United States Patent [19]

Saleh

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[54] **KNEE JOINT PROSTHESIS**

[75] Inventor: **Bahaa Botros Seedhom Saleh,** Leeds, England

[73] Assignee: **National Research Development Corporation,** London, England

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[30] **Foreign Application Priority Data**

June 1, 1971 Great Britain 18278/71

[52] **U.S. Cl.** ..... **3/1,** 128/92 C, 264/222, 264/DIG. 30

[51] **Int. Cl.** **A61f 1/24**

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

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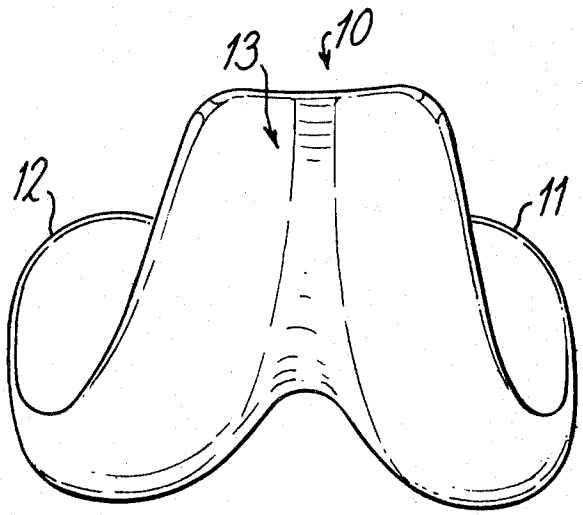
Primary Examiner—Richard A. Gaudet
Assistant Examiner—Ronald L. Frinks
Attorney, Agent, or Firm—Cushman, Darby & Cushman

[57] **ABSTRACT**

A prosthetic knee joint device comprises a femoral component in the form of a shell member having two condylar portions with major convex bearing surfaces areas, which portions are bridged at one end by a portion defining a trough between the convex areas. An associated tibial component has similar portions in a platform bearing member defining major concave bearing surface areas and a ridge therebetween. The convex bearing areas are longer than the concave bearing areas and generally U-shaped longitudinally to simulate the corresponding shaping in the natural joint from which the shell member can in fact be derived. The concave bearing areas however simulate the menisci of the natural joint different phases of rotation to provide an optimized congruity between the bearing surfaces during rotation of the predetermined geometry of the prosthesis as compared to the variable geometry in the natural joint.

9 Claims, 23 Drawing Figures



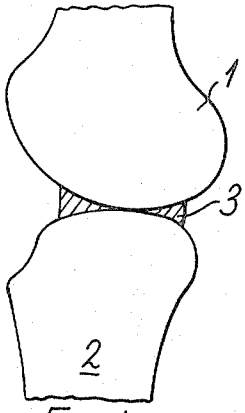


Fig. 1.

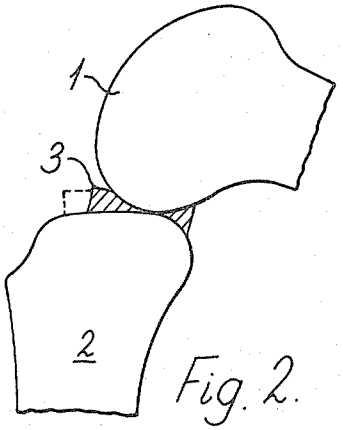
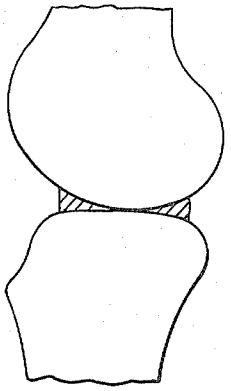


Fig. 2.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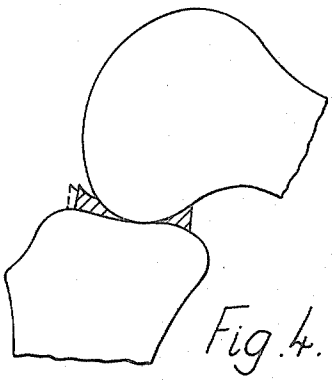
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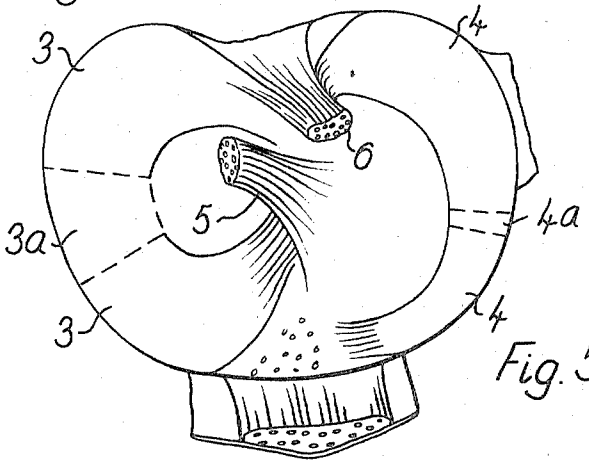

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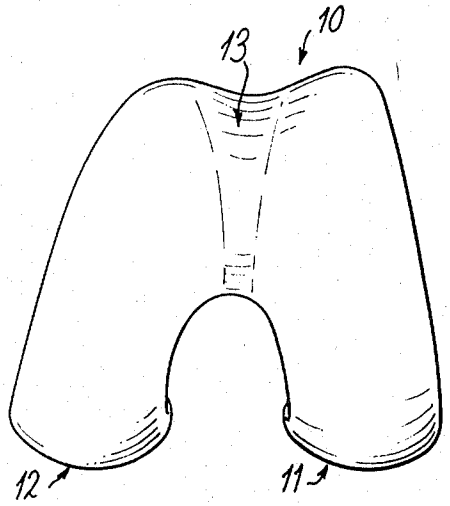
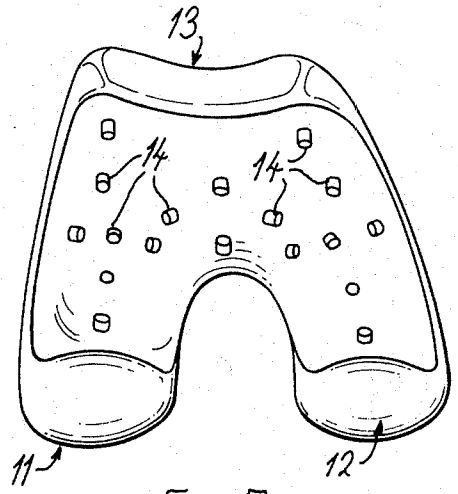


Fig 6.



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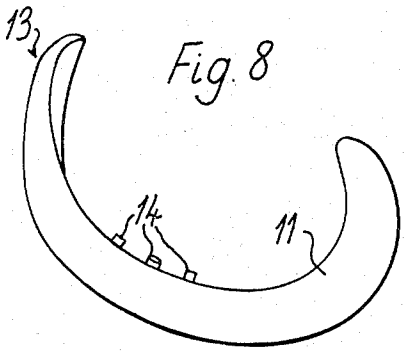


Fig. 8

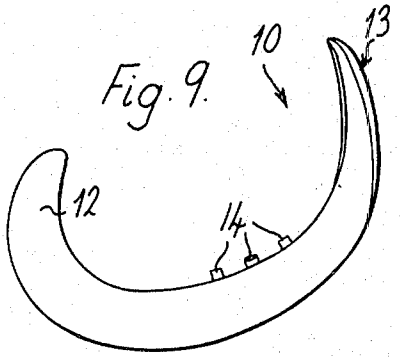
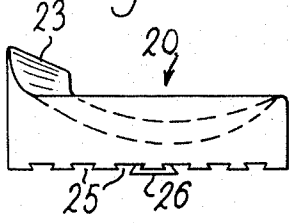


Fig. 9.



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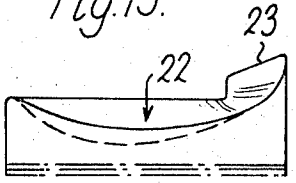

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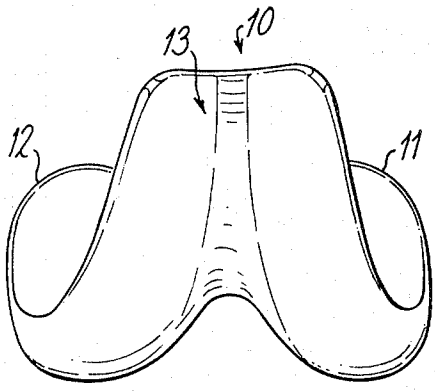


Fig. 10

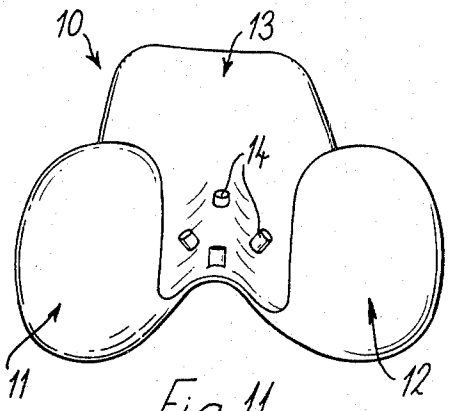
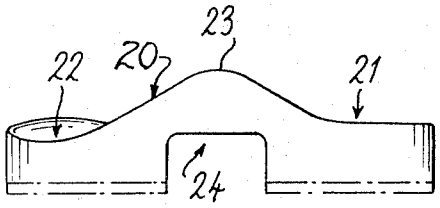


Fig. 11



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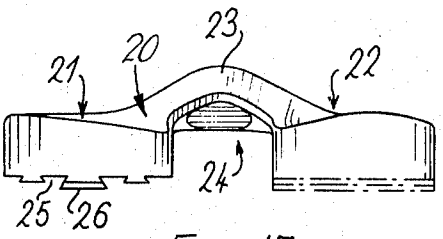

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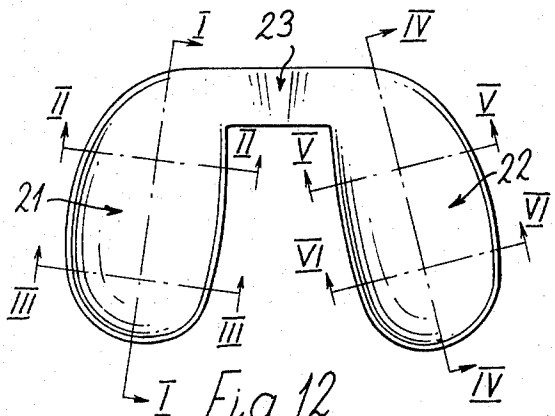


Fig. 12

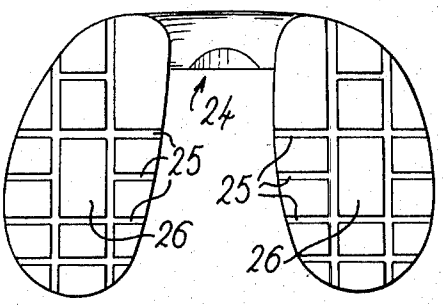
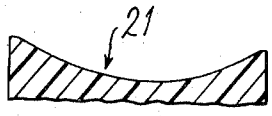


Fig. 13.



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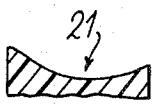

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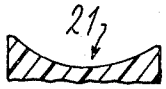
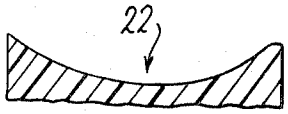


Fig. 20.



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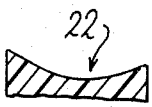

Fig. 22.

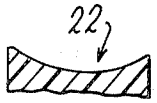

Fig. 23.

KNEE JOINT PROSTHESIS

Various proposals have been made for knee joint prostheses in the past with varying degrees of success in practice. The more successful proposals, in terms of alleviation of pain and long term provision of a useful range of flexion, have involved hinge devices. However, these last devices are not fully satisfactory in that they invariably involve the removal of the natural ligaments and the patella, and, while such devices have their place when the ligaments have deteriorated beyond possible preservation, it is frequently only the condition of the cartilage and the adjacent underlying bone layers which give rise to the need for surgery.

An object of the present invention is to alleviate this situation.

According to one aspect of the present invention, there is provided a prosthetic knee joint device comprising:

a femoral component including a shell bearing member having two first elongate portions and a first bridge portion,

said first elongate portions each being of generally U-shaped form in the longitudinal direction, and generally dished form in the lateral direction, and the curvatures of such forms being of the same sense to provide a major surface of overall convex curvature for each of said first elongate portions,

said first elongate portions being disposed in spaced side-by-side longitudinal relation,

and said first bridge portion integrating said first elongate portions in continuous manner partway along the U-bases and along one pair of corresponding U-arms thereof;

and a tibial component including a platform bearing member having two second elongate portions and a second bridge portion,

said second elongate portions each having a major surface of generally dished form in both the longitudinal and lateral directions to provide overall concave curvature,

said second elongate portions being disposed in spaced side-by-side longitudinal relation,

and said second bridge portion integrating said second elongate portions in continuous manner partway therealong from one pair of corresponding ends;

and wherein the major surfaces of said components opposite to said convex and concave surfaces are adapted for respective fixation to the femur and tibia.

In use of the proposed device, the femoral component replaces the bearing area of the femoral condyles, on the one hand, and the tibial component replaces the lateral and medial menisci together with an area of the tibial condyles, on the other hand. For this purpose the menisci and appropriate parts of the femoral and tibial condyles are removed, and the respective components secured to dispose the same in mutual bearing relationship with their bridge portions generally superposed in the anterior aspect and their non-bridged elongate portion convex and concave surfaces engaged for mutual sliding and rotation along the longitudinal directions thereof.

Regarding the more particular geometry of the device: the convex bearing surfaces of the femoral component simulates the femoral condyles and, in fact, it is preferred that such surfaces closely follow the natural shaping of the condyles. Similarly, it is preferred that the corresponding surface of the associated bridge portion should define a trough between the convex bearing surfaces to simulate, and again preferably follow, the natural form of the inter-condylar trough which receives and guides the patella and associated tendon.

The concave bearing surfaces of the tibial component, on the other hand, do not follow the natural form of the tibial condyles since the latter are not markedly concave in the natural joint, but rather the medial one tends to a flat form and the lateral one to a convex form. Thus, very high stresses would result from direct engagement between natural condyle shaping for each of the engaging surfaces of the prosthesis, with inevitable failure in use. In the present device, the bearing surface form of the tibial component largely follows that of the menisci which are concave and engage the femoral condyles in the natural joint. Even then, the shaping of the menisci varies with the degree of flexion in the natural joint, and to simulate one phase of the menisci with a prosthetic part of fixed shaping would also give rise to undesirably high stresses when the femoral component was in a position corresponding to a degree of flexion other than that for which the menisci shaping had been simulated. For this reason, in a preferred form of the invention, the concave bearing surfaces of the tibial component follow shapings developed from that of the menisci in different phases to provide enhanced congruity and reduce stress between it and the associated femoral part when in use together.

More specifically, according to another aspect of the invention there is provided a method of making a prosthetic knee joint device including a femoral component and a tibial component having respective bearing surfaces for mutual sliding and rotational bearing engagement, which method comprises:

making a first former with two side-by-side spaced elongate convex bearing surface areas respectively closely conforming to the surface shapes of the femoral condyles of a natural knee joint;

making a second former with two side-by-side spaced elongate concave bearing surface areas respectively closely conforming to shapes developed from the menisci of said joint in different phases of rotation thereof, with one pair of corresponding end portions of said concave areas respectively closely conforming to the surface shapes of the anterior aspect of said menisci when said joint is in a rotational phase of relatively full extension, the other pair of corresponding ends of said concave areas similarly conforming to the surface shapes of the posterior aspect of said menisci when said joint is in a rotational phase of relatively full flexion, and intermediate portions of said concave areas being developed to smoothly bridge said ends portions;

smoothing said convex and concave bearing surface areas to provide optimised congruity therebetween in said bearing engagement;

making from said first and second formers respective moulds for said femoral and tibial components; and

casting said components in said moulds.

In order that the invention may be more fully understood, the same will now be described by way of example with reference to the accompanying drawings, in which:

FIGS. 1 and 2 diagrammatically illustrate, in one side view, femoral and tibial components of the natural knee joint in extension and flexion, respectively,

FIGS. 3 and 4 similarly illustrate the same components in the opposite side view,

FIG. 5 diagrammatically illustrates tibial components in a superior view associated with FIGS. 1 and 2,

FIGS. 6 to 11 illustrate the femoral component of one embodiment of the present invention in respective plan (inferior) view, inverted plan (superior) view, one side (medial) view, the other side (lateral) view, front (anterior) view, and rear (posterior) view, the bracketed terms indicating the sense of these views in medical terminology relative to the leg,

FIGS. 12 to 17 similarly illustrate the associated tibial component of the same embodiment, except that in this instance the plan and inverted plan views respectively represent the superior and inferior views, and

FIGS. 18 to 23 respectively illustrate the tibial component in cross-sectional views taken at I—I to VI—VI.

Referring to the drawings more particularly: FIGS. 1 and 2 are schematic views in the lateral aspect and show the femoral condyles at **1**, the tibial condyles at **2**, and the lateral meniscus at **3**. These views show the joint in different phases of rotation, in which the joint is in maximum extension and maximum flexion, respectively, and clearly indicate the large excursion (normally of the order of 10 mm) of the lateral meniscus and associated change of superior form which occurs between these positions.

FIGS. 3 and 4 illustrate corresponding rotational phase views in the medial aspect direction to indicate the corresponding, but smaller (normally of the order of 2mm), excursion and associated change in superior form of the medial meniscus **4**.

FIG. 5 indicates these excursions in the menisci after notionally fixing the anterior aspects of the menisci at maximum extension and the posterior aspects at maximum flexion, with resultant gaps in the menisci being indicated at *3a* and *4a*. FIG. 5 also indicates the anterior and posterior cruciate ligaments at **5** and **6**.

The femoral component of FIGS. **6** to **11** comprises a shell bearing member **10** having two elongate portions **11** and **12** and a bridge portion **13**. The elongate portions **11** and **12** are each of generally U-shaped form in the longitudinal direction and generally dished form in the lateral direction to provide a major surface of overall convex curvature. These major surfaces of the portions **11** and **12** serve as bearing surfaces to respectively replace the corresponding function of the femoral, lateral and medial condyles. For this purpose the portions **11** and **12** are disposed in spaced side-by-side relation. The portions **11** and **12** are held in such relationship by the bridge portion **13** which integrates the same in continuous manner partway along the U-bases and one pair of corresponding U-arms.

The pair of U-arms in question are those which represent the anterior end portions of the femoral condylar bearing surfaces, and the bridge portion is shaped to define a trough between the portions **11** and **12** relative to their convex curvature. This trough also serves as a bearing surface to replace the corresponding function of the similar trough in the natural joint which guides the patella and associated tendon.

In its preferred form, as illustrated, the bearing surfaces of the shell member of the femoral component closely conform to the natural shapings of the corresponding parts of the knee joint and these shapings are such that the member will be normally most conveniently produced by casting. A mould for this purpose can be developed from a former in which the relevant surfaces are derived by direct moulding from the femur of a natural joint.

The remaining parts of the illustrated femoral component are those concerned with its fixation. This is intended to be by use of acrylic resin or other gap-filling agents or cements such as used with bone joint prostheses and, in this connection, the concave surface areas of the elongate portions **11** and **12**, and the associated rear surface of the bridge portion **13**, are formed with a plurality of relatively short studs **14**. These studs serve to space the main body component from the cancellous bone of a suitably prepared femur to allow flow of resin therebetween over a sufficient area and to an adequate thickness to afford good securement. Also, the studs enhance the securement by providing a key between the component and the cement.

The associated tibial component of FIGS. **12** to **23** comprises a platform bearing member **20** which also has two elongate portions **21** and **22**, and a bridge portion **23**. The portions **21** and **22** each have a major surface of generally dished form in both the longitudinal and lateral directions to provide overall concave curvature. These major surfaces serve as bearing surfaces to respectively replace the corresponding function of the lateral and medial menisci and tibial condyles, and to co-operate with the convex bearing surfaces of the illustrated femoral component. Accordingly, the portions **21** and **22** are held in spaced side-by-side relation by the bridge portion **23** which integrates the same in continuous manner partway therealong from one pair of corresponding ends. The corresponding ends in question represent the anterior part of the component and the bridge portion is shaped to define a ridge between the concave dished surfaces, which ridge extends into the trough of the associated femoral component when the two components are engaged in bearing relation in a position representing maximum extension. This position can be envisaged from the four pairs of FIGS. **8** and **14**, **9** and **15**, **10** and **16** and **11** and **17**, which show the components in their respective dispositions for this position, but separated in the longitudinal direction of the relevant leg.

Also, it is to be noted that the bridge portion **23** does not depend below the bearing surface areas of the tibial component to the same extent as the elongate portions **21** and **22**, but is relieved to provide a cavity **24** therebelow.

Regarding fixation of the tibial component:

This also involves use of a resin or cement as used for the femoral component, although in this instance it is preferred to afford spacing and keying by the provision of grooves **25** over the non-concave major surfaces of the elongate portions **21** and **22**. These grooves are preferably of dovetail cross-sectional form to provide an enhanced key, and are also preferably aligned with both the longitudinal and lateral directions of their respective elongate portions to provide a "cross-hatched" effect.

In addition, a central part of each grooved area extends further than the remainder of such area to provide a plateau **26**. This has a similar spacing function to the studs **14** of the femoral component in ensuring

an adequate layer of resin or cement below the tibial component as well as entry of such material into the grooves.

In its preferred form, as illustrated, the bearing surfaces of the tibial component closely conform to those of the menisci in FIG. 3 with the gaps 3*a* and 4*a* effectively reconstructed. Thus, one pair of corresponding ends of the concave bearing surface areas respectively closely conform to the surface shapes of the anterior portions of the menisci of the natural joint when the joint is in a rotational phase of relatively small flexion angle, the other pair of corresponding ends of such areas similarly conform to the surface shapes of the menisci when the joint is in a rotational phase of relatively large flexion angle, and intermediate portions of such areas conform to developments smoothly bridging said anterior and posterior portions. As with the femoral component, such shaping in the tibial component will be normally best achieved by use of casting techniques. A suitable former from which the desired shaping can be obtained has been produced from a natural joint on which a menisectomy was first carried out, leaving all of the ligaments intact. Then a wax was poured into the joint space with the joint at full extension. After at least peripheral setting, the wax was heated at the rear and side regions of the joint, and the joint flexed to generate a fixed surface which had the maximum effective congruence with the femoral condyles throughout the range of flexion.

While the femoral and tibial components can be cast from moulds produced, as described above, from formers which are directly moulded from a natural joint, it is preferred that the bearing surface areas of the moulds, and so of the cast components, be idealized. Thus all undulations resulting from the presence of cartilage should be smoothed, the indentations of the menisci on the natural femoral condyles are not reproduced, and a mutual lapping operation in production of the relevant moulds is effected to provide an optimized fit. Also, it will be normally appropriate to extend the bridge portion of the femoral component to ensure the provision of a bearing surface for the patella in the final degrees of extension.

Features of the final shaping which can be appreciated from the drawings are that the condylar bearing surfaces of the femoral component follow smooth generally spiral curves in their longitudinal directions with increasing radius of curvature from back to front, while the corresponding curvatures of the tibial component are more uniform. More particularly, the components have greater congruity at the front than the rear when engaged in bearing relation in the position corresponding to full extension. Indeed the components are highly congruous, both longitudinally and laterally, in this position in their front parts and bridge portions. This reduces stresses when standing and also assists positioning of the tibial component relative to the femoral component during implantation.

Also, the longitudinal directions of the elongate portions of the femoral component, and those of the tibial component similarly, diverge from their bridged ends by an angle of about 10° – 15°, as do the natural condyles. This enhances antero-posterior stability.

The invention is, of course, not intended to be limited to the form which has been more particularly described with reference to the drawings, but can be varied within the scope of the appendant claims. For example, either of the femoral and tibial components can be provided with suitably located grooves or ribbed formations, studs, spikes, stems, or other fixation formations or members. Indeed, in a presently proposed modification, the majority of the studs of the femoral component are to be replaced by a pair of intracondylar webs extending partway along the longitudinal directions of the respective elongate portions, generally centrally of the bridged parts thereof, while retaining one or two studs at the other ends thereof.

Also, the components can be made in any materials suited to the purpose, although the present preference is for a metal/plastics material combination for the respective components. More particularly, the present preference is that the femoral component be of a metal such as chrome/cobalt alloy, and that the tibial component be of a plastics material such as high density polyethylene.

Lastly, it is useful to mention practical advantages of the device of the invention. Since the bearing surfaces closely simulate those of the natural joint, the former can afford a range of flexion and extension closely approximating that of the latter. The use of shell and platform bearing members does not involve removal of large amounts of bone from the natural joint as is commonly the case with hinged forms of knee joint prostheses. Also, the proposed device need not involve the use of long intramedullary stems or like members for the purposes of fixation, and so obviates the need for lengthy excursions of foreign material into and along the medullary canals. These last two points mean that the device can, if the need arises, be removed without undue difficulty after implantation and, more important, still afford the possibility of alternative remedial action such as use of another form of joint prosthesis (including a hinge device), or arthrodesis. These possibilities are significantly reduced if large amounts of bone are removed in an initial remedial action.

Further factors of advantage are that all of the natural ligaments, and also the patella, can be retained.

I claim:

1. A prosthetic knee joint device comprising:

a femoral component including a shell bearing member having two first elongate portions and a first bridge portion, said first elongate portions each being of generally U-shaped form in the longitudinal direction and generally dished form in the lateral direction, and the curvatures of such forms being of the same sense to provide a smooth major surface of overall convex curvature for each of said first elongate portions, said first elongate portions being disposed in spaced side-by-side longitudinal relation, said first bridge portion integrating said first elongate portions in continuous manner partway along the U-bases and along one pair of corresponding U-arms thereof, and said major convex surfaces follow a generally spiral curvature in their longitudinal directions with increasing radius of curvature towards their non-bridged ends,

and a tibial component including a platform bearing member having two second elongate portions and a second bridge portion,

said second elongate portions each having a major surface of generally dished form in both the longitudinal and lateral directions to provide smooth overall concave curvature,

said second elongate portions being disposed in spaced side-by-side longitudinal relation;

said second bridge portion integrating said second elongate portions in continuous manner partway therealong from one pair of corresponding ends,

and said major concave surfaces follow a more uniform curvature in their longitudinal directions than do said major convex surfaces, with said major concave surfaces being more congruous with the bridged ends of said major convex surfaces,

said femoral and tibial components being disposed in mutual bearing relationship with their respective bridge portions generally superposed and their respective non-bridged elongate portion convex and concave surfaces engaged for mutual sliding and rotation along the longitudinal directions thereof;

and wherein the major surfaces of said components opposite to said convex and concave surfaces are adapted by the provision of shallow configurations thereon for respective fixation to the femur and tibia by a gap-filling agent.

2. A device according to claim **1** wherein said first bridge portions defines a first trough, relative to said convex curvature, between said first elongate portions integrated thereby; and said second bridge portion defines a ridge relative to said concave curvature, between said second elongate portions integrated thereby.

3. A device according to claim **1** wherein said convex surfaces are generally divergent in their longitudinal directions from their bridged ends, and said concave areas are similarly divergent.

4. A device according to claim **1** wherein said femoral component is adapted for fixation to the femur with a gap-filling agent by the provision of a plurality of relatively short members projecting from the major surface thereof opposite to said convex surfaces.

5. A device according to claim **1** wherein said tibial component is adapted for fixation to the tibia with a gap-filling agent by the provision of a grooved formation on the major surface thereof opposite to said concave surfaces.

6. A device according to claim **5** wherein each groove of said grooved formation has a dovetail cross-sectional form.

7. A device according to claim **5** wherein said grooved formations define generally central regions of the respective surfaces of said second elongate portions which central regions extend further than the remainder of such surfaces to define plateaus.

8. A device according to claim **1** wherein said femoral and tibial components are respectively made of metal and plastics material.

9. A prosthetic knee joint device, comprising a femoral component and a tibial component;

the femoral component being a shell having two laterally spaced convex bearing surfaces respectively closely conforming to the surface shapes and spatial orientation of the femoral condyles of the natural knee joint, and having a trough portion bridging between the two bearing surfaces adjacent their respective convergent ends for receiving and guiding the patella and associated tendon should these be retained;

the tibial component being a platform having two laterally spaced concave bearing surfaces closely conforming to shapes developed from menisci of the natural knee joint in a plurality of different phases of rotation thereof, with one pair of corresponding end portions of said concave bearing surfaces respectfully closely conforming to the surface shapes of the anterior aspect of said menisci when said natural knee joint is in a rotational phase of relatively full extension, the other pair of corresponding ends of said concave bearing surfaces similarly conforming to the surface shapes of the posterior aspect of said menisci when said natural knee joint is in a phase of relatively full flexion, and intermediate portions of said concave bearing surfaces between the respective ends smoothly bridging therebetween, said concave bearing surfaces being dished both longitudinally and laterally, the corresponding anterior end portions of said platform being held in spaced, side-by-side relation by a bridge portion which forms a ridge between the concave dished surfaces and extends into the trough of said femoral component when these two components are engaged in a bearing relation representing maximum extension;

the convex bearing areas being longer than the concave bearing areas and being generally U-shaped longitudinally and low relief protuberance and recess means formed on the reverses of the two components from the bearing surfaces, for keying, spacing and permitting resin fixation of the components without need for removal of so large amounts of bone from the natural knee joint of the patient as is generally the case with hinged forms of knee joint prostheses and without lengthy excursions of foreign material along the medullary canals.

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