# United States Patent [19]

**Horne**

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[45] **Dec. 18, 1973**


[54] **ARTIFICIAL JOINT**


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[51] **Int. Cl.** ....... **F16c 11/00,** A61f 1/04, A61f 5/00

[58] **Field of Search** ............. 128/80 R, 80 C, 80 E, 128/80 F, 80 H; 3/2, 22–30, 33–35, 12.2, 12.3; 287/100, 101, 92; 46/161, 173



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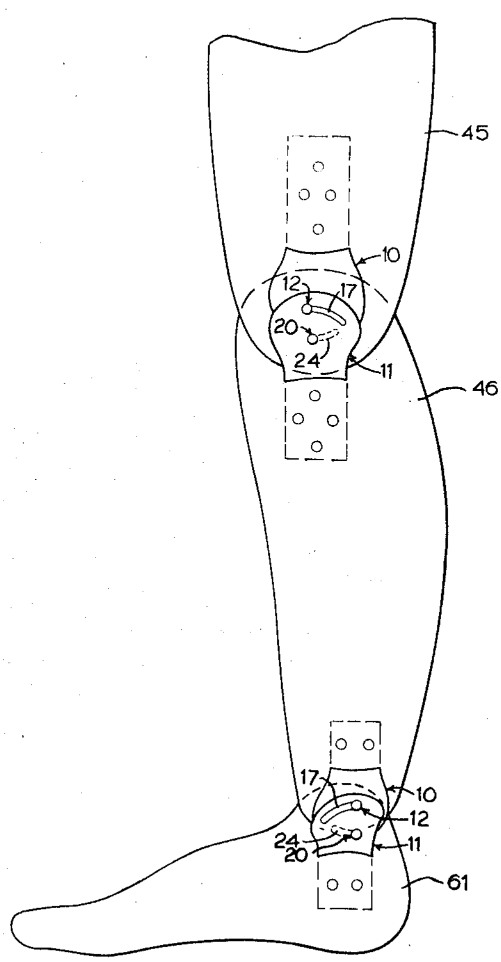
*Assistant Examiner*—Ronald L. Frinks
*Attorney*—Greer Wells et al.



[57] **ABSTRACT**

An artificial joint for simulating motion of a natural slide and hinge joint of the body, such as those at the knee, elbow or ankle. The disclosed joint comprises rigid overlapping plates connected by a pivot and slide arrangement. First and second pivot bearing elements engage first and second arcuate bearing surfaces on the respective plates to interconnect the plates for controlled sliding and pivoting action relative to one another. One bearing surface has a configuration approximating the convex extremity of one member in the simulated joint. The remaining bearing surface controls the spacing of the two pivot axes to introduce proper forward or rearward displacement thereof in simulating joint movement. The joint may be utilized as a lateral brace for a natural joint, or may be utilized as a lateral brace for a natural joint, or may be modified to serve as an articulating joint in an artificial limb.


**4 Claims, 11 Drawing Figures**



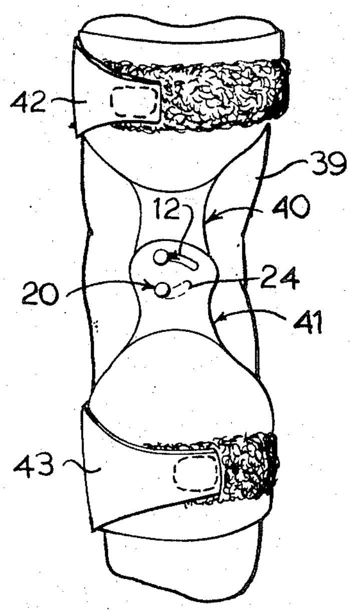



FIG 1

FIG 2

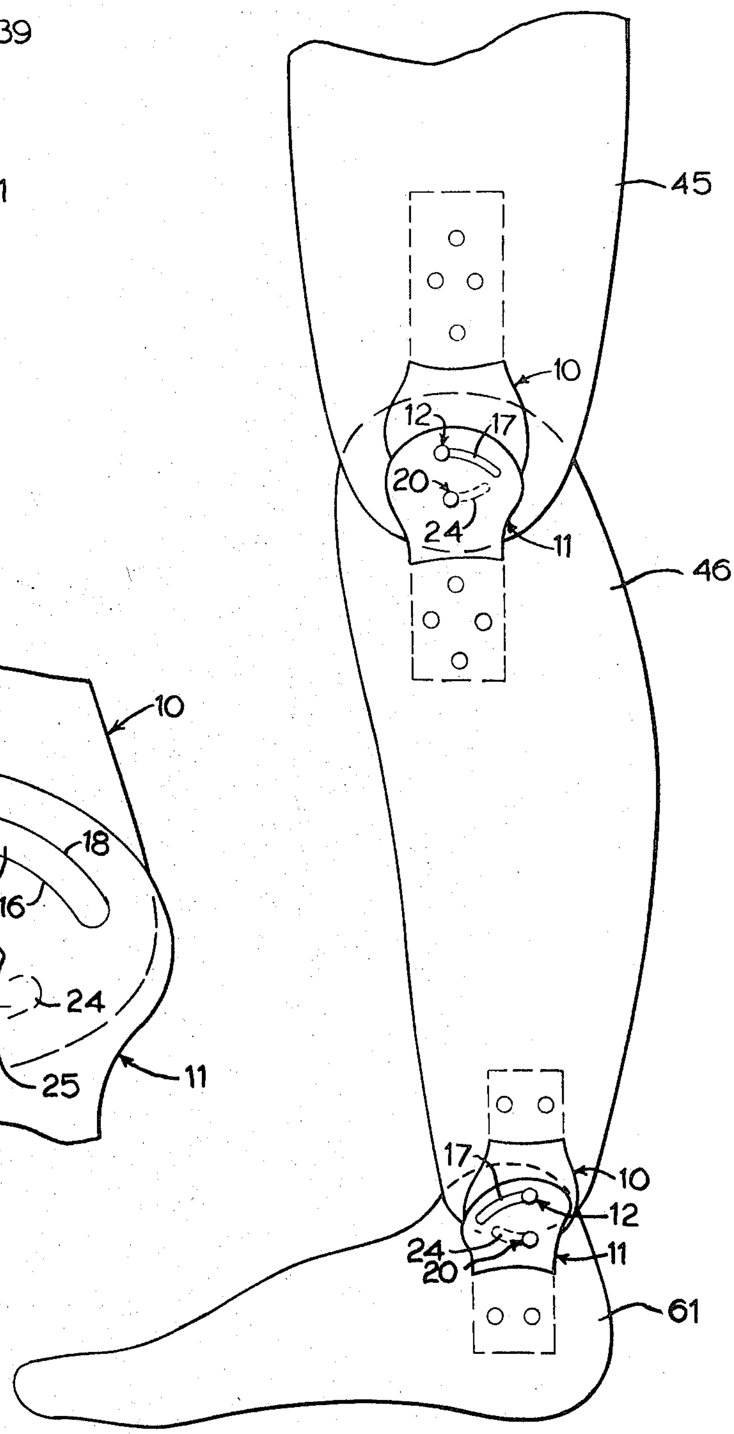



FIG 3

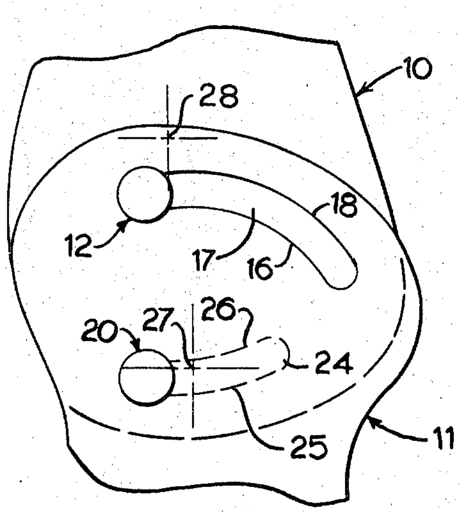


FIG 5

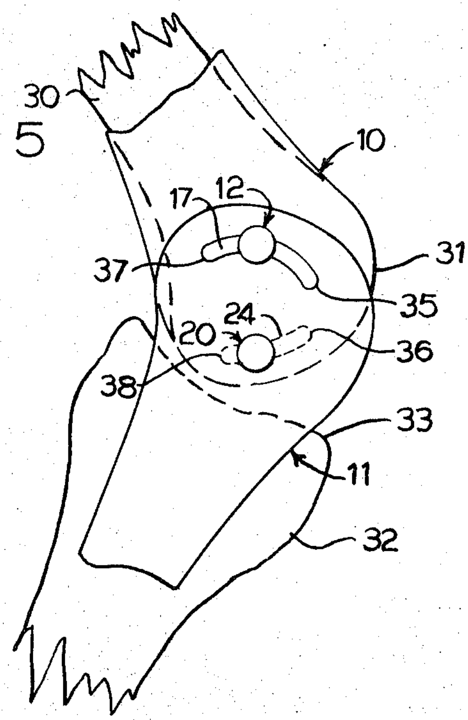



FIG 4

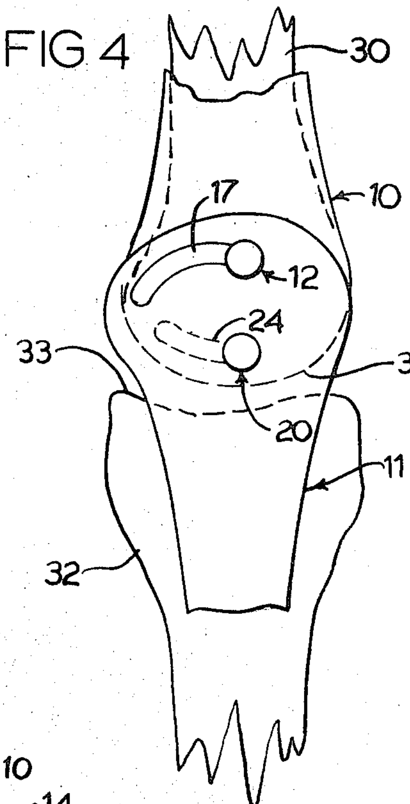



FIG 6

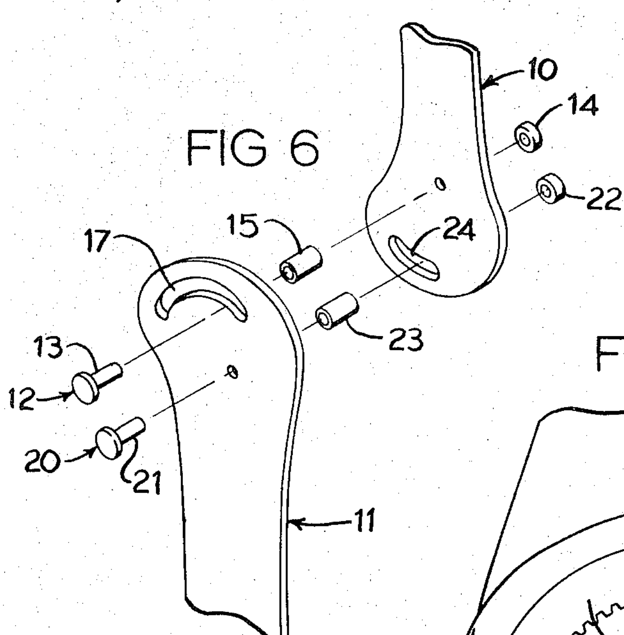



FIG 7

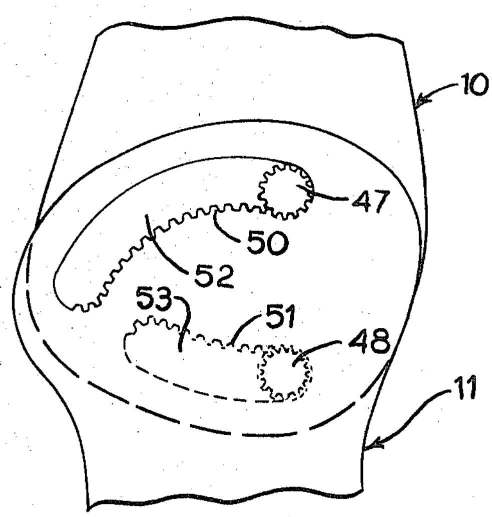


FIG 10

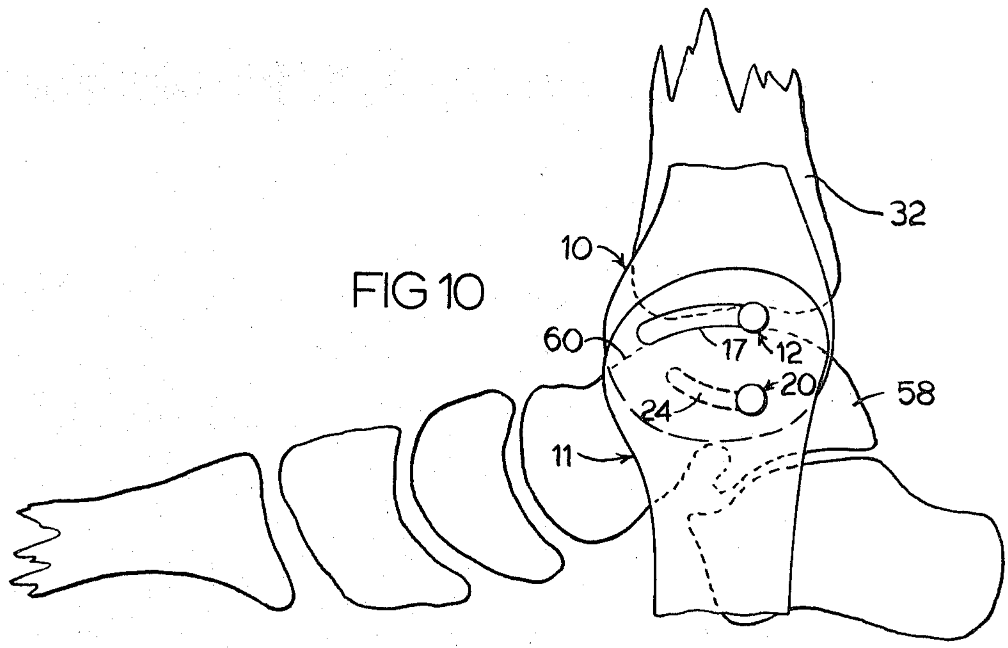



FIG 11

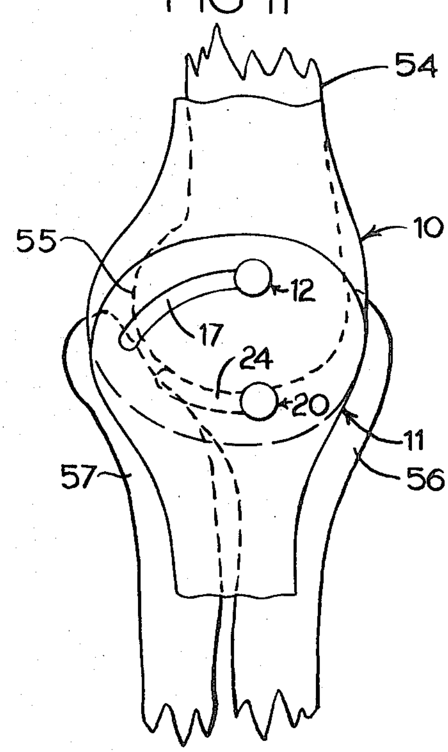



FIG 8

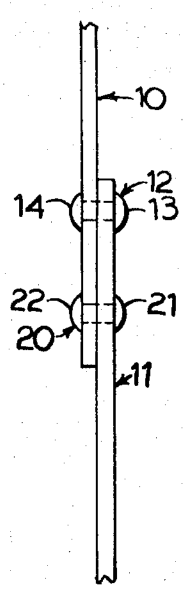
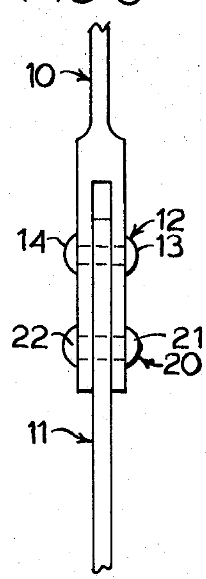



FIG 9



# ARTIFICIAL JOINT

## BACKGROUND OF THE INVENTION

The present disclosure relates to an artificial joint designed to closely simulate and approximate the movement of a natural slide and hinge joint in the human body. It has specific application to support or replacement of the joint found at the knee, elbow and ankle. It may be used as a lateral protective device alongside a normal, healthy joint. It might also be designed as a load-supportive and motion-controlling brace for a damaged, weakened or diseased joint. Furthermore, it can be designed to serve as an effective joint in an articulated artificial limb.

The design of joints, in both artificial limbs and braces, has developed through the years as those designing such joints have attempted to approximate the complex natural movement which will be discussed in greater detail below. The earliest joints, which are still used in many applications today, involve simple single pivots with controlling stops to limit angular movement. Early examples of such joints, illustrated in artificial legs, are shown in U.S. Pat. Nos. 26,753 and 41,282. A supportive leg brace including such a pivot is illustrated in U.S. Pat. No. 2,558,986.

Several recent patents have been directed toward the provision of lateral support or bracing alongside the knee so as to protect the knee area from injury due to lateral forces. These have been proposed primarily as protection for the legs of persons playing football. Examples are shown in U.S. Pat. No. 2,959,168, which utilizes a single fixed pivot and U.S. Pat. No. 3,350,719, which uses a double pivot, each pivot connection being centered about a single axis. Two very recent U.S. Pats., No. 3,575,166 and No. 3,581,741 disclose knee braces of the lateral type which purport to simulate the rocking-hinge joint motion and sliding motion of a knee by a pivot that includes a pivot shaft within an enlarged opening so as to leave the pivot shaft free to move radially within the confines of the opening.

It is well-recognized that no single fixed pivot can approximate natural hinge joint movement. The use of a brace containing a fixed pivot connection alongside a healthy knee soon becomes uncomfortable because the action of the fixed pivot causes the joint members in the body to rub and bind in an unnatural manner. The use of a loosely-mounted pivot, while it might afford additional freedom for joint movement, necessarily fails to assure proper longitudinal load support at the artificial joint or adequate control of movement so as to serve as an effective supportive brace. Dual pivots, whether simple bearings or geared, do not assure both the proper longitudinal load support and freedom of movement, as well as control of the relative motion between the joint members.

One further joint for approximating a natural joint movement is French Pat. No. 1,162,322, granted to Deprez. It discloses two roller bearings mounted in a special groove, both bearings being on a single artificial joint member. While the pivot connections are fixed in their spacing relative to one another, they can travel through an irregular arc to provide a sliding-type pivot in an artificial limb. The close simulation of natural joint movement in a healthy joint, which is required in a lateral brace, would be most difficult to achieve with this type joint, which would require custom design of the arcuate path to fit each particular natural joint.

In general, no prior joint has successfully simulated the complex sliding-pivot movement of the natural joint in the human body. While certain types of joints, such as geared joints using dual pivots, have found acceptance in the support of diseased limbs, and while other approximate joints serve to varying degrees to simulate joint movement in artificial limbs, the available joints have not succeeded in providing both free joint movement and longitudinal load-bearing capability so as to have acceptance as a supportive device for healthy limbs for athletic purposes and other applications where lateral protective systems alongside a limb joint might avoid injury or reduce fatigue. The present joint was developed specifically to fill this gap and solve this real need for a practical artificial joint that can be used alongside a natural joint without creating undesirable binding or uncontrolled motion and having the capability of withstanding the longitudinal forces that might be applied to the natural joint.

## SUMMARY OF THE INVENTION

The present invention comprises a pivoted joint structure that might be incorporated in a lateral brace or in an artificial limb. It simulates the motion of the articulated members in a hinge joint of the body. It essentially comprises a pair of rigid plates having end portions transversely arranged in overlapping relation. The plates are interconnected by first and second pivots or bearings, one being mounted to each plate. Each pivot or bearing engages an arcuate bearing surface on the plate opposite to the one on which it is located. One of these bearing surfaces approximates the arcuate configuration of the convex extremity of one member in the simulated joint. The other bearing surface is formed about a center adjacent the axis of the pivot or bearing that engages the first bearing surface and faces in a direction opposite to the first bearing surface. Its arcuate curvature controls the relative displacement between the two pivots or bearings. The bearing surfaces includes stops that are positioned in the path of the two pivots or bearings to limit relative movement between the interconnected plates between positions that simulate extension and flexion of the simulated joint.

It is a first object of this invention to provide a mechanical joint structure that simulates the movement of the articulated member in a slide and hinge joint of the body and which has full longitudinal load-supporting capability in all angular positions.

Another object of this invention is to provide such a pivoted joint structure that can be utilized adjacent a normal healthy slide and hinge joint without binding or discomfort to the user, affording full freedom of limb use and lateral protective support to the natural joint.

Another object of this invention is to provide such a joint structure that can be used in supportive bracess or in the joints incorporated within or alongside artificial limbs.

These and further objects will be evident from the following disclosure, taken along with the accompanying drawings, which illustrate the preferred embodiments of the joint and show the manner by which the joint elements are related to the natural bone structures of the body. Modifications can obviously be made in the structural features of the joint as necessary to accommodate it to a particular application, and such changes are not excluded from the content of this disclosure.

## DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of a knee brace incorporating the present joint;

FIG. **2** is a side view of an artificial limb incorporating the present joint at both the knee and ankle;

FIG. **3** is a schematic side view of a typical joint structure according to this disclosure;

FIG. **4** is a side view of the joint, showing the relationship of the joint to a natural knee;

FIG. **5** is a view similar to FIG. **4** showing partial bending of the joint and knee structure;

FIG. **6** is an exploded perspective view of the basic joint structure shown in FIGS. **3–5**;

FIG. **7** is an enlarged side view of a joint similar to that shown in FIG. **4** but illustrating the use of gears as the pivoted bearing members;

FIG. **8** is a rear elevation view from the left in FIG. **4** showing a single lap connection between the joint members;

FIG. **9** is a rear elevation view showing a double lap joint configuration;

FIG. **10** is a side view of a second embodiment of the joint and its relation to the bones of the ankle; and

FIG. **11** is a side view of another embodiment of the joint and its relation to the bones at the elbow.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The drawings illustrate several variations representative of practical applications of the joint disclosed herein. FIG. **1** and FIGS. **3** through **6** show the basic joint structure as it would be incorporated in a lateral brace designed for use alongside the knee of a wearer. FIG. **2** shows application of the joint structure to the knee and ankle joints of an artificial limb. FIG. **10** schematically illustrates application of the joint structure to an ankle brace. FIG. **11** similarly illustrates schematically application of the joint to an elbow brace.

The present joint is designed to simulate the natural movement of articulated body joints of the human body which are freely movable combination and sliding and hinge joints of the diarthroses type. The action in such a combination sliding and hinge joint is limited to movement in one plane, either forward or backward. The hinge joints with which this disclosure is concerned are specifically the knee, ankle, and elbow. Such diarthrodial joints have a rather elaborate structure and complex motion pattern.

The two or more bones of these joints are united by fibrous tissue and the opposed ends of the bone are covered by a layer of cartilage, called articular cartilage. The joint is reinforced and strengthened by ligaments. Specific details of each joint are described below.

Movement at combination sliding and hinge joints of the body is limited to flexion and extension. Flexion is the bending of the joint to decrease the angle between the parts. Extension is the straightening or stretching out of the joint, increasing the angle between the parts. It is the reverse of flexion. When such joints are bent, reference is made to movement about a transverse axis at the joint, this axis being taken as an imaginary line about which movement occurs. Since the articular surfaces are not regular, as they would be in a mechanical ball and socket, or in hinge or pivot joints of uniform radius, there is no single center of movement. The "axis" at such joints shifts its position slightly during movement of the joint. Flexion and extension take place about this moving transverse axis. It is essentially perpendicular to the longitudinal axes along the bones of the member, these two longitudinal axes of the joined bone structures being essentially aligned when the joined members are extended.

The present joint structure, which is best seen in FIG. **3**, essentially comprises a pair of rigid plates **10, 11** which are transversely arranged in an overlapping relation. Plates **10** and **11** have substantially parallel side surfaces slidably engaging one another for lateral strength in a direction perpendicular to such surfaces. The outer end of upper plate **10** locates a first pivot or bearing unit **12.** As shown in FIG. **6,** the upper pivot or bearing **12** might be a simple bolt and nut assembly **13, 14** having enlarged heads at its outer ends and rotatably journaling an intermediate collar **15.**

The outer cylindrical surface of collar **15** is movably engaged within a curved upper slide groove **17** formed through plate **11.** The curved surfaces of groove **17** are designated by the numerals **16** and **18.**

Plates **10** and **11** are also pivotally joined by a second lower pivot or bearing unit **20** which is located on plate **11.** It is shown in FIG. **6** as comprising a bolt and nut assembly **21, 22** along with an encircling collar **23.** The periphery of collar **23** rides within an arcuate lower slide groove **24.** Groove **24** includes an arcuate surface **25** that is facing in a direction opposed to surface **18,** and a similarly arched surface **26** that faces oppositely to surface **16.**

As can be seen in FIG. **4,** the curvature of surfaces **25, 26** along groove **24** substantially correspond to the curvature of the convex end of one of the members in the natural bone joint which is simulated by the connection between plates **10** and **11.** The curvature of surfaces **16, 18** in groove **17** varies from the curvature of surfaces **25, 26.** In the illustrated example, the radius of groove **17** is less than the radius of groove **24.** Referring to FIG. **3,** the center of curvature for groove **17** is indicated at **27** and the center of curvature for groove **24** is indicated at **28.** It can be seen that the centers **27, 28** are adjacent the respective axes of pivots **20** and **12,** but are not necessarily coincidental. The exact choice of location of the various pivot points, axes and each groove radius is determined by analysis of the size and bone structure configuration in the joint that is being simulated.

If the grooves **17** and **24** were both respectively centered at the axes of pivots **20** and **12,** the plates **10** and **11** would pivot about a single fixed axis located centrally along a line connecting their respective axes. The joint would then function as a single pivot joint and would fail to simulate the complex articulating motion of the natural body joint.

I have found that by varying the respective radius of the grooves **17** and **24** with respect to one another and by properly offsetting the centers of grooves **17, 24** from the axes of pivots **20** and **12,** that I can impart, under normal loading conditions, a varying sliding and pivoting motion to the plates **10** and **11** which quite accurately simulates normal joint movement. The resultant momentary pivotal axis between plates **10** and **11** will vary in location in the same manner as does the natural transverse axis of rotation in the hinge joint of the body.

Reference shall now be made to FIGS. 4 and 5, which relate the above joint structure to the anatomy of the knee. The bone structure at the knee is well known and described in detail in various anatomy texts. FIGS. 4 and 5 merely illustrate the general outline of the principal members with which this device is concerned. They are shown in a single plane that would be essentially vertical and taken through the longitudinal center of a knee joint. The drawings illustrate the lower or distal end of the thigh bone or femur **30.** The distal end of the femur **30** presents a generally convex surface, indicated at **31,** which extends over the outer ends of the condyles. The medial bone of the leg is the tibia **32,** which has a flattened, slightly concave proximal end shown at **33.** The space between the areas indicated by surfaces **31** and **33** is filled by tissue and cartilage.

In the design of the present joint, shown in FIGS. 4 and 5 as being superimposed on the basic bone structure, the curvature of the lower slide groove **24** closely approximates the curvature of the convex end surface **31** at the end of member **30.** When located on a natural limb, the groove **24** is preferably positioned just slightly inward along member **30** from the natural occuring location of surface **31.** The upper slide groove **17** is also located so as to overlie the member **30.** The radius of each groove **17, 24** is preferably selected so as to maintain the width of plates **10** and **11** within the normal width of the natural joint members and eliminate any necessity of the artificial joint protruding beyond these natural members.

As can be seen in FIG. **5,** during flexion of the artificial joint, or bending of plates **10** and **11** relative to one another, the pivots **12** and **20** move along the lengths of the respective slide grooves **17** and **24.** This movement of pivots **12** and **20** occurs simultaneously as each plate **10** and **11** is guided by the bearing surfaces contacted by the two pivots. When the joint is under compression loading, the pivot **12** will bear against surface **16** and pivot **20** will bear against surface **26.** If the joint is in tension, pivot **12** will bear against surface **18** and pivot **20** will bear against surface **25.**

The movement of pivot unit **12** within slide groove **17** causes the lower end of plate **10** to follow the natural movement of the lower end of the femur **30.** As pivot unit **12** moves along the length of groove **17,** the compressive loading forces exerted on plates **10** and **11** tend to maintain pivot units **12** and **20** at a minimum separation from one another, limited by the curvature of the respective grooves **17** and **24.** Thus, the plate **10** will slide forwardly relative to plate **11** while pivoting about the axis at pivot unit **12.**

The slide grooves **17** and **24** further serve to define the extent of bending movement permitted between plates **10** and **11.** They include end stop surfaces **35** and **36** which are abutted by pivots **12** and **20** respectively when the plates **10** and **11** are extended (FIG. 4). In this condition, pivots **12** and **20** will be substantially aligned along the longitudinal axis of the simulated joint. Slide grooves **17** and **24** also include opposite end stops **37** and **38,** which are engaged by pivots **12** and **20** respectively when plates **10** and **11** are fully flexed to the normal limits of the simulated joints. Thus, plates **10** and **11** provide positive loading support to prevent unnatural bending of the joint in question.

One important feature of this joint is its ability to operate under normal load conditions. Under any load, whether in compression or tension, the joint is under complete control of the wearer, since the forces directed by the weight of the person upon the pivots and the bearing surfaces permit only one relative angular location of plates **10** and **11** with respect to one another at any given moment, this being the usual articulated position of the natural joint that is simulated.

FIGS. 1 and 2 illustrate practical applications of the present joint. FIG. 1 shows the joint incorporated in a brace designed to be worn alongside the knee for vertical and lateral protective support. The previously described plates **10** and **11** are formed integrally as upwardly and downwardly extended supports **40, 41,** which respectively encircle a portion of the thigh and calf of the user's leg **39.** The supports **40, 41** are securely held in place by encircling straps **42, 43,** which are adjustably locked by any suitable means. One preferable manner of locking straps **42, 43** is by use of "Velcro" type fastening material. Common buckles, laces and other fastening devices may be substituted as needed. The supports **40, 41,** as well as the areas about the joint structure itself, may be suitably molded and padded so as to be worn in comfort directly adjacent the leg **39.**

The brace illustrated generally in FIG. 1 is applicable to use in orthopedic or in surgical brace situations, as well as providing protective knee supports for sports and athletic use, especially in relation to football, basketball and rodeo. Clinical indications that would specify use of such a knee brace are a painful knee joint due to chronic osteoarthritis, chronic synovitis, trauma, surgical operations to correct internal damage or rupture of the quadriceps tendon or any of the tendons giving strength to the leg in medial-lateral and anterior-posterior stability.

A brace such as shown in FIG. 1 can assist in alleviating the condition of the user in the above situations. First, when worn by a healthy person with normal knee joints, it can assist in preventing the problem. It is particularly useful in providing transverse reinforcement to the body joint. Second, during rehabilitation or healing periods, the brace can assist in strengthening the knee by holding it in correct medial-lateral alignment during flexion or extension of the knee. Because the brace assists in taking some of the normal longitudinal loading of the leg, it reduces friction at the weight-bearing areas of the femur and tibia. This is particularly helpful in the case of an arthritic joint or in situations where the natural padding between these bones has either been removed or has deteriorated. The limits to angular movement provided by the end stop surfaces **35, 36** assist in the orthodic management of genu recurvatum, which is commonly termed "back knee."

The brace incorporating this joint was designed not only for the function of assisting the knee in comfort, but also as an economical alternative to available braces to aid in reducing the cost of expensive custom-made braces presently used to assist in correcting the above clinical situations. The joint structure can be manufactured from suitable sheet material or molded in the form of plates to provide load support equal to that now provided by complicated braces made of heavy steel and using both medial and lateral uprights. A single joint on the outside of the limb as shown in FIG. 1 can effectively replace the extensive and complicated brace structures as are in use today. This type of brace should be able to be manufactured in large quantities, sized over several ranges and marketed at a moderate price. It is extremely adaptable and can probably be self-fitted by individuals needing such an appliance for preventive purposes.

The joint structure might be constructed of metals, such as aluminum, stainless steel, orthopedic steel, or various plastics and resins. If a soft-surfaced material or plastic is used in the construction of the joint, reinforced pivots and bearing surfaces should be provided to prevent excess wear during use. In more deluxe permanent braces or artificial limbs, ball bearings, can be utilized for the bearing or pivot units. The brace may be secured to the limb by leather lacers, elastic supports, lacings, straps and other alternative fastenings. The joint should be padded to make use of the facility of locating the joint structure directly adjacent to the limb. Such close use does not result in abrasion, because the joint perfectly matches the moving functions of the knee.

FIG. 2 illustrates the joint as it might be used in connection with an artificial limb or prosthesis. The particular artificial limb structure is shown as designed for an above-the-knee amputation. The present joint, consisting of the previously described plates **10, 11** is provided at the outer sides of the limb members **45, 46** which form the artificial knee. When used in such an application, the previously-described pivots or bearing units should be geared for positive movement. This arrangement is generally illustrated in FIG. 7, where gears **47, 48** engage matching geared tracks **50, 51** in grooves **52, 53.** Grooves **52, 53** correspond to the previously-described grooves **17, 24,** respectively. Gears **47** and **48** may be operatively connected by a gear train, drive belt, operating cylinders or motors (not shown) in the manner commonly used to impart movement in the joints of artificial limbs.

To further analyze the somewhat complex action of the present joint, the simulated body joint motion is substantially keyed to the curved lower slide groove **24,** which simulates the bearing surface at the top of the tibia in its relation to the rolling motion of the lower surface at the distal end of the femur. The lower pivot and bearing unit **20** not only acts as a bearing structure engaged within the lower slide groove **24,** but laterally holds the upper and lower plates **10, 11** to one another. The enlarged surfaces of bolts **13, 21** maintain the desired transverse relationship between the parallel structures of plates **10** and **11.** The unit **20** supports the weight transmitted from plate **10** by rolling or sliding along the lower slide groove **24.** It simulates the bearing surface of the femur as it relates to the proximal end of the tibia.

In a simulated knee joint, the upper pivot or bearing unit **12** is located approximately 1 inch above the unit **20.** Unit **12** also acts as a weight bearing member for the plates **10** and **11,** but its main function is to serve as a roller guide bearing that moves along the graduated surface across groove **17.** Its movement forces the outer end of plate **10** to move rearwardly and the plate **11** to move forwardly relative to one another when the joint is in flexion and to move oppositely when it is in extension. This is accomplished by varying the distance between the two pivot and bearing units **12, 20,** whereby achieving a guided sliding action to control the joint in the same manner as provided in the natural knee joint. Without the control afforded by the two pivot and bearing units, the lower plate **11** would shift uncontrollably along the path of groove **24** and would fail to provide vertical load support capability.

The end stop surfaces **35, 36** prevent plates **10** and **11** from moving too far relative to one another in extension. The positive contact of these stop surfaces by pivot and bearing units **12, 20** gives double strength to the joint structure when in a completely extended condition (FIG. **4**). The locations of units **12, 20** when in full extension is substantially along the aligned longitudinal axes of plates **10, 11.**

The mechanical structure of the joint can be varied depending on the material used in its construction and the nature of the load applied to it. Two exemplary configurations are shown in FIGS. **8** and **9.** In FIG. **8** which corresponds to FIGS. **4, 5** and **6,** the plates **10** and **11** are directly adjacent to one another in a single lap joint, being held laterally by the enlarged heads of bolts **13, 21** and nuts **14, 22.** FIG. **9** illustrates a modification using a box or clevis joint in a double lap configuration. Upper plate **10** is divided into two sections which fit over the lower plate **11.** This would provide a more stable transverse structure, but increases the effective width of the apparatus.

FIG. **11** shows the present joint applied to an arm brace or prosthesis. The joint structure is shown superimposed over the outline of the basic bone structure at the elbow. The arm joint at the elbow is very similar to that described above with respect to the knee. It is not a fixed pivot joint, but again is best described as a slide and hinge joint. The distal end of the arm bone (humerus) **54** has two articulating surfaces which are indicated by the convex outline at **55.** One of these surfaces articulates with the head of the radius **56,** and the other with the proximal end of the ulna **57.** The ulna **57** and radius **56** slide up over the convex configuration of the humerus, giving the elbow the same action in flexion or extension as the knee. As can be seen in FIG. **8,** the joint structure consisting of plates **10** and **11** is essentially identical to the plates **10** and **11** described with respect to the knee. The lower slide groove **24** is located outwardly adjacent to the lower end surface **55** of the humerus **54.** The upper slide groove **17** is positioned alongside humerus **54** and inward of the groove **24.**

When used as an arm joint to simulate action of the elbow, the present joint simulates the natural motion of the arm when it is flexing or extending. It does not bind the arm into the end of the bone socket, nor will it pull an amputated arm from a supporting socket at the elbow. Also, the limits to sliding movement due to the arcuate length of each groove **17, 24** prevents unnatural flexion of the arm when it is bent.

FIG. **10** shows application of the joint to the ankle structure. The ankle joint is extremely complex and definitely not a fixed pivot joint. It is a slide and hinge joint involving considerable compression ability. The tibia and fibula, shown generally at **32,** rest on the talus, indicated at **58.** The upwardly facing top surface of the talus has a generally convex configuration and the lower or distal end of the tibia and fibula are slightly concave. The convex surface of the talus is generally indicated at **60.** As a person bears weight on a leg and moves over the foot, the foot is brought into dorsal flexion. A fixed pivot, if utilized in an ankle brace, has a tendency not to follow the joint and causes the brace to raise and lower. The center of the ankle joint itself shifts anteriorly and posteriorly.

As shown in FIG. 10, the relative location of the plates 10 and 11 is reversed in applying the present joint to the ankle structure. Again, the groove 17 is shaped to conform to the general outline of the bone structure at 60, which is convex, and the controlling groove 24 is located inwardly of that simulating bone surface provided by groove 17. The joint otherwise is identical to that previously described and its functional operating relationship is believed to be evident from the earlier discussion. The joint provides the ankle with much more freedom of motion than a single pivot and eliminates the movement of a brace up and down relative to the ankle structure. The joint will remain in a more central position relative to the fibula as the foot is flexing and extending. As the two pivot bearing units 12, 20 come to full extension and engage the ends of grooves 17, 24, the brace prevents the foot from going into planter flexion if the person has a drop foot. The limits of pivotal movement can be modified and set at different degrees of planter flexion. Another advantage of the joint is that it so closely simulates the movement of the natural body joint that it can be padded and worn directly against the body.

FIG. 2 further illustrates use of the inverted joint as an artificial joint in an artificial ankle structure, connecting the lower end of an artificial calf 46 to a foot 61. Again, the joint can be provided at both sides of the artificial limb structure and can be powered or drivingly connected to produce the required artificial movement in such a limb, according to known practices.

It is to be understood that the joint structure can be modified to incorporate gears, rollers, springs, pulleys, belts, and rubber bands to drivingly interconnect the pivot and bearing units and surfaces of the slide grooves above. When geared, the positive engagement of the gears provides more graduated control of joint movement and strength to the resulting action. A geared joint can be powered or have a belt, roller, or spring control. The purpose of a belt would be to slow down the movement of the joint. Rubber bands connecting the geared rollers so that they would roll in opposite directions and work against each other would assist the patient in extending the leg when the brace is used on a leg or limb that needs help in extension. This also can be utilized in artificial limb joints to assist in the extension of the lower or outer part of the limb. Springs may be used in place of such rubber bands. Springs connected to the gears would be wound as the gears turned in one direction, tightening the spring, and then as the load is removed, the brace would automatically extend itself. The use of such driving connections is believed to be well within the skill of one trained in the art of designing limbs and braces of this general type.

Other modifications might be made with respect to this structure, both as to designs of the joint elements and choice of materials. These structural design changes are intended to be within the scope of this disclosure, which is defined only in the following claims.

Having thus described my invention, I claim:

1. An artificial joint for use in braces, artificial limbs and the like, for simulating the functions of the articulating members in a natural slide and hinge joint of the body, such as the knee, elbow, or ankle, comprising:

first and second joint elements having overlapping end portions and being movable with respect to one another to one side of a position wherein the joint elements are in longitudinal alignment;

first arcuate bearing surface means formed across the end portion of said first joint element within the zone of overlap of said joint elements, said first arcuate bearing surface means including a curved edge surface substantially corresponding in curvature to a lateral projection of the curvature of the convex extremity of one member in the natural body joint being simulated;

second arcuate bearing surface means formed across the end portion of said second joint element within the zone of overlap of said joint elements, said second arcuate bearing surface means including a curved edge surface having a radius of curvature differing from that of the curved edge surface of said first arcuate bearing surface means;

first pivot and bearing means mounted to said second joint element about a first axis, said first pivot and bearing means being engageable with the curved edge surface of said first arcuate bearing surface means;

second pivot and bearing means mounted to said first joint element about a second axis spaced from said first axis, said second pivot and bearing means being engageable with the curved edge surface of said second arcuate bearing surface means;

the centers of curvature of the curved edge surfaces of said first and second bearing surface means being respectively offset from said first and second axes;

first and second stop surfaces formed respectively on said first and second joint elements and located respectively at corresponding ends of said curved edge surfaces of said first and second arcuate surface bearing means in the path of movement of said first and second pivot and bearing means for engagement therewith when the first and second joint elements are longitudinally aligned, said curved edge surfaces extending to one side of a line through said first and second axes when said first and second pivot and bearing means are in engagement with said first and second stop surfaces;

said curved edges through the first and second axes converging toward one another as they extend to said one side of said line when the first and second joint elements are in longitudinal alignment, whereby the spacing between said first and second axes is varied in response to movement of said first and second pivot and bearing means along the curved edge surfaces during relative motion between said first and second joint elements.

2. A joint as set out in claim 1 wherein each of said first and second bearing surface means comprises a groove having equally spaced curved convex and concave edge surfaces facing inwardly toward one another and engageable by said first and second pivot and bearing means respectively;

said first and second stop surfaces comprising end surfaces extending between the convex and concave surfaces of the grooves to define the limits of travel of said first and second pivot and bearing means along said grooves.

3. A joint as set out in claim 2 wherein said joint elements are in the form of sheets or plates of structural material having planar outer surfaces;

said grooves being formed through said sheets or plates;

said pivot and bearing means each having radially enlarged heads at their outer ends bearing against the planar outer surfaces of said joint elements and maintaining them in adjacent, overlapping, parallel positions along their zone of overlap.

**4.** An artificial joint structure for simulating the motion of the articulating members in a natural slide and hinge joint of the body, such as the knee, elbow or ankle, comprising:

a pair of rigid plates adapted to be secured to the articulating members of the joint for movement therewith to one side from a position of longitudinal alignment of the members, the plates each having an end portion arranged in overlapping relation to one another;

pivot and slide means interconnecting the end portions of said pair of rigid plates, comprising:

a first pivot unit mounted to the end portion of one plate about a first axis perpendicular thereto;

a first groove across the end portion of the remaining plate defining opposed convex and concave edges engaged by said first pivot unit and approximating in curvature a lateral projection of the curvature of the convex extremity of the articulating members of the natural joint being simulated;

a second pivot unit mounted to the end portion of the remaining plate about a second axis perpendicular



thereto and spaced from said first axis;

a second groove across the end portion of said one plate defining opposed convex and concave edges engaged by said second pivot unit, the curvature of the second groove differing from that of said groove;

the centers of curvature of said first and second grooves being respectively offset from said second and first axes;

said first and second grooves terminating at corresponding ends thereof along first and second stop surfaces between their convex and concave edges in the paths of movement of said first and second pivot units for engagement therewith when the plates are at said position of longitudinal alignment of the joint members, said grooves extending to one side of a line through the first and second axes when the first and second pivot units are in engagement with said first and second stop surfaces;

said grooves converging toward one another as they extend to said one side of said line through said first and second axes when the plates are at said position of longitudinal alignment of the joint members, whereby the spacing between the first and second axes is varied in response to movement of said pivot units along the grooves during relative motion between the plates.

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