April 22, 1952

C. V. SMITH

LOCKING KNEE JOINT FOR ARTIFICIAL LIMBS AND ORTHOPEDIC BRACES

2,594,227

Filed May 25, 1951

2 SHEETS—SHEET 1

FIG. 1

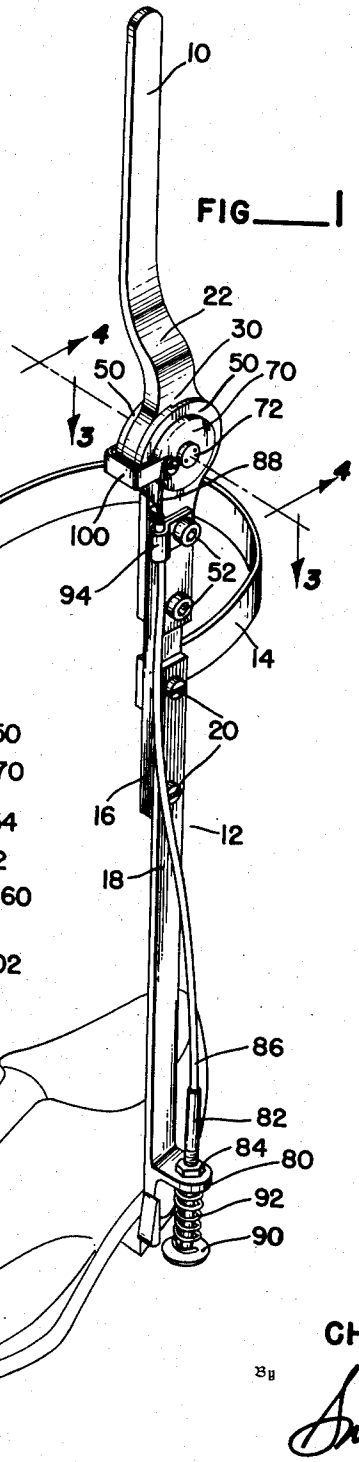


FIG. 3

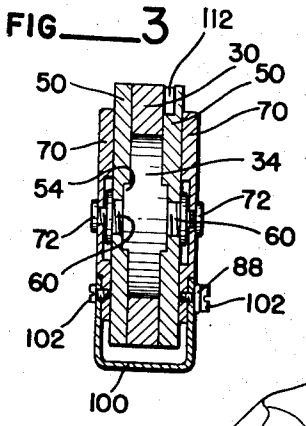
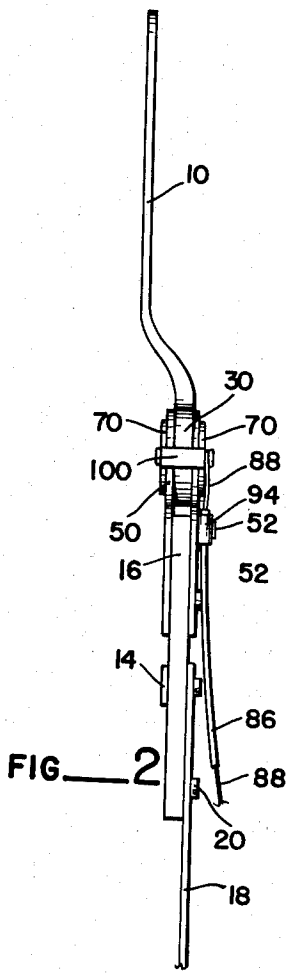


FIG. 2



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2 SHEETS—SHEET 2

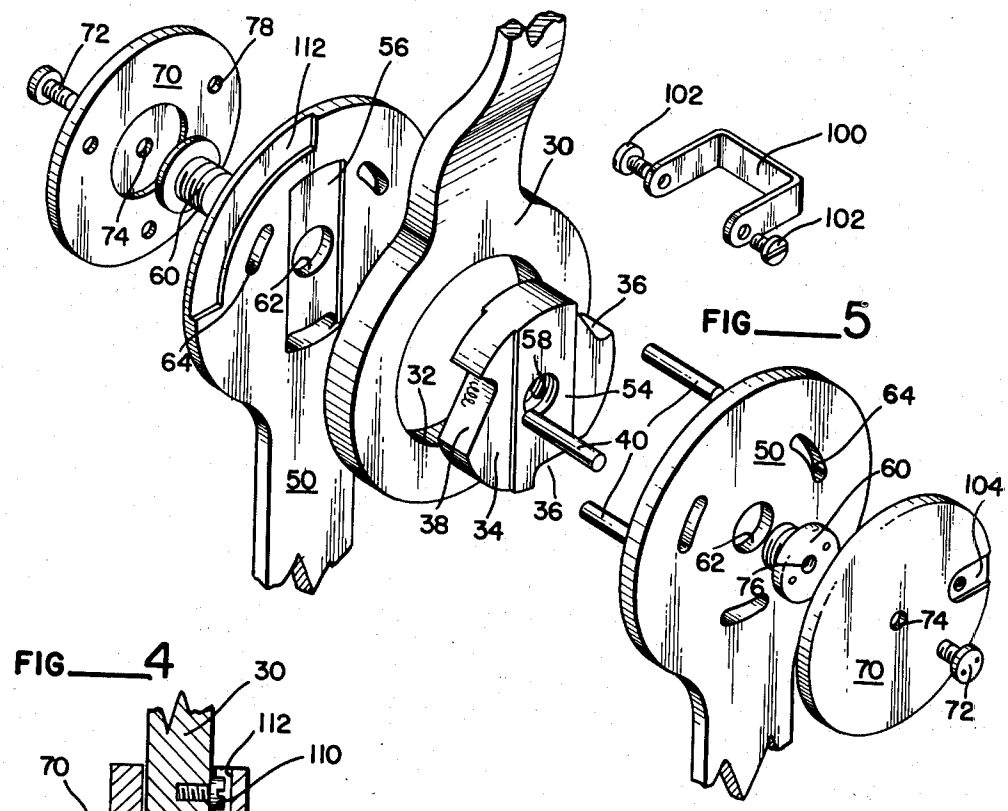
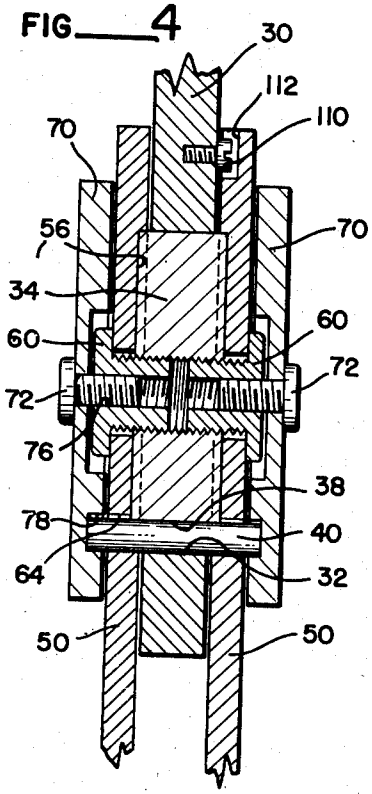


FIG. 5

FIG. 4



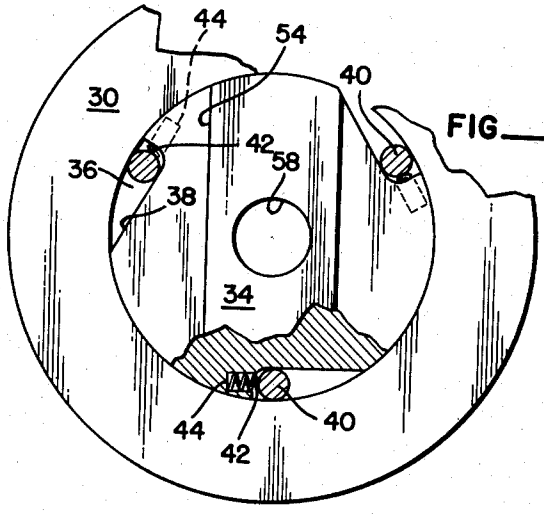


FIG. 6

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LOCKING KNEE JOINT FOR ARTIFICIAL LIMBS AND ORTHOPEDIC BRACES

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Application May 25, 1951, Serial No. 228,145

14 Claims. (Cl. 3—2)

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My invention relates to a locking knee-joint for artificial limbs and orthopedic braces and, more particularly, provides for locking such a joint when it is supporting weight with the exception that the limb or brace may always be straightened.

While this invention applies to both orthopedic and prosthetic devices for aiding the walking of crippled persons, the description herein of a preferred embodiment is as applied to a brace. It will be understood, of course, that I do not thereby intend to limit the invention to its application to a brace but have in mind its obvious useful employment in the knee joint of an artificial limb.

Locking is obtained, essentially, by a lockable journalling couple between one leg member and the other leg member. The couple includes cam recesses and rolling bodies are positioned in said recesses and means is provided to wedge said bodies between the cam surfaces and an adjacent face of the couple. Means is also provided to retract the rolling bodies from wedging position on occasion. The rolling bodies lock the joint and prevent folding of the thigh and lower leg members until weight is removed from the leg. However, the cam surfaces are shaped and positioned to wedge only when the leg members tend to fold. The leg may always be unfolded or straightened.

Many types of knee locks are to be found in the prior art and they operate with relatively little satisfaction. These prior structures include friction locking by means of a latch member; hydraulic locking; multiple-position locking by notches or cam surfaces and latches; friction locking similar in action to a brake band; and dog and ratchet locking. None of these devices appear to obtain the desirable characteristics of a knee lock as efficiently and simply as does the present structure.

The desirable characteristics of a satisfactory knee lock include the following:

The joint should permit the user to simulate natural movement while providing for stable support. To rise from a sitting position, the thigh and lower leg members should be locked against folding continually from the time that weight is placed on the heel preparatory to rising. In standing, likewise the members should be locked from folding. When the leg is freely moving above the ground during walking, the leg should be permitted to fold to simulate natural limbs, e. g., the leg should fold as it is moved from behind the body to in front of the body where it

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straightens again as the heel touches the ground. The joint should be locked against folding from the time the heel contacts the ground in front of the body until the weight is removed from the foot. Emphasis is placed on the ability to lock against folding at any point in the opening movement while weight is being supported, on the freedom to open at any time regardless of whether or not weight is being supported, and on the unlocking whenever weight is not being supported. Locking during weight supporting period should be present regardless of whether the heel or the toe is in contact with the ground with the exception that initial locking may be had only when the heel is on the ground because almost always the heel is on the ground when weight must be first supported. A careful analysis of the process of rising and walking will show the importance of these features. A joint that will lock only at certain points or only will remain locked when the heel is on the ground is a handicap. The joint should never be locked against opening movement. At the same time, the device should be of simple design with little to maintain as the artificial leg must stand the great amount of work to which it is subjected without embarrassing failures. The expense of purchase and maintenance should be as low as possible because the persons purchasing the devices are often suffering financial hardships; and a minimum of maintenance is especially important because the user is disabled during repairs and for a considerable time for those repairs with some devices that cannot be done by the user.

The objects of my invention include, therefore, the following: to provide a simple, efficient and automatic locking knee joint; to maintain locking against folding during weight supporting regardless of whether the heel or the toe is in contact with the ground and to allow opening or straightening of the joint at all times; to initiate locking whenever the heel starts to support weight and regardless of the relative position of the leg members; to unlock the joint whenever weight is removed from the leg members; to furnish a knee joint of economical construction and with low maintenance time and expense; to furnish a knee joint which will allow the wearer to simulate closely natural movement while providing for stable support.

Briefly, the foregoing objects are accomplished by providing an annular ring on the thigh member or brace and securing a trunnion member to the lower member and positioning the same in

said ring. The trunnion member has several peripheral recesses each including a cam surface. Cylindrical rods are positioned in these recesses. The cam surfaces are disposed to perform a wedging action with the inner surface of the ring on said rods when the rods are moved toward the narrow end of the recesses and when movement of the braces is toward folding. A spring at the wide end of each recess urges the rod into wedging position. A retraction spring more powerful than the combined force of the recess springs is connected to the rods by means of a flexible link. The retraction spring is positioned at one side of the shoe and rests on a button. The button is free to move below the heel level of the shoe and is pressed upwards when the heel is placed on the ground. This compresses the retraction spring, relaxes the flexible link and permits the recess springs to bias the rods into wedging position. Once the rod is in wedging position it remains wedged until weight is removed from the joint regardless of whether the heel or toe is in ground contact because the ring and cam surfaces maintain pressure on the same. Opening movement will dislodge the rod as the contacting surfaces move apart unless the button is still pressed on the ground. As the objects are analyzed it will be seen that this mechanism simply and efficiently performs the described objectives.

The invention will best be understood, however, from the following detailed description, when read with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of an embodiment of my invention in an orthopedic brace including the shoe of the user although it will be understood how the structure would be associated with an artificial limb;

Figure 2 is a fragmentary elevation view of the same structure as seen from the front;

Figure 3 is a cross-sectional view of the joint taken on line 3—3 of Figure 1, the parts being shown on an enlarged scale;

Figure 4 is a view of the joint taken on line 4—4 of Figure 1, the parts being shown on a much larger scale, partly in section, and in fragmentary form;

Figure 5 is a perspective view of the parts making up the joint in exploded form, the showing being of the opposite side of the joint from Figure 1 and being on an enlarged scale; and

Figure 6 is an enlarged view of the raceway portions of the device in fragmentary form and partly in section with certain portions broken away for convenience of illustration.

Referring to Figure 1, the specific embodiment is an orthopedic device with thigh brace 10, lower leg brace 12 and the lower leg embracing member 14. In an artificial limb, upper and lower leg members of conventional form would be substituted for thigh brace 10 and lower leg brace 12. It will be noted that lower leg brace 12 is constructed of upper member 16 and lower member 18 spliced together by screws 20. This permits the joint to be manufactured without regard to the height of a particular individual, and the length from the knee to the shoe is adjusted for the individual by the boring of holes for screws 20 according to the desired length. Member 14 may be secured by upper screw 20. Lower member 18 is secured to shoe S in a conventional manner. Thigh brace 10 is offset inwardly at 22 above the joint to lie against the thigh of the user and in well known manners will be associated to a boot to encircle the thigh. The lower end of thigh brace 10 has annular ring 30 formed as a part thereof. Ring 30 has a circular opening therethrough forming a circular raceway 32. Journalled inside of raceway 32 is trunnion 34 which is circular and of a size approximating the circular opening. Formed in the trunnion are several peripheral recesses 36. These recesses have cam surfaces 38. Rods 40 are disposed in these recesses and are urged toward an engaging position between cam surfaces 38 and raceway 32 by springs 42 set in sockets 44 at the larger ends of recesses 36.

Juxtaposed to trunnion 34 on either side are cheek plates 50 which are attached to opposite sides of upper member 16 by screws 52. Trunnion 34 has a boss 54 on either side and cheek plates 50 have rectangular grooves 56 in adjacent surfaces in which the bosses 54 are positioned to key the trunnion to the cheek plates. Trunnion 34 has a central threaded opening 58 and screw 60 runs through central opening 62 in each cheek plate and into central threaded opening 58 in trunnion 34 to secure these members together. Cheek plates 50 have elongated slots 64 through which the ends of rod rollers 40 pass.

Shifter plates 70, positioned on the outside of cheek plates 50, are each secured thereto by a screw 72 running through central opening 74 in shifter plate 70 and screwed into threaded axial opening 76 of screws 60. Central opening 74 not being threaded, shifter plate 70 is free to rotate about screw 72. Shifter plates 70 have a plurality of sockets 78 in their inner surfaces and the ends of rollers 40 are positioned therein and held between the shifter plates. Sockets 78 are somewhat larger than rollers 40, as will be seen from Figure 4. The purpose of the shifter plates is not to positively move rollers 40 into wedging engagement as that is the function of springs 42. Instead the function of shifter plates 70 is to pull rollers 40 out of wedging position against the action of springs 42 under conditions hereinbelow described.

Lower member 18 has outstanding flange 80 and base tube 82 runs vertically therethrough and is secured by lock nuts 84. A hollow guide cable 86 is secured to tube 82 and runs from adjacent the ground level to near the knee joint. Wire 88 is slidably positioned in hollow cable 86 and is connected to button 90 at its lower end. Spring 92, encircling tube 82, tends to force button 90 downward. Button 90 extends below shoe S when unpressed and pulls downwards on wire 88 by the force of spring 92. Whenever shoe S is resting on the ground button 90 is moved upward against spring 92 in the release of tension on resulting wire 88. The upper end of hollow cable 86 is secured by clip 94 held by screw 52.

Yoke 100 is secured at each end to a shifter plate 70 by a screw 102. The ends of yoke 100 are preferably set in grooves 104 in the outer surfaces of shifter plates 70. The upper end of wire 88 is looped and secured by one of the screws 102. Downward pressure on button 90, by the force of spring 92 as when the heel is off the ground, forces shifting plates 70 to rotate. It will be seen from Figure 5 that this pulls roller rods 40 out of wedging engagement between cam surfaces 38 and raceway 32. As explained later, this force is not great enough to pull the rollers out of engagement if the joint is supporting weight. Springs 42 are not strong enough to force rods 40 into engagement against the resistance of

spring 92 when button 90 is free but they press rollers 40 into wedging engagement when button 90 is pressed.

A limit on the relative movement of braces 10 and 12 is provided by stop screw 110 acting on shoulders at the ends of groove 112 in one of the check plates 50. A braking band or spring is positioned between adjacent surfaces of cheek plates 50 and annular ring 30 to retard the speed of folding and unfolding action in the joint, but this is such a conventional element that it is deemed unnecessary to illustrate the same.

Method of operation

When weight is placed on the heel of a shoe, as preparatory to rising or as the foot comes down in the forward stride, button 90 is pressed against spring 92 releasing tension on wire 88, permitting springs 42 to bring rollers 40 into wedging engagement between cam surface 38 and internal raceway 32. Braces 10 and 12 cannot fold while rollers 40 are thus in engaging relation so that any opening movement of the braces cannot be lost as long as button 90 is pressed. When the user is standing the rollers are in wedging position. The joint remains locked if the user shifts his weight from the heel to the toe once the rollers are in locking position; because internal raceway 32 and cam surfaces 38 have sufficient pressure on the rollers due to the weight of the user. Trunnion 34 is slightly smaller than internal raceway 32 so the supported weight causes pressure on rollers 40 between the compressed surfaces of the trunnion and annular ring. This difference in dimensions is only a few thousandths of an inch, as in most journal arrangements but this is sufficient for the locking action described. Of course when weight is shifted to the toes, spring 92 tends to pull the rollers away from engagement but this force is not sufficient to disengage the rollers as long as the joint is under compression.

At all times braces 10 and 12 may move toward opening movement because of the facing of the angle formed by raceway 32 and cam surface 38. If the process of rising, standing and walking be analyzed it will be seen that invariably it is permissible for the joint to open and often it is necessary for such action to be possible.

As the foot comes back in a stride the heel will be lifted before the toe and it is undesirable that the brace become unlocked until the toe is lifted. The brace will remain locked until pressure is taken off the toe as explained above. When the toe is lifted and the leg starts forward, the leg folds in walking with natural limbs. Likewise in the present device, once the toe is lifted the pressure is taken off the joint and spring 92 will bring the rollers out of engagement, and then the braces may fold as the leg starts forward. The leg straightens out in walking with natural limbs as the heel reaches the end of its forward movement and is ready to be depressed. Similarly the lower brace will continue to move due to its momentum when the upper brace has reached its foremost position and is stopped and the leg will straighten preliminary to the placing of the heel on the ground. The joint will be locked against folding when button 90 is pressed as the heel contacts the ground to receive the weight of the user. The leg may straighten out further, normally, if the pace is very slow. It would be undesirable for the brace to become unlocked as it straightens out after weight has been placed on it. However, the joint will remain locked against folding in the present device because button 90 is still pressed during the straightening of the leg.

To sit down, the user grasps the arm of a chair for support and lifts the weight from his foot momentarily and the braces are unlocked and may fold. Stop screw 110 prevents the braces from opening and closing beyond the range of movement of normal limbs.

Referring to the objects of my invention, it will be observed that the device is simple, efficient and automatic, furnishing stable support when needed while allowing the wearer to closely simulate natural movement. The joint may be opened at any time. The locking knee joint maintains locking against folding during weight-supporting regardless of whether the heel or toe is in contact with the ground. Locking is initiated whenever the heel supports weight and regardless of the relative position of the braces. The joint is unlocked whenever weight is removed from the braces. The knee joint is of relatively inexpensive construction and should require little maintenance.

As stated before, the teachings of this invention are fully applicable to artificial legs. Certain modifications will be apparent to those skilled in the art and I do not wish to be limited to the exact structure shown, but desire to cover those modifications within the scope of my invention and the appended claims.

I claim:

1. A knee action to lockably articulate and connect the thigh and lower leg members of a prosthetic or orthopedic aid to walking, comprising: a pair of bars each forming part of a leg member; one of said bars including an annular ring rigid therewith; the other of said bars including a pair of cheek plates spaced apart from each other and disposed adjacent the opposite faces of said annular ring; a trunnion member non-rotatably secured to said cheek plates and forming a journal for said annular ring between said cheek plates; said trunnion member having a plurality of peripheral recesses each including a cam surface; a roller in each recess, said rollers being of a length greater than the combined thickness of said cheek plates and said ring; said cheek plates having aligned slots located to permit the protrusion of the ends of the rollers; means for securing said cheek plates and trunnion member in assembled relation to said ring; a pair of shifter plates, each rotatably juxtaposed to the external face of the cheek plates and having socketed connections with the protruding ends of the rollers; a yoke connecting said shifter plates external of said ring for conjoint movement; and means carried by one of the bars and operable upon the pressing of the aid to the ground to rotate said shifter plates to initiate movement of the rollers relative their respective cam surfaces and the locking of the trunnion member within the annular ring member, said means to rotate said shifter plates being automatically retractible upon removal of the pressure of the aid to the ground to unlock the knee action.

2. The structure according to claim 1 in which the trunnion member is non-rotatably secured to each cheek plate by a boss-and-socket connection.

3. The structure according to claim 1 in which the means to rotate said shifter plates is a push-pull, spring-retracted, flexible cable having a button end to press upon the ground.

4. The structure according to claim 1 in which the bar including the annular ring is associated with the thigh leg member and the bar including the cheek plates is associated with the lower leg member of the aid, and the means to rotate said shifter plates is carried by the bar associated with the lower leg member.

5. A knee action to lockably articulate and connect the thigh and lower leg members of a prosthetic or orthopedic aid to walking, comprising: an exterior member having an internal annular raceway and rigidly coupled to said thigh member; an interior member journalled in said raceway and having a peripheral plurality of recesses for cylindrical rollers aligned with the axis of the knee action, said recesses each including a cam surface; a pair of cheek plates secured to said interior member and rigidly connected to the lower leg member; a cylindrical roller disposed in each said recess; a shifter member rotatable about the axis of said knee action exterior of said cheek plates and associated with said rollers to move the same in their recesses on the cam surfaces; and means operable upon the pressing of the leg member to the ground to rotate said shifter member and move said cylindrical rollers to initiate binding between said cam surfaces, roller, and the internal raceway to lock the knee action; said means to rotate the shifter member being automatically retractible upon the removal of pressure of the leg member from the ground surface whereupon the knee action is unlocked; said cam surfaces being uniformly directed to permit the straightening of the thigh and leg members but to resist the folding thereof while the rollers have been shifted to binding position.

6. In an aid for walking including thigh, lower leg and foot members, a knee action connecting said thigh and leg members and for lockably articulating said members to hinge freely or be locked against folding at normal angular positions upon the application and retention of pressure upon the foot member; said knee action comprising: an exterior member having an internal annular raceway; an interior member journalled in said raceway and having a peripheral plurality of recesses for cylindrical rollers disposed in alignment with the axis of the knee action, said recesses each including a cam surface; a cylindrical roller disposed in each recess and extending longitudinally to outside said exterior member; a shifter plate rotatably mounted alongside said exterior member and having a socketed connection with said rollers to cause the same to move on said cam surfaces toward the lesser portions of said recesses; and means operable upon the application of pressure on the foot member to rotate said shifter plate to initiate binding between said cam surfaces, rollers and the internal raceway to lock the knee action, said means to rotate said shifter being automatically retractible upon the removal of the foot member from the ground surface; said cam surfaces being uniformly directed to permit the straightening of the thigh and leg members but to resist the folding thereof while the rollers have been shifted to binding position.

7. A knee action to lockably articulate and connect the thigh and lower leg members of a prosthetic or orthopedic aid to walking, comprising: an exterior member having an integral annular raceway and rigidly coupled to one of the leg members; an interior trunnion member rigidly connected to the other leg member and rotatably fitted in said raceway; said interior trunnion member having a plurality of recesses for rolling bodies, said recesses each including a cam surface; a rolling body disposed in each recess; a shifter member rotatable about the axis of said trunnion member and associated with the rolling bodies to move the same in their recesses on the cam surfaces; and means carried by the lower leg member and operable upon the pressing of the same to the ground to rotate said shifter member to initiate the binding between said exterior and trunnion members through the instrumentality of said rolling bodies and cam surfaces to lock said knee action; said means to rotate said shifter member being automatically retractible upon the removal of pressure of the lower leg member to the ground whereupon the knee action is unlocked; said cam surfaces being uniformly arranged to permit the straightening of the thigh and leg members but adapted to resist the folding thereof while the rollers are shifted to binding position.

8. The structure according to claim 7 in which the rolling bodies are cylindrical rollers and the trunnion recesses are shaped to receive the same.

9. The structure according to claim 7 in which the external member is rigidly connected with the thigh leg member and the trunnion member is rigidly connected with the lower leg member.

10. The structure according to claim 7 in which the means to rotate the shifter member is a push-pull, spring-retracted, flexible cable having a button end to press upon the ground.

11. A knee action to lockably articulate and connect the thigh and lower leg members of a prosthetic or orthopedic aid to walking, comprising: a uni-directional clutch of the type employing rolling bodies and inclined planes and having its relatively movable external and internal parts rigidly connected between the thigh and lower leg member; a shifter member to move the rolling bodies of said clutch toward the clutching position; and means carried by the lower leg member and operable upon the pressing of the same to the ground to move said shifter member and cause the engagement of said clutch.

12. The structure according to claim 11 in which the rolling bodies are cylindrical rollers and the inclined planes are adapted to receive and coact with the same.

13. The structure according to claim 11 in which the external member of the clutch is rigidly coupled to the thigh member and the internal relatively movable member is rigidly coupled to the lower leg member.

14. The structure according to claim 11 in which the means to move the shifter member of the clutch is a push-pull, spring retracted, flexible cable having a button end located to be pressed to the ground.

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No references cited.