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(74) Agent: **ROBINSON, William, R.**; Norris McLaughlin & Marcus, P.A., 721 Route 202-206, P.O. Box 5933, Bridgewater, NJ 08807-5933 (US).

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(71) Applicant (for all designated States except US): **HIP INNOVATION TECHNOLOGY LLC**; 95 Main Street, West Orange, NJ 07052 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **TERMANINI, Zafer** [US/US]; 208 Eileen Drive, Cedar Grove, NJ 07009 (US).

[Continued on next page]

(54) Title: INTERLOCKING REVERSE HIP AND REVISION PROSTHESIS

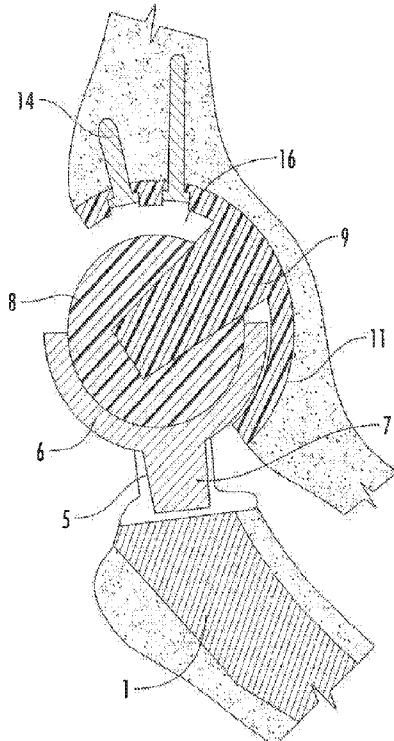


FIG. 4

(57) Abstract: A reverse hip prosthesis comprising an acetabular cup for implanting in an acetabular socket. The acetabular cup is secured to the acetabular socket of the pelvis using fasteners. The acetabular cup has a stem extending from the center of a concave portion thereof and an acetabular ball is attached to the stem, preferably by means of a Morse taper. A femoral implant is provided with a femoral cup attached to the proximal end thereof. The femoral cup has a stem which can be constructed in a modular fashion with several stem lengths in order to accommodate the various sizing requirements of different patients. After implantation of the acetabular cup and ball and the femoral cup, the members are assembled together so that the femoral cup can articulate on the acetabular ball. The prosthesis of the invention has a wide range of motion and substantially improved tribology. As the femoral cup is articulated, the edge of the femoral cup moves into a space located between the acetabular cup and the acetabular ball and thereby becomes restrained, thus reducing the likelihood of dislocation during extreme ranges of motion.



SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, **Published:**  
GW, ML, MR, NE, SN, TD, TG).

— *with international search report (Art. 21(3))*

## INTERLOCKING REVERSE HIP AND REVISION PROSTHESIS

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

[0001] The present invention relates generally to hip prostheses and more specifically to an interlocking reverse hip prosthesis allowing increased range of motion and stability during excessive range of motion.

#### 2. Description of the Prior Art

[0002] It can be appreciated that several hip implants have been in use for years. Typically, conventional hip implants comprise a femoral component having an articular femoral ball attached to a stem. A femoral stem is inserted into the medullary canal of the femur after preparation and reaming using appropriate reamers by the operating surgeon. The stem can be secured with bone cement or press fit. An acetabular component having the shape of a cup is inserted into an acetabular socket after preparation and appropriate reaming and secured with cancellous screws through holes in the cup. It can also be secured with bone cement or press fit or a combination thereof.

[0003] The acetabular cup is metallic and it is internally lined with high-density polyethylene or ceramic. Said lining is secured into the acetabular cup by a press-fit mechanism.

[0004] The main problem with conventional hip implants is the instability of the prosthesis at the extreme range of motion, thereby allowing

the articular femoral ball to dislodge and dislocate. Prior art teaches constrained and preassembled ball and cup devices or devices wherein the ball and cup members are implanted separately whereupon the ball element is forced into a resilient opening in the cup and thereafter held in place by the resilient material. Other constrained acetabular cups may include a locking ring such as the one described by Albertorio et al. U.S. Pat. 6,527,808. In the case of cup elements having retaining rings, the ball member is forcefully inserted into the cup after the two elements are implanted. This constitutes a weak link where forces exerted on the prosthesis by ambulatory motion may exceed the forces used to assemble the implant thereby causing the ball to be separated from the cup.

**[0005]** While these devices may be suitable for the particular purpose which they address, they do not provide an interlocking mechanism as in the reverse hip implant design of the present invention. The very nature of applicant's design allows increased range of motion and increased stability at extreme ranges of motion thereby reducing the risk of dislocation.

**[0006]** In these respects, the interlocking reverse hip prosthesis according to the present invention substantially departs from the conventional concepts and designs of the prior art because the articular femoral ball of the prior art is replaced with an articular femoral cup and the acetabular cup is provided with an acetabular ball. Thus an apparatus is provided which is primarily developed for the purpose of reducing the risk of dislocation of hip implants at extreme ranges of motion.

[0007] Furthermore, since the articular surface of the femoral cup of the invention is fully in contact 100% of the time with the surface of the acetabular ball, it is clear that this will improve tribology because the weight bearing distribution is improved on the articular surfaces, thus decreasing the wear of the surfaces in contact and reducing the risk of wear particles being released in the joint. The later, being very detrimental to the proper function of the joint.

## SUMMARY OF THE INVENTION

[0008] The present invention provides a new interlocking reverse hip prosthesis construction wherein an acetabular ball is solidly and concentrically attached to a central protrusion or stem of the acetabular cup via Morse taper. A metallic acetabular cup is used in the preferred embodiment. A femoral cup, also referred to herein as a hemispherical femoral cup or an articular femoral cup, is preferably solidly attached to a femoral implant by means of a Morse taper. Other means of attachment known to those in the art can be used. And whenever a Morse taper is referred to herein, it is intended to describe a preferred embodiment. The Morse taper can be replaced by other suitable means of attachment as will be apparent to those having skill in the art.

[0009] The acetabular cup is implanted in an acetabular socket constructed by the surgeon in the pelvic bone to which it is firmly secured by one or more fasteners through one or more openings in the acetabular cup. The fasteners can be cancellous screws or biocompatible resorbable studs of variable number. The femoral implant is then inserted and impacted into the

femoral medullary canal which has been prepared and hollowed by the surgeon using appropriate reamers. During ambulation, the articular femoral cup edge or lip will glide conformably and concentrically into a space located between the acetabular ball and the acetabular cup. As will be apparent to those having skill in the art, the geometrical configuration of applicant's invention makes it very difficult for the femoral cup to dislocate when the range of motion increases since it becomes constrained in the locking space between the acetabular cup and the acetabular ball.

**[0010]** As noted above, the articular surface of the femoral cup is fully in contact at all times with the articular surface of the acetabular ball. This improves the weight distribution, decreases the wear of the surfaces in contact and reduces the risk of wear particles being released in the joint.

**[0011]** In an optional embodiment of the invention, applicant has addressed the rare possibility that soft tissue may get lodged in the implant in the space between the acetabular cup and the acetabular ball. A protective sheath can be used to avoid this possibility. As discussed in more detail below, the sheath is disposed in the space between the acetabular cup and the acetabular ball and is allowed to glide freely therein.

**[0012]** There has thus been outlined the more important features of the invention in order that the detailed description may be better understood, and so that the present contribution to the art may be better appreciated. A novel feature of this invention is that the location of the articular surfaces of the hip joint, namely the ball and socket, is reversed. This results in a new reverse hip implant which is not anticipated, rendered

obvious, suggested or even implied by any prior hip prosthesis when considered alone or in any combination.

**[0013]** In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not committed in its application to the details of construction and arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways as will be apparent from the description herein to those having skill in the art. Also, it is to be understood that the terminology employed herein are for the purpose of the description and should not be regarded as limiting.

**[0014]** To the accomplishment of the above and related objects, this invention may be embodied in the form illustrated in the accompanying drawings. However, the drawings are elicited only and changes may be made into any specific construction illustrated without departing from the principles of the invention.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

**[0015]** Various other objects, features and advantages of the present invention will become fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar elements throughout the several views, and wherein:

[0016] FIG. 1 is a perspective view of the interlocking reverse hip prosthesis of the invention.

[0017] FIG. 2 is a section view of the interlocking reverse hip prosthesis.

[0018] FIG. 3 is a section view of the interlocking reverse hip prosthesis in extension and external rotation.

[0019] FIG. 4 is a section view of the interlocking reverse hip prosthesis in flexion and internal rotation.

[0020] FIG. 5 is a perspective view of the prosthesis of the invention illustrating an optional soft tissue protective sheath.

[0021] FIG. 5A is a perspective view of the protective sheath by itself.

[0022] FIG. 6 is a section view of the embodiment of FIG. 5.

[0023] FIG. 7 is a section view illustrating a femoral cup having a recess instead of a stem for connection to a femoral implant.

[0024] FIG. 8 is a section view of the embodiment of FIG. 7 which has been articulated to an extreme position.

#### **DETAILED DESCRIPTION OF THE INVENTION**

[0025] Turning now to the drawings, in which the reference characters denote the same or similar elements throughout the several views, FIGS. 1-4 illustrate an interlocking reverse hip prosthesis, which comprises an acetabular cup (11) having a smooth concave surface and a convex nonarticular surface. The convex non-articular surface abuts a socket in the pelvic bone when the acetabular cup is implanted in a patient and provides a

porous surface with multiple asperities and micro-voids to allow bone ingrowth. Furthermore, the acetabular cup (11) provides one or more holes (12) at different locations for the purpose of using one or more fasteners (14). The fasteners (14) can be screws or resorbable nonmetallic and biocompatible studs of different diameters and lengths. The studs, which can be called orthobiologic resorbable studs, will secure the acetabular cup (11) during the initial phase of bone ingrowth and will resorb within one year, being replaced by newly generated bone and become part of the host pelvic bone. During that period, the acetabular cup (11) becomes solidly attached to the acetabular socket in the pelvic bone (4) by bone ingrowth. The acetabular cup (11) has a concave hemispherical surface in which a large acetabular cup stem (9) is disposed. The acetabular cup stem (9) has a male Morse taper for assembly to the acetabular ball (8) by means of the acetabular ball recess (10) which has a female Morse taper. Referring to FIGS. 2-4 and 6, the femoral cup (6) has a femoral cup stem (7) with a male Morse taper while the femoral implant (1) has a cooperating femoral implant recess (5) having a female Morse taper located in neck (3). FIGS. 7 and 8 illustrate a femoral cup (20) with a neck (22) and a femoral cup recess (21) having a female Morse taper. This cooperates with a femoral implant stem having a male Morse taper (not shown). In a preferred embodiment, a modular system is used in a kit according to the invention wherein the femoral cup stem (7) or neck (22) can come in different lengths to accommodate the sizing needs of a patient. Therefore, in a kit of the invention, two or more femoral cups are provided having different stem lengths. In a less preferred embodiment, the length of

the neck (3) of femoral implant (1), or the femoral implant stem (not shown) can also have various lengths to accommodate patient sizing needs and in a kit comprising this embodiment two or more neck or stem components having different lengths will be included. Other variations on the design to meet different sizing needs will be apparent to those having skill in the art.

**[0026]** An important advantage of the present invention is that the greater the interdigitation the more stability of the implant as opposed to conventional ball and socket hip implants, where increased range of motion is usually associated with increased risk of dislocation.

**[0027]** Referring to FIG. 2, the proximal femoral bone (2) is reamed in the usual fashion to accept a femoral implant (1) that can be cemented or press fitted in the femoral medullary canal. The acetabular socket in the pelvic bone (4) is reamed to the appropriate size to accept the acetabular cup (11), which is impacted for press fit at the correct angle of inclination and anteversion. Fasteners (14) in the form of fixation screws or biocompatible resorbable studs are then inserted in place to secure the acetabular cup (11). The acetabular ball (8) is then affixed onto the acetabular cup stem (9). FIG. 2 also illustrates center line (C-C). In the position shown, the center line (C-C) passes through the center of the acetabular cup (11), the longitudinal center line of the acetabular cup stem (9), the center of acetabular ball (8), the longitudinal center line of femoral cup stem (7) and the longitudinal center line of femoral implant recess (5). Obviously, when the femoral cup is articulated on the ball the center line associated with the femoral components will not be colinear with the center

line of the acetabular components. The line is simply illustrated in this way for convenience.

**[0028]** Referring to FIGS. 3, 4 and 8, when the femoral cup (6) or (20) articulates on the acetabular ball (8), the edges of the femoral cup (6) or (20) move into and out of hemispherical space (16) and the articular surface of the femoral cup (6) or (20) maintains the same area of contact with the acetabular ball (8) over the entire range of motion. In other words, 100% of the articular contact area of the femoral cup (6) or (20) is maintained over the entire range of motion. FIG. 3 illustrates the prosthesis of the invention in extension and external rotation. FIG. 4 illustrates the prosthesis in flexion and internal rotation and FIG. 8 illustrates an extreme articulation position of the femoral cup (20) on the acetabular ball (8).

**[0029]** In one embodiment, the articular surface of the femoral cup (6) or (20) contains a high molecular weight polyethylene lining of varying thickness, but no less than 4 mm. In a different embodiment the lining could be porcelain, ceramic or a metallic alloy.

**[0030]** An important feature of the present invention is the ability to place acetabular ball (8) in a position that minimizes or eliminates torsional forces on the acetabular cup and acetabular stem. This is illustrated in FIG. 3 wherein the acetabular ball (8) is affixed on acetabular cup stem (9) in a position wherein the equatorial plane (P-P) of the acetabular cup passes through the center (15) of the acetabular ball.

**[0031]** An optional embodiment of the invention illustrated in FIGS. 5-8 adds a soft tissue protective sheath (17) to the embodiments

described above. The protective sheath, also illustrated by itself in perspective in FIG. 5A, addresses the rare cases wherein soft tissue might get lodged in the space (16) as a result of articulation of the prosthetic joint of the invention.

**[0032]** Referring to FIGS. 6-8, the sheath (17) extends beyond the circular outer edge of the acetabular cup (11) and has a retaining ring (18). The sheath (17) is installed by placing it into the acetabular cup (11) before the acetabular ball (8) is installed. The sheath (17) can have a solid surface as illustrated or it can be perforated with holes, slots or the like having the same or different shapes and dimensions as may be desired.

**[0033]** As can be seen from FIGS. 6-8, the sheath (17) is allowed to move freely within the space (16), restrained only by the acetabular ball (8) and acetabular cup stem (9). The sheath (17) also is moved by contact of retaining ring (18) with the outer edge of femoral cup (6) or (20). The retaining ring (18) will, for example, contact the outer edge of femoral cup (6) or (20) particularly in positions of extreme articulation of the prosthetic joint as illustrated in FIG. 8.

**[0034]** In another embodiment of the present invention, also illustrated in FIGS. 6-8, the acetabular cup (11) is designed for use in revision surgery of the hip. Revisions are surgical procedures where the existing implant is removed. This most frequently requires removal of the acetabular cup and it is associated with a high level of morbidity. The removal of a previously implanted acetabular cup may be quite difficult surgically, especially when the cup has metallic beads for bone ingrowth. In these

cases, the removal is also associated with iatrogenic bone loss leading to difficulty in inserting another conventional acetabular cup.

**[0035]** There are instances where the acetabular cup was not implanted correctly or where the lining of the existing implant becomes worn out and needs to be replaced. Recurrent dislocations of the hip implant are usually secondary to surgical misplacement of a conventional acetabular cup. For example, if during the initial procedure, the cup was placed either too vertical or retroverted (e.g., facing backward instead of forward).

**[0036]** To remedy the above cited complication, there are times where the surgeon simply cements a conventional revision cup into the previously implanted acetabular cup using conventional bone cement. However, problems arise if the initial position of the previously implanted acetabular cup is too vertical or retroverted, preventing a conventional revision cup from being glued in the previously implanted acetabular cup. As a result, removal of the previously implanted acetabular cup becomes necessary - entailing significant risk and possible morbidity to the patient as described above.

**[0037]** Another important advantage of the present invention is that the angle of inclination and retroversion are not critical since the interlocking mechanism of applicant's implant will compensate for the misalignment of a previously implanted acetabular cup.

**[0038]** The acetabular cup (11) of applicant's interlocking reverse hip prosthesis can optionally be provided with a thin circumferential

groove (19) located in proximity of the equatorial plane of said cup as illustrated in FIGS. 6-8.

**[0039]** In revision surgery using the hip prosthesis of applicant's invention, the plastic polyethylene insert of the previously implanted acetabular cup is removed. The circumferential groove (19) of the interlocking reverse hip prosthesis will host a retaining "o-ring" of the previously implanted acetabular cup being revised thereby providing solid fixation of applicant's revision interlocking reverse hip prosthesis to the previously implanted acetabular cup.

**[0040]** The components of the reverse hip prosthesis of the invention are made from biocompatible materials commonly used in the art and suitable materials will be apparent to those skilled in the art based upon the disclosures herein. Metals or metallic alloys such as titanium or cobalt chrome are suitable. For some components, such as the acetabular ball, metals or ceramics can be used. High density polyethylene is also suitable for some components, for example the protective sheath or an optional lining for the concave portion of the femoral cup. Other biocompatible materials or combinations thereof can be used for various components as will be apparent to those having skill in the art.

**[0041]** The dimensions of the various components of the reverse hip prosthesis of the invention can be readily determined by those skilled in the art based upon the disclosures herein. For the acetabular cup, which is hemispherical, an outer diameter from about 35 millimeters (mm) to about 65 mm will be suitable for most applications. The spherical acetabular ball

should have a diameter from about 28 mm to about 45 mm. The diameter of the acetabular ball should be from about 7 mm to about 12 mm smaller than the inner diameter of the acetabular cup, thus creating a hemispherical space or gap having a width from about 7 mm to about 12 mm to allow articulation of the femoral cup therein. Of course, the concave, hemispherical, articular surface of the femoral cup will be sized compatibly with the acetabular ball to allow for smooth articulation. Highly polished cobalt chrome is an excellent material for the articular surface of the femoral cup but other materials such as biocompatible metallic alloys can be used. The femoral cup also may contain a lining fabricated from high-density polyethylene, ceramic or biocompatible metallic alloys.

**[0042]** It is therefore the object of the present invention to provide a new and improved interlocking and restrained reverse hip prosthesis system, where two conventional articular surfaces of the hip joint are reversed and interlocked. The system described in the present invention, which has all of the advantages of the prior art designs, none of the disadvantages, and numerous improvements over the prior art, particularly in respect of remarkably increased range of motion and reduced risk of wear particles being released into the joint.

**[0043]** With respect to the above description then, it is to be realized that the optimum dimensional relationships for the parts of the invention, to include variations in size, materials, shape, form, function and manner of operation, assembly and use, are deemed readily apparent to those skilled in the art, and all equivalent relationships to those illustrated in

the drawings and described in the specification are intended to be encompassed by the present invention. Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

## CLAIMS

What is claimed is:

1. A reverse hip prosthesis comprising
  - an acetabular cup having a convex surface for attachment to an acetabular socket in a pelvic bone and a concave surface having an acetabular cup stem affixed therein and projecting outwardly therefrom,
  - an acetabular ball affixed to the acetabular stem, the acetabular ball having a surface,
  - a femoral implant for implantation in a medullary canal of a proximal end of a femur, and
  - a femoral cup affixed to a proximal end of the femoral implant, the femoral cup having a concave surface sized for articulation on the surface of the acetabular ball.
2. The prosthesis of claim 1 wherein the concave surface of the acetabular cup is hemispherical, the acetabular ball is spherical and the concave surface of the femoral cup is hemispherical.
3. The prosthesis of claim 1 wherein the concave surface of the acetabular cup has a center and the acetabular cup stem is affixed to and in the center.
4. The prosthesis of claim 1 wherein the acetabular ball has an acetabular ball recess sized to receive the acetabular cup stem.
5. The prosthesis of claim 1 wherein the femoral cup has a femoral cup stem projecting outwardly therefrom in a direction opposite the concave

surface thereof and the femoral implant has at its proximal end a recess sized to receive the femoral cup stem.

6. The prosthesis of claim 1 wherein the femoral implant has a femoral implant stem extending proximally therefrom and the femoral cup has a recess sized to receive the femoral implant stem.

7. The prosthesis of claim 4 wherein the acetabular ball has a center, the acetabular cup stem has a longitudinal center line and the acetabular ball recess has a longitudinal center line, both longitudinal center lines being colinear and passing through the center of the acetabular ball.

8. The prosthesis of claim 5 wherein the femoral cup has a concave hemispherical portion having a center line, the femoral cup stem has a longitudinal center line and the femoral implant recess has a longitudinal center line wherein all of the center lines are colinear.

9. The prosthesis of claim 6 wherein the femoral cup has a concave hemispherical portion having a center line, the femoral implant stem has a longitudinal center line and the femoral cup recess has a longitudinal center line wherein all of the center lines are colinear.

10. The prosthesis of claim 1 wherein the acetabular cup further comprises a circumferential groove in the convex surface, said circumferential groove located in proximity to a circumferential edge of the acetabular cup.

11. The prosthesis of claim 1 further comprising a hemispherical protective shield moveably disposed in a space between the acetabular ball and the concave surface of the acetabular cup, the protective shield having a retaining ring for engagement with a circumferential outer edge of the femoral

cup whereby articulation of the femoral cup on the articular ball causes movement of the protective shield.

12. A method of implanting in a patient the prosthesis of claim 1 comprising preparing an acetabular socket in a pelvis and affixing the acetabular cup therein, preparing a medullary canal at the proximal end of a femur and affixing the femoral implant therein, affixing the acetabular ball to the acetabular cup stem, affixing the femoral cup to the proximal end of the femoral implant and aligning the concave surface of the femoral cup with the acetabular ball so that the concave surface of the femoral cup will articulate on the acetabular ball.

13. The method of claim 12 further comprising disposing a protective shield in the acetabular cup prior to affixing the acetabular ball to the acetabular cup stem.

14. A revision surgery method of implanting in a patient the prosthesis of claim 1, the patient having an implant in need of revision which comprises a hip joint prosthesis with an implanted acetabular cup and a femoral stem having an articular femoral ball affixed to the proximal end thereof, the implanted acetabular cup having a concave articular surface, the method comprising

removing the femoral stem and articular femoral ball,  
affixing to the concave articular surface of the implanted acetabular cup the acetabular cup of claim 1,  
preparing a medullary canal at the proximal end of a femur and affixing the femoral implant therein, affixing the acetabular ball to the

acetabular cup stem, affixing the femoral cup to the proximal end of the femoral implant and aligning the concave surface of the femoral cup with the acetabular ball so that the concave surface of the femoral cup will articulate on the acetabular ball.

15. The method of claim 14 further comprising disposing a protective shield in the acetabular cup prior to affixing the acetabular ball to the acetabular cup stem.

16. A kit comprising the prosthesis of claim 5 and further comprising one or more additional femoral cups, wherein the femoral cup stems have different lengths.

17. A kit comprising the prosthesis of claim 6 wherein the femoral cup recess is disposed in a neck projecting outwardly from the femoral cup in a direction opposite the concave surface thereof, further comprising one or more additional femoral cups, wherein the femoral cup necks have different lengths.

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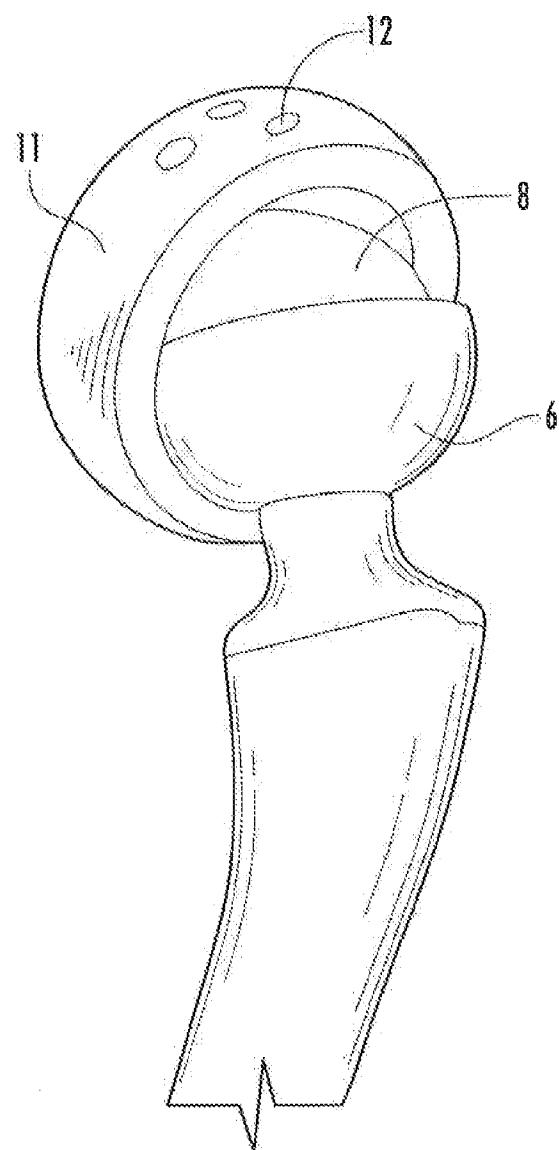


FIG. 1

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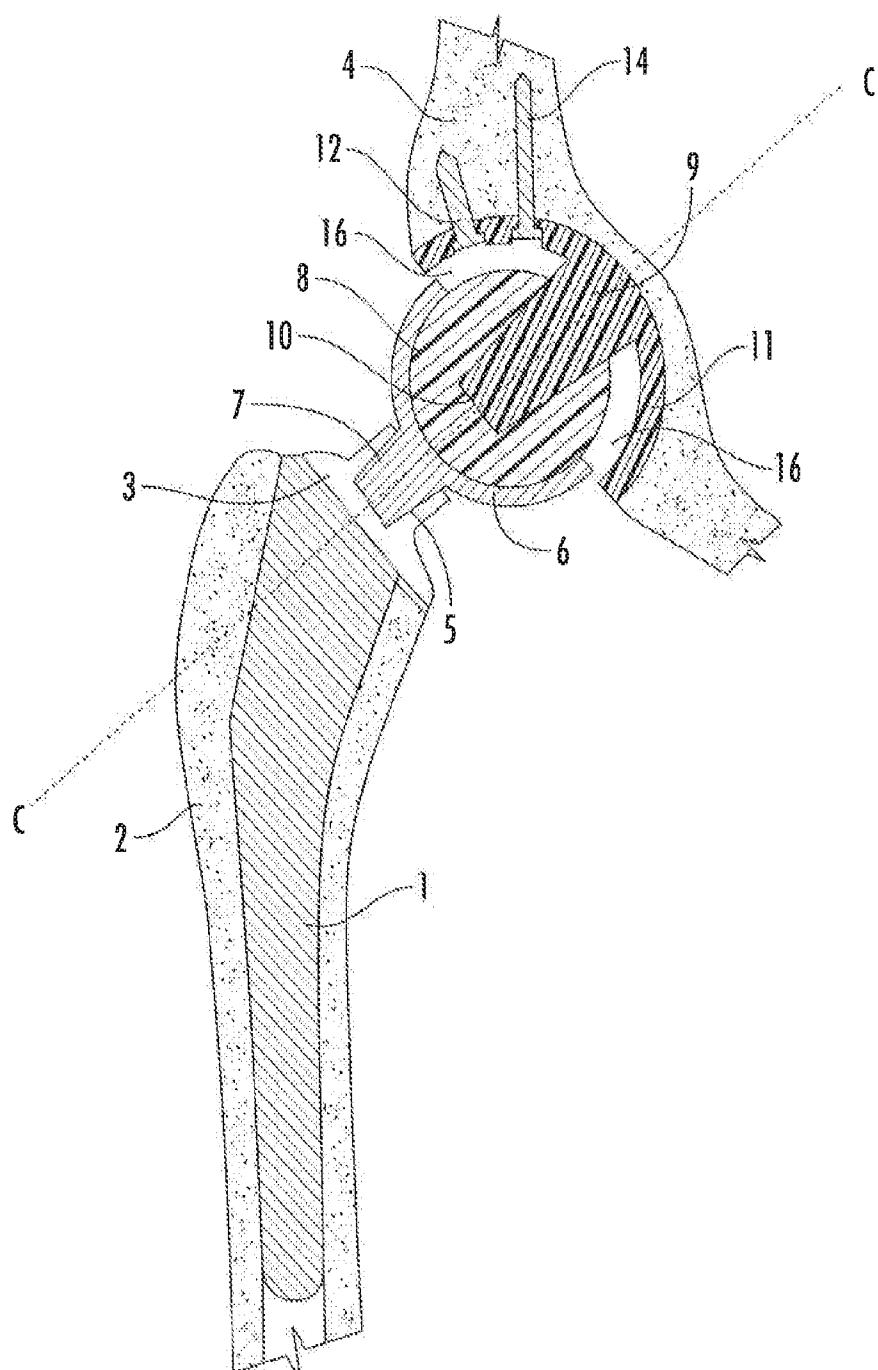


FIG. 2

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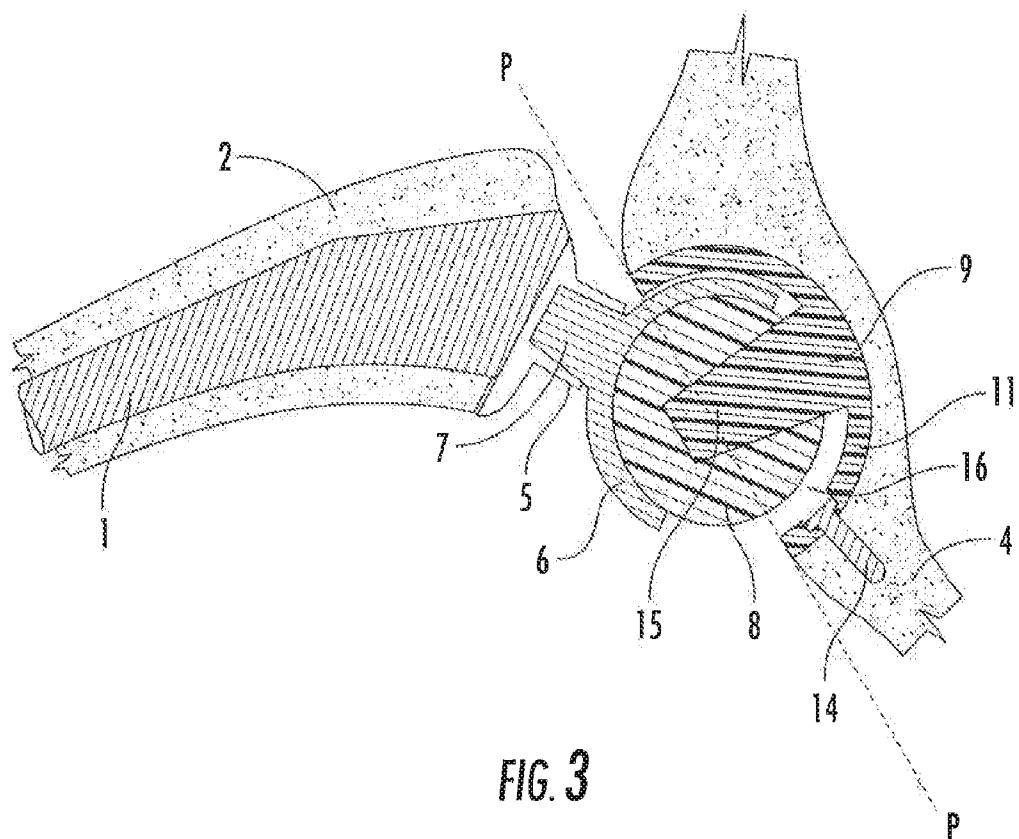


FIG. 3

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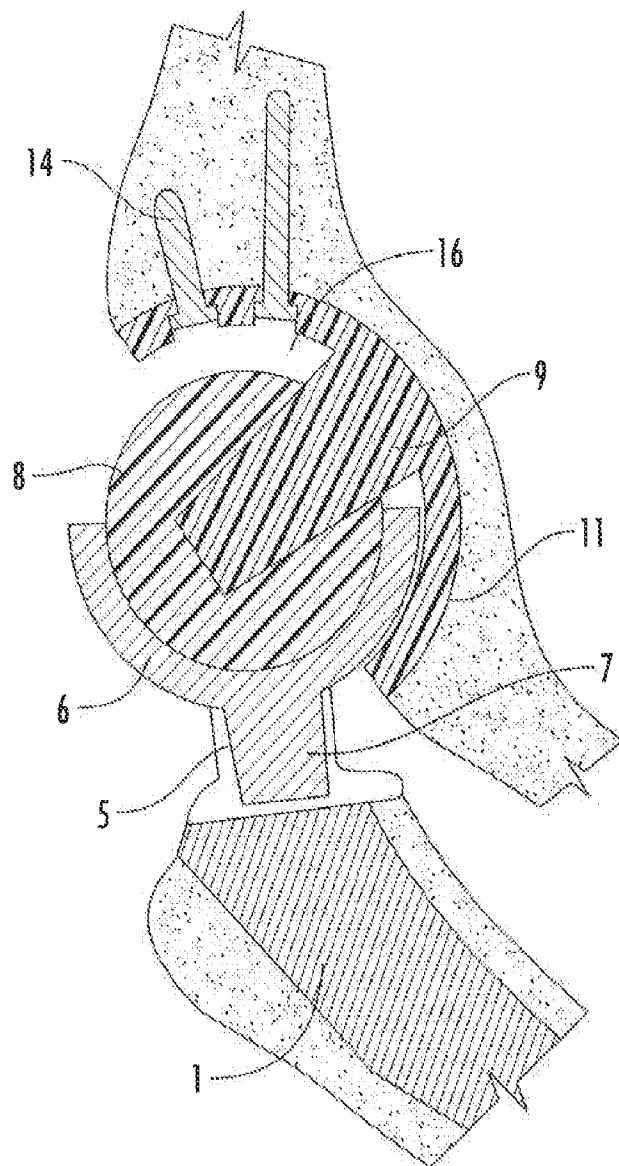


FIG. 4

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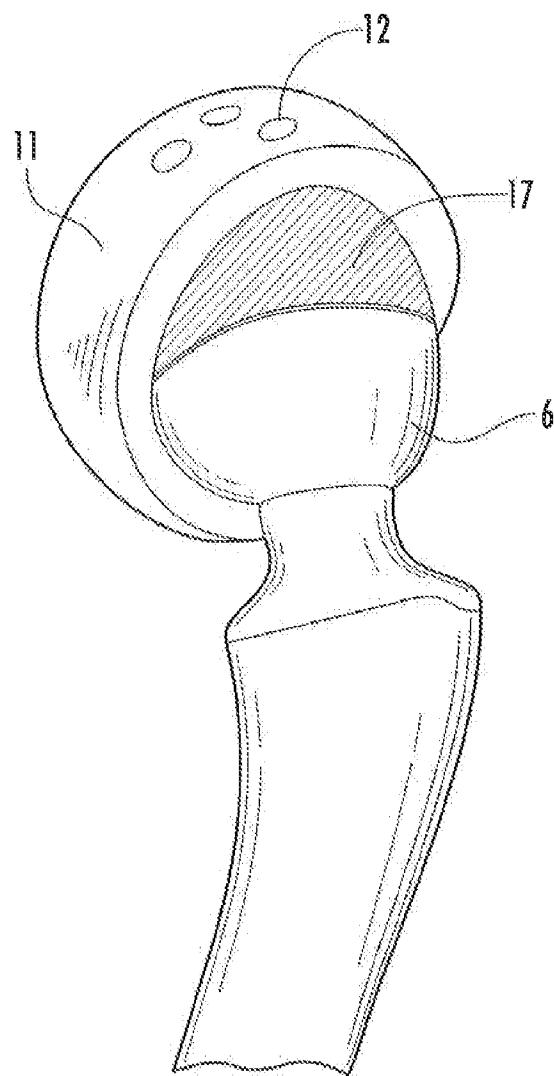


FIG. 5

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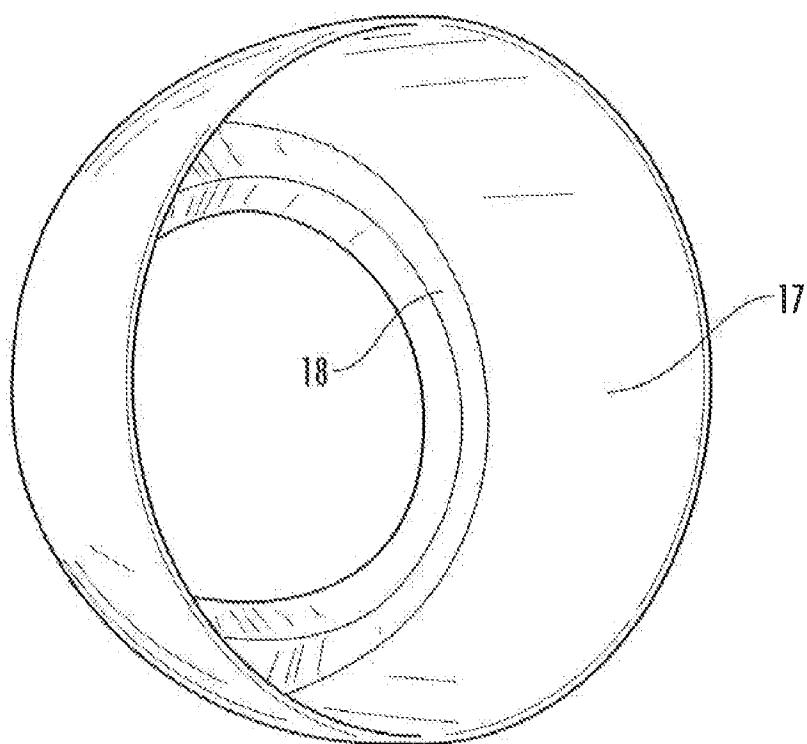


FIG. 5A

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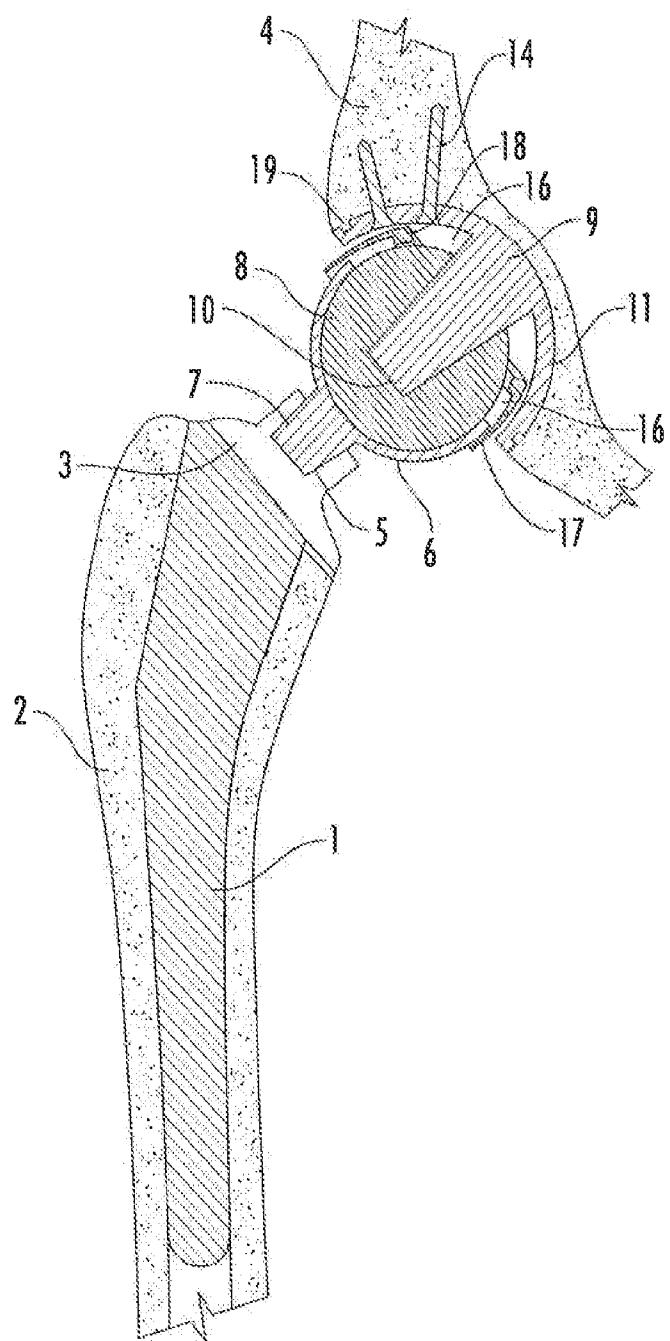


FIG. 6

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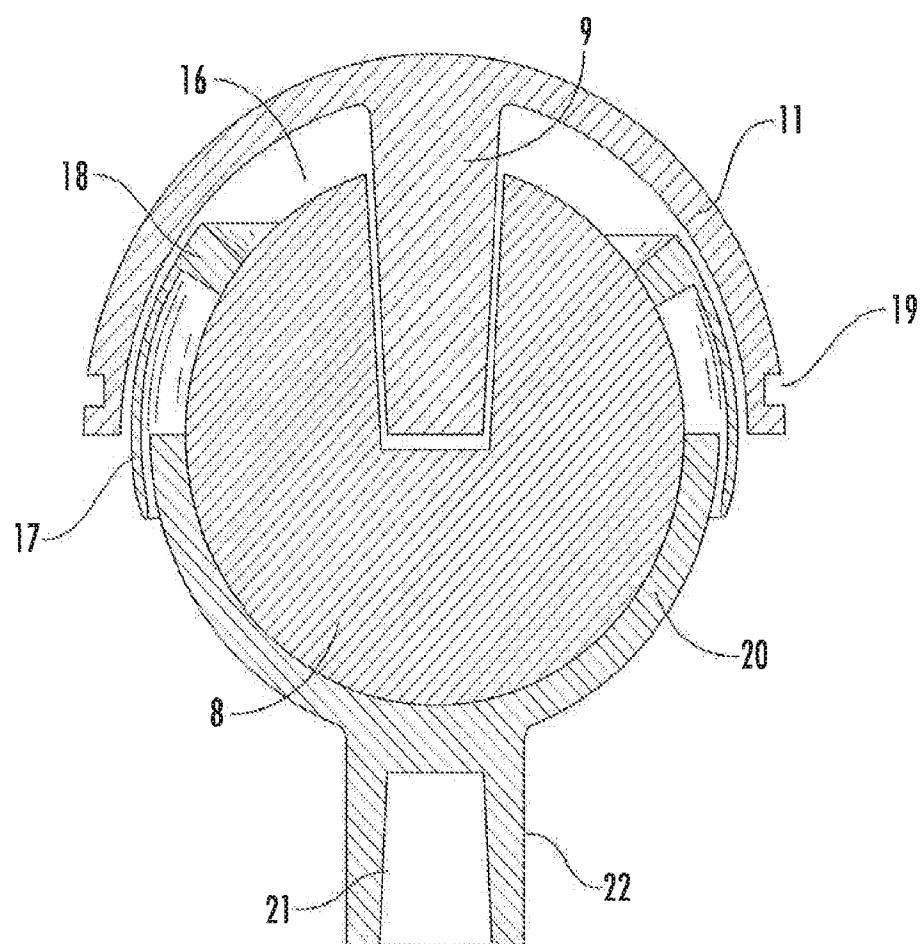


FIG. 7

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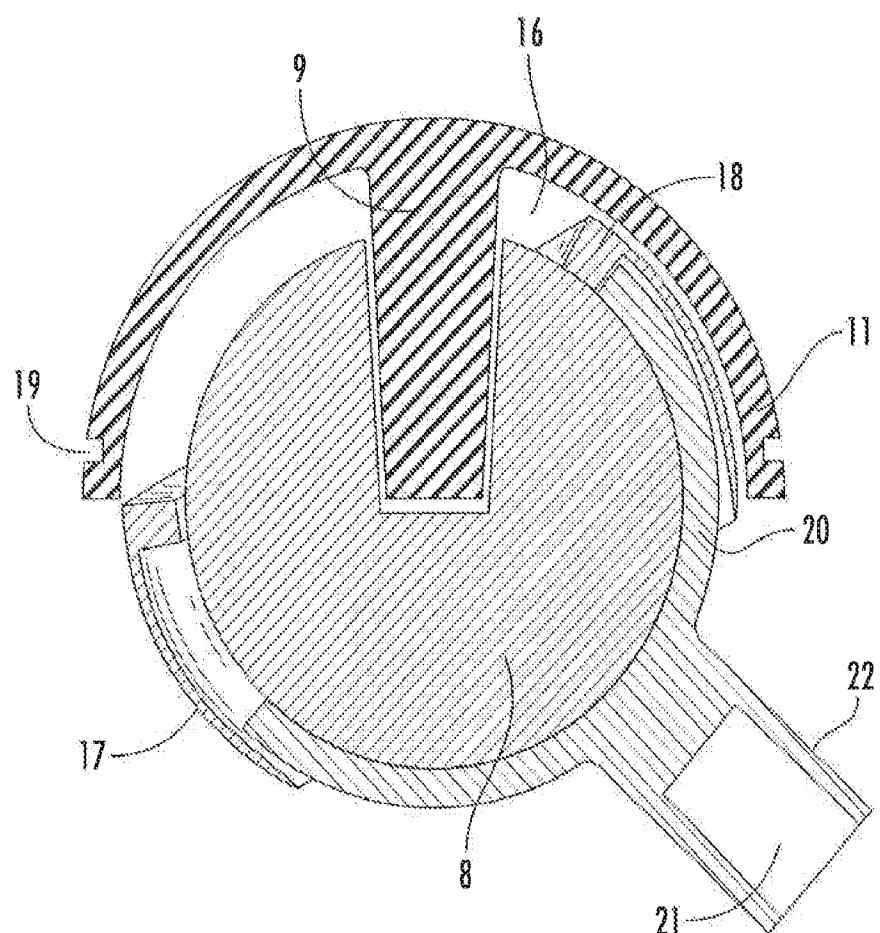


FIG. 8

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/025790

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A61F 2/32 (2011.01)

USPC - 623/22.11

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A61F 2/30, 2/32, 2/34, 2/36 (2011.01)

USPC - 623/22.11, 22.21, 22.23, 22.31, 22.32, 22.4, 22.46, 23.11, 23.12, 23.15

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatBase, Google Scholar

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 3,916,451 (BUECHEL et al) 04 November 1975 (04.11.1975) entire document	1-17
A	US 4,206,517 (PAPPAS et al) 10 June 1980 (10.06.1980) entire document	1-17
A	US 2004/0039449 A1 (TORNIER) 26 February 2004 (26.02.2004) entire document	1-17
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Further documents are listed in the continuation of Box C.

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Date of the actual completion of the international search

11 April 2011

Date of mailing of the international search report

09 MAY 2011

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 P.O. Box 1450, Alexandria, Virginia 22313-1450  
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