shaped so as to comprise, in a polar region thereof, a centering element able to be inserted inside the through aperture.

**[0040]** The centering element and the through aperture are able to allow the centering of the acetabular cup and the insert during the assembly step.

**[0041]** The present invention also concerns a method to assemble an acetabular prosthesis as described above, such assembly being typically carried out during an industrial production step.

**[0042]** The method provides:

- to make available an acetabular cup comprising an internal surface defining a coupling cavity,
- to make available an insert able to be inserted inside the coupling cavity and comprising an external surface,
- to couple the acetabular cup and the insert along a common coupling axis and to clamp them reciprocally in an assembled condition using respective clamping means.

**[0043]** According to the present invention, before coupling, in a disassembled condition, the coupling cavity of the acetabular cup has an internal diameter which is less than the largest external diameter of the insert while, after the coupling, in the assembled condition, the internal diameter of the coupling cavity of the acetabular cup is equal to the largest external diameter of the insert.

**[0044]** The internal diameter of the coupling cavity of the acetabular cup is considered in correspondence to a coupling plane between the acetabular cup and the insert defined along the coupling axis.

**[0045]** Moreover, the clamping of the acetabular cup and the insert is achieved by means of clamping means which comprise:

- a first clamping surface, made on the internal surface of the acetabular cup,
- a second clamping surface, made on the external surface of the insert, and cooperating with the first clamping surface.

**[0046]** The first clamping surface and the second clamping surface are a truncated cone shape, with an inclination different from each other with respect to the coupling axis, so as to obtain a conical coupling of the insert and the acetabular cup, with variable interference, along the coupling axis.

**[0047]** The method to assemble the acetabular prosthesis comprises at least a step in which the acetabular cup is gripped by elastic gripping means in correspondence to a through aperture, a step in which the insert is positioned on a support and centering element, a step in which the elastic gripping means are moved and the acetabular cup is coupled, by variable interference, with the insert, making the first clamping surface and the second clamping surface cooperate with each other, and a step in which the elastic gripping means release the acetabular cup coupled with the insert.

**[0048]** In some forms of embodiment, the method includes a preliminary step of aligning and centering the elastic gripping means and the insert, positioned on the support and centering element, moving the elastic gripping means downward.

**[0049]** In some forms of embodiment, after the alignment and centering of the elastic gripping means and the insert, the elastic gripping means are raised, the insert is removed from the support and centering element, the acetabular cup is placed on the support and centering element, the elastic gripping means are moved downward to grip the acetabular cup, the elastic gripping means associated to the acetabular cup are raised and the insert is once again positioned on the support and centering element in order to proceed with the conical coupling.

**[0050]** In some variants, the assembly can be obtained by applying a thermal load, or a thermal deformation.

**[0051]** In other variants, the assembly can be obtained mechanically, or by means of mechanical forcing.

**[0052]** Other variants can provide an assembly made by combining the application of a thermal load to a mechanical assembly.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0053]** These and other characteristics of the present invention will become apparent from the following description of some forms of embodiment, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a perspective view of an acetabular prosthesis according to some forms of embodiment of the present invention;
- fig. 2 is another perspective view of the acetabular prosthesis in fig. 1;
- fig. 3 is a lateral view of the acetabular prosthesis in fig. 1;
- fig. 4 is a transverse section of the acetabular prosthesis in fig. 3;
- fig. 5 is a part of fig. 4;
- fig. 6 is an enlarged detail of fig. 5;
- fig. 7 is another part of fig. 4;
- fig. 8 is an enlarged detail of fig. 7;
- fig. 9 is an enlarged detail of fig. 4;
- fig. 10 is another enlarged detail of fig. 4;
- fig. 11 is a schematic representation of a part of the present invention;
- fig. 12 schematically shows a variant of the method to assemble the acetabular prosthesis in fig. 1.

## DETAILED DESCRIPTION OF SOME FORMS OF EMBODIMENT

**[0054]** We shall now refer in detail to the various forms of embodiment of the present invention, of which one or more examples are shown in the attached drawing. Each example is supplied by way of illustration of the invention and shall not be understood as a limitation thereof. For example, the characteristics shown or described insomuch as they are part of one form of embodiment can be adopted on, or in association with, other forms of embodiment to produce another form of embodiment. It is understood that the present invention shall include all such modifications and variants.

**[0055]** With reference to figs. 1 and 2, an acetabular prosthesis 10 according to the present invention is able to be inserted inside an acetabular seating, not shown in the drawings, of the hipbone of a patient, acting as a positioning and rotation seating for the head of a femoral prosthesis, also not shown in the drawings. In non-restrictive example embodiments of the present invention, we maintain that the acetabular prosthesis 10 can be applied effectively to achieve resurfacing prostheses.

**[0056]** In some forms of embodiment, the acetabular prosthesis 10 can substantially be shaped like a hemispherical or semi-spherical cap, which is hollow inside

and, in this case shown by way of example, axial symmetric with respect to an axis of symmetry Y (figs. 3 and 4), also called coupling axis.

**[0057]** According to the present invention, the acetabular prosthesis 10 mainly comprises two elements, that is, an acetabular cup 11 and a mating insert 12, both of a substantially semi-spherical shape which are reciprocally constrained and assembled by conical coupling with interference that is variable and imposed along a common coupling axis which in this case is represented by said axis Y.

**[0058]** In particular, in some forms of embodiment, the acetabular cup or shell 11 is insertable inside the acetabular seating of the hip, and the mating insert 12 is insertable inside the acetabular cup 11.

**[0059]** The configuration of the acetabular prosthesis 10 defines overall a semi-spherical cavity 13.

**[0060]** The acetabular cup 11 can in this case be made of titanium, titanium alloys, or in any case a material with a titanium base.

**[0061]** The acetabular cup 11 can comprise an internal surface 14 (fig. 5), which can define a coupling cavity 15, in this case semi-spherical, and an external surface 16 which, during use, faces toward the bone of the acetabular seating. The acetabular cup 11 can comprise or be defined by an equatorial band 17, a polar region 18 and an intermediate zone 19, the latter provided between the equatorial band 17 and the polar region 18, with a greater extension and of a semi-spherical shape.

**[0062]** According to some forms of embodiment of the present invention, in a disassembled condition the coupling cavity 15 of the acetabular cup 11 has an internal diameter Dc (fig. 5) which is less than a largest external diameter Di (fig. 7) of the insert 12.

**[0063]** Moreover, according to the present invention, in the assembled condition the largest external diameter, indicated by Di' in fig. 4, of the insert 12 is equal, following mechanical and/or thermal deformation, to the internal diameter, indicated by Dc' in fig. 4, of the coupling cavity 15 of the acetabular cup 11.

**[0064]** In particular, in some forms of embodiment of the invention, an interference "i" can be identified given by the difference between the values of the diameters Di and Dc, external and internal, respectively of the insert 12 and the acetabular cup 11, in the disassembled condition: i=Di - Dc

**[0065]** Without being constrained by theory, in practice we maintain that the stable coupling of insert 12 and acetabular cup 11 is given in large part by the deformation of the material of the acetabular cup 11 which, following the forced coupling, mechanical and/or thermal, with the insert 12, has a deformation which increases the internal diameter from Dc to Dc'.

**[0066]** In possible forms of embodiment, values "i" of diameter interference can be equal to or more than 0.01 mm, for example can vary in a range between 0.01 and 0.25 mm, and can include every possible sub-range. Examples of embodiments of lower limits of diametral interference values "i" can be 0.01 mm, 0.0125 mm, or 0.025 mm, or 0.05 mm. Examples of embodiments of higher limits of diametral interference values "i", which can be combined with examples of embodiment cited of lower limits of diametral interference values "i", can be 0.25 mm, or 0.20 mm, or again 0.15 mm. For example, a sub-range of diametral interference values "i" can be between 0.025 mm and 0.20 mm, or another example of sub-range of diametral interference values "i" can be between 0.05 mm and 0.15 mm.

**[0067]** For the sake of completeness, we maintain that the shape or size of the insert 12 can also be minimally deformed, and that as a consequence the external diameter of the insert 12 varies slightly from Di to the value Di' after coupling with the acetabular cup 11. However, we maintain that in most cases the difference in absolute value between Di and Di' is negligible, in that the deformation of the material which constitutes the insert 12 is negligible, while the difference between Dc and Dc' is significant. Indeed, as we said, the largest deformation occurs on the acetabular cup 11, the internal diameter of which increases from Dc to Dc'.

**[0068]** In some forms of embodiment, the internal diameter Dc, Dc' of the coupling cavity 15 of the acetabular cup 11 is considered, both in the disassembled condition and in the assembled condition, in correspondence to a coupling plane P of the acetabular cup 11 and the insert 12, defined along the coupling axis Y.

**[0069]** In some forms of embodiment, in correspondence to the equatorial band 17, the internal surface 14 can be shaped so as to comprise a first clamping surface 20, shaped like a truncated cone, with an inclination $\alpha$ with respect to the axis Y (fig. 6) and able to achieve the reciprocal clamping with the insert 12, as will be seen hereafter in the present description. Moreover, the equatorial band 17 can be shaped so as to comprise an external ring 21. In some forms of embodiment, the external ring 21 is a solid and compact part of the acetabular cup 11.

**[0070]** The external ring 21 can have the function of modulating the rigidity of the whole acetabular cup 11. By way of example, we maintain that the greater the height of the external ring 21, the greater is the overall rigidity of the acetabular cup 11. In some forms of embodiment, the desired rigidity can be obtained, in the design stage, according to the sizes of the prosthesis to be made, by varying the height of the external ring 21. The polar region 18 can be shaped so as to have a through aperture 23 of a circular shape, delimited by an upper ring 24, configured for example as a protruding annular projection.

**[0071]** The acetabular cup 11 can comprise, in the space between the external ring 21 and the upper ring 24 of the equatorial band 17, a solid and compact internal part 22 and a trabecular part, or reticular trabecular structure 25, in this case external, associated to the external surface 16. The trabecular part 25 can be defined by a lattice which, for example, acts as a gripping and osseo-

integration element for the hipbone during the re-growth step following the operation undergone by the patient.

**[0072]** In other forms of embodiment, the trabecular part 25 can be in a single body with the solid and compact internal part 22 and with the external ring 21, that is, from the inside to the outside, the material which constitutes the acetabular cup 11 is solid, in correspondence to the external ring 21 and, continuous with the material, varies in order to subsequently define the structure of the trabecular part 25.

**[0073]** In other forms of embodiment, the acetabular cup 11 can consist completely of the trabecular part 25.

**[0074]** The structure of the trabecular part 25 can be a lattice of cells, achieving a plurality of three-dimensional cavities disposed, open and intercommunicating, connected with each other. The lattice can be solid with the solid and compact internal part 22 and with the external ring 21. In some forms of embodiment, at least part of the lattice of the trabecular part 25 can be formed, without any break in continuity, by one or more models of a plurality of geometric meshes which are repeated in space on all the trabecular part 25, having a cellular geometry with open and contiguous elementary cells, so as to define a plurality of polygons, such as hexagons, with non-coplanar vertexes, with a spatial development delimiting the cavities, so that the lattice is able to promote osseo-integration.

**[0075]** In some forms of embodiment, the structure of the trabecular part 25 mentioned above, possibly in continuity with the solid and compact internal part 22, can be obtained using techniques such as Electron Beam Melting (EBM), or Selective Laser Melting (SLM). Example embodiments are described in the international application WO-A-2008/146141 in the name of the Applicant.

**[0076]** In some forms of embodiment, the acetabular cup 11 can also comprise a plurality, in this case for example four, niches 26 on the external surface 16 of the equatorial band 17, to facilitate the orientation and positioning of the acetabular cup 11 in the acetabular seating.

**[0077]** The insert 12, in this case made of ceramic material, can comprise an internal surface 27 (fig. 7), which can define a semi-spherical cavity 28, and an external surface 29, which during use faces toward the internal surface 14 of the acetabular cup 11. In this case too, the insert 12 can for example be defined by an equatorial band 30, a polar region 31 and an intermediate zone 32.

**[0078]** The insert 12 made of ceramic material allows to adopt relatively thin thicknesses and, at the same time, to obtain optimum mechanical characteristics, resistance to wear, biocompatibility and to prevent the risk of metal ions.

**[0079]** The external surface 29, in correspondence to the equatorial band 30, can be shaped so as to comprise a second clamping surface 33, shaped like a truncated cone and with an inclination $\beta$ (fig. 8) greater than the inclination $\alpha$ of the first clamping surface 20 of the acetabular cup 11.

**[0080]** Consequently, according to some forms of embodiment of the present invention, the first clamping surface 20 and the second clamping surface 33 can be truncated cone shaped with an inclination $\alpha$, $\beta$ different from each other with respect to the coupling axis Y, so as to achieve a coupling of the insert 12 and the acetabular cup 11 with interference "i" that varies along the axis of symmetry Y.

**[0081]** In substance, some forms of embodiment define that said largest external diameter Di, Di' of the insert 12 is the largest base diameter of the truncated cone shape of the second clamping surface 33.

**[0082]** Therefore, some forms of embodiment define that said largest internal diameter Dc, Dc' of the acetabular cup 11 is the diameter of the truncated cone shape of the first clamping surface 20 in correspondence to the annular band of cooperation and coupling with the second clamping surface 33 of the insert 12, along the coupling plane P.

**[0083]** Having already defined above the interference "i" as the difference between the diameters Di and DC, it is clear that this size refers to the base diameters of the truncated cones of the clamping surfaces 20 and 33. With reference to the interference "i", in fig. 11 its variability is schematically shown, in particular decreasing along the coupling axis Y going from the outside to the inside, where it has a maximum value ($i_{max}$) in correspondence to the largest diameters Dc, Di, internal and external respectively, in the disassembled condition of the acetabular cup 11 and of the insert 12, and a minimum value ($i_{min}$), equal to zero, where the two diameters Dc, Di, varying in height along the coupling axis Y, would assume the same value. In this case, said coupling plane P can therefore be defined as the through plane for the annular region of contact and coupling of acetabular cup 11 and insert 12 in the assembled condition, in correspondence to the position for which the interference "i" assumes the value ($i_{max}$) which there would be in the disassembled condition.

**[0084]** In some forms of embodiment, the insert 12 can be shaped so as to comprise, in the polar region 31, a centering peg 34 able to be inserted inside the through aperture 23, with a diameter a little less than that of the through aperture 23.

**[0085]** As we said above, the two different inclination values, that is, conicity, $\alpha$ and $\beta$ of the clamping surfaces 20 and 33 with respect to the axis Y, ensure that the coupling of the insert 12 and the acetabular cup 11 occurs by interference "i" (fig. 9). In particular, we have maximum variable interference "i" on the maximum diameter of the cone, and minimum, in this case zero, on the minimum diameter of the cone (figs. 9 and 11). This configuration is able to compensate the deformations in the monitoring step and to guarantee a solid coupling.

**[0086]** Moreover, the presence of the centering peg 34 can facilitate, in the assembly step, the centering of the insert 12 with respect to the acetabular cup 11.

**[0087]** The acetabular cup 11 and the insert 12 can be

configured so as to cooperate with each other, during assembly, only using the clamping surfaces 20 and 33, defining an interspace 35 in correspondence to the intermediate zones 19 and 32 and the polar regions 18 and 31 (fig. 10). The interspace 35, during assembly, has the function of ensuring that the constraint is caused by the conical coupling. During normal use the insert 12 and the acetabular cup 11 can cooperate in contact with each other.

**[0088]** The acetabular prosthesis 10, in its entirety, confers an optimum stability to the insert 12 and the acetabular cup 11, both in the insertion step of the acetabular prosthesis 10 into the acetabular seating, and also in the insertion step of the head of the femoral prosthesis, or the natural femoral head, inside the insert 12.

**[0089]** According to some forms of embodiment, the coupling of the acetabular cup 11 and the insert 12 can occur as described hereinafter in relation to the schematic representation in fig. 12, which respectively show two variants of possible assembly.

**[0090]** For the assembly, the present invention can use elastic gripping means driven by a press 42 configured to apply a desired vertical thrust. In variant embodiments, the elastic gripping means are for example elastic grippers 37 vertically mobile by means of the press 42. The elastic grippers 37 are equipped with an elastic thruster 38 with a piston which has elastic gripping ends 39 of the flexible type able to deform elastically during opening and closing. The elastic gripping ends 39 protrude from an abutment surface 46 of the elastic thruster 38 of a curvilinear shape, mating with a contact portion 47 of the polar region of the acetabular cup 11 which surrounds the through aperture 23.

**[0091]** The elastic grippers 37 can comprise a containing chamber 43 for the travel of the elastic thruster 38, in which elastic cushioning means are provided, such as a spring 44 for example. The elastic thruster 38 can normally be in an inactive position on the bottom of the containing chamber 43, as can be seen in fig. 12, step A.

**[0092]** In some forms of embodiment, the assembly method, typically carried out during the industrial production step, can include a preliminary step of centering and aligning the insert 12 and the elastic grippers 37 (fig. 12 step A). The insert 12 can be positioned on a support and centering element 40 disposed, in its turn, on a support block 48. The support and centering element 40 has the profile, in negative, of the internal surface 27 of the insert 12. The centering is carried out by moving the elastic grippers 37 downward and aligning them to the centering peg 34, until they contact the latter. In this case, a clamping element 41 is provided which cooperates with the elastic thruster 38, clamping its travel, to prevent the elastic thruster 38 from returning upward (fig. 12, step A).

**[0093]** Subsequently, it is necessary to mount the acetabular cup 11 on the elastic grippers 37. To do this, as seen in fig. 12, the elastic grippers 37, once aligned to the insert 12, are raised and the insert 12 is removed from the support and centering element 40.

**[0094]** The acetabular cup 11 is then positioned on the latter and the elastic grippers 37 are again lowered, keeping the clamping element 41 inserted, until the cooperation is determined between the elastic gripping end 39 and the through aperture 23 of the acetabular cup 11 (fig. 12 step B). We maintain that the removal of the insert 12 from the support and centering element 40 facilitates the mounting of the acetabular cup 11 onto the elastic grippers 37, since otherwise the through aperture 23 would be occupied by the centering peg 34 and could not be engaged by the elastic gripping ends 39.

**[0095]** Subsequently, the elastic grippers 37, and the acetabular cup 11 solid with it, are again raised, in order to place the insert 12 once again on the support and centering element 40 (fig. 12, step C). The clamping element 41 can be removed in order to allow the travel of the elastic thruster 38 as explained below.

**[0096]** Then, the elastic grippers 37 are once again moved downward and the acetabular cup 11 is placed on the insert 12, applying a suitable thrust using the press 42, making the first clamping surface 20 and the second clamping surface 33 cooperate with each other, so as to obtain the conical coupling by variable interference as described above (fig. 12 step D): The cooperation between the first clamping surface 20 and the second clamping surface 33 begins when the abutment surface 46 of the elastic thruster 38 contacts the contact portion 47 of the polar region 18 of the acetabular cup 11. In fact, at this point, the travel of the elastic thruster 38 is caused, backward with respect to its inactive position on the bottom of the containing chamber 43, until the elastic gripping ends 39 are positioned in the containing chamber 43, disengaging the through aperture 23 (fig. 12, step D). This movement is elastically controlled and cushioned by the spring 44, which as a consequence is progressively compressed (fig. 12, step D). The elastic thruster 38 retracts until the elastic gripping ends 39 are uncoupled from the through aperture 23, also following the insertion of the centering peg 34. In this way, moreover, the through aperture 23 is positioned around the centering peg 34, ensuring the centering of the acetabular cup 11 on the insert 12 (fig. 12, step D).

**[0097]** In some forms of embodiment, in step D the assembly of the acetabular cup 11 and insert 12 can be obtained only mechanically, by means of said conical coupling, or by applying a thermal load, so that the thermal dilation of the material of the acetabular cup 11 due to heating facilitates the conical coupling of the acetabular cup 11 and insert 12, or by means of a combination of these techniques.

**[0098]** In any case, the technique selected is suitable to obtain the forced coupling of the insert 12, which in the disassembled condition has a largest external diameter Di larger than the internal diameter Dc of the acetabular cup 11, so that, in the assembled condition, the largest external diameter Di' is equal to the internal diameter Dc' of the acetabular cup 11.

**[0099]** Subsequently, the elastic grippers 37 are

raised, separating from the acetabular cup 11 which stays coupled to the insert 12 by variable interference (fig. 12, step E). As it rises, the elastic thruster 38 is once again thrust toward the outside by the extension of the spring 44 (fig. 12, step E).

**[0100]** It is clear that modifications and/or additions of parts may be made to the acetabular prosthesis and the corresponding method as described heretofore, without departing from the field and scope of the present invention.

**[0101]** It is also clear that, although the present invention has been described with reference to a specific example, a person of skill in the art shall certainly be able to achieve many other equivalent forms of acetabular prosthesis and corresponding method, having the characteristics as set forth in the claims.

## Claims

**1.** Acetabular prosthesis comprising:

- an acetabular cup (11) comprising an internal surface (14) defining a coupling cavity (15),
- an insert (12) able to be inserted inside said coupling cavity (15) and comprising an external surface (29),

said acetabular cup (11) and said insert (12) having a common coupling axis (Y) and comprising respective clamping means (20, 33) for their reciprocal clamping in an assembled condition, wherein in a disassembled condition the coupling cavity (15) of the acetabular cup (11) has an internal diameter (Dc) which is less than the largest external diameter (Di) of said insert (12), wherein in the assembled condition the largest external diameter (Di') of said insert (12) is equal to the largest internal diameter (Dc') of the coupling cavity (15) of the acetabular cup (11), wherein the internal diameter (Dc, Dc') of the coupling cavity (15) of the acetabular cup (11) is considered in correspondence to a coupling plane (P) between the acetabular cup (11) and the insert (12) defined along said coupling axis (Y), wherein furthermore said clamping means comprise:

- a first clamping surface (20) made on said internal surface (14) of said acetabular cup (11),
- a second clamping surface (33) made on said external surface (29) of said insert (12), and cooperating with said first clamping surface (20),

said first clamping surface (20) and said second clamping surface (33) having a truncated cone shape with an inclination ($\alpha$, $\beta$) different from each other with respect to said coupling axis (Y), so as to obtain a conical coupling between said insert (12) and said acetabular cup (11), with variable interference (i), along said coupling axis (Y), **characterized in that** said acetabular cup (11) comprises a trabecular reticular structure (25), said trabecular reticular structure (25) being a lattice of cells, achieving a plurality of three-dimensional cavities disposed, open and intercommunicating, connected with each other; wherein said acetabular cup (11) is shaped so as to comprise a through aperture (23) in correspondence to a polar region (18) thereof,

wherein said insert (12) is shaped so as to comprise, in a polar region (31) thereof, a centering element (34) able to be inserted inside said through aperture (23).

**2.** Acetabular prosthesis as in claim 1, **characterized in that** said variable interference (i), during use, is maximum ($i_{max}$) in proximity to the maximum diameters of the cones, and minimum ($i_{min}$) in proximity to the minimum diameters of the cones defining said first clamping surface (20) and said second clamping surface (33).

**3.** Acetabular prosthesis as in claim 1 or 2, **characterized in that** said first clamping surface (20) has an inclination ($\alpha$) less than an inclination ($\beta$) of said second clamping surface (33).

**4.** Acetabular prosthesis as in any claim hereinbefore, **characterized in that** at least one of either said acetabular cup (11) and said insert (12) is made of ceramic material.

**5.** Acetabular prosthesis as in any claim hereinbefore, **characterized in that** said acetabular cup (11) comprises a plurality of recesses (26) allowing to position said acetabular prosthesis in an acetabular seating.

**6.** Acetabular prosthesis as in any claim hereinbefore, **characterized in that** the trabecular reticular structure (25) constitutes all or part of the acetabular cup (11).

**7.** Acetabular prosthesis as in any claim hereinbefore, **characterized in that** at least part of the trabecular reticular structure (25) is formed, without a break in continuity, by one or more models of a plurality of geometric meshes which are repeated in space on all the trabecular reticular structure (25), and have a cellular geometry with open and contiguous elementary cells, so as to define a plurality of polygons, with non-coplanar vertexes, with a spatial development delimiting cavities.

**8.** Acetabular prosthesis as in any claim hereinbefore, **characterized in that** the trabecular reticular structure (25) is obtained using Electronic Beam Melting (EBM) or Selective Laser Melting (SLM).

**9.** Method for assembling an acetabular prosthesis, said method providing:

- to make available an acetabular cup (11) comprising an internal surface (14) defining a coupling cavity (15),
- to make available an insert (12) able to be inserted inside said coupling cavity (15) and comprising an external surface (29),
- to couple said acetabular cup (11) and said insert (12) along a common coupling axis (Y) and to reciprocally clamp said acetabular cup (11) and said insert (12) in an assembled condition by means of respective clamping means (20, 33), wherein before coupling, in a disassembled condition, the coupling cavity (15) of the acetabular cup (11) has an internal diameter (Dc) which is less than the largest external diameter (Di) of said insert (12) **and** wherein, after coupling, in the assembled condition, the internal diameter (Dc') of the coupling cavity (15) of the acetabular cup (11) is equal to the largest external diameter (Di') of said insert (12), wherein the internal diameter (Dc, Dc') of the coupling cavity (15) of the acetabular cup (11) is considered in correspondence to a coupling plane (P) between the acetabular cup (11) and the insert (12) defined along said coupling axis (Y), wherein furthermore the clamping between said acetabular cup (11) and said insert (12) is made using clamping means which comprise:
- a first clamping surface (20), made on said internal surface (14) of said acetabular cup (11),
- a second clamping surface (33), made on said external surface (29) of said insert (12), and cooperating with said first clamping surface (20),

said first clamping surface (20) and said second clamping surface (33) having a truncated cone shape with an inclination ($\alpha$, $\beta$) different from each other with respect to said coupling axis (Y), so as to obtain a conical coupling between said insert (12) and said acetabular cup (11), with variable interference (i) along said coupling axis (Y), **characterized in that**
said acetabular cup (11) comprises a trabecular reticular structure (25), said trabecular reticular structure (25) being a lattice of cells, achieving a plurality of three-dimensional cavities disposed, open and intercommunicating, connected with each other; **in that** said acetabular cup (11) is shaped so as to comprise a through aperture (23) in correspondence to a polar region (18) thereof, **in that** said insert (12) is shaped so as to comprise, in a polar region (31) thereof, a centering element (34) able to be inserted inside said through aperture (23),
and **in that** said method comprises at least a step in which said acetabular cup (11) is gripped by elastic gripping means (37) in correspondence to a through aperture (23), a step in which said insert (12) is positioned on a support and centering element (40), a step in which the elastic gripping means (37) are moved and said acetabular cup (11) is coupled through variable interference with said insert (12), making said first clamping surface (20) and said second clamping surface (33) cooperate with each other, and a step in which said elastic gripping means (37) release said acetabular cup (11) coupled with said insert (12), wherein the assembly of said acetabular cup (11) and said insert (12) is obtained by applying a thermal load, or mechanically, or a combination of application of a thermal load and mechanical assembly.

**10.** Method as in claim 9, **characterized in that** it comprises a preliminary step of aligning and centering said elastic gripping means (37) and said insert (12) positioned on said support and centering element (40), moving said elastic gripping means (37) downward.

**11.** Method as in claim 10, **characterized in that,** after the alignment and centering of said elastic gripping means (37) and said insert (12), said elastic gripping means (37) are lifted, said insert (12) is removed from the support and centering element (40), said acetabular cup (11) is placed on the support and centering element (40), the elastic gripping means (37) are moved downward to grip the acetabular cup (11), the elastic gripping means (37) associated with the acetabular cup (11) are lifted and the insert (12) is again positioned on the support and centering element (40) in order to proceed with the conical coupling.

**Patentansprüche**

**1.** Hüftgelenkprothese, aufweisend:

- eine Hüftgelenkpfanne (11), die eine Innenfläche (14) aufweist, die eine Verbindungskavität (15) definiert,
- ein Einsatzstück (12), das geeignet ist, innerhalb der Verbindungskavität (15) eingesetzt zu sein und eine Außenfläche (29) aufweist,

wobei die Hüftgelenkpfanne (11) und das Einsatzstück (12) eine gemeinsame Verbindungsachse (Y) haben und jeweilige Klemmmittel (20, 33) für ihr gegenseitiges Festklemmen in einem Zusammenbauzustand aufweisen, wobei in einem Auseinanderbauzustand die Verbindungskavität (15) der Hüftgelenkpfanne (11) einen Innendurchmesser (Dc) hat, der kleiner als der größte Außendurchmesser (Di) des Einsatzstücks (12) ist, wobei im Zusammenbau-

zustand der größte Außendurchmesser (Di') des Einsatzstücks (12) gleich dem größten Innendurchmesser (Dc') der Verbindungskavität (15) der Hüftgelenkpfanne (11) ist, wobei der Innendurchmesser (Dc, Dc') der Verbindungskavität (15) der Hüftgelenkpfanne (11) in Übereinstimmung mit einer Verbindungsebene (P) zwischen der Hüftgelenkpfanne (11) und dem Einsatzstück (12) betrachtet wird, die entlang der Verbindungsachse (Y) definiert ist, wobei ferner die Klemmmittel aufweisen:

- eine erste Klemmfläche (20), die auf der Innenfläche (14) der Hüftgelenkpfanne (11) ausgebildet ist,
- eine zweite Klemmfläche (33), die auf der Außenfläche (29) des Einsatzstücks (12) vorgesehen ist und mit der ersten Klemmfläche (20) zusammenwirkt,

wobei die erste Klemmfläche (20) und die zweite Klemmfläche (33) eine Kegelstumpfform mit einer Neigung ($\alpha$, $\beta$) haben, die bezüglich der Verbindungsachse (Y) voneinander unterschiedlich ist, um eine konische Verbindung zwischen dem Einsatzstück (12) und der Hüftgelenkpfanne (11) mit variabler Interferenz (i) entlang der Verbindungsachse (Y) zu erhalten,
**dadurch gekennzeichnet, dass**
die Hüftgelenkpfanne (11) eine trabekuläre netzartige Struktur (25) hat, wobei die trabekuläre netzartige Struktur (25) ein Gitter von Zellen ist, wobei eine Mehrzahl von dreidimensionalen Kavitäten erhalten wird, die offen und miteinander kommunizierend miteinander verbunden angeordnet sind,
wobei die Hüftgelenkpfanne (11) geformt ist, um eine Durchgangsöffnung (23) in Übereinstimmung mit einem Polbereich (18) davon aufzuweisen,
wobei das Einsatzstück (12) geformt ist, um in einem Polbereich (31) davon ein Zentrierelement (34) aufzuweisen, das geeignet ist, innerhalb der Durchgangsöffnung (23) eingesetzt zu sein.

**2.** Hüftgelenkprothese wie in Anspruch 1, **dadurch gekennzeichnet, dass** die variable Interferenz (i) während der Nutzung in der Nähe der maximalen Durchmesser der Konusse maximal ($i_{max}$) ist und in der Nähe der minimalen Durchmesser der Konusse, die die erste Klemmfläche (20) und die zweite Klemmfläche (33) definieren, minimal ($i_{min}$) ist.

**3.** Hüftgelenkprothese wie in Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die erste Klemmfläche (20) eine Neigung ($\alpha$) hat, die kleiner als eine Neigung ($\beta$) der zweiten Klemmfläche (33) ist.

**4.** Hüftgelenkprothese wie in irgendeinem vorhergehenden Anspruch, **dadurch gekennzeichnet, dass** mindestens eine/eines von entweder der Hüftgelenkpfanne (11) und dem Einsatzstück (12) aus Keramikmaterial hergestellt ist.

**5.** Hüftgelenkprothese wie in irgendeinem vorhergehenden Anspruch, **dadurch gekennzeichnet, dass** die Hüftgelenkpfanne (11) eine Mehrzahl von Aussparungen (26) aufweist, die ein Positionieren der Hüftgelenkprothese in einer Hüftgelenkaufnahme ermöglichen.

**6.** Hüftgelenkprothese wie in irgendeinem vorhergehenden Anspruch, **dadurch gekennzeichnet, dass** die trabekuläre netzartige Struktur (25) die gesamte oder einen Teil der Hüftgelenkpfanne (11) bildet.

**7.** Hüftgelenkprothese wie in irgendeinem vorhergehenden Anspruch, **dadurch gekennzeichnet, dass** zumindest ein Teil der trabekulären netzartigen Struktur (25) ohne eine Unterbrechung der Kontinuität durch ein oder mehrere Modelle einer Mehrzahl von geometrischen Maschen ausgebildet ist, die sich räumlich auf der gesamten netzartigen Struktur (25) wiederholen und eine zelluläre Geometrie mit offenen und zusammenhängenden Elementarzellen haben, um eine Mehrzahl von Polygonen mit nichtkoplanaren Scheitelpunkten mit einem Kavitäten begrenzenden räumlichen Verlauf zu definieren.

**8.** Hüftgelenkprothese wie in irgendeinem vorhergehenden Anspruch, **dadurch gekennzeichnet, dass** die trabekuläre netzartige Struktur (25) mittels Elektronenstrahlschmelzens (EBM) oder selektiven Laserschmelzens (SLM) erhalten wird.

**9.** Verfahren zum Zusammenbauen einer Hüftgelenkprothese, wobei das Verfahren vorsieht:

- eine Hüftgelenkpfanne (11) bereitzustellen, die eine Innenfläche (14) aufweist, die eine Verbindungskavität (15) definiert,
- ein Einsatzstück (12) bereitzustellen, das geeignet ist, innerhalb der Verbindungskavität (15) eingesetzt zu sein, und eine Außenfläche (29) aufweist,
- die Hüftgelenkpfanne (11) und das Einsatzstück (12) entlang einer gemeinsamen Verbindungsachse (Y) zu verbinden und die Hüftgelenkpfanne (11) und das Einsatzstück (12) in einem Zusammenbauzustand mittels jeweiliger Klemmmittel (20, 33) gegenseitig festzuklemmen,

wobei vor dem Verbinden, in einem Auseinanderbauzustand, die Verbindungskavität (15) der Hüftgelenkpfanne (11) einen Innendurchmesser (Dc) hat, der kleiner als der größte Außendurchmesser (Di) des Einsatzstücks (12) ist, und wobei nach dem Verbinden im Zusammenbauzustand der Innen-

durchmesser (Dc') der Verbindungskavität (15) der Hüftgelenkpfanne (11) gleich dem größten Außendurchmesser (Di') des Einsatzstücks (12) ist, wobei der Innendurchmesser (Dc, Dc') der Verbindungskavität (15) der Hüftgelenkpfanne (11) in Übereinstimmung mit einer Verbindungsebene (P) zwischen der Hüftgelenkpfanne (11) und dem Einsatzstück (12) betrachtet wird, die entlang der Kupplungsachse (Y) definiert wird, wobei darüber hinaus das Festklemmen zwischen der Hüftgelenkpfanne (11) und dem Einsatzstück (12) mittels Klemmmitteln erfolgt, die aufweisen:

- eine erste Klemmfläche (20), die auf der Innenfläche (14) der Hüftgelenkpfanne (11) ausgebildet ist,
- eine zweite Klemmfläche (33), die auf der Außenfläche (29) des Einsatzstücks (12) ausgebildet ist und mit der ersten Klemmfläche (20) zusammenwirkt,

wobei die erste Klemmfläche (20) und die zweite Klemmfläche (33) eine Kegelstumpfform mit einer Neigung ($\alpha$, $\beta$) haben, die bezüglich der Verbindungsachse (Y) voneinander unterschiedlich ist, um eine konische Verbindung zwischen dem Einsatzstück (12) und der Hüftgelenkpfanne (11) mit variabler Interferenz (i) entlang der Verbindungsachse (Y) zu erhalten,
**dadurch gekennzeichnet, dass**
die Hüftgelenkpfanne (11) eine trabekuläre netzartige Struktur (25) aufweist, wobei die trabekuläre netzartige Struktur (25) ein Gitter von Zellen ist, wobei eine Mehrzahl von dreidimensionalen Kavitäten erhalten wird, die offen und miteinander kommunizierend miteinander verbunden angeordnet sind, dass die Hüftgelenkpfanne (11) geformt ist, um eine Durchgangsöffnung (23) in Übereinstimmung mit einem Polbereich (18) davon aufzuweisen, dass das Einsatzstück (12) geformt ist, um in einem Polbereich (31) davon ein Zentrierelement (34) aufzuweisen, das geeignet ist, innerhalb der Durchgangsöffnung (23) eingesetzt zu werden,
und dass das Verfahren aufweist: mindestens einen Schritt, bei dem die Hüftgelenkpfanne (11) durch elastische Greifmittel (3) in Übereinstimmung mit einer Durchgangsöffnung (23) ergriffen wird, einen Schritt, bei dem das Einsatzstück (12) auf einem Stütz- und Zentrierelement (40) positioniert wird, einen Schritt, bei dem die elastischen Greifmittel (37) bewegt werden und die Hüftgelenkpfanne (11) durch variable Interferenz mit dem Einsatzstück (12) verbunden wird, wobei bewirkt wird, dass die erste Klemmfläche (20) und die zweite Klemmfläche (33) miteinander zusammenwirken, und einen Schritt, bei dem die elastischen Greifmittel (37) die Hüftgelenkpfanne (11), die mit dem Einsatzstück (12) verbunden ist, freigeben,
wobei der Zusammenbau der Hüftgelenkpfanne (11) und des Einsatzstücks (12) durch Aufbringen einer thermischen Belastung oder mechanisch oder durch eine Kombination der Anwendung einer thermischen Belastung und eines mechanischen Zusammenbaus erhalten wird.

**10.** Verfahren wie in Anspruch 9, **dadurch gekennzeichnet, dass** es einen vorangehenden Schritt des Ausrichtens und Zentrierens der elastischen Greifmittel (37) und des Einsatzstücks (12) aufweist, das auf dem Stütz- und Zentrierelement (40) positioniert ist, wobei die elastischen Greifmittel (37) nach unten bewegt werden.

**11.** Verfahren wie in Anspruch 10, **dadurch gekennzeichnet, dass** nach dem Ausrichten und Zentrieren der elastischen Greifmittel (37) und des Einsatzstücks (12) die elastischen Greifmittel (37) angehoben werden, das Einsatzstück (12) von dem Stütz- und Zentrierelement (40) entfernt wird, die Hüftgelenkpfanne (11) auf dem Stütz- und Zentrierelement (40) platziert wird, die elastischen Greifmittel (37) nach unten bewegt werden, um die Hüftgelenkpfanne (11) zu greifen, die mit der Hüftgelenkpfanne (11) assoziierten elastischen Greifmittel (37) angehoben werden und das Einsatzstück (12) wieder auf dem Stütz- und Zentrierelement (40) positioniert wird, um mit dem konischen Verbinden fortzufahren.

**Revendications**

**1.** Prothèse cotyloïdienne comprenant :

- une coupelle cotyloïdienne (11) comprenant une surface interne (14) formant une cavité de couplage (15),
- un insert (12) apte à être inséré à l'intérieur de ladite cavité de couplage (15) et comprenant une surface externe (29),

ladite coupelle cotyloïdienne (11) et ledit insert (12) ayant un axe de couplage commun (Y) et comprenant des moyens de fixation respectifs (20, 33) pour leur fixation l'un à l'autre à l'état assemblé,
dans laquelle à l'état assemblé, la cavité de couplage (15) de la coupelle cotyloïdienne (11) a un diamètre interne (Dc) qui est inférieur au diamètre externe le plus grand (Di) dudit insert (12),
dans laquelle à l'état assemblé, le diamètre externe le plus grand (Di') dudit insert (12) est égal au diamètre interne le plus grand (Dc') de la cavité de couplage (15) de la coupelle cotyloïdienne (11),
dans laquelle le diamètre interne (Dc, Dc') de la cavité de couplage (15) de la coupelle cotyloïdienne (11) est considéré en correspondance avec un plan de couplage (P) entre la coupelle cotyloïdienne (11)

et l'insert (12) formé le long dudit axe de couplage (Y),
dans laquelle en outre lesdits moyens de fixation comprennent :

- une première surface de fixation (20) réalisée sur ladite surface interne (14) de ladite coupelle cotyloïdienne (11),
- une seconde surface de fixation (33) réalisée sur ladite surface externe (29) dudit insert (12) et coopérant avec ladite première surface de fixation (20),

ladite première surface de fixation (20) et ladite seconde surface de couplage (33) ayant une forme tronconique avec une inclinaison ($\alpha$, $\beta$) différente l'une de l'autre par rapport audit axe de couplage (Y), de manière à obtenir un couplage conique entre ledit insert (12) et ladite coupelle cotyloïdienne (11), avec une interférence variable (i) le long dudit axe de couplage (Y),
**caractérisée en ce que**
ladite coupelle cotyloïdienne (11) comprend une structure réticulaire trabéculaire (25), ladite structure réticulaire trabéculaire (25) étant un réseau de cellules, formant une pluralité de cavités tridimensionnelles disposées ouvertes et en communication entre elles, connectées les unes aux autres ;
ladite coupelle cotyloïdienne (11) étant conformée de manière à comprendre une ouverture traversante (23) en correspondance avec une région polaire (18) de la coupelle,
ledit insert (12) étant conformé de manière à comprendre, dans une région polaire (31) de cet insert, un élément de centrage (34) apte à être introduit à l'intérieur de ladite ouverture traversante (23).

**2.** Prothèse cotyloïdienne selon la revendication 1, **caractérisée en ce que** ladite interférence variable (i), durant l'utilisation, a une valeur maximale ($i_{max}$) à proximité des diamètres maximaux des cônes et une valeur minimale ($i_{min}$) à proximité des diamètres minimaux des cônes formant ladite première surface de fixation (20) et ladite seconde surface de fixation (33).

**3.** Prothèse cotyloïdienne selon la revendication 1 ou 2, **caractérisée en ce que** ladite première surface de fixation (20) a une inclinaison ($\alpha$) inférieure à l'inclinaison ($\beta$) de ladite seconde surface de fixation (33).

**4.** Prothèse cotyloïdienne selon l'une quelconque des revendications précédentes, **caractérisée en ce qu'**au moins la coupelle cotyloïdienne (11) ou ledit insert (12) est réalisé(e) en matériau céramique.

**5.** Prothèse cotyloïdienne selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ladite coupelle cotyloïdienne (11) comprend une pluralité de renfoncements (26) permettant de positionner ladite prothèse cotyloïdienne dans un siège cotyloïdien.

**6.** Prothèse cotyloïdienne selon l'une quelconque des revendications précédentes, **caractérisée en ce que** la structure réticulaire trabéculaire (25) constitue tout ou partie de la coupelle cotyloïdienne (11).

**7.** Prothèse cotyloïdienne selon l'une quelconque des revendications précédentes, **caractérisée en ce qu'**au moins une partie de la structure réticulaire trabéculaire (25) est formée, sans défaut de continuité, par un plusieurs modèles d'une pluralité de mailles géométriques qui sont répétées dans l'espace sur toute la structure réticulaire trabéculaire (25), et ont une géométrie cellulaire avec des cellules ouvertes et contigües, de manière à former une pluralité de polygones, avec des sommets non coplanaires, avec une extension spatiale formant des cavités.

**8.** Prothèse cotyloïdienne selon l'une quelconque des revendications précédentes, **caractérisée en ce que** la structure réticulaire trabéculaire (25) est obtenue par fusion par faisceau d'électrons (Electron Beam Melting - EBM) ou fusion sélective par laser (Selective Laser Melting - SLM).

**9.** Procédé d'assemblage d'une prothèse cotyloïdienne, ledit procédé prévoit :

- de se procurer une coupelle cotyloïdienne (11) comprenant une surface interne (14) formant une cavité de couplage (15),
- de se procurer un insert (12) apte à être inséré à l'intérieur de ladite cavité de couplage (15) et comprenant une surface externe (29) ;
- de coupler ladite coupelle cotyloïdienne (11) et ledit insert (12) le long d'un axe de couplage commun (Y) et de fixer l'une à l'autre ladite coupelle cotyloïdienne (11) et ledit insert (12) à l'état assemblé à l'aide de moyens de fixation respectifs (20, 33),

dans lequel, avant le couplage, à l'état désassemblé, la cavité de couplage (15) de la coupelle cotyloïdienne (11) a un diamètre interne (De) qui est inférieur au diamètre externe le plus grand (Di) dudit insert (12) et dans lequel, après le couplage, à l'état assemblé, le diamètre interne (Dc') de la cavité de couplage (15) de la coupelle cotyloïdienne (11) est égale au diamètre externe le plus grand (Di') dudit insert (12), le diamètre interne (Dc, Dc') de la cavité de couplage (15) de la coupelle cotyloïdienne (11) étant considéré en correspondance avec un plan de couplage (P) entre la coupelle cotyloïdienne (11) et l'in-

sert (12) formé le long dudit axe de couplage (Y), la fixation entre ladite couple cotyloïdienne (11) et ledit insert (12) étant en outre réalisée en utilisant des moyens de fixation qui comprennent :

- une première surface de fixation (20), réalisée sur ladite surface interne (14) de ladite coupelle cotyloïdienne (11),
- une seconde surface de fixation (33), réalisée sur ladite surface externe (29) dudit insert (12) et coopérant avec ladite première surface de fixation (20),

ladite première surface de fixation (20) et ladite seconde surface de fixation (33) ayant une forme tronconique avec une inclinaison ($\alpha$, $\beta$) différente l'une de l'autre par rapport audit axe de couplage (Y), de manière à obtenir un couplage conique entre ledit insert (12) et ladite coupelle cotyloïdienne (11), avec une interférence variable (i) le long dudit axe de couplage (Y),

**caractérisé en ce que**

ladite coupelle cotyloïdienne (11) comprend une structure réticulaire trabéculaire (25), ladite structure réticulaire trabéculaire (25) étant un réseau de cellules, constituant une pluralité de cavités tridimensionnelle disposées ouvertes et communicant entre elles, connectées les unes aux autres ; **en ce que** ladite coupelle cotyloïdienne (11) est conformée de manière à comprendre une ouverture traversante (23) en correspondance avec une région polaire de la coupelle, **en ce que** ledit insert (12) est conformé pour comprendre, dans une région polaire (31) de cet insert, un élément de centrage (34) apte à être introduit à l'intérieur de ladite ouverture traversante (23),

et **en ce que**

ledit procédé comprend au moins une étape au cours de laquelle ladite coupelle cotyloïdienne (11) est saisie par des moyens de préhension élastiques (37) en correspondance avec une ouverture traversante (23), une étape dans laquelle ledit insert (12) est positionné sur un support et un élément de centrage (40), une étape dans laquelle les moyens de préhension élastiques (37) sont déplacés et ladite coupelle cotyloïdienne (11) est couplée par l'intermédiaire d'une interférence variable avec ledit insert (12), faisant coopérer l'une avec l'autre ladite première surface de fixation (20) et ladite seconde surface de fixation (33), et une étape dans laquelle lesdits moyens de préhension élastiques (37) relâchent ladite coupelle cotyloïdienne (11) couplée audit insert (12),

dans lequel l'assemblage de ladite coupelle cotyloïdienne (11) et ledit insert (12) est obtenu en appliquant une charge thermique, ou mécaniquement, ou par une combinaison d'application d'une charge thermique et d'un assemblage mécanique.

**10.** Procédé selon la revendication 9, **caractérisé en ce qu'**il comprend une étape préliminaire d'alignement et de centrage desdits moyens de préhension élastiques (37) et dudit insert (12) positionné sur ledit support et élément de centrage (40), de déplacement desdits moyens de préhension élastiques (37) vers le bas.

**11.** Procédé selon la revendication 10, **caractérisé en ce que,** après l'alignement et le centrage desdits moyens de préhension élastiques (37) et dudit insert (12), lesdits moyens de préhension élastiques (37) sont soulevés, ledit insert (12) est enlevé du support et de l'élément de centrage (40), ladite coupelle cotyloïdienne (11) est placée sur le support et l'élément de centrage (40), les moyens de préhension élastiques (37) sont déplacés vers le bas pour saisir la coupelle cotyloïdienne (11), les moyens de préhension élastiques (37) associés à la coupelle cotyloïdienne (11) sont soulevés et l'insert (12) est à nouveau positionné sur le support et l'élément de centrage (40) afin de procéder au couplage conique.

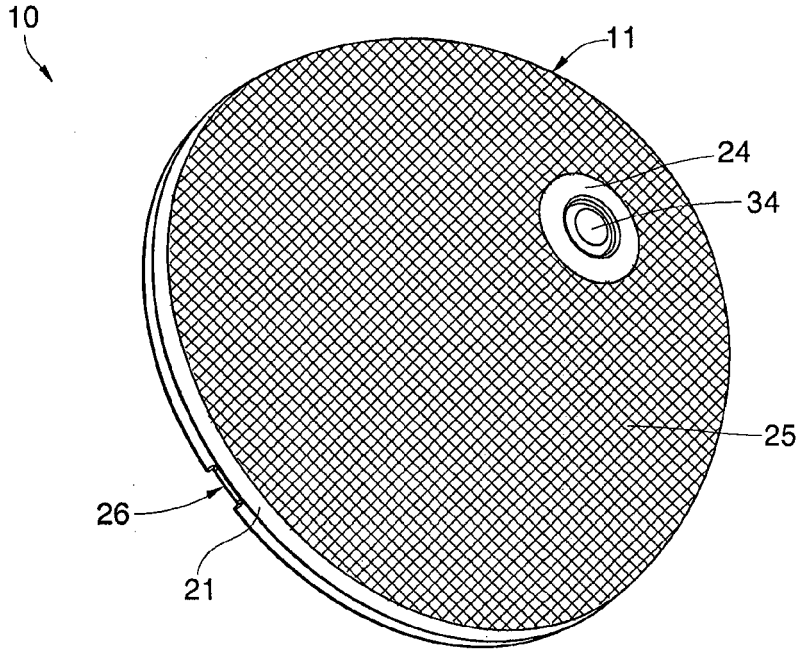


fig. 1

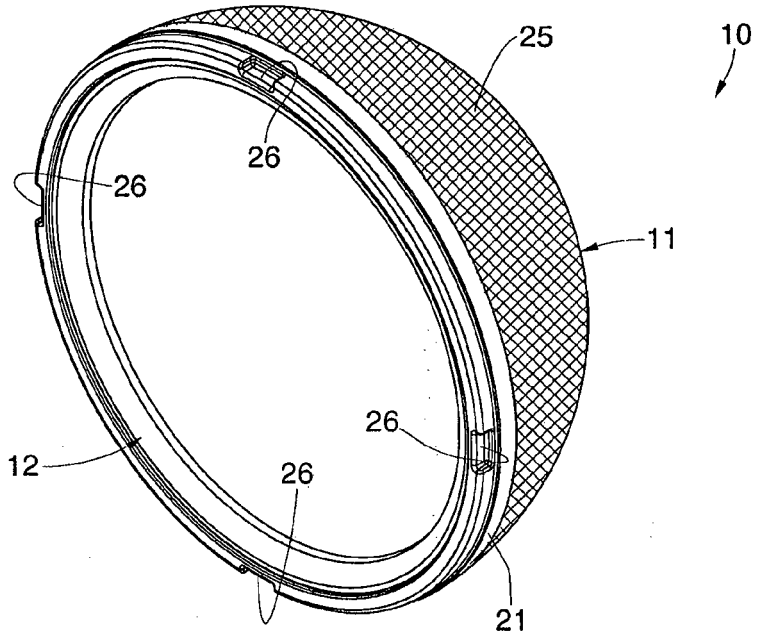


fig. 2

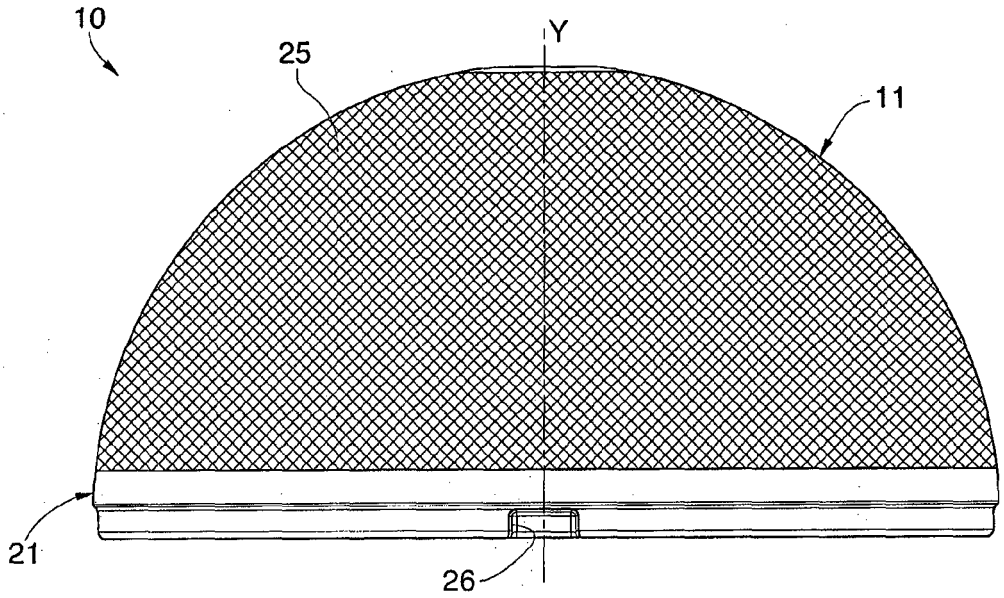


fig. 3

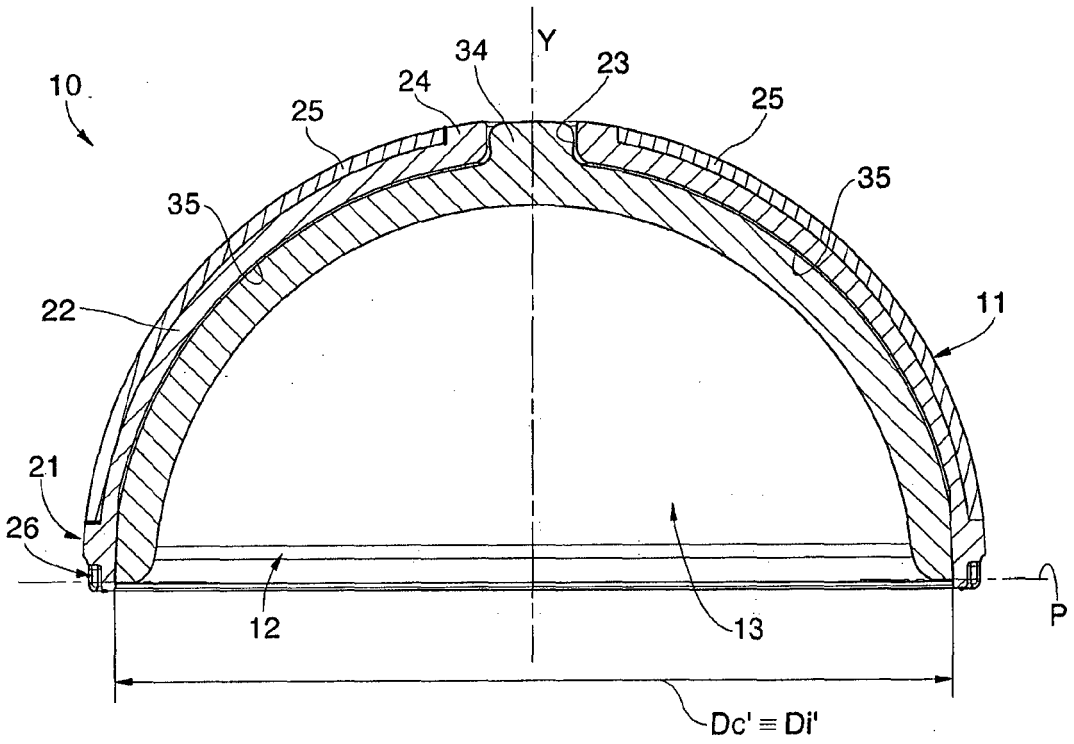


fig. 4

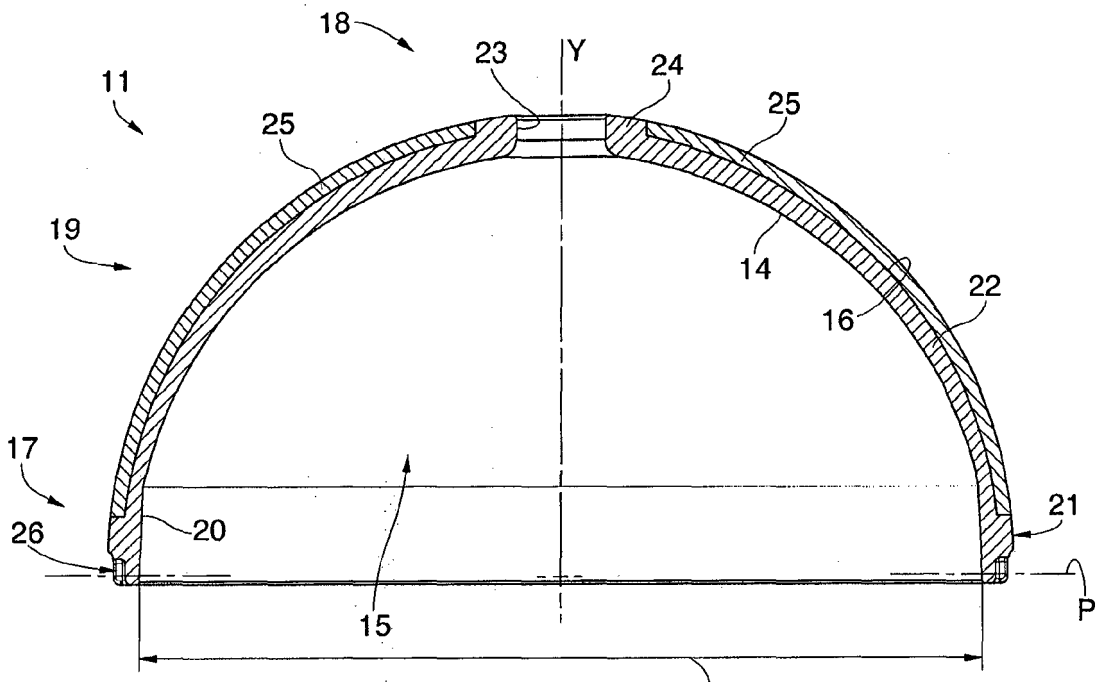
18
11
19
17
26
20
23
Y
24
25
25
14
16
22
21
15
P
Dc

fig. 5

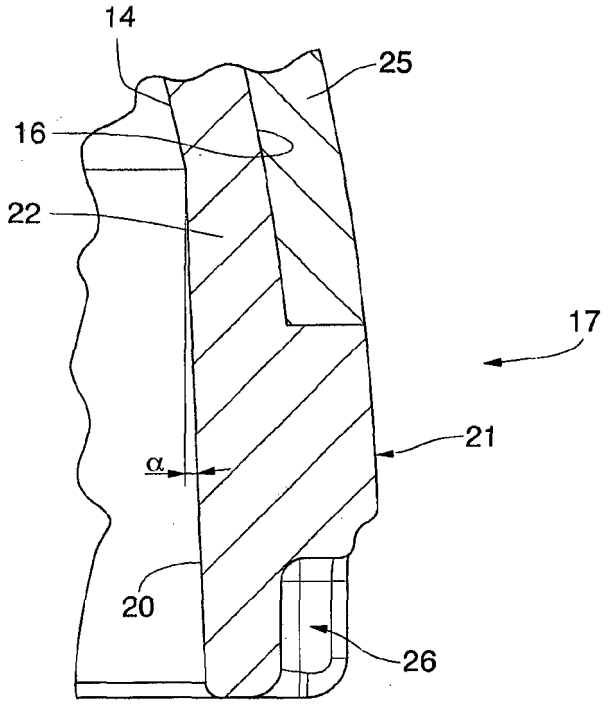
14
25
16
22
17
21
α
20
26

fig. 6

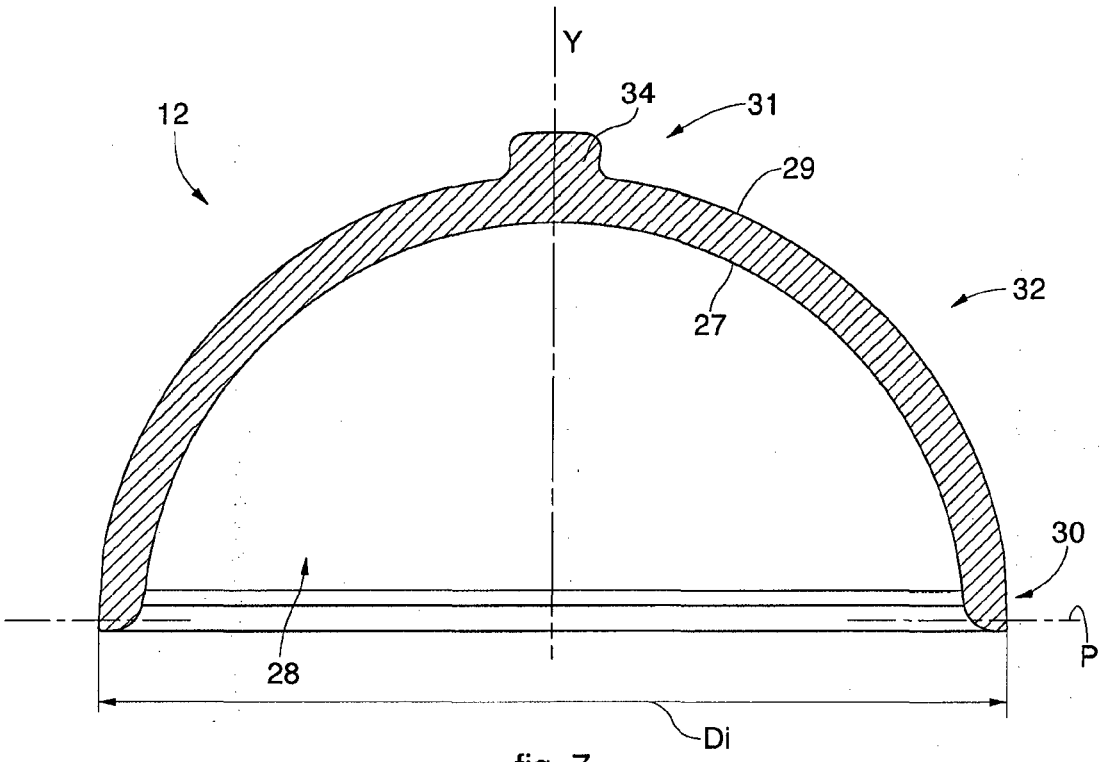


fig. 7

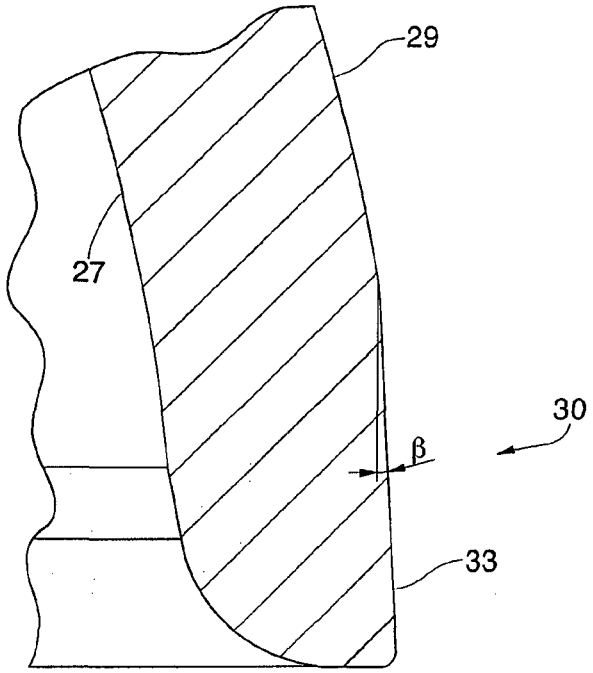


fig. 8

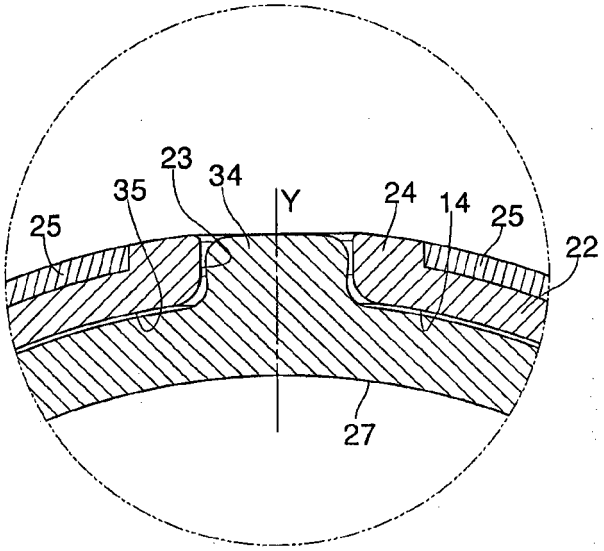


fig. 10

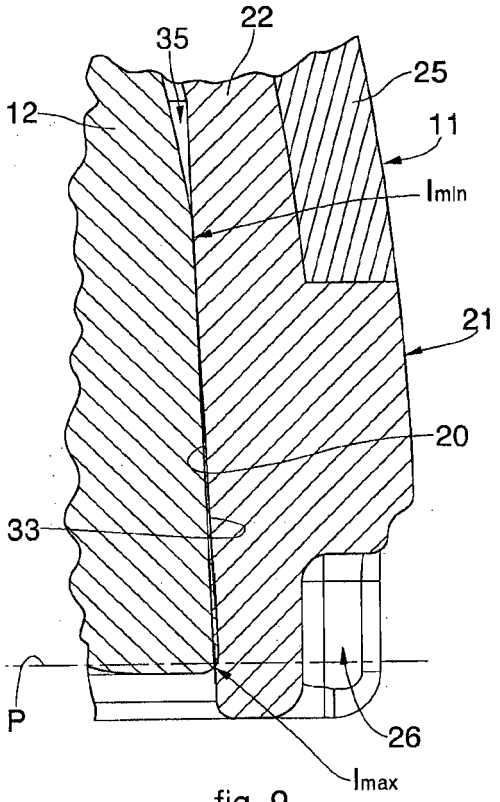


fig. 9

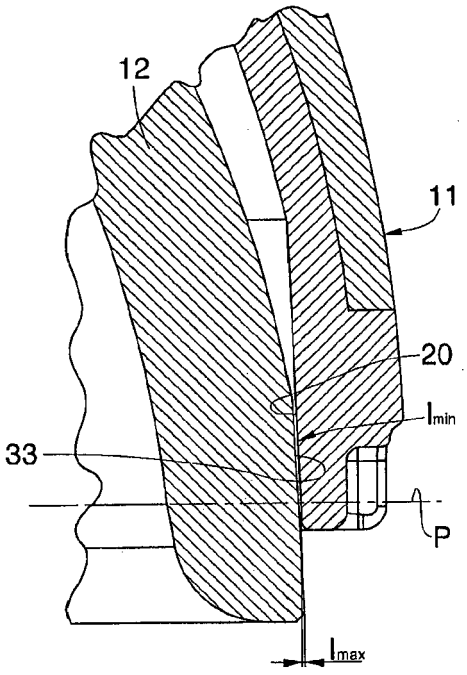


fig. 11

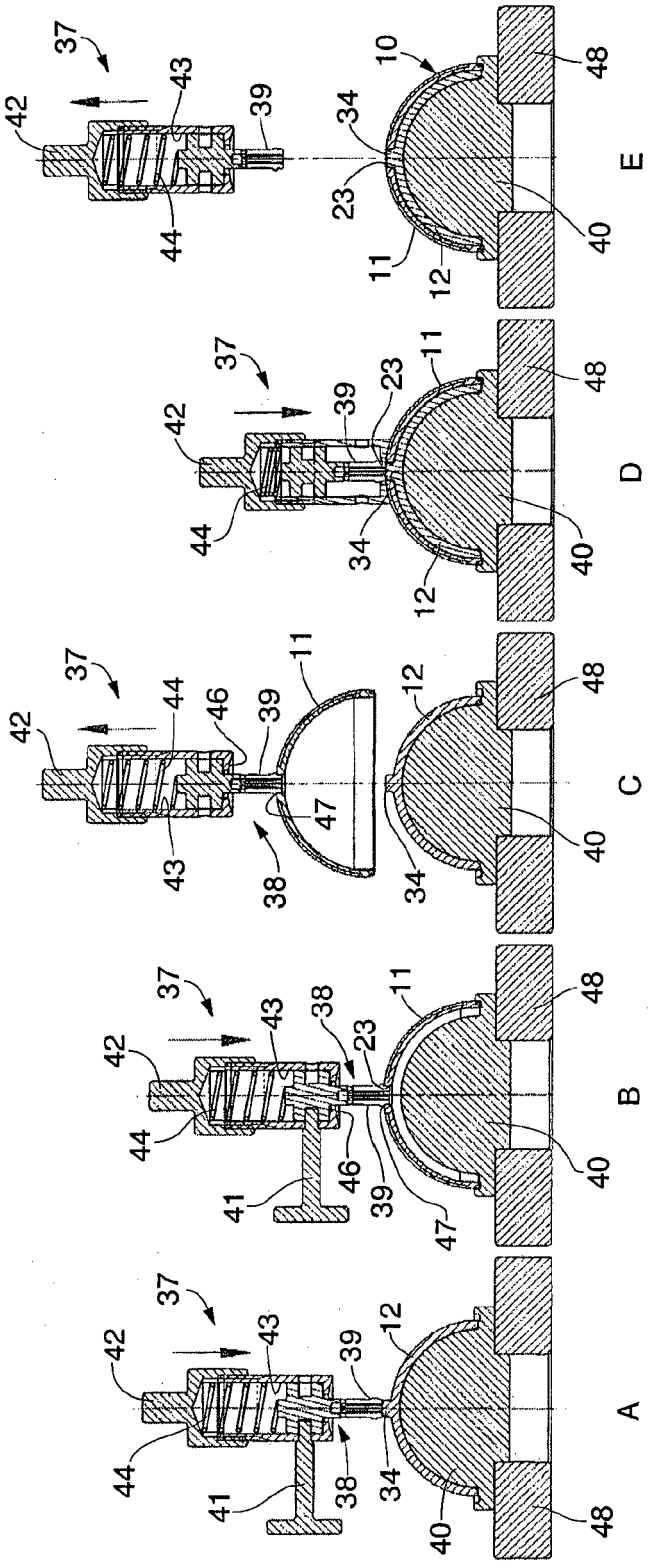


fig. 12

## REFERENCES CITED IN THE DESCRIPTION

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