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# Limb Prosthesis

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**Latour, Jr. et al.**

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(54) **LIMB PROSTHESIS**

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- (73) Assignee: **Clemson University**, Clemson, SC (US)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 38 days.

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- (22) Filed: **Sep. 21, 2011**

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- (51) **Int. Cl.**  
*A61F 5/01* (2006.01)  
*A61H 3/00* (2006.01)
- (52) **U.S. Cl.**  
USPC ..... **623/32; 623/27; 623/39; 135/65**
- (58) **Field of Classification Search**  
USPC ..... **623/29, 32; 135/65, 68; 602/3**  
See application file for complete search history.

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*Primary Examiner* — David Isabella

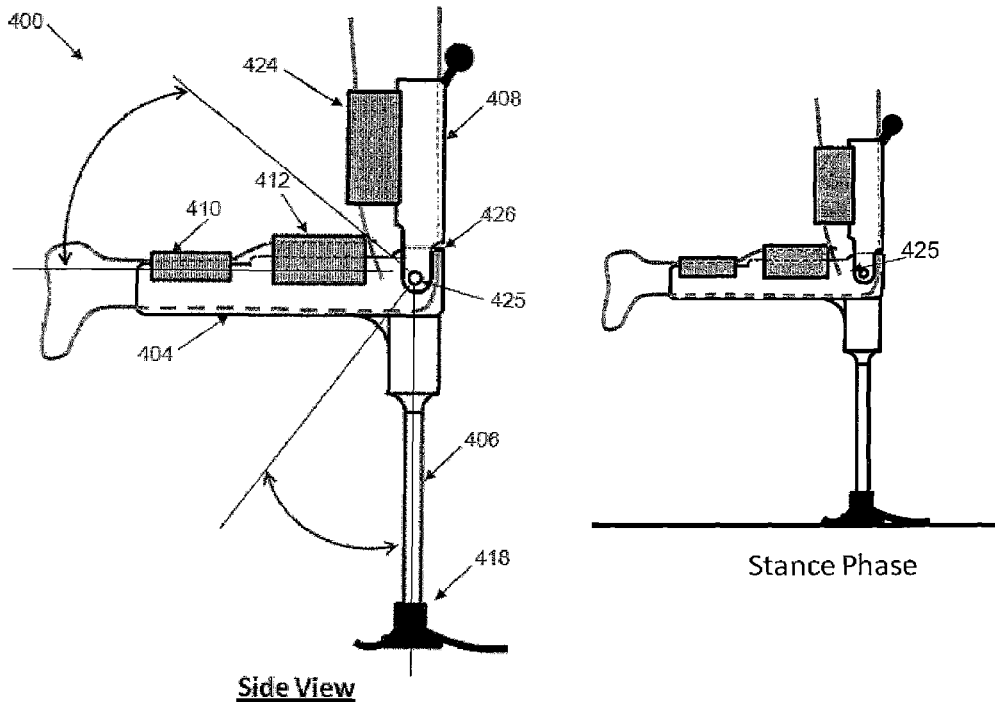
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(57) **ABSTRACT**

Disclosed are limb prostheses for use when normal use of the lower leg is temporarily or permanently lost due to lower leg injury or disease, including below-knee amputation. Disclosed prostheses provide full body weight support and allow a wearer to maintain the use of the hands and arms during ambulation. In addition, a wearer can maintain use of their own knee to flex and extend during ambulation, thereby better controlling the prosthesis during motion and providing a more normal gait as compared to previously known devices. In the event of permanent loss of the lower leg due to below-knee amputation, the disclosed prosthesis provides an alternative to socket-type prosthetic devices.

**12 Claims, 9 Drawing Sheets**



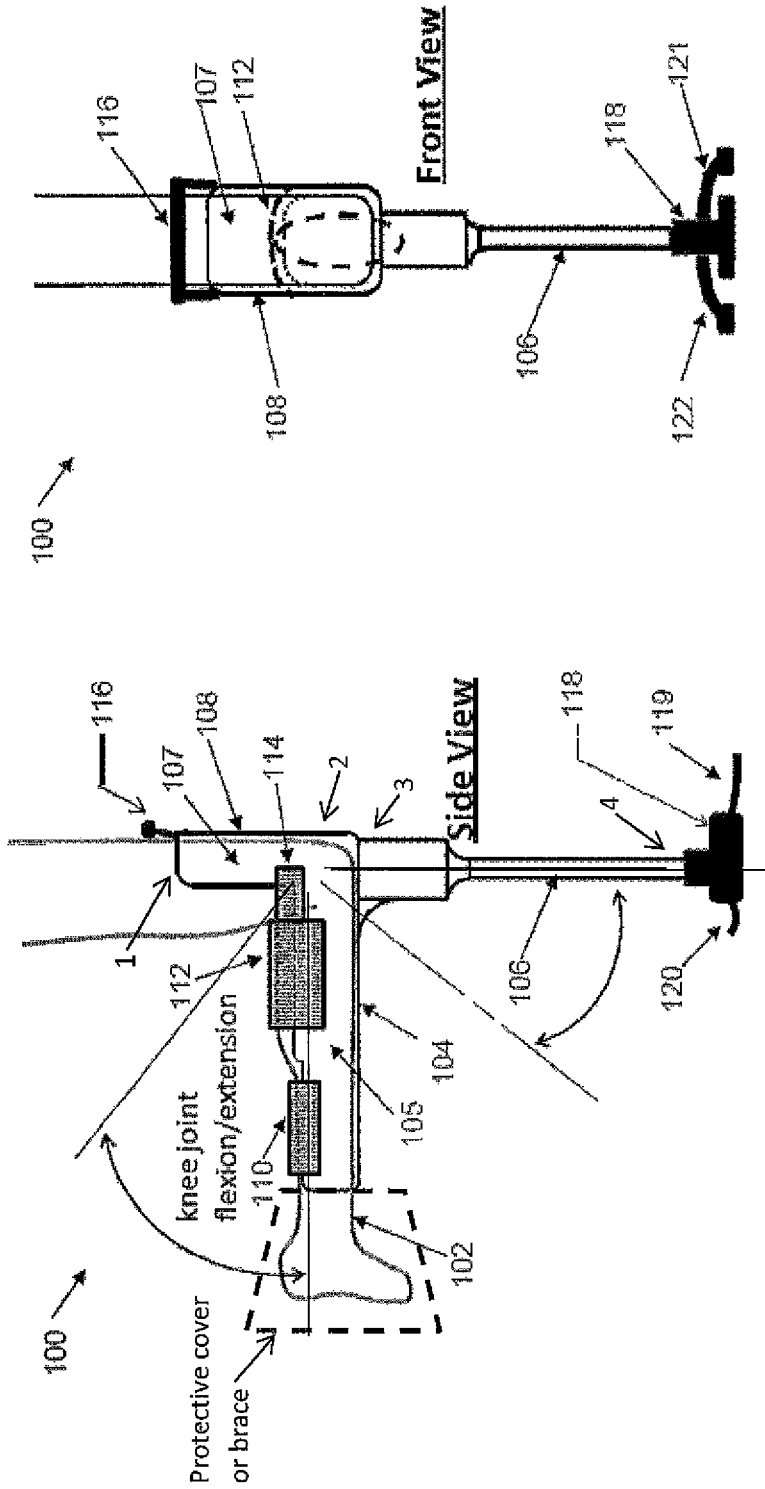


FIG. 1B

FIG. 1A

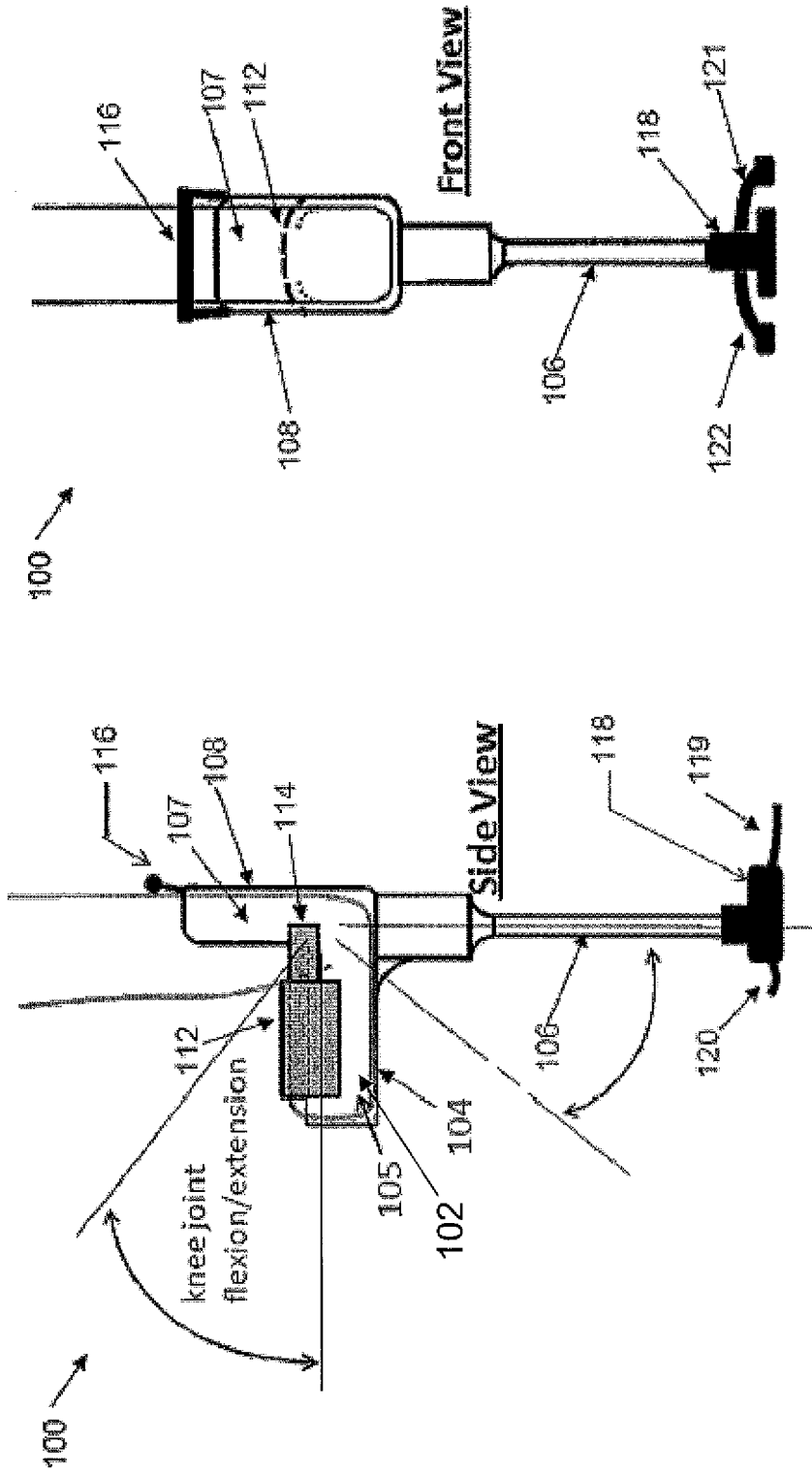


FIG. 1D

FIG. 1C

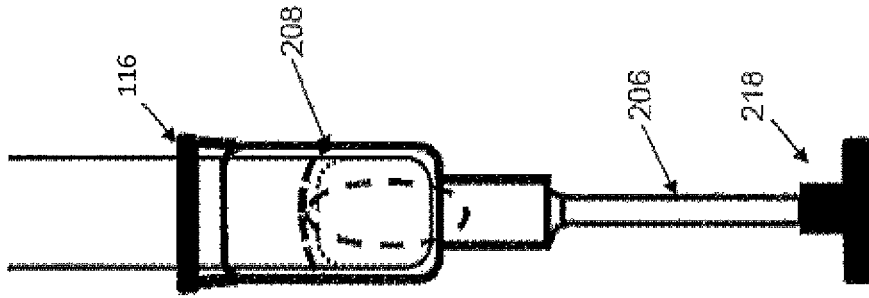


FIG. 2B

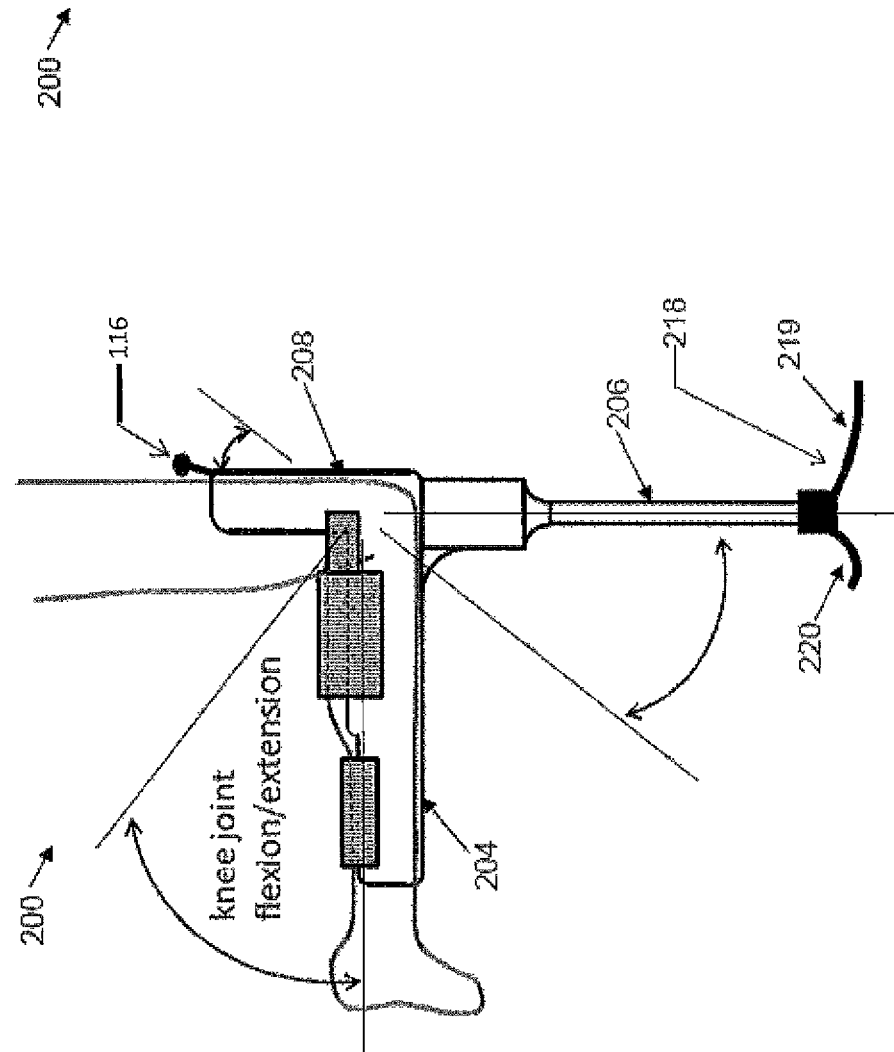


FIG. 2A

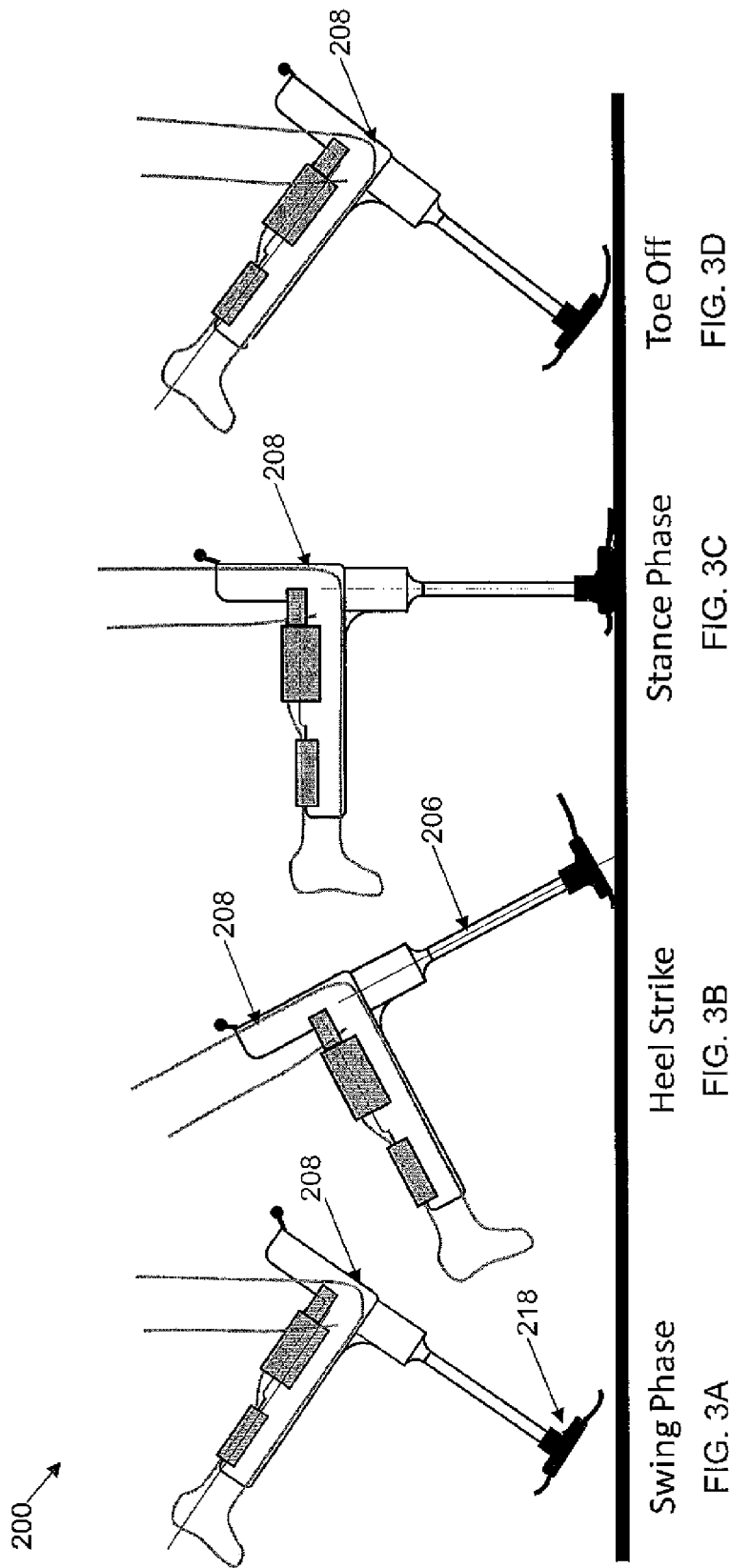
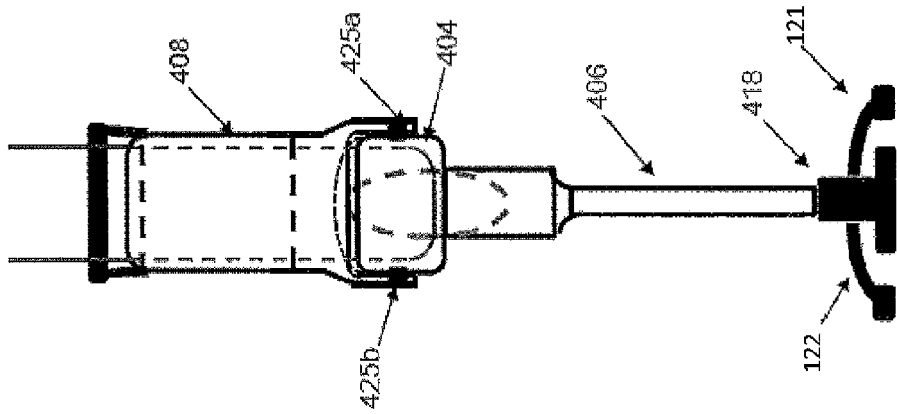
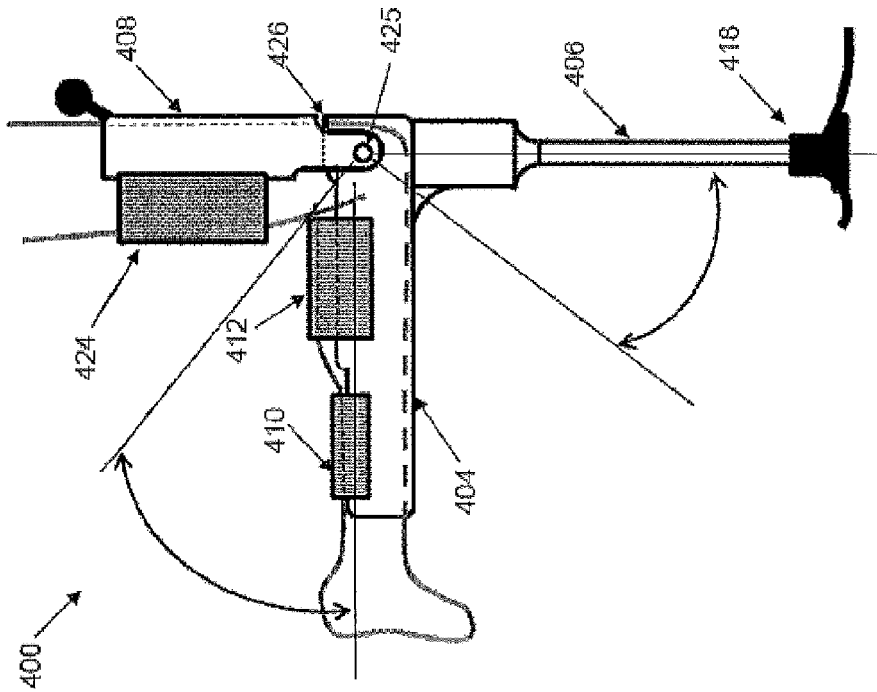


FIG. 3



Front View  
FIG. 4B



Side View  
FIG. 4A

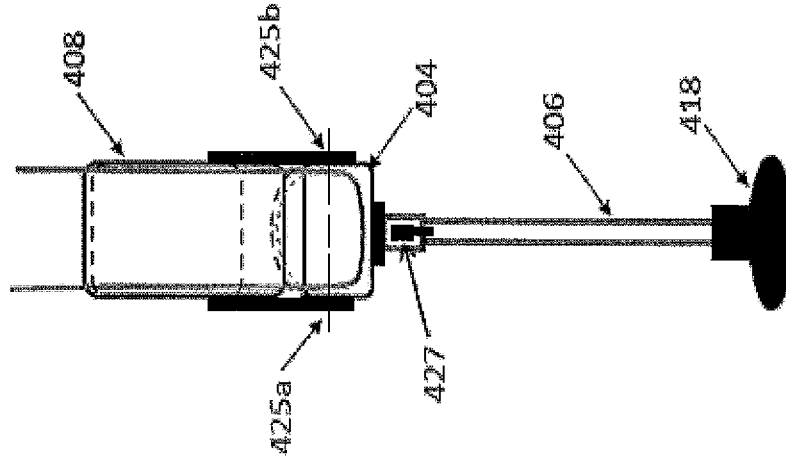


FIG. 4D

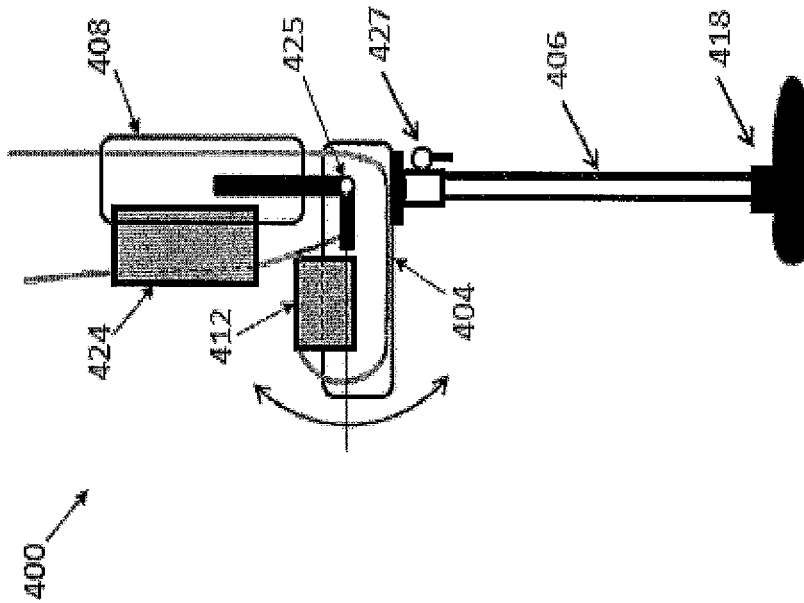


FIG. 4C



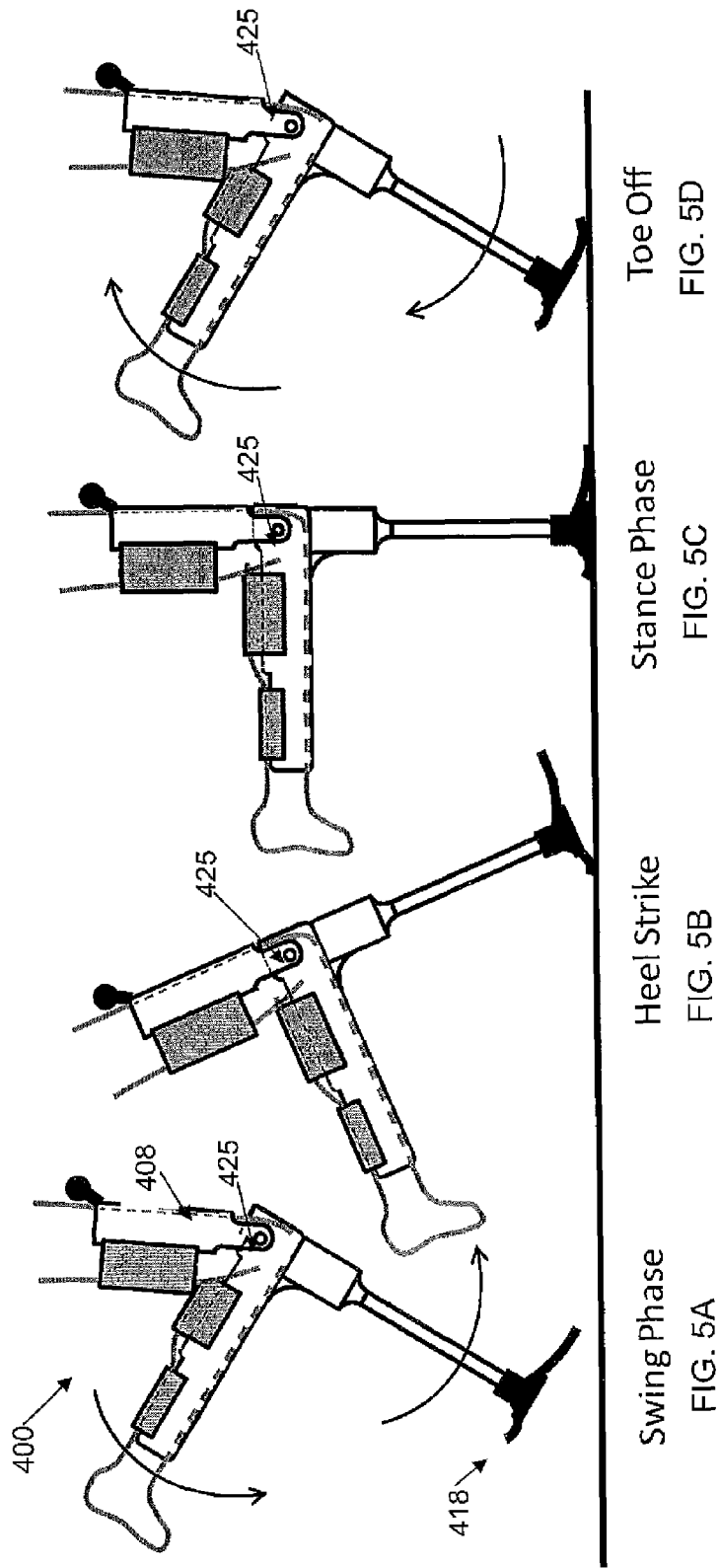


FIG. 5

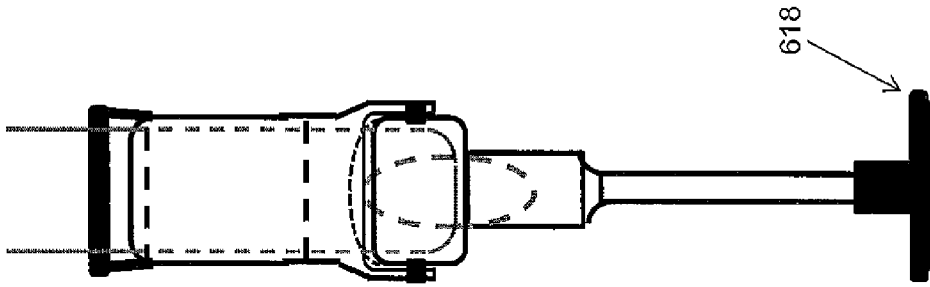


FIG. 6B

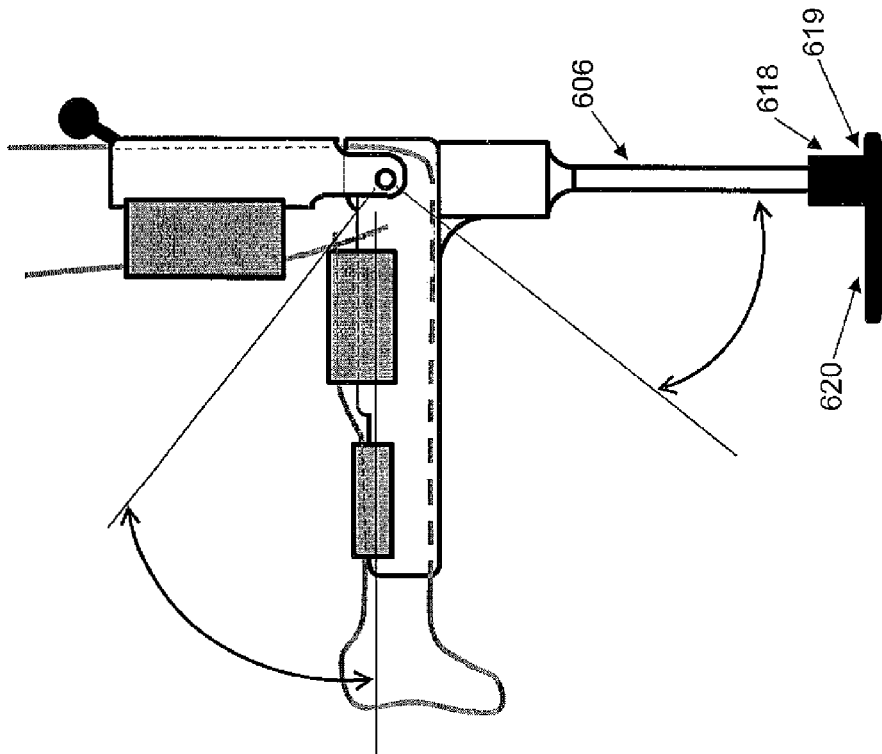
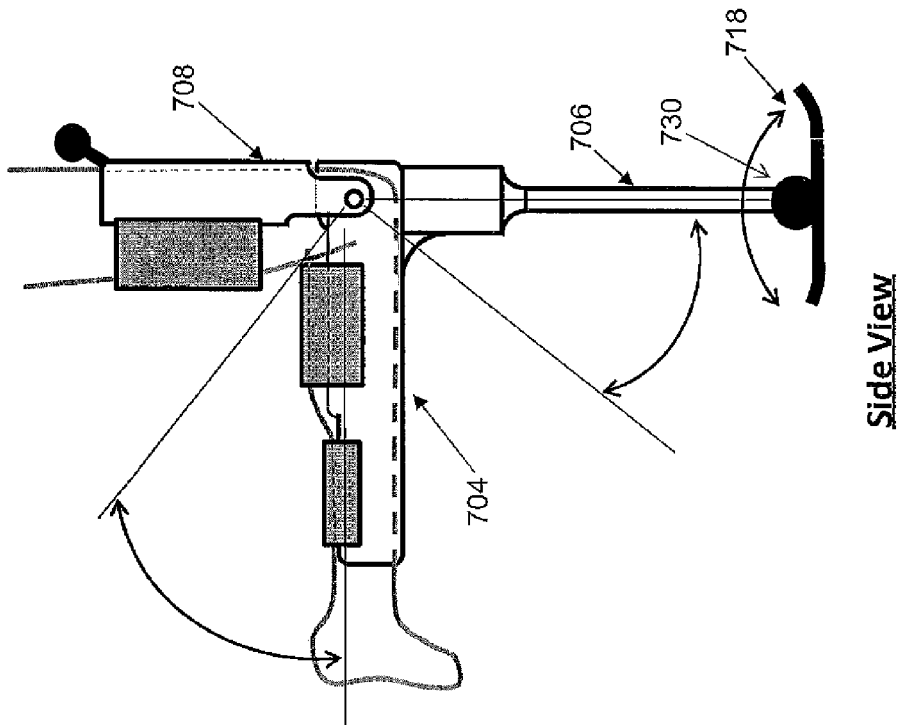
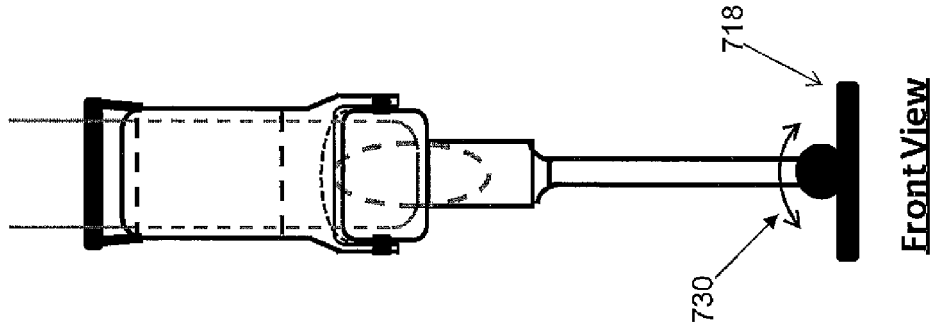


FIG. 6A



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**LIMB PROSTHESIS****CROSS REFERENCE TO RELATED APPLICATION**

This Application claims filing benefit of U.S. Provisional Patent Application Ser. No. 61/385,756 having a filing date of Sep. 23, 2010, and U.S. Provisional Patent Application Ser. No. 61/388,918, having a filing date of Oct. 1, 2010, both of which are incorporated herein by reference.

**BACKGROUND OF THE INVENTION**

Injury or disease leading to the loss of the use of the lower leg, including soft tissue and bone injury or disease, occur every day and lead to ambulation difficulties for the sufferer. Often, the damage is such that an individual should keep weight and pressure off of the injured limb for several weeks or months. In cases of severe injury or disease (such as diabetes), below-knee amputation may be necessary, in which case the use of the lower limb is permanently lost. Most individuals are able to utilize crutches during the period of rehabilitation, but use of crutches requires a basic level of upper body strength and the contact points between the crutch and the user can develop skin irritation and pain due to pressure. Moreover, a person who also suffers arm or shoulder weakness may need to utilize a wheelchair during rehabilitation.

In the case of below-knee amputation, patients who are not able to comfortably use or afford a socket-type prosthesis permanently need an alternative means of assistance for ambulation. Alternatively, patients who use a socket-type prosthesis may encounter situations when a socket-based prosthesis cannot be worn, such as for a period of time following amputation surgery while the residual limb is healing from the surgery, or when the use of a socket-type prosthesis must be discontinued to provide time to heal from socket-induced pressure sores and/or irritation.

Crutches and wheelchairs both present difficulties for users in navigating doorways, steps, slopes, getting in and out of automobiles, and the like. Crutches also present difficulties due to the loss of the use of the hands and arms, making the carrying of items and other basic functions quite difficult.

Crutchless ambulation devices have been proposed. For instance, U.S. Pat. Nos. 7,303,537, 6,494,919, 6,799,592, 7,600,524, and U.S. Patent Application Publication No. 2007/0251560 describe devices that may be coupled to an individual's leg with the leg held in a flexed position, so as to provide arm free ambulation and support for the injured limb. Unfortunately, such devices prevent any flexion and extension of the knee, leading to an awkward gait for anyone utilizing the devices.

What are needed in the art are limb prostheses for people suffering a lower leg injury or disease that provides for a more natural walking motion. More specifically, what is needed in the art is a limb prosthesis that allows the wearer to use the motion of their own knee to control their motion and maintain the freedom of the arms and hands of the user.

**SUMMARY OF THE INVENTION**

According to one embodiment, disclosed is a prosthetic device for a lower limb. For instance, the prosthetic device can include an upper portion, a lower leg support, a lower portion, and a prosthetic foot.

The upper portion can have a top **1** and a base **2** that is opposite the top of the upper portion along a longitudinal

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length of the upper portion. In addition, the upper portion can be free of any attachments for securing the thigh of a wearer to the upper portion.

The lower leg support can extend from the base **2** of the upper portion and can include a proximal end and a distal end, the distal end being opposite the proximal end along a longitudinal length of the lower leg support, and the proximal end being closer to the upper portion than the distal end. The lower leg support can include one or more attachments for securing the lower leg of a wearer to the lower leg support.

The lower portion can extend from the base **2** of the upper portion and can include a top **3** and a base **4** that is opposite the top **3** of the lower portion along a longitudinal length of the lower portion.

The prosthetic foot can be located at the base **4** of the lower portion.

According to another embodiment, disclosed is a prosthetic device that includes an upper portion, a lower leg support, a lower portion, and a prosthetic foot. In this embodiment, the upper portion can include one or more attachments for securing the thigh of a wearer to the upper portion. In addition to the other features, this embodiment of a prosthetic device can include a hinge between the upper portion and the lower leg support, the hinge allowing the upper portion and the lower leg support to flex and extend with respect to one another.

**BRIEF DESCRIPTION OF THE DRAWINGS**

A full and enabling disclosure of the present invention, including the best mode thereof, to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying figures, in which:

FIG. 1A is a side view of one embodiment of a limb prosthesis as disclosed herein for use by a patient with an intact lower limb.

FIG. 1B is a front view of the limb prosthesis of FIG. 1A.

FIG. 1C is a side view of one embodiment of a limb prosthesis as disclosed herein for use by a patient with a below-knee amputation.

FIG. 1D is a front view of the limb prosthesis of FIG. 10.

FIG. 2A is a side view of another embodiment of a limb prosthesis as disclosed herein.

FIG. 2B is a front view of the limb prosthesis of FIG. 2A.

FIGS. 3A-3D illustrate each phase of a complete step taken utilizing the limb prosthesis of FIG. 2A.

FIG. 4A is a side view of another embodiment of a limb prosthesis as disclosed herein for use by a patient with an intact lower limb.

FIG. 4B is a front view of the limb prosthesis of FIG. 4A.

FIG. 4C is a side view of one embodiment of a limb prosthesis for use by a patient with a below-knee amputation.

FIG. 4D is a front view of the limb prosthesis of FIG. 4C.

FIGS. 5A-5D illustrate each phase of a complete step taken utilizing the limb prosthesis of FIG. 4.

FIG. 6A is a side view of another embodiment of a limb prosthesis as disclosed herein.

FIG. 6B is a front view of the limb prosthesis of FIG. 6A.

FIG. 7A is a side view of another embodiment of a limb prosthesis as disclosed herein.

FIG. 7B is a front view of the limb prosthesis of FIG. 7A.

Repeat use of reference characters in the present specification and drawings is intended to represent the same or analogous features or elements of the present invention.

### DETAILED DESCRIPTION OF REPRESENTATIVE EMBODIMENTS

Reference will now be made in detail to various embodiments of the invention, one or more examples of which are set forth below. Each embodiment is provided by way of explanation of the invention, not limitation of the invention. In fact, it will be apparent to those skilled in the art that various modifications and variations may be made in the present invention without departing from the scope or spirit of the invention. For instance, features illustrated or described as part of one embodiment, may be used in another embodiment to yield a still further embodiment.

Disclosed herein are limb prostheses for use due to a lower leg injury, amputation, or disease. The limb prostheses can be utilized temporarily, for instance during rehabilitation, or can be used permanently, as in the case of amputation. Disclosed prostheses provide full body weight support and allow a wearer to maintain the use of their hands and arms. In addition, a wearer can maintain use of his/her own knee to flex and extend during ambulation, thereby better controlling the prosthesis during motion and providing a more normal gait as compared to previously known devices.

FIGS. 1A-1D present side and front views of one embodiment of a limb prosthesis **100**. As can be seen, a wearer's lower leg **102** can be supported by prosthesis **100**. As shown in FIGS. 1A and 1B, prosthesis **100** can be used during rehabilitation of an injury to the lower leg **102** including both soft tissue and bone injuries during which a patient wishes to ambulate without bearing body weight on the injured lower leg, ankle, or foot. Exemplary injuries include fractures of the foot or ankle (e.g., talus or calcaneus fractures) and/or the distal tibia (e.g., pilon fracture) as well as injuries to ligaments, tendons or muscles, wounds to the foot or toes (e.g., lacerations or surgical wounds), and so forth. As shown in FIGS. 1C and 1D, prosthesis **100** can be used as an alternative to a socket-type lower-leg prosthesis in the event of below-knee amputation.

In one embodiment, a limb prosthesis can be utilized temporarily following a lower leg amputation surgery, for instance prior to complete healing of an amputation site. The limb prosthesis could provide a route for a patient to become ambulatory prior to healing of the amputation site to the point of supporting a standard prosthesis, a healing process that can take several months. Following complete healing of the amputation site, portions of the limb prosthesis, for instance, lower portion **106** and/or prosthetic foot **118** could be used again in a more permanent prosthetic limb for the patient.

In one embodiment, the limb prosthesis can be used as a permanent ambulation device for individuals with a below-knee amputation, or used as a secondary means of ambulation when an individual has reason to not use a more traditional socket-type prosthesis, such as during healing due to socket-related pressure sores or other forms of irritation.

Prosthesis **100** includes lower leg support **104**, upper portion **108** and lower portion **106**. Lower leg support **104** can be formed to comfortably fit and hold a length of the lower leg of a wearer. Lower leg support **104** can be of a unitary construction that is sized to fit a wide range of different sized legs, e.g., small, medium, large. Alternatively, lower leg support **104** can be adjustable to provide a more specific sizing capability. For instance, lower leg support can include multiple interconnected components that allow the length of lower leg support **104** (e.g., the distance generally corresponding to the distance from the knee of a wearer to the distal end of the lower leg support **104** near or at the ankle of a wearer or the end of the residual limb in the case of amputation) to be adjusted. Like-

wise, the cross sectional shape of lower leg support **104** (shown in FIG. 1B, discussed further below) can be adjustable to provide a personalized fit around the calf/leg section of a wearer. In addition, the cross sectional shape of lower leg support **104** can vary along the length of the support. For instance, lower leg support **104** can be tapered so as to be wider at the calf section of the support and narrower at the ankle section of the support.

Lower leg support **104** can include an outer shell **105**. Outer shell **105** can be formed of a material such as a moldable plastic or metal, so as to partially encircle a portion of the wearer's lower leg. Lower leg support **104** can also include a material adjacent to the outer shell **105** that will contact the leg of the wearer that can provide improved fit and comfort to a wearer. For instance, inside outer shell **105** of lower leg support **104**, a device can include a foam or other cushioning material that can contact and hold the lower leg of a wearer. A contacting material at the inner surface of lower leg support **104** can be moldable so as to more specifically fit the shape of the leg of the wearer, further improving comfort and fit of the prosthetic **100**.

In FIG. 1A, the foot of the wearer extends out from the distal end of lower leg support **104**. In another embodiment, additional protection can be provided to the ankle and/or foot through inclusion of a protective cover or brace for the wearer. For example, lower leg support **104** can extend and be shaped so as to provide protection to the ankle and/or foot. Alternatively, a prosthetic **100** can include a releasably attachable ankle/foot brace or cover. For instance, an ankle/foot brace can snap or otherwise attach to the distal end of the lower leg support **104**. When considering use by patients with a below-knee amputation, additional protection could be provided for the distal end of the residual limb.

Lower leg support **104** also includes attachments **110**, **112**, **114** for securing the leg of a wearer to the prosthesis **100**. Attachments can be adjustable to accommodate a wearer of various leg sizes. For example, attachments **110**, **112**, **114** can include straps or belts of any convenient width that can wrap the posterior of the lower leg, as shown.

Attachments **110**, **112** can be of any suitable size, shape, and number so as to secure the lower leg of a wearer to the lower leg support **104**. For example, one, two, three or more individual attachments can be utilized. An attachment **110**, **112**, can be, for instance, a strap having a width between about 1 and about 9 inches. In one embodiment, a single attachment can overlay a section of the posterior of the lower leg and can secure the lower leg of a wearer to the lower leg support **104**. An attachment can use any suitable closure, such as hook and loop style closures, snaps, buckles, ties, clips, etc. as are generally known in the art. An attachment can be a single piece that extends from a first outer edge of the supportive shell **105** of lower leg support **104** and releasably attaches to the opposite outer edge of the supportive shell. Alternatively, an attachment can be a two piece attachment including a first and second section that are affixed to opposite outer edges of the supportive shell **105** and that can be releasably attached to one another, for instance with an adjustable belt clip closure or via a hook and loop type closure.

Attachment **114** is an optional attachment that secures the leg of a wearer to the upper portion **108** of device **100**. When included, attachment **114** can be of similar type to attachments **110**, **112**. However, attachment **114** will not prevent the flexion of the knee of the wearer. Accordingly, attachment **114** will not extend up the posterior of the wearer's leg to any great length and will not be excessively tight.

Upper portion **108** of prosthesis **100** can be formed of a similar material as lower leg support **104**. For instance, upper

portion **108** can include an outer shell **107** and an inner cushioning material to improve comfort of the device. Additionally, the curvature of upper portion **108** can be fixed or adjustable, as described previously for lower leg support **104**. In the embodiment of FIG. 1, upper portion **108** and lower leg support **104** are fixed at an angle of approximately 90° to one another.

Upper portion **108** can partially wrap the thigh of a wearer when standing so as to provide improved stability. Additionally, upper portion can be adjustable in length, so as to extend to any desired height on the thigh of the wearer.

Upper portion **108** may also include a handle **116** that can be located at the front of the device, as shown, or alternatively on either side of the device. Handle **116** can be permanently or removably attached to device **100**, and can provide the wearer with additional control during use. For instance, a wearer can use the handle **116** to help in lifting the device, for instance when climbing stairs, or to use the device as a crutch or cane for short distances when the lower leg is not secured to the lower leg support **104** with the attachments **110**, **112**. A handle **116** can include a formed grip that can be formed of a material such as a metal, ceramic, rubber, a silicone, or a molded thermoset or thermoplastic polymer.

Also included in prosthesis **100** is lower portion **106**. Lower portion **106** can be formed of any material that can provide the necessary strength and support to the device. For instance, lower portion **106** can include a reinforced plastic, steel, aluminum, or other metal post that can support the full weight of the wearer during ambulation. Lower portion **106** can generally be adjustable, so as to be properly fitted to the height of the wearer. For instance, a steel shaft of lower portion **106** can include an inner and outer portion that can be moved up and down with relation to one another and can be fixed at a desired height, for instance with a bolt, pin, screw threads, or the like.

At the base of lower portion **106** is a prosthetic foot **118**. Prosthetic foot **118** can be similar to known designs of prosthetic feet that are often used for below-the-knee amputee prosthetics. For instance, a prosthetic foot can be hinged or fixed at the ankle, and can generally include a material that will contact the walking surface (e.g., the floor or the ground) that can prevent excessive slippage of the wearer during use, or be covered by a shoe. By way of example, the prosthetic foot **118** can include a natural or synthetic rubber on at least a portion of the base of the prosthetic foot **118**.

In one embodiment, prosthetic foot **118** can include a front section **119** and a rear section **120** that can provide shock absorption capability, such as leaf springs, as are generally known in the art. For instance prosthetic foot **118** can simulate both ankle and foot motion at the heel strike and toe-off phases of the gait.

FIG. 1B is a front view of the prosthesis **100** of FIG. 1A. As can be seen, prosthetic foot **118** can include extensions **121**, **122**, that can provide a broad, self-standing base to the prosthetic foot. Extensions **121**, **122** can prevent instability in the foot **118** due to rotation about the long axis of the lower leg support **104**. For instance, extensions **121**, **122**, can extend about two inches or more beyond the width of upper portion **108** to improve side-to-side stability of the prosthetic. Extensions **121**, **122** can be permanently affixed to prosthetic foot **118**, or can be detachable or retractable, as desired. Optionally, extensions can be adjustable. For instance, extensions **121**, **122** can be adjusted to as to rotate and move the distal end of the extension closer to the toe or heel of the prosthetic foot **118**. Moreover, the extensions can be adjustable with regard to height from the base of the prosthesis. For example, extensions **121**, **122** can rotate upward slightly so as to allow some

side to side rotation of the foot **118**, but prevent excessive rotation and prevent the wearer from falling.

It should be understood that there is no particular limitation to the design of the prosthetic foot **118**. For instance, FIGS. 2A and 2B illustrate side and front views, respectively, of prosthesis **200**. Prosthesis **200** includes a lower leg support **204**, an upper portion **208**, a lower portion **206**, and a foot **218**. In addition prosthesis **200** includes attachments for securing the lower leg of a wearer to the prosthesis **200** while allowing the flexion and extension of the knee of the wearer, as described above for prosthesis **100** of FIGS. 1A and 1B. Specifically, the thigh of a wearer is not attached to upper portion **208** so as to prevent the wearer's knee from flexing.

Foot **218** of prosthesis **200** includes front section **219** and rear section **220** that allow some flexibility of the foot **218**. For instance, front section **219** and rear section **220** can be leaf springs. As seen in FIG. 2B, prosthesis **200** does not include the side to side extensions as are present in the prosthesis **100** of FIGS. 1A and 1B. Rather, the front section **219** and rear section **220** together are sufficiently wide to provide stability to the prosthesis to help prevent side to side rolling motion of the prosthesis during use.

FIG. 3 illustrates the prosthesis **200** over the course of a single step. In the initial swing phase at FIG. 3A, the wearer's knee is flexed as the prosthetic foot **218** is lifted off of the ground and swung forward by the combined action of the knee and hip joints. The knee of the wearer extends to the point at which the thigh of the wearer strikes the upper portion **208**. At the same time the wearer's hip flexes to pull the entire leg forward to the heel strike position (FIG. 3B). The wearer then moves forward through extension at the hip until the foot is flat on the walking surface at the stance phase (FIG. 3C). Finally, the knee of the wearer flexes again away from the upper portion **208** to the toe off phase of the step (FIG. 3D). Throughout the step, the wearer is able to flex and extend both the hip and the knee, which provides better control and a more natural gait to the step as compared to other devices in which flexing and extending of the knee is either prevented or does not impart extension or flexion motion to the lower-limb segment of the prosthesis. Moreover, the design allows for the use of the wearer's own muscles, e.g., the quadriceps, hamstring, etc. to control the step, leading to improved stability and the retention of muscle mass and function.

FIGS. 4A-4D illustrate another embodiment of a prosthetic limb **400** as disclosed herein, which can be used for patients with either lower leg injuries (FIGS. 4A and 4B) or patients with below-knee amputation (FIGS. 4C and 4D). This embodiment, as with the embodiments discussed above, allows the knee of a wearer to flex and extend during use, so as to provide improved stability and a more natural gait to the wearer.

Prosthetic limb **400** includes attachments **410** and/or **412** for attaching the lower leg of a wearer to Lower leg support **404**. In addition, prosthetic limb **400** includes an attachment **424** that attaches the wearer's upper leg to upper portion **408**. Attachment **424** can include straps, buckles, hook and loop closures, snaps, and the like, as previously described. The attachment of the wearer's upper leg to the upper portion **408** can help prevent side to side rotation around lower leg support **404** of the device during use, thus providing increased stability.

In order to allow the knee of a wearer to flex and extend, prosthetic **400** pivots at a hinge **425** that is located at or near the rotation axis of the knee of the wearer. As shown in FIG. 4B, upper portion **408** and lower leg support **404** can be separate pieces and can be joined with a hinge **425a**, **425b** at either side of the wearer's knee generally coaxial with the

knee's rotational axis. Hinges **425a** and **425b** can be simple pin hinges, as shown, or can have any other suitable design that can allow the upper portion **408** and the lower leg support **404** to pivot with respect to each other, for instance as exemplified by the two types of designs illustrated in FIGS. **4A** and **4C**. The lower leg support **404** can include a stop **426** (FIGS. **4A** and **4B**) that meets upper portion **408** as shown, so as to prevent hyperextension of the prosthetic lower leg compared to the position of the lower leg during normal ambulation. Any suitable mechanism for preventing hyperextension can be utilized, with such mechanism be located on lower leg support **404**, on upper portion **408**, or as a component of hinge **425**.

In one embodiment, the device can be designed without a stop such to allow full extension of the normal knee joint (FIGS. **4C** and **4D**). Additionally, the hinge can be designed to be able to be locked and unlocked by the user at any desired angle, such as  $0^\circ$  (i.e., full knee extension) or  $90^\circ$  (i.e.,  $90^\circ$  knee flexion). For instance, the hinge can include a peg or stop locking mechanism that can be inserted and removed by the user so as to lock the hinge in any desired position.

In one embodiment, the lower portion **406** of the prosthesis can be connected to the lower leg support **404** with a separable connection **427** (FIGS. **4C** and **4D**), which can be, for example, a quick-connect, a pin joint, or the like. Separable connection **427** can allow a user to remove the lower portion **406** from the rest of the device **400**. For instance when a wearer wishes to sit or lay down and wishes to fully extend the leg, removal of the lower portion **406** can be carried out quickly and easily. The lower portion **406** can then be easily reattached to resume ambulation.

As shown in FIGS. **4A** and **4C**, in one embodiment the hinge **425** of prosthesis **400** can be aligned with the center of lower portion **406** to mimic the alignment of the knee and ankle of a leg, so as to better mimic a natural gait during use.

The upper portion **408** and lower leg support **404** can optionally be of uniform construction, provided that the two sections can allow the wearer's knee to flex and extend as described. For instance, the device can include an extendable portion between the upper portion **408** and the lower leg support **404** that can allow the desired flexing of the prosthesis. An extendable portion can be, for example, an elastic segment.

FIG. **5** illustrates the prosthesis **400** over the course of a single step. In the initial swing phase at FIG. **5A**, the wearer's knee is flexed, and the prosthesis **400** is pivoted at the knee hinge **425** as the prosthetic foot **418** is lifted off of the ground while keeping the thigh attached to the upper portion **408** of the prosthesis **400**. The knee of the wearer extends along with the upper portion **408** as the foot swings forward. At the same time the wearer's hip flexes to pull the entire leg forward to the heel strike position (FIG. **5B**). The wearer then moves forward through extension at the hip until the foot is flat on the walking surface at the stance phase (FIG. **5C**). Finally, the knee of the wearer flexes again carrying the upper portion **408** as the hinge **425** pivots to the toe off phase of the step (FIG. **5D**). Throughout the step, the wearer is able to flex and extend both the hip and the knee.

FIGS. **6** and **7** illustrate other embodiments of devices that include prosthetic feet **618**, **718**, as may be utilized in prosthetic devices as described herein. For instance, in the embodiment of FIGS. **6A** and **6B**, the prosthetic foot **618** includes a back section **620** and a front section **619** that are fixed and are rounded somewhat along the base of the foot **618** to improve a wearer's gait. In addition, the back section **620** is relative long, for instance between about 3 inches and about 5 inches as measured from the center of lower portion **606** to

the distal end of the prosthetic foot **618**. Additionally, the front section is somewhat short, for instance between about  $\frac{1}{2}$  inch and about 2 inches, which, when combined with the slightly rounded base, can provide a toe-off rolling motion to a wearer. In addition, as can be seen in FIG. **6B**, prosthetic foot **618** can have a relatively wide side to side base to increase stability of the prosthetic so that it is self-standing when not attached to the leg.

The prosthetic foot **718** illustrated in FIGS. **7A** and **7B** allows for rotation at the joint **730** between lower portion **706** and prosthetic foot **718**. In this embodiment, the joint **730** allows both front to back rotation (FIG. **7A**) and limited side to side rotation (FIG. **7B**), so as to better simulate the range of motion of an ankle. The base of prosthetic foot **718** can also be relatively wide, as shown, to provide stability during use. Prosthetic foot **718** can prove useful on multiple surfaces, for instance on uneven surfaces, due to the ability of the joint **730** to rotate about both the front to back and side-to-side axes. Of course, a prosthetic foot can also be designed to allow rotation about one axis only. For instance, a prosthetic foot can rotate in the front to back (i.e., toe to heel) direction, while preventing rotation in the side to side direction.

It should be understood that any prosthetic foot as is known in the art can be utilized in conjunction with any embodiment of the disclosed prosthetic limbs. For instance, a prosthetic limb as illustrated in FIGS. **4**, **5**, **6**, and **7**, in which the wearer's thigh is attached to the upper portion can include a self-standing prosthetic foot including relatively wide extensions, as present in the embodiment illustrated in FIG. **1**.

While the invention has been described in detail with respect to the specific embodiments thereof, it will be appreciated that those skilled in the art, upon attaining an understanding of the foregoing, may readily conceive of alterations to, variations of, and equivalents to these embodiments. Accordingly, the scope of the present invention should be assessed as that of the appended claims and any equivalents thereto.

What is claimed is:

1. A prosthetic device comprising:

an upper portion, the upper portion having a top and a base that is opposite the top of the upper portion along a longitudinal length of the upper portion, the upper portion including one or more attachments for securing the thigh of a wearer to the upper portion;

a lower leg support extending from the base of the upper portion, the lower leg support including a proximal end, the lower leg support including a distal end that is opposite the proximal end along a longitudinal length of the lower leg support, the proximal end being closer to the upper portion than the distal end, the lower leg support including one or more attachments for securing the lower leg of a wearer to the lower leg support;

a hinge joining the upper portion and the lower leg support, the hinge allowing the upper portion and the lower leg support to flex and extend with respect to one another over the course of a step of a wearer such that an angle between the upper portion and the lower leg support varies during the step of a wearer and may attain a value of less than  $90^\circ$  over the course of the step;

a lower portion extending from the base of the upper portion, the lower portion including a top and a base that is opposite the top of the lower portion along a longitudinal length of the lower portion; and

a prosthetic foot at the base of the lower portion, the prosthetic foot being attached to the base of the lower portion at an attachment point; wherein

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the lower portion has a side view center line, the hinge and the attachment being aligned with this center line such that a side view alignment between the hinge of the device and the attachment point of the prosthetic foot of the device mimics a side view alignment of a natural knee and a natural ankle.

2. The prosthetic device according to claim 1, wherein the lower leg support defines a cross sectional curvature that is tapered from the proximal end to the distal end.

3. The prosthetic device according to claim 1, wherein the lower leg support defines a cross sectional curvature, the lower leg support being adjustable in size in at least one of the longitudinal length of the lower leg support and the cross sectional curvature of the lower leg support.

4. The prosthetic device according to claim 1, further comprising a covering or brace at the distal end of the lower leg support, the covering or brace providing protection to the foot or distal end of the limb of a wearer.

5. The prosthetic device according to claim 4, wherein the covering or brace is releasably attachable to the lower leg support.

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6. The prosthetic device according to claim 1, further comprising a handle at the top of the upper portion.

7. The prosthetic device according to claim 1, wherein the lower portion is removably attachable to the upper portion.

8. The prosthetic device according to claim 1, further comprising a rotatable joint between the lower portion and the prosthetic foot.

9. The prosthetic device according to claim 1, wherein at least one of the lower leg support and the upper portion include a cushioning material at a surface.

10. The prosthetic device according to claim 1, wherein the hinge includes a lock.

11. The prosthetic device according to claim 1, wherein the device allows full extension of the knee joint of a wearer.

12. The prosthetic device according to claim 1, wherein the device includes a stop that prevents hyperextension of the lower leg support during ambulation.

\* \* \* \* \*



UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 8,778,031 B1  
APPLICATION NO. : 13/238857  
DATED : July 15, 2014  
INVENTOR(S) : Robert A. Latour et al.

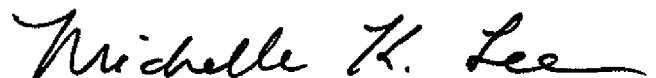
Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In The Claims

In claim 1, Column 9, Line 2, the word “point” is missing -- “...the attachment point being aligned with this center line such...” --

Signed and Sealed this  
Sixth Day of January, 2015



Michelle K. Lee  
*Deputy Director of the United States Patent and Trademark Office*