

April 24, 1962

M. M. BAIR

3,030,634

PROSTHESIS FOR BELOW-KNEE AMPUTEES

Filed Oct. 30, 1958

3 Sheets-Sheet 1

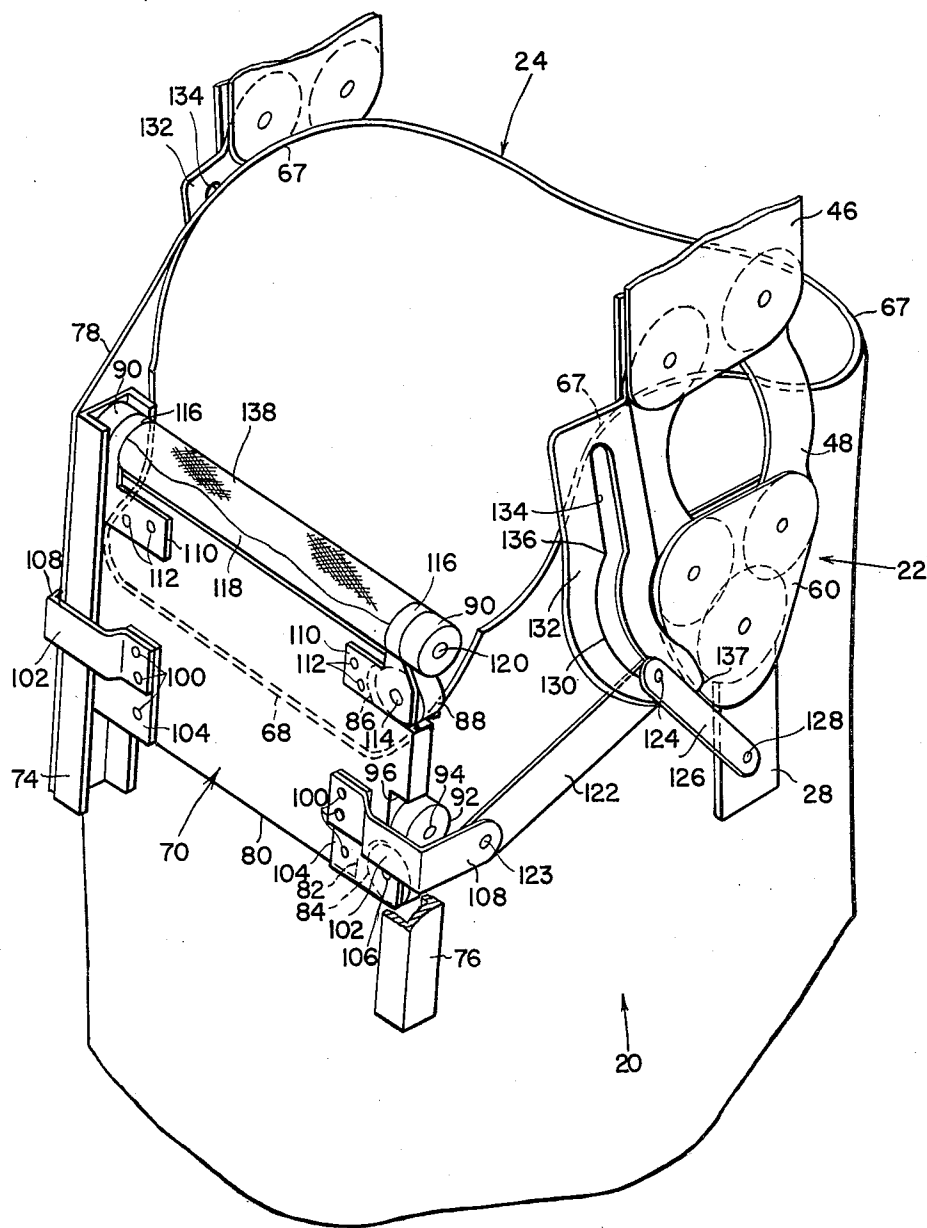


FIG. 1

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3 Sheets-Sheet 2

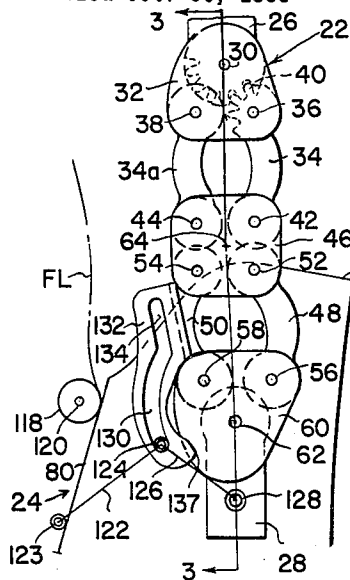


FIG. 2

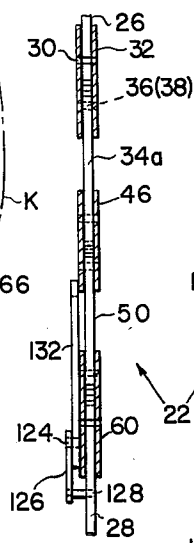


FIG. 3

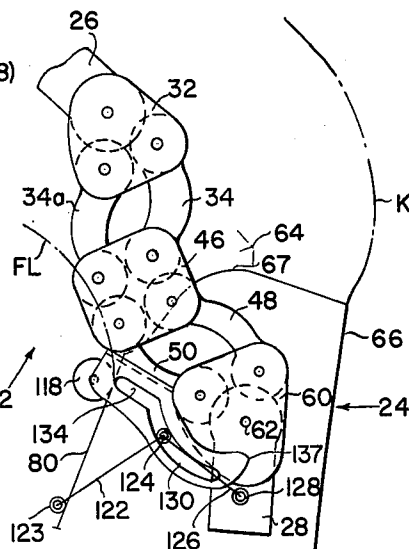


FIG. 4

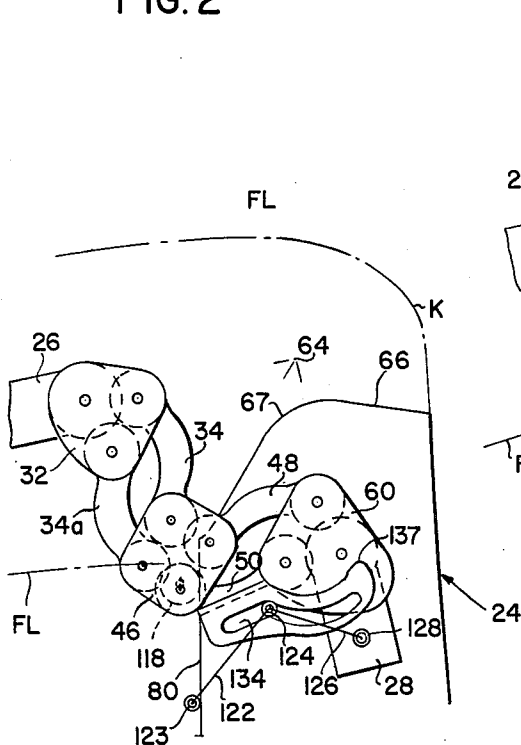


FIG. 5

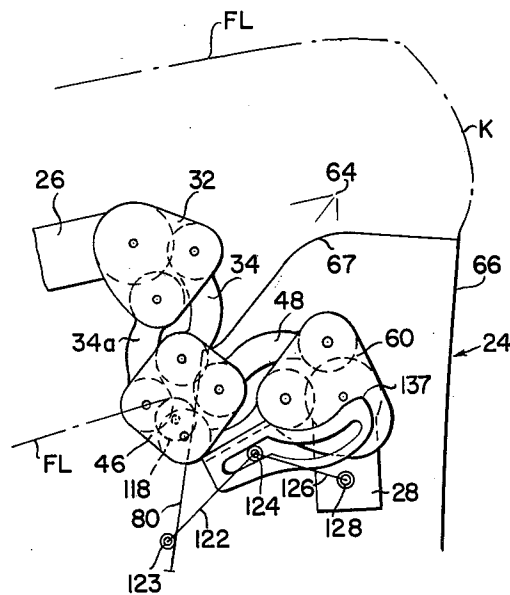


FIG. 6

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3 Sheets-Sheet 3

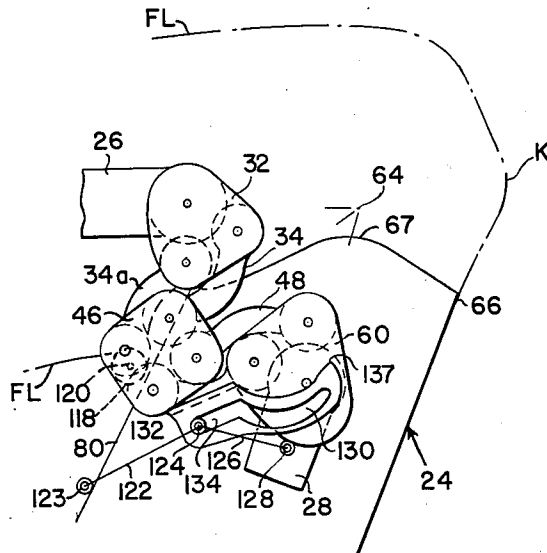


FIG. 7

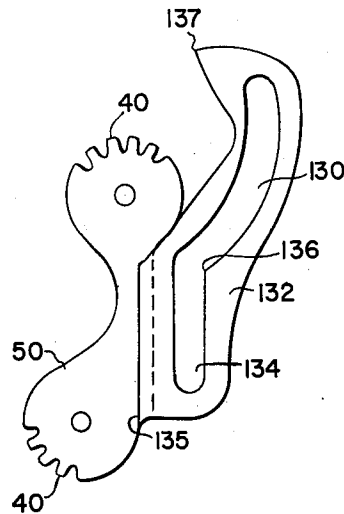


FIG. 10

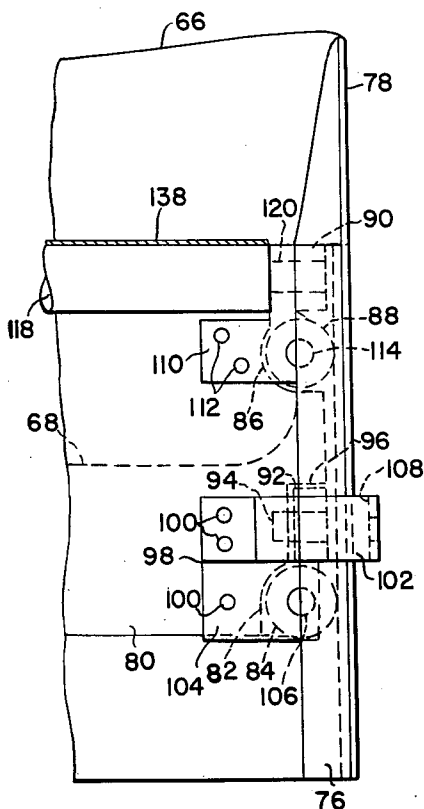


FIG. 8

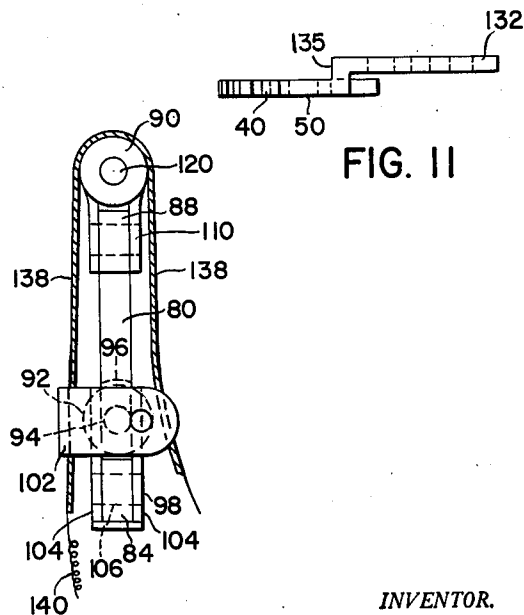


FIG. 9

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3,030,634

PROSTHESIS FOR BELOW-KNEE AMPUTEES

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17 Claims. (Cl. 3—22)

The present invention relates to prosthesis for below-knee amputees.

The desideratum of the present invention is to enable below-knee amputees to flex their knees from a substantially straight-out position to a maximum bent position without the painful cutting effects resulting from the movement of the amputated tibia relative to the boot support in which the same is accommodated or received; to enable below-knee amputees to do all those things that they formerly did with their normal limbs; to sit with their legs bent under them, to squat on their knees, dangle their legs off the end of a pier or dock, to take high steps without abnormal manipulations and, in particular, to do the same things in the same way that normal people can.

Although below-knee amputees have the ability to operate and manipulate their knees, they cannot do so at the present time without unsightly prosthetic devices that bulge from the sides of the knees and severely mangle and subsequently tear the clothing that they wear. The present invention has as its object the provision of an artificial knee joint which permits the wearer to operate his knee without creating an unusual or unsightly appearance along the sides of his trouser, to provide a knee joint in which the working parts are so encased and covered that clothing coming in contact therewith will not be gripped thereby as to be torn or mangled.

It is another object of the invention to provide a knee joint that permits the movement of the human knee without obstruction but which is adapted to retract or to be displaced so as not to interfere with the wearer's knee.

It is another object of the invention to provide a prosthesis for below-knee amputees that includes a boot having a unique retractable rear portion for the receipt of the amputated tibia such that the boot will retain a constant engagement with a predetermined aft portion of the wearer's knees despite the movements of the boot relative to the wearer's amputated leg during manipulations of the knee, thus assisting and providing the wearer with a full measure of contact about the amputated leg such that full manipulations of the knee may be made.

Another object of the invention is to provide a prosthetic device comprising an artificial knee joint and stump receiving boot that will cooperate in a unique manner as to permit the aft portion of the boot to vary in height in accordance with the flexing of the knee to remain in constant engagement with a predetermined aft portion of the wearer's knee.

Other and further objects of my invention reside in the structures and arrangements hereinafter more fully described with reference to the accompanying drawings in which:

FIG. 1 is a perspective view of a portion of the boot and knee hinge constructed according to the teaching of the invention,

FIG. 2 is a side view of the knee hinge and a diagrammatic showing of its cooperation with the boot,

FIG. 3 is a section taken along lines 3—3 of FIG. 2,

FIG. 4 is a view similar to FIG. 2 wherein the wearer's knee is slightly bent,

FIG. 5 is a view similar to FIG. 2 showing the wearer's knee bent to approach a sitting position,

FIG. 6 shows the knee joint bent into substantially a perpendicular position,

FIG. 7 shows the knee so that the femur and tibia are

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angularly moved with respect to each other such that the angle therebetween is less than 90°,

FIG. 8 is a partial view of the aft side of the boot,

FIG. 9 is a side view of the slide shown in FIG. 8,

FIG. 10 is a plan view of the slide actuator link and mechanism, and

FIG. 11 is an end view of FIG. 10.

Referring now to the drawings, the prosthetic device shown in FIG. 1 is generally identified by the numeral 20. For ease of explanation and to aid in the description of the device 20, the same is arbitrarily divided into two parts. The first, an anatomical knee joint or hinge is generally identified by the numeral 22. The second comprising a boot, is generally termed a posture adapter and is identified by the numeral 24.

The knee joint 22 comprises at its ends, a pair of relatively movable levers 26 and 28. Lever 26 is identified as the upper lever while lever 28 is identified as the lower lever. The upper lever 26 is adapted to be secured in such manner as to be fixed with respect to the femur of the wearer of the device 20 for coordinated movements therewith. The lower lever 28 is adapted to be secured so as to be fixed for relative and coordinated movement with the amputated tibia of the wearer. Hence, the movement of the lower lever 28 follows that of the amputated tibia while the upper lever 26 follows the movements of the femur. In practice and as more clearly seen in FIG. 1, the lower lever 28 is fixed to the boot structure 24 in a manner to be described. At this time however, it will be recognized that by securing the lower lever 28 to the boot structure 24, it is caused to move with the amputated tibia that is adapted to be received therein.

The upper lever 26 is mounted at 30 in an upper lever housing 32 for pivoted movement therein. An upper link means or structure 34 and 34a are also pivotally mounted within the upper lever housing at 36 and 38. Attention is directed to FIG. 3 wherein it is to be noted that the lever and link combination of structure thus described defines a planar relationship between the side walls of the upper lever housing 32. This provides for a very compact narrow engagement of structure that is carried forth throughout the remainder of the knee joint to be described.

The upper link means 34 and 34a are bulbous in shape and are permitted relative movement but engaging cooperation with the lower widened portion of the upper lever 26. This engaging cooperation may be in the form of cooperating gear teeth 40 as shown in FIGS. 1 and 10, although, here again, it will be understood that other convenient engaging means may be employed. In practice, however, it has been found that the use of the engaging gear teeth provides a simple yet efficient mechanism whereby the relative movement between the lever and link structures may be predeterminedly limited.

The lower ends of the upper link means 34 are pivotally mounted at 42 and 44 respectively, in a fulcrum housing 46. The pivoted lower bulbous ends of the link means 34 and 34a cooperatively engage with upper bulbous portions of a lower link structure or means 48 and 50 respectively that are also pivotally mounted within the confines of the fulcrum housing 46 at 52 and 54. The lower bulbous ends of the lower link means 48 and 50 are pivotally mounted at 56 and 58 in a lower lever housing 60. Pivotaly mounted at 62 in the lower lever housing 60 for engagement with the lower bulbous portions of the link means 48 and 50, is the lower lever 28.

As previously noted, the planar arrangement of the upper and lower levers 26 and 28 and the respective upper and lower link structures 34, 34a, 48 and 50, is shown in FIG. 3. This provides for a narrow compact arrangement of structure. The bulbous ends of the up-

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per lever 26 and the lower lever 28 may be provided with engaging teeth 40 such as that shown in FIG. 1 or as shown in FIG. 10 wherein there is an expanded view of one of the lower link means 50. The cooperating upper and lower link structures engaging the upper and lower levers 26 and 28 respectively are bulbous in shape to accommodate the proper number of engaging gear teeth 40 for cooperative engagement with the gear teeth on the bulbous portions of both the upper and lower levers 26 and 28.

It will be noted from the drawings that the central connecting body portion of each of the link means 34, 34a, 48 and 50, is bowed outwardly with convex outer surfaces and concave inner facing surfaces. Their outwardly bowed connection portions permit their relative movement from a position as depicted in FIG. 2 wherein the upper and lower lever members 26 and 28 are approximately or substantially in alignment to an extreme bent position as depicted in FIG. 7. Since it is well known that the human knee joint is not a perfect hinge, when in the standing position, the femur and tibia are not in a straight line. Rather, they are slightly angularly bent with respect to each other at an angle more nearly approaching 178° 25' about the aft portion of the leg. Progressive bending of the tibia and femur angularly relative to each other from the substantially straight position, results in a decrease of the angular separation therebetween about the aft portion of the knee.

The present inventive hinge 22 is adapted to bend or flex with the human knee without, however, creating an unsightly appearance along the sides of the knee by bulging the clothes outwardly during such bending movement, on gripping and tearing the clothes during such outward bulging. It has often been a common complaint of amputees that the knee hinge provided for them has so many exposed working parts that these parts grip the clothes and tear them, rendering a new set of trousers old in appearance after only a short period of wear. Also, in the attempt to make the artificial knee joint operate in the same manner as the human knee, there is created an unsightly bulge along adjacent sides of the knee. The instant unique knee joint 22 is intended to permit the human knee to operate in its normal manner and although it can be positioned along the adjacent sides of the human knee, its unique features and design obviate the possibility of gripping and tearing of clothes and also eliminates the unsightly bulges that are created along the sides of the wearer's knee.

To accomplish this, the instant knee joint 22 functions to move the fulcrum housing 46 linearly toward and away from a theoretical pivot 64 during the relative angular movements of the amputated tibia and femur. Thus, for example, the substantially straight line position of the upper and lower levers 26 and 28 as depicted in FIG. 2 has positioned therebetween the fulcrum housing 46. As the upper and lower levers 26 and 28 are moved angularly toward or away from each other in response to the corresponding angular movements of the femur and amputated tibia, the fulcrum housing 46 is also caused to be displaced linearly either toward or away from the theoretical pivot point 64 defined between the angularly spaced upper and lower levers 26 and 28. This movement is widened in subsequent FIGS. 4, 5, 6 and 7 wherein as the upper and lower levers 26 and 28 are moved angularly toward or away from each other, the fulcrum housing 46 is similarly linearly displaced toward or away from the theoretical pivot 64.

It is to be understood, and this will be recognized from viewing FIGS. 2 to 7 inclusive, that the fulcrum housing 46 is displaced in the direction of the aft portion of the human knee into the space that normally results between the tibia and femur when the same are angularly moved toward each other. This is illustrated more clearly in the aforementioned figures of the drawing wherein the human flesh line is shown in dot-dash

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lines and is identified by the letters FL while the human knee is denoted by the letter K. As the inventive knee hinge 22 is moved from its substantially straight standing or full reclining position as shown in FIG. 2 toward its partially bent or sitting position, as shown in FIG. 4, the engaging gear teeth 40 on the cooperating levers and links, cause the fulcrum housing 46 to be displaced linearly away from the theoretical pivot 64. During this movement, the upper lever 26 pivots at 30 relative to the upper housing 32. Its engaging teeth 40, cooperating with the teeth on the upper bulbous ends of the link means 34 and 34a, cause such link means to rotate about their pivots 36 and 38 respectively relative to the upper housing 32 in which they are mounted.

At the same time, the lower lever 28, fixed for movement with the amputated tibia, rotates about its pivot 62 relative to the lower housing 60. Its gear teeth, cooperating with the engaging gear teeth on the lower bulbous ends of the lower link means 48 and 50, cause the link means to rotate about their pivots 56 and 58 respectively within the housing 60. Inasmuch as the lower bulbous ends of the upper link means 34 and 34a are fixedly pivoted in the fulcrum housing 46 are cooperatively engaged with the upper bulbous ends of the lower link means 48 and 50 which are also fixedly pivoted in the same fulcrum housing, the displacement of the upper and lower link means by their upper and lower levers respectively, cause such link means to rotate relative to each other about their pivots. Their pivoting rotation displaces the housing 46 linearly toward the aft portion of the human knee joint into the angular space defined between the wearer's femur and amputated tibia.

During this displacing movement, the upper bulbous portion of the link means 34a is caused to move toward the adjacent concave surface of the link means 34 while the lower bulbous surface of the link means 34 is caused to move upwardly toward the adjacent concave face of the link means 34a. A similar action and cooperation occurs with respect to the lower link means 48 and 50. Hence, the inner concave or arched surfaces of the adjacent link means 34, 34a, 48 and 50, serve to accommodate the bulbous end portions of the next adjacent link members when the hinge 22 is moved toward its extreme bent position substantially as shown in FIG. 7, enabling the hinge to perform its extreme movement.

In practice, the upper and lower housings 32 and 60 are closed along all sides thereof except for those portions that are required to be left open to permit the relative movement of the links and levers mounted therein. The fulcrum housing 46, on the other hand, is fully enclosed on its aft side and open on its other three sides to permit the relative engaged movement of the upper and lower link means about their pivots therein. The closed sides of both the upper and lower housing and also of the fulcrum housing serve to completely enclose the working exposed portions of the gear teeth of the cooperating upper and lower links and levers to prevent from gripping and tearing the clothes. The retraction of the fulcrum housing 46, linearly into the angular space formed between the femur and amputated tibia, eliminates and completely obviates the possibility of unsightly bulges along the sides of the human knee joint.

In order to insure the proper angular movement of the inventive knee joint 22 so that the angularly spaced upper and lower levers 26 and 28 shall have a maximum and minimum limited angular movement about the theoretical pivot 64, the engaging means or gear teeth 40 are predeterminedly arranged on the cooperating bulbous ends of the levers and links in number and size. By predeterminedly selecting the size and number of cooperating teeth 40 and predeterminedly arranging the same on the cooperating engaged ends of the levers and link means of the hinge 22, the maximum and minimum relative movement of such levers and link means may be predetermined and limited. Thus it may be noted that the

engaging means 40 defines a limiting structure which permits relative movement of the upper and lower levers to a predetermined limited maximum and minimum spacing. The engaging means thus insures that the relationship of the upper and lower levers relative to the theoretical pivot 64 will be such as never to exceed the maximum and minimum angular positions that normal non-amputated femur and tibia assume with respect to each other when actuated by a human knee.

In considering the instant invention, it is to be noted that the upper lever 26 of the hinges 22 disposed on opposite sides of the posture adapter 24, may be securely fixed with respect to a brace or rigid frame structure similar in nature to that disclosed in a co-pending application, Serial No. 630,236, filed December 24, 1956, and now Patent No. 2,915,760, while the lower lever 28 is adapted to be fixed in relation to the amputated tibia in any convenient manner, for example, by fixedly mounting the same on the boot structure 24 to be described. The boot structure 24 has an open top through which the amputated tibia is received. The lower portion of the boot 24 may be connected by some convenient rigid supports to an artificial foot, not shown.

In the main, the boot structure 24 comprises a rigid metallic boot body member or leg skin 66 that is cut slightly higher along the lateral sides thereof than the front or aft portions. As is usual, the boot structure 24 comprises a fabric or leather insert that seats in and is removable from the metallic boot body or leg skin 66. Since these minor details form no part of the invention, for purposes of explanation, the member 66 is referred to as the boot that is intended to include the insert. The slightly higher sides are adapted to encompass portions of the sides of the human knee to provide lateral support therefor when the amputated tibia is firmly seated within the boot. This provides temporary additional support at the sides of the knee as the wearer rises to a standing position or bends his knee to sit. The front of the boot is formed slightly lower than the sides as to extend about the front portion of the human knee K and slightly beneath the kneecap as not to interfere with the operation of the same. This may be seen more clearly in the diagrammatic arrangement of the boot with respect to the flesh line FL and knee K in FIGS. 2 to 7 inclusive.

In the instant invention, the aft portion 68 of the rigid body 66 is cut substantially lower than boot structures known heretofore, for a reason to be described. In order that one may more clearly understand the operation and function of the instant unique boot structure 24, it is important to recognize the boot structures presently in use by below-knee amputees, are rigid and immovable; that is to say, that the boot generally comprises no moving parts but rather includes a rigid, unyielding structure that peripherally encompasses the amputated tibia. Although the design of such boots has been predicated upon the belief that below-knee amputees must have adequate lateral and aft knee support, in the past this has been accomplished by providing higher lateral sides 67, sufficient forward support in the area defined immediately beneath the human kneecap K, and a high rigid, unyielding support about the aft portion of the knee.

However, in practice, the boot constructions thus described resulted in a cutting and rubbing at the aft portion of the knee when the wearer thereof performed various normal knee bending manipulations or movements. Those skilled in the art will readily understand this when they realize that the boot construction 24 is generally fitted to be fixedly mounted with respect to the femur when the wearer is in a standing position and his femur and tibia are in substantial vertical alignment. However, when the wearer of present rigid boot constructions bends his knee to walk, sit or dangle his legs, the distance between the boot and the aft portion of the femur shortens as a result of the imperfect hinging action of the human knee. This shortening of the distance between the top

of the aft portion of the boot and the femur, results in bringing the aft portion of the rigid boot cutting upward against the large flat muscles located above and at the aft side of the knee. Although this cutting effect is painful indeed, and the amputee often performs unusual and abnormal moving contortions to prevent it, it cannot be avoided in present rigid boot constructions. Moreover, this upward cutting movement has the effect of lifting or pulling the stump out of the boot liner and out of full snug contact therewith. The elimination of this full contact prevents the amputee from using the full area of his stump to control the boot thus making control ineffective.

The present invention recognizes this problem and has as its object to provide a unique boot structure 24 that performs the function of a posture adapter, namely, to supply the support necessary at the aft portion of the knee, without the cutting effect inherent in presently known boot structures. This is accomplished in the instant invention by providing a boot construction 24 comprising a rigid boot 66 having at the aft portion 68 thereof, a slide apparatus generally identified by the numeral 70 that may be operated to vary the rear height of the boot in response to the relative movements of the femur and amputated tibia. The slide apparatus 70 is adapted to be actuated by a mechanism directly related to the movement of the knee hinge 22, which in turn, is directly controlled and corresponds to the relative angular movement of the femur and amputated tibia about the human knee K and of the knee joint 22 about its theoretical pivot 64.

For a clearer illustration of the operation of the slide apparatus and its structural relation with the boot member 66, reference is made to FIGS. 1, 8 and 9. FIG. 8 is a partial view of the aft right side of FIG. 1. Slide apparatus 70 comprises a slide means or structure 80, that is freely movable relative to the aft portion 68 of the opening of the boot 66. Its free movement is guided by members 74 and 76 disposed on opposite sides thereof. Although only the one guide 74 is shown in full in FIG. 1, it is to be recognized that the guides 74 and 76 are mirror-hand images of each other, and channel shaped. Each guide member 74 and 76 is securely and fixedly mounted to its respective side of the boot 66 by a support 78 (only one of which is shown in FIG. 1) and positioned slightly to the aft thereof to guide the slide member for free sliding movement thereat.

The slide 80 may be a micarta plate that is substantially shorter in length than the side guides 74 and 76. It has a free roller bearing engagement with both the body and side flanges of the side guides. Slide plate 80 is arcuately recessed at both of its lower end corners 82, to accommodate therein roller means 84 that have their bearing surfaces arranged for rolling engagement with the body portions of the channel guides 74 and 76. In a similar manner the opposite top ends or corners of the plate 80 are recessed at 86 to accommodate the roller means 88 that are also arranged for rolling bearing engagement with the inner surfaces of the body portions of the channel guides.

The upper and lower roller bearing structures 84 and 88 thus prevent undesired lateral or tilting movement of the plate 80 between the guides. Undesired forward and aft movement of the plate 80 relative to the guides is eliminated by the provision of upper and lower longitudinally spaced roller bearing structures 90 and 92 positioned on opposite ends of the plate. The bearing surfaces of the rolling structures 90 and 92 are arranged to engage with the inner surfaces of the intumed flanges of the guide members. This unique arrangement of bearing engagement insures against undesired or unwanted movement of the plate relative to its guides.

The lower set of bearing members 92 are mounted on pins 94 that are secured into the ends of the body 80 after the same are received in suitable recesses 96. The lower set of bearing means 84 are pivotally fixed in their

recesses 82 by mounting brackets 98. Brackets 98 are somewhat U shaped as seen in FIG. 9 to extend from one side of the plate 80 about the underside thereof and along the other side. The brackets are fixedly secured to the plate 80 at 100 to define the bearing mount arms 104. The forward and aft mounting arms 104 of each bracket have a pivot pin 106 passing therethrough to retain the bearing means 84 in their recesses 82. The actuator arm 102 is mounted on the bracket 98 and is slightly offset rearward to extend laterally over the aft flange of the adjacent guide channel member and then in a forward direction at 108.

The upper sets of bearings 88 and 90 are fixedly secured with respect to the plate 80 by brackets 110. The brackets 110 are adapted to be secured to the forward and aft surfaces of the plate 80 by the securing means 112. The body engaging set of rollers 88 are pivotly mounted at 114 to the upper brackets 110. An encompassing band 116 is adapted to rotatably mount a posture adapted roller 118 to the plate 80. A pivot pin 120 extending through the roller 118, serves to mount the side flange bearing member 90 at the opposite ends thereof.

From what has been described it will be seen that the posture adapter roller 118 is fixedly mounted by the brackets 110 to the plate 80 to form a part of the slide mechanism 70, thus it moves with the slide mechanism in response to the movements of the knee joint 22. The posture adapter roller 118 defines the top-most portion of the slide 70 for constant engagement with the aft portion of the knee K, while the slide mechanism itself defines the aft portion of the opening of the boot 66.

The slide mechanism 70 operatively serves to vary the height of the aft portion of the opening of the boot 66. It is operated in response to the movement of the hinge or end joint 22. For this reason it is adapted to be connected at its arm 108 by an inner actuator link 122 to a cam pivot or roller 124. An outer shorter arm or actuator link means 126 is pivotly mounted at its upper end to the cam pivot or roller 124, and at its lower end it is pivotly mounted at 128 to the lower lever 28. The pivot or roller 124 is movable in a cam slot 130 of a cam member 132 that forms a part of a slide actuator mechanism.

The slide actuator mechanism may be seen more clearly in FIGS. 10 and 11 wherein it comprises the lower link means 50 and the cam actuator 132. The lower link means 50 is offset at 135, a distance equal to the thickness of the adjacent wall of the lower housing 60, over which it is adapted to slide and move in a manner depicted more clearly in FIGS. 2 to 7 inclusive. To provide for the smooth relative sliding movement of the cam actuator 130 over the adjacent surface of the lower housing 60, the cam actuator is provided with a nose portion 137 that is continually in overlapping relationship with the adjacent surface of the housing 60. The smooth relative sliding movement of the nose 137 over the lower housing 60 insures against the gripping of clothing and obviates the possibility that adjacent portions of garments covering the same will not be caught therebetween, thus eliminating the possibility of tearing of clothing.

It is noted that the outer and inner link means 126 and 122 are operable on opposite sides of the cam actuator 132; that is to say, the outer link 126 moves over the outer surface of the cam actuator, while the inner link moves laterally against the inner adjacent offset surface of the cam actuator.

The actuating mechanism including the cam actuator 132 is operated during the operation of the knee joint 22 in response to the movement of link 50 of which it forms a part. As the cam actuator is displaced from its position shown in FIG. 2 towards its position as shown in FIG. 7, during the bending of the knee K from its substantially aligned position as shown in FIG. 2, to its extreme bent position as shown in FIG. 7, the cam pivot or roller 124 is caused to move relative to the cam opening 130. The cam opening or guide 130 is predeter-

minately formed or shaped to selectively permit the raising or lowering of the slide mechanism 70. When the mechanism 70 is operated its attendant posture adapter roller 118 is moved also to vary the height of the aft of the opening of the boot 66 to remain in constant supporting engagement with a predetermined aft portion of the wearer's knee K. This is illustrated in the figures of the drawing wherein the posture adapter roller 118 is caused to move up or down relative to the rear of the boot 66. As such it forms a constant posture support for the aft portion of the knee K at a height that provides the wearer with the greatest feeling of support throughout all degrees of bending movement of the knee.

The amputee may be said to be in the standing or in the complete reclining position when the femur and tibia are substantially in alignment and the included angle therebetween is at a maximum as shown in FIG. 2. In this position the cam roller 124 is at the lowermost end of its travel in the cam slot or guide 130 and the actuator link means 122 and 126 interconnect the knee joint 22 with the slide mechanism 70. As the knee K is slightly bent from its position in FIG. 2 to its position as shown in FIG. 4, reducing the included angle between the amputated tibia and femur, hinge 22 is actuated to retract the fulcrum housing 46 linearly rearward away from the theoretical pivot 64.

During this movement, the link 50 and its integral cam actuator 132 is displaced. The links 122 and 126 of the actuator mechanism, being fixed at their ends 123 and 128 respectively, permit the cam slot to move relative to the joining cam roller 124. As noted previously, as the angle between the amputated tibia and femur decreases the boot 66 is displaced upwards along the knee K toward the aft portion thereof and the aft portion of the femur, cutting into the muscles at the back of the knee. This cutting effect normally occurs when the amputated tibia and femur are in their relative positions as shown in FIG. 5. Therefore, unless some means is provided whereby the aft portion of the opening of the boot in which the amputated tibia is received is variable, the same will dig and cut progressively deeper into the muscles as the tibia and femur are bent further and progressively toward each other.

For this reason the guide 130 is predeterminedly designed and shaped to actuate the slide mechanism 70 to vary the aft height of the boot 66, only after knee K is bent into the position in FIG. 5 and progressively therebeyond. To facilitate this operation the cam opening 130 is initially predeterminedly curved and terminates in a displacing linear cam portion 134 that begins abruptly at 136. Although the fulcrum housing 46 is displaced linearly throughout the progressive relative bending movement of the amputated tibia and femur, the curved cam surface is predeterminedly shaped such that its travel relative to the cam follower 124 prevents corresponding movement of the slide mechanism 70. However, as link 50 is continually lowered by the progressive and continued bending of the knee K, the follower 124 is caused to pass over the critical point 136 and into the confines of the displacing cam portion 134. Thereafter further continued progressive bending movement of the knee K operates the parts of the knee joint 22 such that the link 50 and its cam actuator 132 are moved relative to the follower 124 to position the same linearly within and along the displacing portion 134. The predetermined linear shape of cam portion 134 serves to operate the actuator link means 126 and 122 in a straight line motion to lower the slide mechanism 70 relative to the remainder of the boot 66, a distance corresponding to the upward displacing movement of the boot relative to the aft portion of the knee K.

Accordingly the posture adapter roller 118 remains in constant physical engagement with a predetermined aft portion of the wearer's knee K throughout all movements of the boot 66 relative to the femur, knee K and ampu-

tated tibia. By varying the height of the aft portion of the opening of the boot 66, the boot is permitted to move relative to the amputated tibia received therein and upward towards the aft portion of the femur as the knee K is bent to the position shown in FIG. 5 and therebeyond. The ability to vary the height of the aft portion of the opening during such bending movements, and at the same time provide the amputee with the necessary support at the aft part of the knee K, is a major advance in the art. It completely eliminates the cutting that is now in evidence in rigid boot constructions, yet at the same time provides the proper support where the same is needed.

Although the description and figures of the drawings disclose the slide mechanism to be operated at both of its arms 102, one of these arms, may be eliminated. The operation of the mechanism 70 at the sole remaining arm 102 by the hinge 22 will suffice since the same does move freely and smoothly between its guides 74 and 76.

Referring to FIGS. 1, 8 and 9, there is shown a fabric lining or covering 138 that is a continuation of the fabric lining of the boot 66 and is adapted to comfortably fit about the amputated tibia. In the instant invention the lining strip 138 is passed over the posture adapter roller 118 and is lightly spring loaded by a conveniently located spring 140 (FIG. 9) to keep the strip and its fabric liner taut at all times during the movements of the slide mechanism 70.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment thereof, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended thereto.

I claim:

1. An anatomical knee comprising relatively displaceable upper and lower levers, movable link means between said levers, means on said link means and levers having frictional engagement to interconnect the same for relative displacement and to move said link means in response to the relative displacement of said levers, and means on which said link means are pivoted to retain said link means in said frictional engagement, said last named means being displaceable in response to the relative displacement of said levers and the movement of said link.

2. An anatomical knee having a theoretical pivot comprising an upper lever movable about said pivot, a lower lever movable about said pivot, means between said levers movable toward and away from said pivot, and upper and lower link means pivoted on said means, said upper and lower link means each having friction means connected with said upper and lower levers respectively and with each other to move said means between said levers in response to the movement of said levers about said pivot.

3. An anatomical knee comprising angularly displaceable upper and lower levers, means displaceable in response to the angular displacement of said levers, upper and lower link means, means movably engaging said upper and lower link means with said upper and lower levers respectively for movement thereby in response to the angular displacement of said levers, and means movably engaging said link means with each other and pivoted on said fulcrum means to displace the same.

4. An anatomical knee having a theoretical knee pivot comprising an upper lever housing, an upper lever pivoted in said housing, upper link means pivoted in said upper housing and engaging said upper lever for pivoted relative movement, a lower lever housing, a lower lever pivoted in said lower housing, lower link means pivoted in said lower housing and engaging said lower lever for pivoted relative movement, a fulcrum housing, said upper and lower link means being pivotally engaged for rela-

tive movement in said fulcrum housing, and engaging means on said engaged lever and link means to limit the relative movement therebetween.

5. A prosthesis for below-knee amputees comprising an artificial knee joint including upper and lower levers fixed with respect to the wearer's femur and amputated tibia respectively for angular relative movement therewith, fulcrum means, upper and lower link means engaged for limited relative movement with said upper and lower levers respectively and pivotally engaged with each other in said fulcrum means for limited relative movement in response to the relative angular movement of said levers to displace said fulcrum means, a boot in which the amputated tibia is received, means movable on said boot to vary the rear height thereof, and means to move said movable means in response to predetermined relative angular movements of said levers.

6. A prosthesis as in claim 5, said boot being fixed for angular movement with said amputated tibia, and said lower lever being fixed to said boot for movement therewith.

7. The combination of an anatomical knee and posture adapter for below-knee amputees comprising a boot to receive the amputated tibia, a knee joint, said knee joint having an upper lever fixed with respect to the femur, a lower lever fixed with respect to said boot, said levers being movable to permit relative angular movement between the femur and said boot, link means interconnecting said levers for said relative movement, means movable on said boot to vary the rear height of said boot in response to the relative movement of said levers, and means interconnecting said movable means with said knee joint.

8. The combination of a knee joint and posture adapter for below-knee amputees, said knee joint being movable and comprising levers movable in accordance with the relative movements of the femur and amputated tibia, a boot to receive the amputated tibia, link means interconnecting said levers and movable in response to the movement of the same, means on said boot constantly engaging the aft portion of the knee and movable to vary the rear height of said boot, and means connecting said movable means on said boot with said knee joint to move the same in response to the movement of said joint.

9. A prosthesis for below-knee amputees comprising an artificial movable knee joint having lever means fixed with respect to the femur and amputated tibia for corresponding movements therewith, a boot in which the amputated tibia is received, means on the aft portion of said boot operably connected to said knee joint to move in response to the movements of said joint and to remain in constant engagement with a predetermined aft portion of the wearer's knee.

10. A prosthesis for below-knee amputees comprising a boot adapted to receive the amputated tibia for movement therewith and having an aft portion thereof movable to constantly engage a predetermined aft portion of the wearer's knee, a knee hinge having means movable with said boot and including means to move said aft portion of said boot.

11. A prosthesis for below-knee amputees comprising a boot adapted to receive the amputated tibia for movement therewith, means on said boot slidable along a portion thereof to assume a fixed position with respect to the wearer's knee, a knee hinge including means fixed for movement with respect to said boot and the wearer's femur, and means interconnecting said knee hinge with said slidable means to slide the same in response to the relative movement of said tibia and femur.

12. A prosthesis for below-knee amputees comprising a boot adapted to receive the amputated tibia for movement therewith, said boot having an aft portion operable to vary the aft height thereof in accordance with the relative movements of the wearer's femur and tibia, a knee hinge having upper and lower levers fixed for rela-

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tive angular movements corresponding to the relative angular movements of said femur and tibia respectively, and means on said knee hinge interconnected with said aft portion to operate the same.

13. A prosthesis for below-knee amputees comprising a knee hinge having upper and lower levers fixed for relative angular movement with respect to the wearer's femur and amputated tibia respectively, actuator means movable in response to the relative angular movements of said upper and lower levers, a boot in which the amputated tibia is received, means on said boot operable to vary the aft height thereof in accordance with the relative angular movements of said femur and tibia, and means connecting said lower lever and said actuating means with said movable means to operate said movable means to vary the aft height of said boot in accordance with the relative angular movements of said femur and tibia.

14. A prosthesis for below-knee amputees comprising a boot, said boot having an opening at the top thereof through which the amputated tibia is adapted to extend for receipt in said boot, a slide defining the aft portion of said opening of said boot and being freely movable along the length of said boot, and means bearingly mounting said slide for said free movement.

15. A prosthesis as in claim 14, arm means on said slide extending laterally from the sides of said boot and adapted to move the slide along the length of said boot to vary the height of the aft portion of said opening.

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16. A prosthesis for below-knee amputees comprising a boot having an opening at the top portion thereof for the receipt of the amputated tibia therein, a slide defining the aft portion of said opening and movable along the length of said boot to vary the height of said aft portion of said opening, arm means on said slide extending laterally from the sides of said boot to move said slide freely along the length thereof, a knee hinge including upper and lower levers fixed for relative angular movement with the wearer's femur and amputated tibia respectively and actuator means, said actuator means being movable in response to the relative angular movements of said upper and lower levers, actuator link means connecting said lower lever with said actuator means and said arm means to move said slide.

17. A prosthesis as in claim 16, said actuator means including cam means engageable by said actuator link means to control the movements of said actuator link means and predeterminately move said slide in accordance with the relative angular movements of said femur and tibia.

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