Feb. 20, 1951 B. PETERS 2,542,567

ARTIFICIAL LIMB MECHANISM

Filed Nov. 27, 1948 2 Sheets-Sheet 1

FIG. 1

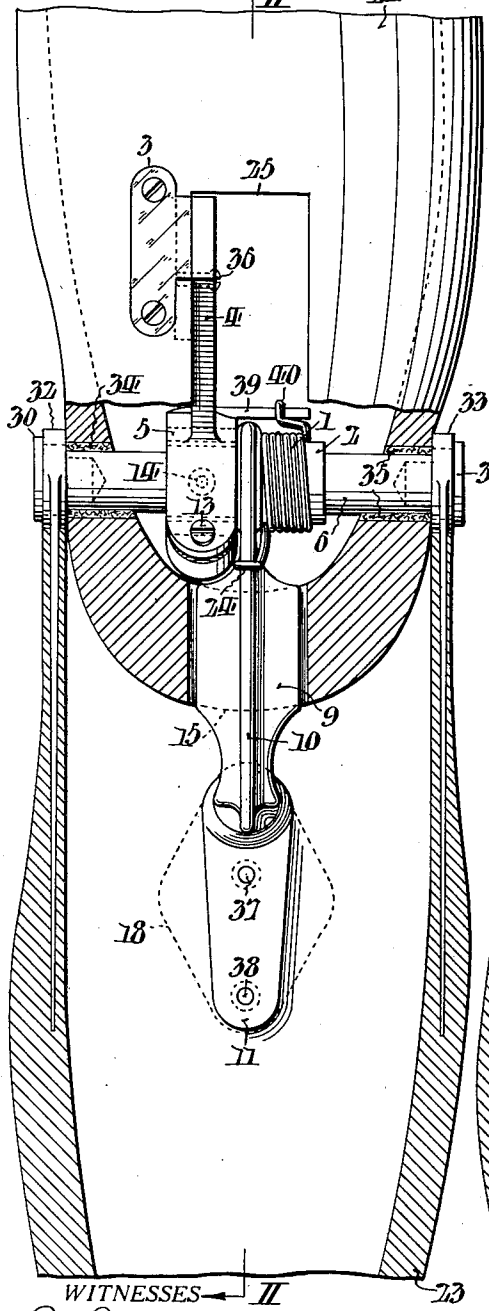
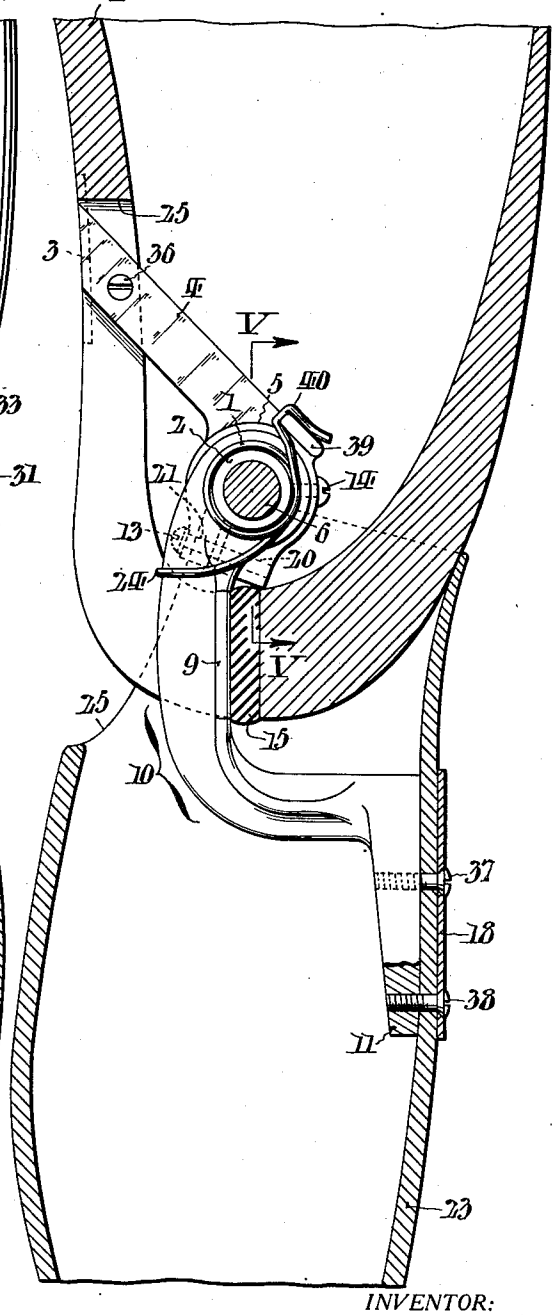


FIG. 2



WITNESSES

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Filed Nov. 27, 1948 2 Sheets-Sheet 2

FIG. 4.

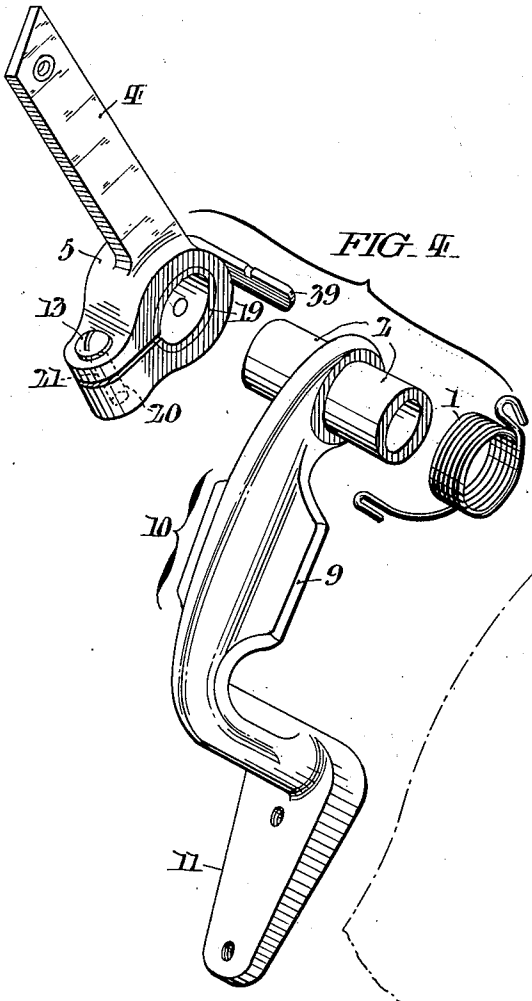


FIG. 3.

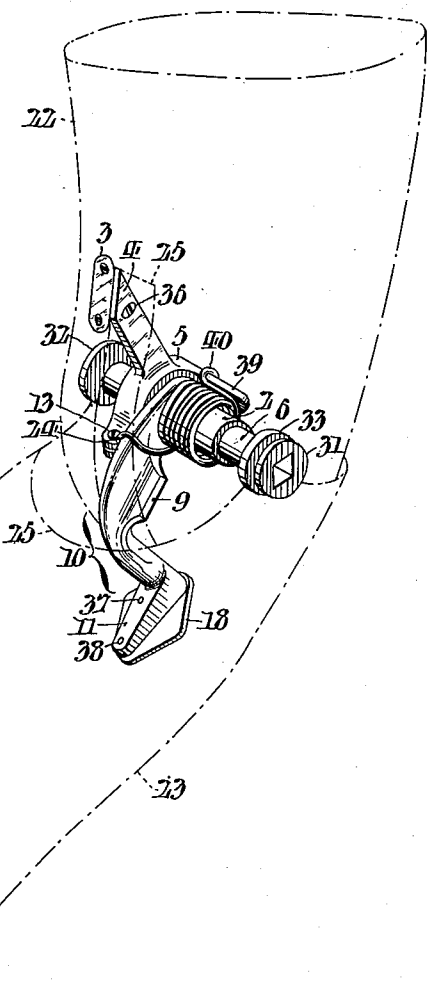
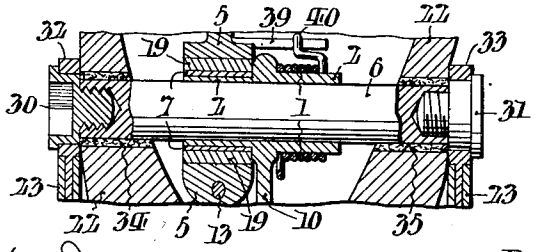


FIG. 5.



WITNESSES

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UNITED STATES PATENT OFFICE

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ARTIFICIAL LIMB MECHANISM

Basil Peters, Philadelphia, Pa.

Application November 27, 1948, Serial No. 62,404

11 Claims. (Cl. 3—2)

1

My invention relates to artificial limbs, particularly to an artificial limb kicking mechanism adapted to provide an initial forward impetus to the lower leg member of an artificial limb from a rearward position reached as the wearer of the limb is walking, with consequent elimination of the normal tendency of the lower artificial limb to lag and hinder the natural walking motion of other parts of the body.

Because there has heretofore been no safe, effective way to induce a natural motion of the lower leg member of an artificial limb during a series of walking steps, many of the early limbs were designed as rigid members that did not bend at the knee at all or could be bent only slightly by applying considerable force. Later, various hinged or pivoted devices were produced which allowed the knee to bend during the walking motion, but they have been found to be relatively clumsy and tiring in that the lower limb lags considerably during the forward swing. The lag is apparently caused by the fact that the motive power of the entire limb is derived from the muscles of the thigh and upper leg and the thigh muscles have very little effective control over the movement of the below-knee member unless some appropriate means is provided for imparting an initial impetus to the lower leg during the forward swing. The effect of the lag varies with the walking speed of the individual wearer, and the available devices have not been equipped with any convenient means for compensating for speed variations without removing the entire limb from the body, or even with means for correcting the aforementioned defects to give a preferred performance at a predesignated speed.

It is therefore an object of this invention to provide a prosthetic device for above-knee amputees which in use allows the wearer closely to simulate the movements of a natural walking step. It is another object of this invention to provide an artificial limb knee mechanism that enables the wearer to walk rapidly with a minimum of effort. A still further object is the provide an internally actuated artificial knee mechanism that may be quickly regulated to give a preferred walking motion for the desired walking speed of the wearer.

Other objects and means for carrying them into the effect will be apparent from the following description of the present invention and from the accompanying drawings wherein:

Fig. 1 is a fragmentary rear elevation of an artificial limb including portions of the upper and lower leg components and a knee actuating

2

mechanism of this invention, with parts broken away and shown in section, in order better to disclose important details.

Fig. 2 is a vertical sectional view of the same taken as indicated by the lines and arrows II—II in Fig. 1.

Fig. 3 is a perspective view of the apparatus with the limb shown in dot and dash lines and in bent position.

Fig. 4 is an exploded view of a knee actuating mechanism of this invention.

Fig. 5 is a transverse vertical sectional view taken as indicated by the lines and arrows V—V in Fig. 2.

According to this invention, the novel knee mechanism is positioned within the hollow space of the knee section in an artificial leg and is operatively connected to the upper and lower leg sections as appears in Fig. 3. The entire mechanism is supported on relatively strong transverse knee bolt 6 which joins the lower limb with the upper limb and is the main supporting member in the knee joint. Referring to Fig. 1, knee-bolt straps 32 and 33 are encased in the material of lower artificial leg 23 which is usually made of wood or plastic material. Knee bolt 6 is held in position by means of shouldered screws 30 and 31 the heads of which bear against knee bolt straps 32 and 33. The knee bolt also passes through cylindrical apertures in the upper leg in order to support the upper limb and the weight of the body bearing on the upper limb. Leather bushings 34 and 35 are fitted tightly between the knee bolt and the upper leg openings in order to distribute the force exerted on the knee bolt to absorb shock.

The knee actuating mechanism of this invention is positioned on the knee bolt as shown particularly in Figs. 1, 2 and 5. Main sleeve 2, which is slidably fitted around the knee bolt, is in frictional engagement with an outer friction surface such as boss 5 or outer friction bushing 19, and the contact surface of sleeve 2 which is the inner friction surface of the mechanism should accordingly be constructed of a wear-resistant material such as friction resistant steel. Since, for reasons which will appear later, it is desirable to use less wear-resistant materials in sleeve 2, I prefer to fit friction resistant steel bushing 7 over a part of sleeve 2 in order to provide a wear-resistant surface for engagement with the surface of boss 5 or bushing 19, as will be apparent upon examining Fig. 5. The friction resistant sleeve is non-rotatable on sleeve 2 and may be affixed to sleeve 2 by swaging, press fitting, heat

shrinking or similar well known procedures. The device should be provided with a wear-resistant inner friction surface whether or not a friction bushing equivalent to bushing 7 is supplied. The inner friction surface bears against an outer friction surface such as the surface of boss 5 or an outer friction bushing 19 in the boss. The bushing may be made of common wear-resistant materials but is preferably bronze or still more preferably an oil-saturated bronze bearing metal which is self-lubricating when used in frictional contact with steel. The boss itself may be made of suitable frictional material without requiring a bushing but it is preferred to connect a bushing to the boss and construct the boss of a light material having relatively inferior wear-resisting characteristics. While it is not entirely necessary I prefer to embody a split-ring design in which the boss is provided with outer friction bushing 19 which is split longitudinally as shown in Fig. 4. Boss 5 is positioned around the outer surface of bushing 19 and these two members are non-rotatably connected by means of set screw 14 as shown in Figs. 1 and 2. Boss 5 is preferably split and provided with a pair of cylindrical openings at 20 and 21 adapted to receive friction adjusting screw 13. Opening 20 is internally threaded in conformance with the threads of friction adjusting screw 13 so a tightening of the adjusting screw brings the split members of the boss toward each other thereby decreasing the diameter of the boss surface and the diameter of the outer friction bushing and increasing the frictional drag between inner friction bushing 7 and outer friction bushing 19. It is apparent that this frictional drag can be regulated by turning adjusting screw 13 an appropriate amount in either desired direction, since the natural elasticity of the boss and the outer friction bushing returns them to their initial positions when adjusting screw 13 is loosened. Arm 4 extends upwardly from friction adjusting boss 5 and is attached to upper limb member 22 by means of plate 3 and screw 36 as shown particularly in Figs. 1 and 2. Extending downwardly from the main sleeve 2 and integral therewith is an arm 10, which is attached by means of attaching plate 11 and reinforcing shin plate 18 by screws 37 and 38 to the lower limb member 23. Kicker spring 1 contacts and bears against lower arm 10 at 24 and is also connected at 40 to projection 39 of clamping member 5 which in turn is integral with upper arm 4. It is therefore apparent that a tension is accumulated in kicker spring 1 as the knee is bent, since the end of the spring contacting arm 10 at 24 moves in accordance with the motion of the lower limb while the other end of the spring does not move. The body of kicker spring 1 is positioned around main sleeve 2 which is fixedly attached to arm 10 or integral therewith and is free to move with respect to knee bolt 6.

At the end of the backward swing of the leg, the weight of the body bears down on the limb and the wearer of the prosthesis exerts a forward force through his thigh and the muscles of the remaining portion of his natural leg thereby bending the knee. The motions of the individual members of the mechanism will be understood more readily by comparing their respective positions in Figs. 2 and 3. The force exerted by the spring is opposed by the force of the floor, ground, or other supporting surface against which the foot bears as long as the wearer's body weight is bearing down on the limb and the lower leg is accordingly prevented from kicking forward. At

the beginning of the forward swing, the wearer merely lifts the limb slightly in a natural walking motion, thus removing the resistive force exerted by the floor against the foot. The internal tension of the kicker spring is transmitted through point 24, stop plate arm 10 and plate 11 to the lower limb and immediately forces the lower limb to move forward around the knee bolt as a pivot. The action of the kicker spring thus induces a controlled kicking motion similar to the motion of a natural leg in performing a walking step.

Since the force exerted by the spring may be considerable, the lower limb tends to move forward rapidly and if this forward swing were not controlled, the wearer of the artificial limb would be obliged to take long ungainly steps because of the unimpeded forward swing of the lower part of the leg. For this reason the cooperating stop plate-bumper pad elements as shown particularly in Fig. 2 are incorporated in the inventive device. Stop plate 9 is positioned on stop-plate arm 10 while bumper pad 15 is fixedly attached by glueing or other affixing means to upper limb 22 as shown particularly in Fig. 2. The stop-plate and bumper pad cooperate to prevent the lower leg member from swinging forward beyond the straightened position of the entire leg and are mounted in such relation that the unbending of the knee joint brings them closer together as the forward swing progresses with resultant contact at the point where the knee is entirely straightened. The stop-plate bears against the bumper pad which is made of felt, sponge rubber or other yieldable material with a resultant smooth firm stop of the unbending motion.

While a kicker spring is described herein as an actuator in my device, it will be apparent that various resilient means urging the relative pivotal movement of the artificial limbs are equivalent thereto and it may generally be stated that other means for storing potential energy and releasing this stored energy at a later time are equivalent to a kicker spring and are effective limb actuators in the device of my invention.

In my experimental work I have found that the desired actuating force should vary in a substantially inverse relation with the desired speed of walking. When the person wearing the device walks quite rapidly, his natural motion is accompanied by a considerable bending at the knees. The increased knee angle produces a relatively powerful tension in the kicker spring which if unimpeded at the beginning of the forward swing of the leg would snap the lower leg suddenly forward and force the entire leg far out in front of the wearer's body causing appreciable discomfort and fatigue. While this difficulty could be overcome by inserting a kicker spring of different size in the knee mechanism for each different walking speed desired, such a measure would be relatively costly and considerable delay might be encountered in changing springs. Accordingly, the artificial knee mechanism of this invention is provided with a friction control unit as described herein. By taking up on friction adjusting screw 13 the frictional force between bushings 7 and 19 is increased thereby establishing an increased resistive force to oppose the force exerted by kicker spring 1 on the lower limb and lessen the rapidity of the forward kick. On the other hand, when the wearer of the device desires to walk slowly, the artificial knee bends relatively slightly and a lesser tension is built up in the kicker spring. Since the forward thrust of the spring

against the lower limb member is relatively small it should be opposed by a similarly reduced frictional force and this is attained with convenience by loosening adjusting screw 13 which is positioned at the back of the knee for ready accession through slot 25 as shown in Fig. 3. The friction adjustment can thereby be varied several times a day in accordance with the desires of the wearer.

Rectangular slots are provided in leg members 22 and 23 as indicated at 25 in Figs. 1 and 3 in order to provide a free space for the movement of arm 10 when the knee is bent and to facilitate the insertion and removal of the entire knee mechanism or of some of its parts. A preferred embodiment of my invention accordingly comprises connecting arm 4 to the rear of the upper limb while arm 10 is attached at the front of the lower limb since a ready access to the hollow knee space is supplied. This arrangement has also been found to contribute stability while the limb is in motion. The easy removal of broken parts, or units in need of adjustment, similarly results from the fact that the main members of my inventive device are not attached permanently to either the upper limb or the lower limb. It is seen for example that the entire knee mechanism is easily and rapidly replaced as a unit by removing the knee bolt, bolts 37 and 38 at shin plate 18, and screw 36 which is in threaded engagement with attaching plate 3. Moreover the individual parts of the mechanism itself are easily replaced as a result of the novel construction of the device.

The particular coiled spring knee device as shown in the appended drawings has been found to exert a relatively uniform force on the lower limb as compared with other spring-actuated means which have been the subject of experiments. For example, a straight helical spring attached to the front of the upper limb at one end and to the back of the lower limb at the other end has been found to exert a sudden force when the spring is extended with the result that an undesirable sudden kick is attained in the lower leg with attendant discomfort. A sudden force of this sort is not produced by the novel friction-controlled coiled spring knee mechanism of this invention, apparently because a very large force is exerted in a direction perpendicular to the axis of the coiled spring and because a large portion of this force is opposed by the force of the friction members. It may also be pertinent that the initial force of the spring is opposed by a relatively great force proportional to the coefficient of starting friction of the friction surfaces while a diminished spring force is opposed by a relatively lesser force proportional to the coefficient of sliding friction of the friction means. At any rate, wearers of artificial legs actuated by my device are easily able to walk with a natural motion largely as a result of the production of a nearly uniform kicker spring force.

While other structural details are clearly workable, the structure of arm 10 is preferably substantially as shown in Fig. 1 since the vertical alignment of members 11 and 9 and the vertically straight configuration of arm 10 as well as arm 4 in conjunction with the entire unit give a minimum tendency in the arms to break or otherwise fail. This is particularly desirable since a breakage of a key part in less efficiently designed artificial limb devices may disable the wearer for several days while repairs are being made.

Arms 4 and 10 have been constructed of steel

and other well known structural metals but I have found that aluminum and the aluminum alloys appear to be particularly desirable as structural materials in my knee mechanism. They are light and durable and their important property of undergoing considerable bending before breaking is of significance in an artificial limb since a total failure of the knee mechanism would be likely to cause inconvenience, discomfort, or even serious permanent injury to the wearer.

Upon reflection it will be apparent that the device I have shown in the drawings and described in the specification herein is a refined embodiment of my basic invention and I accordingly do not limit my claims to the precise details of the mechanism illustrated in the drawings but intend them to cover my invention in its entirety.

Having thus described my invention, I claim:

1. A knee actuating mechanism comprising an inner sleeve having a friction surface, a stop-plate arm attached to said inner sleeve, a stop-plate attached to said stop-plate arm, a boss having its inner surface in frictional engagement with the outer surface of said inner sleeve, a friction adjusting screw in threaded relation with said boss and adapted to vary the frictional force between said friction surfaces, an arm attached to said boss, and a kicker spring connected to each of said arms.

2. A knee actuating mechanism comprising an inner sleeve having a friction surface, a stop-plate arm attached to said inner sleeve, a stop-plate attached to said stop-plate arm, a longitudinally split outer friction bushing having an inner surface in frictional engagement with the friction surface of said inner sleeve, a longitudinally split boss in non-rotatable connection with said outer friction bushing, a friction adjusting screw in threaded relation with said boss and adapted to vary the frictional force between said friction surfaces, an arm attached to said boss, and a kicker spring connected to each of said arms.

3. A knee actuating mechanism comprising an inner sleeve, an inner friction bushing connected thereto and having its inner surface in non-movable contact with the outer surface of said inner sleeve, a stop-plate arm non-rotatably affixed to said inner sleeve and said inner friction bushing, a stop-plate on said stop-plate arm, an attaching plate on said stop-plate arm, a longitudinally split outer friction bushing having its inner surface in frictional engagement with the outer surface of the inner friction bushing, a split-ring boss in non-rotatable connection with said outer friction bushing and having a projecting arm substantially parallel to the axis of said outer friction bushing, a connecting arm fixedly attached to said split-ring boss, a friction-control screw in threaded engagement with said split-ring boss and adapted to control the frictional force between said inner and outer bushings, and a coiled kicker spring having one end operatively connected to said stopper-plate arm and the other end operatively connected to said projecting arm.

4. In an artificial leg actuating mechanism associated with an upper and lower artificial limb: a knee bolt, a transverse inner sleeve rotatably mounted thereon, a stop-plate arm attached to said inner sleeve and to an artificial limb member, a stop-plate attached to said stop-plate arm, an attaching plate affixed to the other

artificial limb member, an arm affixed to said attaching plate, a split boss attached to said arm, a split outer friction tube attached to said boss and having its inner surface in frictional engagement with the outer surface of said inner sleeve, and a kicker spring connected to each of said arms.

5. Claim 4 in which a friction adjusting screw is in threaded relation with said boss and adapted to vary the frictional force between the outer friction tube and the inner sleeve.

6. In a mechanism for providing forward impetus to the lower member of an artificial leg having an upper and lower limb section: a plurality of knee bolt straps connected to said lower limb section, a knee bolt positioned therethrough, a metallic inner sleeve slidably mounted on said knee bolt and having its inner surface in contact therewith, an inner friction bushing non-rotatably mounted on the outer surface of said inner sleeve, a stopper plate arm non-rotatably affixed to said inner sleeve and said inner friction bushing, a stopper plate on said stopper plate arm, an attaching plate on said stopper plate arm and attached to said lower leg member, an outer friction bushing having its inner surface in frictional engagement with the outer surface of the inner friction bushing, a split-ring boss having a projecting arm substantially parallel to the axis of the knee bolt, said split-ring boss being non-rotatably connected to said outer friction bushing, a connecting arm fixedly attached to said split-ring boss and to the upper artificial limb, a friction-control screw in threaded engagement with said split-ring boss and adapted to control the frictional force between said inner and outer bushings, and a coiled kicker spring having one end operatively connected to said stopper plate arm and the other end operatively connected to the projecting arm of said split-ring boss.

7. An artificial limb actuating mechanism for actuation of artificial limbs such as thigh and lower leg members, comprising a knee bolt pivotally connecting the limbs together, opposed frictionally engaged members on said knee bolt including an inner friction piece constructed for operative attachment to one of said artificial limbs and an outer sleeve constructed for operative attachment to the other artificial limb, said outer sleeve being positioned around and in frictionally slidable contact with said inner friction piece, a resilient limb actuator embodied in the limb structure and constructed for operative connection to each of said limbs, said limb actuator also being constructed and effective to actuate relative movement of said limbs about said knee bolt and corresponding movement of the outer sleeve relative to the inner friction piece, and a friction control element in the form of an adjustable brake control supported by said knee bolt connected to one of said frictionally engaged members, said adjustable brake control having capacity to provide variable frictional resistance between said outer sleeve and said inner friction piece, thereby varying the extent of effective action of the resilient limb actuator on the limbs.

8. An artificial limb actuating mechanism for actuation of artificial limbs such as thigh and lower leg members, comprising a knee bolt pivotally connecting the leg members together, a friction piece constructed for operative attachment to one of said artificial limbs, a split sleeve in frictionally slidable contact with said friction piece and constructed for operative attachment to the other artificial limb, an adjustable clamp member connected to the split sleeve to adjust the split sleeve dimensionally relative to the friction piece, thereby regulating the frictional resistance between said sleeve and said friction piece, and a resilient limb actuator in the form of a kicker spring operatively connected to each of said limbs, said limb actuator being constructed and effective to actuate relative movement of said limbs and movement of said split sleeve relative to said friction piece.

9. An artificial limb actuating mechanism for artificial thigh and lower leg elements pivotally connected at the knee, comprising an inner sleeve mounted in the knee portion of the artificial leg, an outer sleeve frictionally interfitted with said inner sleeve, arm means for connecting each sleeve to an artificial leg element, an adjustable friction control brake on said outer sleeve, said brake serving to vary the frictional resistance between said outer sleeve and said inner sleeve, and a kicker spring operatively connected to actuate said artificial leg elements and said inner sleeve and outer sleeve, for relative pivotal movement.

10. In an artificial limb mechanism associated with artificial limbs in the form of a thigh and lower leg moveable relative to each other, an inner friction sleeve mounted in the knee portion of the artificial leg, an outer friction sleeve in frictional contact to form a brake with said inner sleeve, an arm for attaching said inner sleeve to one of the artificial limbs, another arm for attaching said outer sleeve to the other artificial limb, a kicker spring operatively engaged with each of said arms to actuate relative motion of said limbs and said inner and outer sleeves, an adjustable friction control element in the form of a brake control effective to vary the frictional resistance between said inner and outer sleeves, a stop on one of said arms and a bumper positioned on an artificial limb to contact said stop thereby limiting the extent of movement of one artificial limb relative to the other.

11. A knee actuating mechanism for use in pivotally joined artificial legs having a support mounted in the leg joint, comprising an inner sleeve adapted to be mounted on said support, an arm attached to said inner sleeve, means for attaching said arm to one of the artificial legs, an outer sleeve in friction contact with the inner sleeve, a second arm attached to said outer sleeve, means for attaching said second arm to the other of the artificial legs, friction adjusting means in the form of an adjustable clamp for controlling the degree of friction between the outer and inner sleeves, and a kicker spring yieldably connected to each of said arms.

BASIL PETERS.

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