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Freeman et al.

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[54] **ENDOPROSTHETIC BONE JOINT DEVICES**

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[52] **U.S. Cl.** ..... **3/1.912**; 128/92 C; 128/92 CA

[51] **Int. Cl.**[2] **A61F 1/24**

[58] **Field of Search** ..... 3/1, 1.9–1.913; 128/92 C, 92 CA, 92 R

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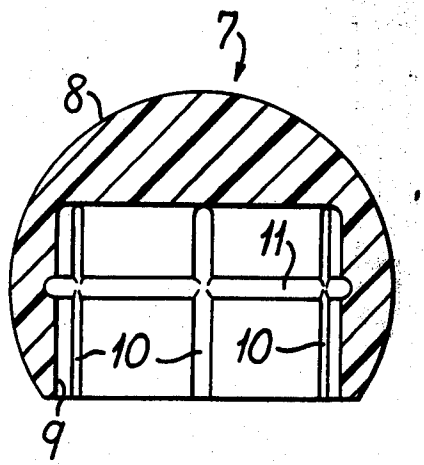
[57] **ABSTRACT**

A hip joint prosthesis is provided with a socket member for the acetabular cavity and a cap member for the femoral head, both members being formed with grooves for fixation to exposed cancellous bone in association with gap-filling medium. The cap member has a major-spherical-segment outer bearing surface, and a coaxial cylindrical inner fixation surface with axial and circumferential grooves to receive said medium. The socket member has a spherically shaped inner bearing surface of not more than hemispherical extent to articulate with the cap member, and an outer fixation surface of hemispherical shape with coaxial annular grooves to receive said medium. The socket and cap members can be respectively of metal and plastics material, in which case the socket is of relatively thin, regular hemispherical form; or these materials can be reversed in which case the socket bearing surface is of minor-spherical-segment shape and can be eccentric to its fixation surface to provide greater thickness remote from its mouth.

5 Claims, 8 Drawing Figures



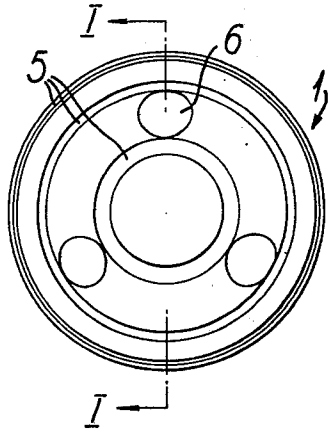


Fig. 1.

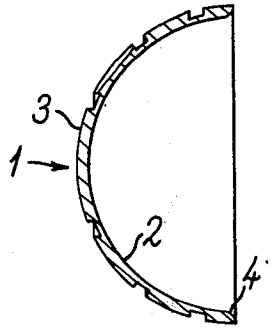


Fig. 2.

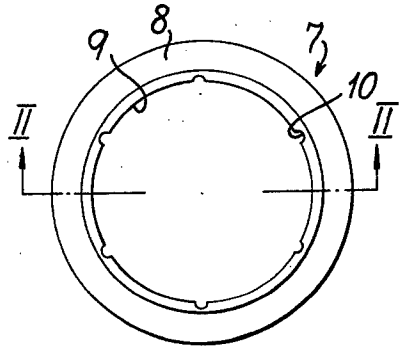


Fig. 3.

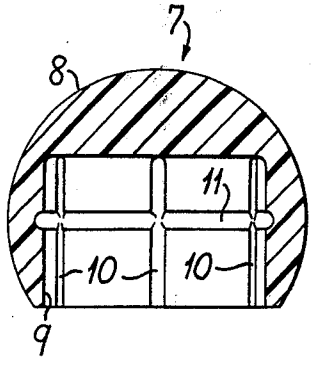


Fig. 4.

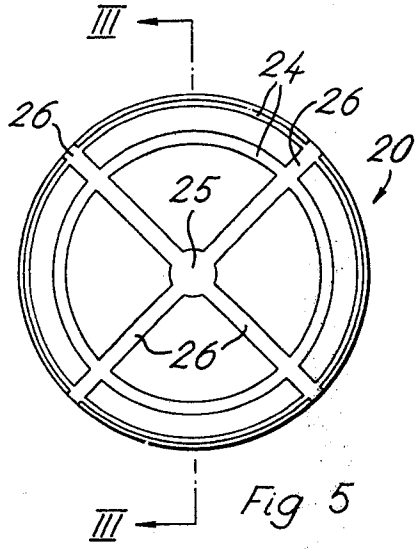


Fig 5

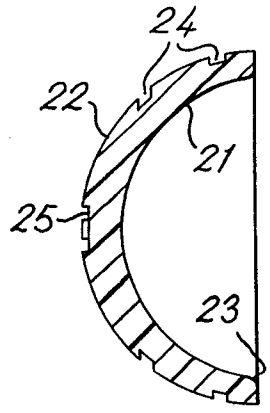


Fig 6

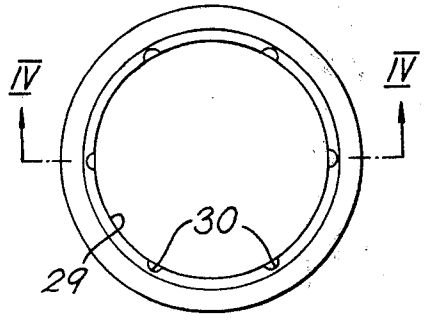


Fig. 7

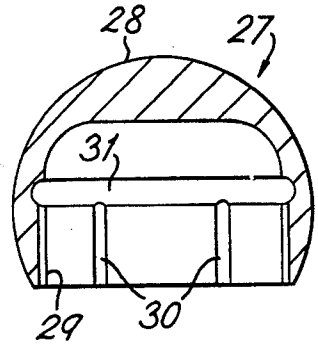


Fig. 8

ENDOPROSTHETIC BONE JOINT DEVICES

This invention concerns endoprosthetic bone joint devices and relates particularly, but not exclusively, to such devices for the hip joint.

In a more general aspect, the present invention provides an endoprosthetic bone joint device comprising: a pair of male and female bearing components; the male component being in the form of a cap member having a convex bearing surface shaped as a surface of revolution about a fixed axis, and a generally concave fixation surface behind said convex bearing surface; the female component being in the form of a socket member having a concave bearing surface substantially complementary with said convex bearing surface for mutual articulatory engagement therewith, and a generally convex fixation surface behind said concave bearing surface; and said fixation surfaces having relieved formations of shallow depth relative to the transverse dimensions across such surfaces, which surfaces receive acrylic cement or equivalent gap-filling medium employed in securement of the components relative to bones of the relevant joint.

In a more particular aspect of the invention such a device is provided for a hip joint prosthesis with said male and female components serving respectively as femoral and acetabular components in the form of cap and socket members having outer and inner substantially part-spherical bearing surfaces.

Normally the two components of the proposed device will be made respectively of metal and plastics material, and in the case of a hip joint device it is presently preferred that the femoral and acetabular components be respectively of metal and plastics material.

The above more general features of the invention are considered advantageous for several reasons. Firstly, both of the components of the device can be sufficiently small to permit insertion substantially or entirely within the capsule of the relevant natural joint, thereby preserving to the greatest possible extent the ligamentous stability of the joint, and minimising the interface between the device and the bones of the joint to reduce the risk of a post-operative infection and the seriousness of the consequences of any such infection which may occur. Secondly, the size, shape and mode of fixation of the components are such that implantation is simpler than conventionally the case, removal is simpler in the event of post-operative infection or other causes, and greater scope is available compared to conventional endoprosthetic situations for the adoption of alternative remedial measures in the event that the endoprosthesis is not completely satisfactory. Thirdly, the bearing surfaces of the components can be shaped so as to constrain one component relative to the other in combination with the remaining ligamentous and muscular constraints, only so far as is necessary for functional stability of the joint, thereby reducing the likelihood of undesirable forces being transmitted through the device and tending to loosen the fixation of the components relative to the bones of the joint. Fourthly, the preferred use of metal and plastics material can provide a low friction bearing relationship between the two components with use of materials which are biologically innocuous in respect of wear particles and other properties, and also provide further advantages of relevance to specific joints.

For a fuller and clearer understanding of the invention, two embodiments of a hip joint device according thereto will now be described by way of example with reference to the accompanying drawings, in which:

FIGS. 1 and 2 respectively illustrate the acetabular component of a first embodiment in plan and cross-sectional view,

FIGS. 3 and 4 similarly illustrate the associated femoral component of the first embodiment,

FIGS. 5 and 6 respectively illustrate the acetabular component of the second embodiment in plan and cross-sectional view, and

FIGS. 7 and 8 similarly illustrate the femoral component of the second embodiment.

The acetabular component of FIGS. 1 and 2 comprises a socket member 1 having concentric hemispherical inner and outer surfaces 2 and 3 which are coaxial in respect of their respective radial axes of symmetry. The inner surface 2 serves as a bearing surface for engagement with the associated femoral component and is provided with a smoothly rounded relieved area 4 around its rim to facilitate receipt of the latter component and to reduce the stresses otherwise associated with a square edge at this rim. The outer surface 3 is provided with relieved formations to afford an enhanced key for acrylic cement or equivalent medium used in securing the cup in a suitably reamed acetabulum. These formations comprise three circular grooves 5 and three circular areas 6, the grooves being successively mutually spaced and concentrically located relative to the radial axis of symmetry of the socket member, and the areas 6 being located in uniform circumferentially spaced manner between the two grooves of smaller diameter to bridge the same.

The associated femoral component of FIGS. 3 and 4 comprises a cap member 7 having an outer surface 8 of major spherical seqment shaping which is of substantially identical radius as the inner surface 2 of the socket member 1 in which it is received in bearing relation. The inner surface 9 of the cap member 7 is of substantially right circular cylindrical shape coaxial with the longitudinal axis of symmetry of the outer surface 8. The inner surface 9 is provided with grooves 10 and 11 having a similar function in relation to fixation of the cap member around a suitably reduced femoral head as the grooves of the socket member to the acetabulum. There are six uniformly circumferentially spaced grooves 10 extending axially along the surface 9, and a single groove 11 extending circumferentially around the surface 9 at a position partway axially therealong. Regarding materials: the socket member 1 is presently made of stainless steel and the cap member 7 of ultra high molecular weight polyethylene.

The acetabular component of FIGS. 5 and 6 comprises a socket member 20 having part-spherically shaped inner and outer surfaces 21 and 22 which surfaces are both symmetrical about a common radial axis. However unlike the corresponding surfaces in the first embodiment, those at hand are not concentric. The outer surface 22 is hemispherical, the inner surface is less than hemispherical, more specifically, minor spherical segment shape, and the respective spherical centres are mutually displaced along the common radial axis so that the wall thickness of the socket member has a maximum value along this axis.

As before, the inner surface 21 serves as a bearing surface for engagement with the associated femoral

component and is provided with a smoothly rounded relieved area **23**, around its rim.

Also, as before, the outer surface is provided with relieved formations for the purposes of securement in association with cement in the acetabulum. In this instance these formations comprise two circular grooves **24** which are mutually spaced, one adjacent the rim and the other partway towards the axis of symmetry, in concentric manner relative to such axis, and a circular area **25** concentrically embracing such axis. In addition, there are four quadrant form grooves **26** extending from the area **25** at successive 90° spacings thereabout to communicate with the grooves **24** in mutually orthogonal manner.

The associated femoral component of FIGS. **7** and **8** comprises a cap member **27** with outer surface **28**, inner surface **29**, axial inner grooves **30**, and circumferential inner groove **31** which are closely similar to the corresponding features of the first embodiment femoral component. Two exceptions to this similarity are that the inner surface **29** is more rounded in its innermost portion as seen in FIG. **8**, and the axial grooves **30** terminate in the circumferential groove **31**.

Remaining differences between the first and second embodiment are that in the latter the choice of component materials is reversed and the difference in component wall thicknesses is less marked.

It is now appropriate to consider the common advantages of the two illustrated embodiments and also their relative advantages.

A major advantage common to both embodiments is the use of a femoral component in the form of a cap member which contrasts markedly with the conventional form of femoral head replacement device. The latter form of device comprises an integral structure of a long intramedullary stem terminating, through a necked portion, in a ball-shaped head. Such a device requires removal of the natural femoral head by sectioning of the femoral neck, and receipt of the device stem in the medullary canal which is usually reamed for this purpose. Clearly the cap member of each illustrated device embodiment, when compared to the conventional device, requires significantly less removal of bone, involves significantly less penetration of foreign matter into the bone for purposes of fixation, it is simpler to implant and remove, and its use is compatible with subsequent adoption of a greater number of alternative remedial measures.

It is also appropriate to consider the relative advantages of the two different forms of illustrated enbodiment. From a theoretical standpoint the first embodiment is more advantageous with its respective allocation of metal and plastics material to the acetabular socket member and femoral head cap member. With this allocation the cap member can have a markedly greater wall thickness than the socket member, with the cap member having a large external diameter in the context of femoral head replacement. This large external diameter, in combination with the correspondingly large internal diameter of the socket member, provides a large area over which the bearing load is spread and can be expected to reduce the rate of radially directed wear in the components, and it also reduces the likelihood of dislocation between the components. At the same time, the greater wall thickness of the cap member appears appropriate to the greater susceptibility to wear of plastics material compared to metal, while the otherwise adverse result of the large internal diameter for the socket member can be compensated by the use of metal to allow the provision of a relatively thin-walled member which does not necessitate extensive reaming of the acetabulum with the associated risk of penetration.

Accordingly, the first embodiment appears to represent a consistent and advantageous arrangement, but is subject to two inter-related provisions. These provisions are that, notwithstanding the larger wall thickness of the femoral cap member, it should still be possible to provide a sufficiently large internal surface area in this member for the purposes of secure fixation over a femoral head reduced to provide a generally complementary stem of cancellous bone, and this stem of bone should not be liable to degeneration. In this connection, an additional advantage of the first embodiment arises in that the plastics material of the cap member is radiotransparent and allows x-ray examination of the bone therewithin to monitor the bone condition. In fact development and clinical testing of this first embodiment over a period of two years indicates that the relevant two provisions can be met.

However, continued laboratory testing of this first embodiment indicates that, while from a theoretical standpoint an advantageously reduced rate of wear can be expected, the rate of wear will be greater than that with the second embodiment. Study of this unexpected phenomenon continues but no fully substantiated explanation has yet been established. In these circumstances, having established that use of the proposed femoral head cap member is practicable, it is considered appropriate to pursue use of the second embodiment for reason of its lesser rate of wear, but subject to two provisions which are, again, inter-related.

These provisions are that the use of a thicker-walled socket member of plastics material, in association with a metal femoral cap member of similar dimensions to those already established as satisfactory with the first embodiment, should not require unduly excessive reaming of the acetabulum and/or reduce the range of free articulatory movement with the cap member by virtue of impaction between the natural femoral neck and the socket member. In practice these provisions can be met on the basis of the finding during development and testing of the first embodiment that the natural acetabular cavity is normally sufficiently deep and extensive to accommodate a size of socket member larger than those now in general use, and the fact that the inner surface of the socket member can be less than fully hemispherical and still afford an adequate range of articulation for the cap member without undue risk of dislocation. Accordingly, in the second embodiment, the inner surface of the socket member is less than hemispherical, the outer surface remains hemispherical to facilitate securement in a conventional mammner, and these two surfaces are mutually eccentrically located to provide not only a thicker wall therebetween but a varying thickness which is at a maximum in the region of likely wear, the otherwise adverse effect on the articulation range of the thicker wall at the rim of the socket member being compensated by the reduced angular extent of the inner surface.

While this last discussion centres on the present preference for use of the second embodiment, others may take the view that the greater rate of wear found with the first embodiment is not such as to outweigh its other advantages. Alternatively, an understanding of the reasons for this greater wear rate may allow the

adoption of additional measures which inhibit the same and so render the first embodiment clearly advantageous.

Lastly, it will also be appreciated that the two illustrated embodiments are given by way of example and are capable of modification.

We claim:

1. An endoprosthetic hip joint device comprising:
an acetabular component in the form of a socket member having an inner bearing surface concavely spherically shaped to not more than hemispherical extent, and a hemispherically shaped outer fixation surface formed with a shallow relieved configuration, said socket member being formed of metal with its inner and outer surfaces both being substantially hemispherical and concentrically located to define a thin uniform thickness therebetween,
and a femoral component in the form of a cap member having an outer bearing surface of convex majorspherical-segment shape in complementary, mutually articulatory engagement with said inner bearing surface, and a concave inner fixation surface of generally cylindrical shape coaxial with the axis of symmetry of said outer bearing surface and formed with a shallow relieved configuration,
said cap member being formed of a plastic material of significantly greater thickness between its respective inner and outer surfaces than said acetabular component;
both of said fixation surfaces having relieved formations for receiving gap-filling medium in respective direct securement with the acetabulum and femur.

2. An endoprosthetic hip joint device comprising:
an acetabular component in the form of a socket member having an inner bearing surface concavely spherically shaped to not more than hemispherical extent, and a hemispherically shaped outer fixation surface formed with a shallow relieved configuration,
said inner bearing surface being of a minor spherical segment shape coaxial with said outer fixation surface, but having its spherical center displaced from that of said outer fixation surface to provide said socket member with the greatest thickness remote from its mouth, said socket member being formed of an integral plastic material;
and a femoral component in the form of a cap member having an outer bearing surface of convex majorspherical-segment shape in complementary mutually articulatory engagement with said inner bearing surface, and a concave inner fixation surface of generally cylindrical shape coaxial with the axis of symmetry of said outer bearing surface and formed with a shallow relieved configuration, said cap member being formed of a metal material; both of said fixation surfaces having relieved formations to receive gap-filling medium in respective direct securement with the acetabulum and femur.

3. A device according to claim 2 wherein said displacement of spherical centres is in the associated coaxial direction.

4. An endoprosthetic hip joint device comprising:
an acetabular component in the form of a socket member of integral metal construction having an inner bearing surface and outer fixation surface, which surfaces are of concentric substantially hemispherical shape defining a thin thickness theretween, and said outer fixation surface having a shallow relieved formation to receive gap-filling medium in securement with the acetabulum;
and a femoral component in the form of a cap member of integral plastics material construction having an outer bearing surface of major-spherical-segment shape in mutual articulatory engagement with said inner bearing surface, and an inner fixation surface of substantially cylindrical shape coaxial with the axis of symmetry of said outer bearing surface, said outer bearing and inner fixation surfaces defining a significantly greater thickness therebetween for said cap member than said socket member, and said inner fixation surface having grooves in the axial and circumferential directions of its cylindrical shape to receive gap-filling medium in direct securement with the femur.

5. An endoprosthetic hip joint device comprising:
an acetabular component in the form of a socket member of integral plastic construction having an inner bearing surface of minor-spherical-segment shape and an outer fixation surface of hemispherical shape, said inner bearing and outer fixation surfaces having coaxial axes of symmetry, but eccentrically disposed respective spherical centres to provide greater thickness between such surfaces remote from their peripheral edges, and said outer fixation surface having a shallow relieved formation to receive gap-filling medium in securement with the acetabulum;
and a femoral component in the form of a cap member of integral metal construction having an outer bearing surface of major-spherical-segment shape in mutual articulatory engagement with said inner bearing surface, and an inner fixation surface of generally cylindrical shape, said inner fixation surface having grooves in the axial and circumferential directions of its cylindrical shape to receive gap-filling medium in direct securement with the femur.

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