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Kaufer et al.

[11] 3,868,730

[45] Mar. 4, 1975

[54] KNEE OR ELBOW PROSTHESIS

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[22] Filed: **Feb. 6, 1974**

[21] Appl. No.: **440,190**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 400,202, Sept. 24, 1973, abandoned.

[52] **U.S. Cl.** ..... **3/1,** 128/92 C

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

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

[56] **References Cited**

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Primary Examiner—Richard A. Gaudet
Assistant Examiner—Ronald L. Frinks
Attorney, Agent, or Firm—Connolly and Hutz

[57] **ABSTRACT**

The femoral and tibial components of a knee joint prosthesis are rotatably coupled by a ball and socket connection in which a ball on a connecting rod extending upwardly from the tibial component is engaged up into a high density polyethylene socket insert in the bottom of the femoral component. A pair of spaced substantially parallel spheroidally curved condyle runners straddle the socket opening in the femoral component and have a compound curvature with a larger radius lower portion and a smaller radius upper portion. A slot in the ball retaining socket insert permits the required angular movement of the connecting rod through the angle of flexure, and the connecting rod engages the terminal end of the slot to limit the flexure. The upper edges of the condyle runners are thickened to cause the leading edges of the polyethylene plateau shoes on the tibial component to firmly wedge into them to smoothly arrest flexed tibial movement. The slot is larger than the connecting rod thereby enabling flexure movement, and non-interference with natural rotational and wobbling movement as in a natural knee joint. The concave plateaus substantially correspond with the lower larger radius condyle surfaces to intimately engage them with each other in the extended position for firm extended leg support. The clearance between the plateau and condyle surfaces during flexure is small enough to cause them to interfere after only a slight degree of twisting or wobbling is permitted. This clearance and the associated control of medial and lateral angulation and medial and lateral rotation is maintained by the precise controlled entrapment of the ball in the socket.

15 Claims, 12 Drawing Figures

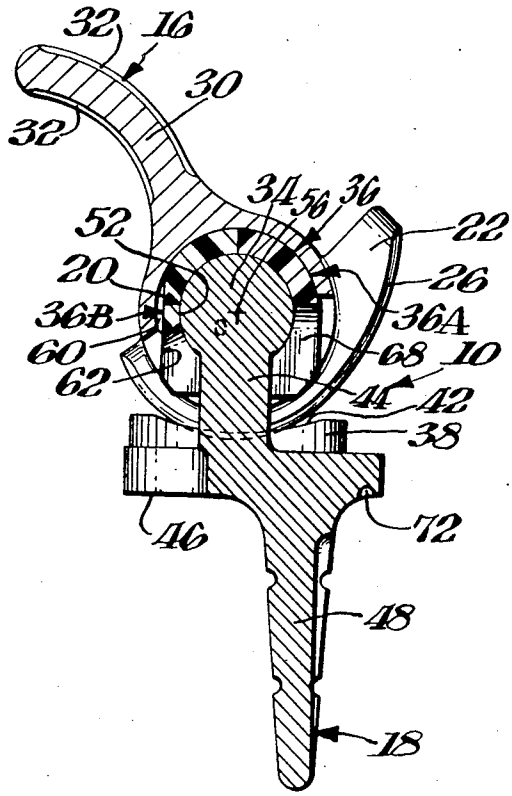


Fig. 1.

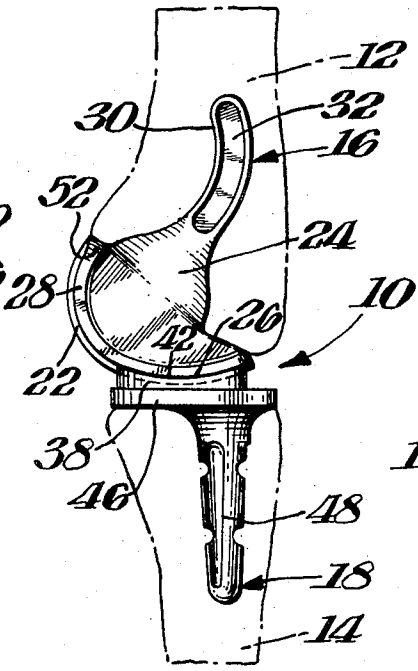


Fig. 2.

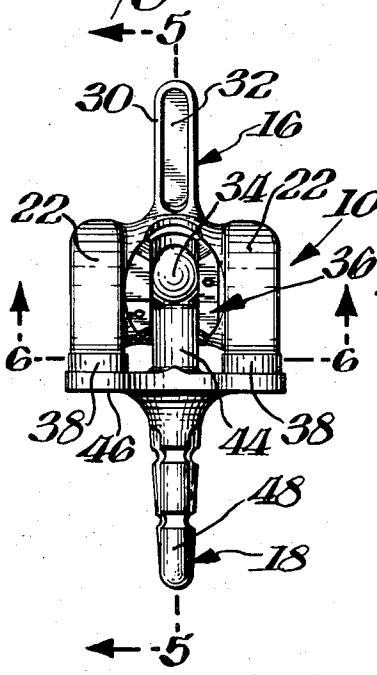
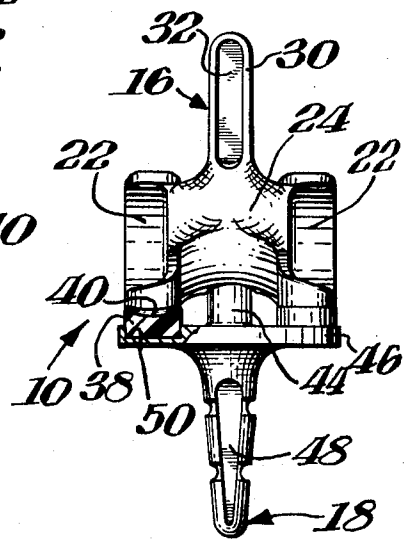


Fig. 3.



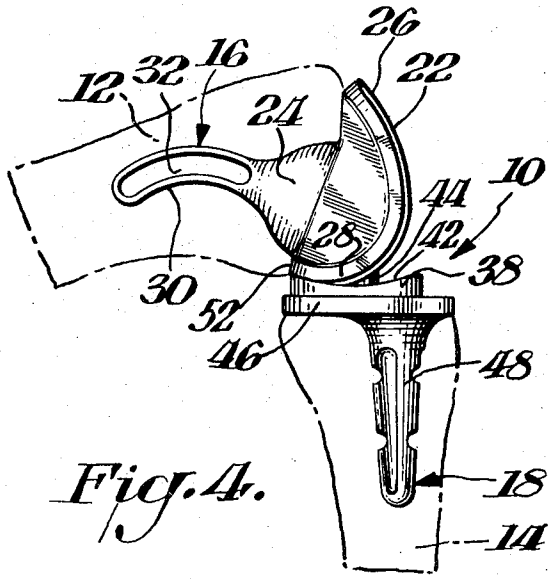


Fig. 4.

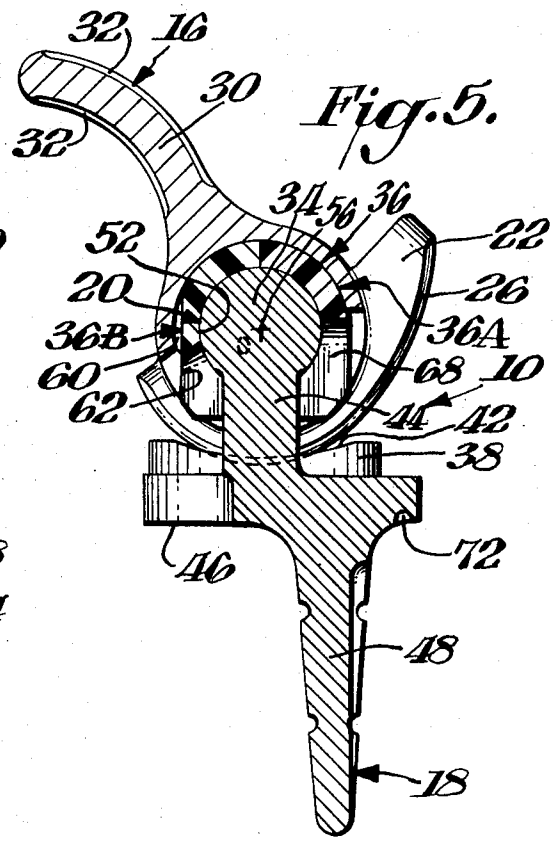


Fig. 5.

Fig. 7.

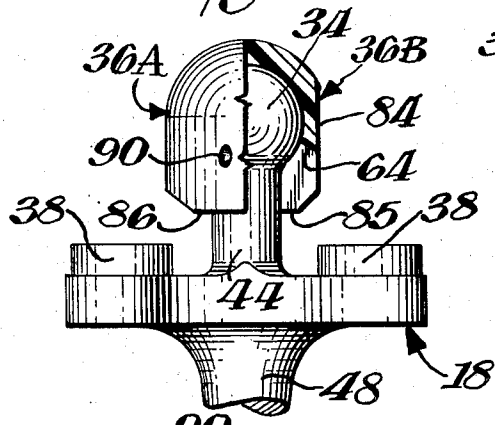


Fig. 8.

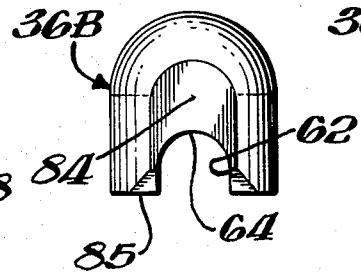
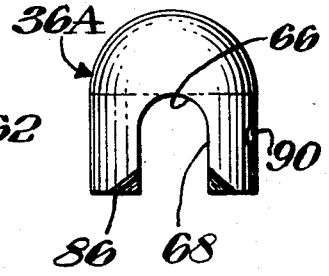


Fig. 9.



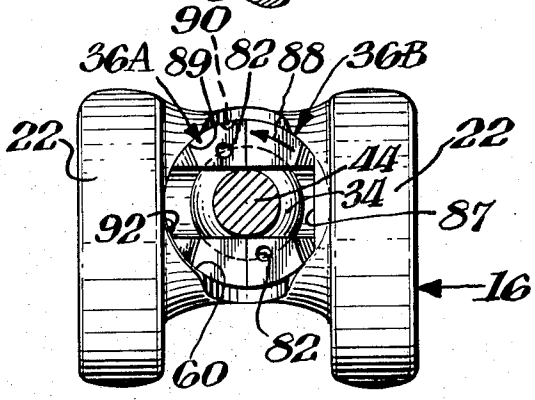


Fig. 10.

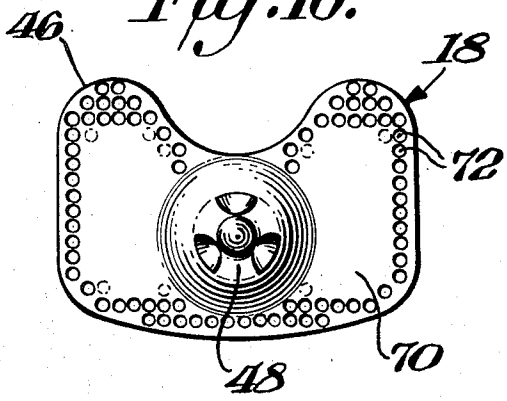
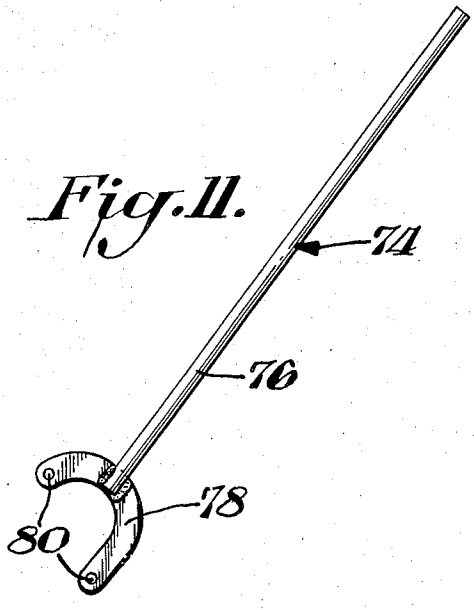


Fig. 6.

Fig. 11.



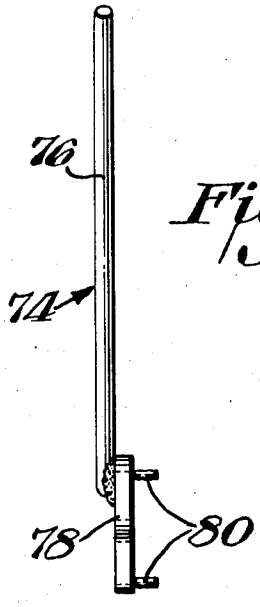


Fig. 12.

KNEE OR ELBOW PROSTHESIS

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of copending application Ser. No. 400,202 filed Sept. 24, 1973, now abandoned.

BACKGROUND OF THE INVENTION

A substantially effective knee or elbow joint prosthesis is described in U.S. Pat. No. 3,728,742 having spherical convex condyle and concave plateau surfaces on the femoral and tibial components. The spherical surfaces provide smooth flexure but do not completely duplicate all of the complex anatomical movement obtained in normal knee or elbow joint motion. An object of the present invention is to provide a knee or elbow joint prosthesis having parallel convex condyle and concave plateau elements, which more exactly copies natural knee or elbow joint movement and provides a very high degree of intrinsic stability.

SUMMARY

The femoral and tibial components of a knee joint prosthesis are rotatably coupled by a ball and socket connection in which a ball on a connecting rod extending upwardly from the tibial component is engaged up into a socket in the bottom of the femoral component. A pair of spaced substantially parallel spheroidally curved condyle runners straddle the socket opening in the femoral component and have a varying curvature with a larger radius lower portion and a small radius upper portion. A slot in the ball retaining socket insert permits the required angular movement of the connecting rod through the angle of flexure, and the connecting rod engages the terminal end of the slot to limit the flexure. The upperedges of the condyle runners are thickened to cause the leading edges of the polyethylene plateau shoes in the tibial component to firmly wedge against them to smoothly arrest flexed tibial movement. The slot is larger than the connecting rod to enable a degree of play throughout the flexure movement, thus providing an unencumbered natural rotational and wobbling movement. The precise geometry of the entrapped ball associated with the controlled clearance and fit between the runners and plateaus or shoes provides intrinsic stability and simulates the natural rotational and wobbling movement of a natural knee joint. The concave plateaus substantially correspond with the lower larger radius condyle surfaces to intimately engage them with each other in the extended position for firm extended leg support. The clearance between the plateau and condyle surfaces during flexure is small enough to cause them to interfere after only a controlled degree of twisting or wobbling is permitted. The socket and sliding shoe surfaces may be effectively provided by organic polymer inserts, suitably composed of high molecular weight polyolefin, e.g. high density polyethylene. The socket insert may be segmented and rotationally locked within the socket cavity in the femoral component to facilitate its replacement and to assure assembled stability.

BRIEF DESCRIPTION OF THE DRAWING

Novel features and advantages of the present invention will become apparent to one skilled in the art from a reading of the following description in conjunction with the accompanying drawings wherein similar reference characters refer to similar parts and in which:

FIG. **1** is a side view in elevation of an embodiment of this invention serving as the knee joint between a femur and tibia, which are shown in phantom outline;

FIG. **2** is a left elevational view of the embodiment shown in FIG. **1** showing the rear of the knee joint;

FIG. **3** is a right elevational view of the embodiment shown in FIG. **1** showing the front of the knee joint;

FIG. **4** is a side elevational view of the embodiment shown in FIG. **1** with the knee joint flexed in the sitting position;

FIG. **5** is an enlarged full-size cross-sectional view taken through FIG. **2**, along the line **5—5**;

FIG. **6** is an enlarged full size cross-sectional view taken through FIG. **2** along the line **6—6**;

FIG. **7** is a full size rear view in elevation of the tibial component of the embodiment shown in FIGS. **1–5** with the ball of the connecting rod disposed within the plastic socket of the femoral component, which is partly broken away in cross section;

FIG. **8** is an outside view in elevation of the rear portion of the segmented plastic socket;

FIG. **9** is an outside view in elevation of the front portion of the segmented plastic socket;

FIG. **10** is a bottom plan view of the tibial portion of the embodiment shown in FIGS. **1–9**;

FIG. **11** is a top plan view of the wrench for installing and removing the socket shown in FIGS. **7–9**; and

FIG. **12** is a side view in elevation of the wrench shown in FIG. **11**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIGS. **1–3** and **5** is shown a knee joint prosthesis **10** in the extended and in the partially flexed positions, respectively, in which the upper and lower portions of the leg represented by femur **12** and tibia **14** are in anatomical alignment with each other. Joint **10** includes a femoral component **16** and a tibial component **18** coupled by ball and socket connection **20.** Femoral component **16** has a pair of spaced substantially parallel spheroidally curved condyle runners **22** straddling a hollow central housing **24.**

Condyle runners **22** each have a front lower portion **26** having a relatively larger radius of curvature and a rear upper portion **28** having a relatively smaller radius portion. The radius of curvature of front lower portion **26** is, for example, twice as large as the radius of curvature of rear upper portion **28.** Femoral attaching stem **30** is attached to the top of hollow central housing **24** and is substantially of square cross-section with slight lateral depressions **32** in each of the sides for facilitating cementing and retention in the femur.

Ball and socket connection **20** in hollow housing **24** includes spherical ball **34** entrapped within segmented plastic socket **36** including front half **36A** and rear half **36B**, later described in detail. Socket **36** is suitably made of high molecular weight polymer such as high density polyethylene. All other portions of knee joint **10** are made of a strong non-corrosive metal having stable expansion and other physical characteristics, with

the exception of shoes **38** which are also made of high molecular weight polymer such as high density polyethylene. The metal portions are advantageously made of metal compatible with the human body such as Vitallium, the trademark of Howmedica Inc. for a cobalt-chromium alloy, developed and used for cast partial and full dentures, and for internal application by surgeons. When polished, it is exceedingly smooth and permanently lustrous. Its outstanding qualities are permanent inertness in relation to living tissues, and high resistance to corrosion.

Condyle runners **22** correspond to the condyle portions of a human knee joint and also have a transverse radius of curvature shown in FIG. **3** to make their surfaces substantially spheroidal. Transverse radius of curvature **40** shown in FIG. **3** is preferably substantially equal to the smaller radius of curvature of condyle runner upper rear portions **28.**

Shoes **38** shown in FIG. **5** correspond to the plateau portions of the human knee and have a concave surface **42** shown in FIG. **5,** which substantially correspond to the shape of lower condyle runner portions **26** to cause these portions to intimately nest with each other in the extended position shown in FIG. **1** and provide firm support for the extended leg. Shoes **38** have substantially the same transverse radius as curvature **40** shown in FIG. **3.** This geometry helps provide the aforementioned stable nesting in the extended position, and provides an interference control of the rotation and wobbling movements facilitated by the ball **34** and socket **36.**

Ball **34** is disposed on the top of connecting rod **44,** which is mounted on the top of base **46** of tibial component **18.** A regularly gouged tibial connecting stem **48** extends downwardly into tibia **14** from the bottom of base **46.** Shoes **38** are mounted in recesses **50** in the upper surface of base **46.**

FIG. **4** shows the position of joint **10** when femoral component **16** is rotated to a horizontal position, such as when a person is in the sitting position. This engages the upper rear portions **28** of condyle runners **22** with shoes **38.** The flexure motion is smoothly arrested by an outward protrusion or slight thickening of the terminal ends **52** of upper rear condyle portions **28** which wedge against the rear ends of shoes **38.** This smoothly arrests the flexure movement without any clunking and simulates the normal knee action. The flexure movement of joint **10** is also arrested by the abutment of connecting rod **44** against the rear edge **64** of rear socket portion **36B.**

The extending movement of joint **10** about axis **56** of ball and socket joint **20** is arrested by the nesting of lower larger radius of curvature portions **26** of condyle runners **22** within shoes **38.** Smaller radius of curvature condyle portions **28** have a coaxial axis of rotation with ball center **56** in the position shown in FIG. **5.** This causes the larger radius of curvature condyle runner portions **26** to firmly engage into the concave surfaces **42** within shoes **38** and thus provide secure abutment and firm support for each other. During movement of joint **10** from the extended position shown in FIG. **1** to the flexed position shown in FIG. **4** through intermediate position **5,** smaller radius of curvature portions **28** of condyle runners **22** move slightly free of internal shoe surfaces **42** which thus allows a light wobbling or controlled play within the confines of shoes **38** until the bottoms of condyle runners **22** engage the outer edges **58** of shoes **38** which limit such movement. This simulates the normal rotational inward and outward tilting or wobbling of a normal knee joint throughout the flexed positions and with more restraint in the extended position.

FIGS. **7–10** show the manner in which segmented plastic insert halves **36A** and **36B** are disposed about ball **34** and inserted within cavity **60** in hollow central housing **24.** Rear insert portion **36B** has a slot **62** having a relatively lower outer dome **64** relative to higher outer dome **66** of slot **68** in front socket segment **36A.** This provides for movement from the extended position shown in FIG. **1** to the flexed position shown in FIg. **4** and accordingly provides the necessary clearance for the relative angular movement of connecting rod **44.** Connecting rod **44** is narrower than the width of slots **62** and **68** to insure non-interference with the play or wobbling action throughout the flexed orientation of knee joint **10.**

FIG. **10** shows the bottom surface **70** of tibial base **46** serrated by spherical pits **72,** which help cement base **46** to tibia **14.**

FIGS. **11** and **12** show wrench **74** having stem **76** connected to arcuate rod **78** upon which pins **80** are mounted. Pins **80** are inserted into holes **82** in the bottom edges **85** and **86** of rear and front socket segments **36B** and **36A** for rotating the segments about ball **34,** for insertion into and removal from cavity **60** as shown in FIG. **6.** Assembled socket segments **36A** and B are accordingly inserted into cavity **60** in the position shown in FIG. **6** in which flat edge **84** of rear segment **36B** clears overhanging edge **87** of cavity **60.** After such insertion, rotation of segments **36A** and B in the direction of arrow **88** locks the outer circumference **89** of socket segments **36A** and B under overhanging edge **87** to lock the segments in place. The locked position is indexed and stabilized by the rotation of indentation **90** in front segment **36A** into alignment with detent projection **92** on the wall of cavity **60.** Reverse rotation back to the position shown in FIG. **6** allows removal of ball and socket insert **20** from cavity **60.**

Knee joint **10** has the following advantages:

1. Ease of surgery: A medical parapatellar incision allows exposure for a single transverse saw cut across the tibia approximately ½ cm. below the joint surface. The angled transverse saw cuts across the femur are then made. The medullary spaces are broached. Bone cement is placed in the femoral broached space and across the osteotomy site. The femoral component is inserted. The tibial component is similarly installed. The knee is flexed, the ball and socket insert snapped into place, the knee extended, and the wound closed.

2–3. Versatility — Inherent Stability: Knee joint **10** is an inherently stable prosthesis which enables treatment of joints lacking viable capsules and ligaments in addition to pathologic articular surfaces, both condylar and patellar. Few sizes are needed (three are foreseen).

4. Range of Motion: Design of runner-insert geometrics enables the motion characteristics desired. Flexion-extension from −5° to 100° is readily accomplished. Valgus-varus and rotational freedom is attained by the "sloppy" though carefully controlled interplay between runners and inserts. Runner-insert track sidewall camming action yields a non-impact but secure arrest of motion.

5. Controlled Decceleration: The camming action arrestment prevents "clunk" impact loadings at full extension (FIG. 1) and full flexion (FIG. 4).

6. Materials: All components are made of medically accepted metal and high density polyethylene.

7. Load Bearing Areas: The runner-track bearing areas are as large as currently available partial knee configurations. The ball-socket area is a significant additional increase in bearing surface.

8. Prosthesis-Bone Interface: Only metal-cement-bone interfaces are used.

9. Replacement of Failed Components: The parts susceptible to wear (two tibial inserts and one socket insert) are readily replaced.

10. Shear Forces: High density polyethylene is not in contact with cement. Low frictional characteristics of high density polyethylene polished metal bearing surfaces minimize shear forces on both components.

11. Salvage Possibilities: A knee joint compression arthrodesis is possible as a salvage procedure.

12. In addition to the above, knee joint **10** looks like a knee to surgeon and patient alike, and its functional characteristics are similar to those of the normal knee.

We claim:

1. A joint prosthesis suitable for a knee or elbow comprising a femoral component, a tibial component, a ball and socket connection coupling said components, said femoral component having a pair of spaced substantially parallel spherodically curved condyle runners straddling a hollow central housing, said condyle runners having a front lower portion with a relatively larger radius of curvature joining a rear upper portion having a relatively smaller radius of curvature as compared to said front lower portion, a slot in the bottom of said housing disposed substantially parallel to said runners, a femoral attaching means in the top of said femoral component, said tibial component having a base, tibial connecting means on the bottom of said base, a pair of spherodially curved spaced parallel concave sliding shoes on said base having upper surfaces substantially corresponding with the front lower portions of said condyle runners for intimately nesting them together when said joint is in the extended position, said ball and socket connection including a connecting rod rigidly fixed to and extending upwardly from said base of said tibial component, the ball of said ball and socket connection being disposed on the upper end of said connecting rod, said hollow central housing enclosing the socket portion of said ball and socket connection disposed for entry through its bottom, said ball portion being rotatably engaged in said socket portion, the smaller radius of curvature of said rear upper portions of said runners providing clearance between said shoes and said rear upper portions in flexed positions of said components, said connecting rod being disposed in said slot which permits said connecting rod to pivot through the angle of flexure of said joint, said connecting rod being narrower than said slot, said clearance between said shoes and said rear upper portions being limited to restrain the twisting and wobbling between interfering portions of said shoes and said runners whereby a natural degree of controlled joint twisting and wobbling is provided.

2. A joint prosthesis as set forth in claim **1**, wherein the upper ends of said rear upper portions of said runners slightly protrude radially outwardly for wedging against said shoes whereby the terminal flexure motion of said shoe is smoothly arrested.

3. A joint prosthesis as set forth in claim **1**, wherein said ball and socket connection has an axis of rotation, said rear upper portions of said condyle runners having a center of curvature, and said axis of rotation and said center of curvature being coaxial with each other.

4. A joint prosthesis as set forth in claim **1**, wherein said runners have a transverse radius of curvature substantially equal to said smaller radius of curvature of said rear upper portions of said condyle runners.

5. A joint prosthesis as set forth in claim **1**, wherein said concave shoes have a radius of curvature substantially corresponding to said radius of curvature of said front lower portions of said condyle runners.

6. A joint prosthesis as set forth in claim **5**, wherein said concave shoes have a transverse radius of curvature substantially corresponding to the transverse radius of curvature of said runners.

7. A joint prosthesis as set forth in claim **1**, wherein said tibial connecting means comprises a tibial connecting stem disposed to extend downwardly from said base.

8. A joint prosthesis as set forth in claim **1**, wherein said femoral attaching means comprises a femoral attaching stem.

9. A joint prosthesis as set forth in claim **1**, wherein said socket portion of said ball and socket connection comprises a slotted insert.

10. A joint prosthesis as set forth in claim **9**, wherein said slotted insert comprises high molecular weight polymer.

11. A joint prosthesis as set forth in claim **10**, wherein said shoes also comprise high molecular weight polymer.

12. A joint prosthesis as set forth in claim **11**, wherein said polymer comprises high density polyethylene.

13. A joint prosthesis as set forth in claim **1**, wherein said base includes shoe-containing recesses, said shoes being securely mounted in said recesses.

14. A joint prosthesis as set forth in claim **1**, wherein said socket portion of said ball and socket connection comprises a segmented insert, said hollow central housing having an inner cavity, said cavity having overhanging edges on portions of its mouth, said segmented insert being keyed with said overhanging edges whereby said insert may be inserted clear of said overhanging edges in one rotational orientation and interlocked with said edges in another rotational orientation.

15. A joint prosthesis as set forth in claim **14**, wherein said keying is constructed and arranged to permit insertion of said insert in only one rotational orientation in said cavity and interlocked in said other rotational orientation of said insert in said cavity.

* * * * *