(54) Title: SUIT DESIGN FOR A LEG PROSTHETIC

(57) Abstract: A garment for retaining a prosthesis assembly includes a sleeve configured to encase at least a portion of a limb and at least a portion of a prosthesis for the limb. The garment further includes tension bands extending along the sleeve and configured to secure the prosthesis to the limb. Another exemplary garment is a body suit including a pant leg configured to encase at least a portion of a leg and at least a portion of a leg prosthesis. The body suit further includes tension bands integrally extending from the pant leg along a torso portion of the body suit and around a shoulder portion of the body suit and configured to secure the leg prostheses - is to the leg.


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— with amended claims (Art. 19(1))
SUIT DESIGN FOR A LEG PROSTHETIC

FIELD OF THE DISCLOSURE

[0001] The embodiments disclosed herein relate generally to prosthetics, and more specifically to garments configured to retain and manage force transfer from prosthetics.

BACKGROUND

[0002] A variety of prosthetics and limb enhancements have been developed for both aesthetic and functional needs, including leg prosthetics and enhancements to aid wearers in activities such as walking, performing job functions, and playing sports. One group of leg prosthetics in this category includes trans-tibial prosthetics, often referred to as below the knee (BK) leg prosthetics. These have come to include blade type leg prosthetics, also known as "flex-foot cheetah" prosthetics, for athletic use. Although blade type leg prosthetics are otherwise satisfactory, wearers of blade-type leg prosthetics may desire improvements in attachment and retention systems and in managing force transfer from the blade-type prosthetic to the wearer's body while the wearer performs various activities.

SUMMARY

[0003] In one aspect, a garment comprises a sleeve configured to encase at least a portion of a limb and at least a portion of a prosthesis for the limb and tension bands extending along the sleeve and configured to secure the prosthesis to the limb.

[0004] In another aspect, a body suit comprises a pant leg configured to encase at least a portion of a leg and at least a portion of a leg prosthesis. The body suit further comprises tension bands integrally extending from the pant leg along a torso portion of the body suit and around a shoulder portion of the body suit and configured to secure the leg prosthesis to the leg.

[0005] In another aspect, a garment comprises tension bands configured to secure a prosthesis to a limb. The tension bands partially encase the prosthesis and integrally extend along the limb to encircle at least one of a neck and a waist and a torso of the wearer.
These and other aspects will be discussed in additional detail below.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0007] The description herein makes reference to the accompanying drawings wherein like reference numerals refer to like parts throughout the several views, and wherein:

[0008] FIG. 1 is a partially exploded side view of a below the knee blade-type leg prosthesis assembly including a socket, blade, and an example of a base plate;

[0009] FIG. 2 is a perspective view of another example of a blade for a blade-type leg prosthesis assembly;

[0010] FIG. 3 is a side view of an example pair of pants retaining the prosthesis assembly of FIG. 1 to the wearer by tension;

[0011] FIGS. 4A - 4C are front and rear views of exemplary shirts and pants configured to retain the prosthesis assembly of FIG. 1 to the wearer by tension; and

[0012] FIGS. 5A-5C are front and rear views of exemplary body suits for retaining the prosthesis assembly of FIG. 1 to the wearer by tension.

**DETAILED DESCRIPTION**

[0013] Garments, or articles of clothing such as shirts, pants, and body suits are disclosed herein for use in attaching and retaining leg prosthetics or limb enhancements. Examples of such clothing may include tension bands formed into or integrated with the article of clothing to transfer tension forces for retaining the leg prosthetic or limb enhancement up through the legs, and optionally, to the upper body. In some embodiments, portions of the tension bands located at or forming a bottom edge of the article of clothing extend around and capture a portion of the prosthetic or enhancement, such as the socket in the case of a leg prosthetic, and the remainder of the tension bands transfer tension forces for retaining the prosthetic or enhancement up through the legs, and optionally, to the upper body.

[0014] As used herein, the terminology "prosthesis" or "prosthetic" may indicate any artificial limb or limb enhancement, including upper extremity enhancements, lower extremity trans-tibial and trans-femoral prostheses, or other lower extremity enhancements. The non-limiting examples disclosed herein describe blade-type leg
prosthetics, but it is contemplated that the features described may be utilized with
a variety of prosthetics or enhancements known to those skilled in the art.

[0015] FIG. 1 is a partially exploded side view of a below the knee blade-type leg
prosthesis assembly including a socket, blade, and an example of a base plate. The
prosthesis assembly 100 may be described as generally comprising blade 102, base plate
104, and socket 106. Prosthesis assembly 100 is shown as a trans-tibial prothetic, and
often referred to as a below the knee (BK) prothetic, but it is contemplated that
embodiments of base plate 104 may be utilized with a variety of prosthetic devices or
limb enhancements.

[0016] Blade 102 may include blade bottom 108, a first inflexion 112, a second
inflexion 114, and blade top 116. Blade inflexions 112, 114 may allow blade 102 to
compress when a load is applied in certain directions. For example, blade 102 may
compress and expand during walking or running. Blade 102 may be constructed from a
variety of natural or synthetic materials capable of withstanding forces associated with
walking, running, or other wearer activities, such as metal, rubber, and polymer. For
example, blade 102 may be made out of a carbon fiber reinforced polymer. Blade 102
may be used either with or without base plate 104.

[0017] Base plate 104 may be fixedly attached to blade 102 at a blade bottom 108
or may be capable of being removably attached and detached using a variety of
attachment components. For example, base plate 104 may be attachable to blade 102
using an adapter, sliding engagement, bolts, clips, pins, screws, adhesive, or straps. In the
example shown in FIG. 1, a set of holes is present in both base plate 104 and blade bottom
108 sufficient for bolts, pins, or other means to be threaded through both base plate 104
and blade bottom 108 to connect base plate 104 to blade bottom 108. In some
embodiments, base plate 104 may attach and capture a portion of blade 102 while
contacting both a top and bottom surface of blade bottom 108.

[0018] Removable and interchangeable base plates 104 may allow a wearer to
customize prosthesis assembly 100 depending on the wearer’s activity type and/or the
ground surface characteristics experienced by the wearer during the activity. For example,
base plate 104 may have a bottom surface 110 including shapes and structures, such as
spikes, cleats, scoops, grooves, nubs, cups, and ridges, designed to provide a desired
interaction with the ground surface for a specific activity. Further, base plate 104 can
include a hook 192 providing attachment means for a garment or serving as a retaining means for storage of base plate 104.

[0019] Socket 106 may include an open socket top 118 and a closed socket bottom 120. Socket 106 may be substantially hollow, having a uniform or varying thickness. Socket top 118 may be sized accordingly to receive at least a portion of a wearer's limb. Socket 106 may be attached to a wearer during use through a variety of methods. In some embodiments, friction based attachment features may be used such as straps or clips configured to attach to a garment on a wearer. In some embodiments, suction based attachments may be utilized, such as a sock or sleeve designed to extend over socket 106 and a wearer's limb. For example, a method of attachment may include a wearer placing socket 106 at the end of a limb and attaching socket 106 by pulling a compression sock over socket 106 in a direction from socket bottom 120 to socket top 118 and onto the wearer's limb.

[0020] In some embodiments, socket 106 may be attachable to blade 102 at blade top 116 using socket attachment members 122. For example, attachment members 122 may be pins or bolts configured to extend through apertures defined in blade top 116. Socket 106 may be constructed out of any natural or synthetic material capable of substantially retaining its shape, such as metals and polymers. For example, socket 106 may be formed from carbon fiber reinforced polymer and may be formed in a custom shape to match a particular wearer's partial limb.

[0021] FIG. 2 is a perspective view of another example of a blade for a blade-type leg prosthesis assembly 100. Blade 200 may define a front face 202 and a rear face 204. In some embodiments, front face 202 may oppose and be substantially parallel to rear face 204, where thickness T may define a distance between front face 202 and rear face 204. It is also contemplated that front face 202 and rear face 204 may be angled with respect to each other, or that thickness T may vary along the length of blade 200. Blade 200 may have a maximum width W. In some embodiments, width W may remain constant along blade 200 as illustrated in FIG. 2.

[0022] In the example shown in FIG. 2, portions of blade 200 may not twist or rotate about its length, with front face 202 being substantially perpendicular to a plane orthogonal to longitudinal axis A. In other words, in this example, a blade bottom 206 and a blade top 208 of blade 200 remain untwisted. Furthermore, blade 200 of FIG. 2 may be designed such that axis A lies in a common plane, with blade 200 being symmetrical.
about the common plane including axis A, such as may be suitable for left and right side leg prosthetics.

[0023] FIG. 3 is a side view of an example pair of pants 300 for retaining the prosthesis assembly 100 of FIG. 1 to the wearer by tension. The pants 300 may integrally extend from an overlap portion 310 that covers a portion of socket 106 up to and around a waist portion 320 that covers a wearer's waist. In some embodiments, pants 300 may support the retention of the prosthesis assembly 100 to the wearer utilizing tension and friction. For example, overlap portion 310 may be shaped as a sleeve sized to retain socket 106 within pants 300.

[0024] Overlap portion 310 may extend over and beyond a portion of socket 106, terminating with bottom edge 312. Overlap portion 310 may include attachment 314 to aid in the attaching or removal of pants 300 to a wearer and/or to prosthetic assembly 100. In some examples, attachment 314 may be a zipper configured for travel between an open and closed position. In an open position, the zipper may allow separation between two loose edges that increase the size of an opening created by bottom edge 312. In the closed position, the zipper may bring two edges of the opening together to reduce the size of the hole or opening created by bottom edge 312.

[0025] The attachment may alternatively be a hook, button, and/or loop used to decrease the size of the opening created by bottom edge 312. In another example where the attachment 314 is a strap or lasso (not shown), pants 300 may be connected to prosthesis assembly 100 by, for example, capturing a portion of blade bottom 108 or base plate 104 using the strap. In one example, the strap can be attached to pants 300 and stretched to encircle or capture the hook 192 located on bottom surface 110 of base plate 104 shown in FIG. 1. In some embodiments, the opening created by bottom edge 312 may be sized smaller than at least a portion of socket 106 that is covered by overlap portion 310. Thus, bottom edge 312 of overlap portion 310 may resist or prevent movement of socket 106 relative to pants 300.

[0026] The partial encasement of socket 106 by pants 300, secured by any of the described attachment methods, may eliminate or reduce any suction required to retain prosthesis assembly 100. It is further contemplated that pants 300 may attach to socket 106 using a variety of mechanical fasteners, such as straps or clips rather than physically capturing a portion of socket 106.
In some examples, pants 300 may include integrated tension bands 330 to transfer the force required to retain prosthesis assembly 100 to areas of the body beyond the legs. Tension bands 330 may provide, in whole or in part, the necessary force to keep overlap portion 310 and socket 106 in a desired position against the wearer's limb. In some examples, tension bands 330 are elastic and generally resist tensile forces. Tension bands 330 may include bottom band 332 that may include the bottom edge 312 of overlap portion 310. Thus, tension band 332 may itself serve to close the opening created by bottom edge 312 when fit against socket 106.

Tension bands 330 may be integrally formed in a cover material 340 forming the sleeve-like body of pants 300 or, alternatively, be connected to cover material 340, for example, using stitching, hot melting, adhesive, or other connection means. Cover material 340 may also define a plurality of openings 350, where at least some of the openings 350 are disposed between some of the tension bands 330. Openings 350 may allow for ventilation of the wearer's limb as well as for increased flexibility of pants 300.

FIGS. 4A - 4C are front and rear views of exemplary shirts and pants configured to retain the prosthesis assembly 100 of FIG. 1 to the wearer by tension. In FIG. 4A, shirt 400 is shown as including a pair of side tension bands 402, 403 extending along the sides and around the shoulders of a wearer as well as waist tension band 404 and shoulder tension band 406. Shoulder tension band 406 extends in a loop about a wearer's torso on the front side of shirt 400 and, in a manner similar to suspenders, extends down the wearer's back on the back side of shirt 400. In FIG. 4B, shirt 408 is shown as including a single yolk-style tension band 410 extending both around a wearer's waist and over a wearer's shoulders.

In FIG. 4C, pants 412 are shown as including a pair of side tension bands 414, 416 that each extend from the inside of the wearer's thighs, down to a sleeve edge defining a sleeve opening, back up along the leg of the wearer to partially encircle the waist of the wearer. Either of the shirts 400, 408 can be worn in combination with and attached to either style of pants 300, 412 in order to create a full body garment configured to secure prosthesis assembly 100 to the wearer and transfer impact forces of use along the wearer's body.

Wearing a combination of shirts 400, 408 and pants 300, 412, or simply a pair of pants 300, 412 alone may provide forces that aid in movements during walking, running, or other wearer activities. For example, in the case of pants 300, 412, any of the
tension bands 330, 414, 416 may be forced into extending when a wearer extends his or her leg while taking a stride, resulting in a tensile force within tension bands 330, 414, 416. Tension bands 330, 414, 416 may also exert a force as the leg moves from an extension back to bending which may be beneficial to the wearer.

[0032] FIGS. 5A - 5C are front and rear views of exemplary body suits for retaining the prosthesis assembly 100 of FIG. 1 to the wearer by tension. Body suit 500 of FIG. 5A includes waist tension bands 502, 503, leg tension bands 504, 505, and knee tension bands 506, 507. In some examples, each of the waist tension bands 502, 503, leg tension bands 504, 505, and knee tension bands 506, 507 are continuously integrated with one another. This may allow for the force for retaining prosthesis assembly 100 to be transferred from knee tension bands 506, 507 up through leg tension bands 504, 505 and further up to waist tension bands 502, 503 of body suit 500.

[0033] Body suit 508 of FIG. 5B includes intersecting side tension bands 510, 512 each extending from a thigh interior of the wearer down a leg and around a knee before extending back up the leg to an armpit of the wearer and then down an arm. In body suit 508, no intersection of side tension bands 510, 512 is present on the front of the wearer's body at the waist; instead, the intersection of side tension bands 510, 512 occurs near the small of the wearer's back. Prosthesis assembly 100 can be retained to the wearer using body suit 508 and force can be transferred from a knee portion of tension bands 510, 512 up along the insides and outsides of the wearer's legs as well as around the wearer's back and up the sides of the wearer's torso.

[0034] Body suit 514 of FIG. 5C includes leg tension bands 516, 518 looping around the thighs and knees of the wearer and extending up to intersecting back tension bands 520, 522. Back tension bands 520, 522 extend under the armpits and across the back of the wearer to intersect between the wearer’s shoulder blades before extending down the torso to intersect with leg tension bands 516, 518. Prosthesis assembly 100 can be retained to the wearer using body suit 514 and force can be transferred from the knee and thigh portions of leg tension bands 516, 518 up along the insides and outsides of the wearer's legs across the wearer's back at the intersection of back tension bands 520, 522 before extending out along the wearer's arms.

[0035] Additionally, body suits 500, 508, 514 may include cover material located between the various tension bands 502, 503, 504, 505, 506, 507, 510, 512, 516, 518, 520, 522. Body suits 500, 508, 514 may be constructed from a variety of materials known to
those skilled in the art. In some examples, the cover material may be a lightweight fabric, such as polyester or nylon blends. Similarly, the various tension bands 502, 503, 504, 505, 506, 507, 510, 512, 516, 518, 520, 522 may be formed from any flexible and/or elastic material, for example, polyurethane (TPU).

[0036] In some embodiments, shirts 400, 408, pants 300, 412, or full body suits 500, 508, 514 may replace the need for traditional inner and/or outer socks to retain socket 106. This may reduce complexity, cost, and weight as well as allowing for a greater range of motion. Additionally, the force produced by the extension and contraction of any of the tension bands (see FIGS. 3, 4A-C, 5A-C) may allow a wearer to be more explosive during movements. Though in the illustrated examples, shirts 400, 408, pants 300, 412, and full body suits 500, 508, 514 generally include both tension bands and cover material, it is understood that in other embodiments, tension bands alone can form any manner of shirt, pants, or full body suit. When tension bands alone form the garment, a plurality of openings are disposed between the tension bands.

[0037] The above-described embodiments have been described in order to allow easy understanding of the invention and do not limit the invention. On the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structure as is permitted under the law.
What is claimed is:

1. A garment, comprising:
   a sleeve configured to encase at least a portion of a limb and at least a portion of a prosthesis for the limb; and
   tension bands extending along the sleeve and configured to secure the prosthesis to the limb.

2. The garment of claim 1, wherein the garment is a body suit and the tension bands integrally extend from the sleeve along a leg portion of the body suit and over a torso portion of the body suit.

3. The garment of claim 1, wherein the garment is a pair of pants and the tension bands integrally extend from the sleeve along a pant leg of the pants and around a waist portion of the pants.

4. The garment of claim 1, wherein the sleeve comprises a cover material.

5. The garment of claim 4, wherein the tension bands are one of integrally formed in the cover material and connected to the cover material.

6. The garment of claim 4, wherein the cover material defines a plurality of openings disposed between at least some of the tension bands.

7. The garment of claim 4, wherein the cover material includes a plurality of surface feature elements.

8. The garment of claim 1, wherein the sleeve includes a sleeve edge defining a sleeve opening and including an attachment element.

9. The garment of claim 8, wherein the attachment element is configured to reduce the size of the sleeve opening to secure the sleeve edge around the encased portion of limb and the encased portion of the prosthesis.
10. The garment of claim 8, wherein the attachment element includes at least one of a tension band, zipper, hook, button, and loop.

11. The garment of claim 1, wherein the sleeve is a pant leg configured to encase at least a portion of a leg and at least a portion of a leg prosthesis, the tension bands integrally extending from the pant leg along a torso portion of the body suit and around a shoulder portion of the body suit and configured to secure the leg prosthesis to the leg.

12. The garment of claim 11, wherein at least some of the tension bands further integrally extend from the torso portion along an arm portion of the body suit.

13. The garment of claim 11, wherein the pant leg comprises a cover material.

14. The garment of claim 13, wherein the tension bands are one of integrally formed in the cover material and connected to the cover material.

15. The garment of claim 13, wherein the cover material defines a plurality of openings disposed between at least some of the tension bands.

16. The garment of claim 13, wherein the cover material includes a plurality of surface feature elements.

17. The garment of claim 11, wherein the pant leg includes a bottom edge defining a leg opening and including an attachment element.

18. The garment of claim 13, wherein the attachment element is configured to reduce the size of the leg opening to secure the bottom edge around the encased portion of the leg and the encased portion of the leg prosthesis.

19. The garment of claim 13, wherein the attachment element includes at least one of a tension band, zipper, hook, button, and loop.
20. A garment, comprising:

tension bands configured to secure a prosthesis to a limb, wherein the
tension bands partially encase the prosthesis and integrally extend along the limb to
encircle at least one of a neck and a waist and a torso of the wearer.
1. A body suit, comprising:
   a pant leg configured to encase at least a portion of a wearer's leg and at least a portion of a prosthesis for the wearer's leg;
   a shirt configured to encase at least a portion of a wearer's torso; and
   tension bands integrally extending along the pant leg and across the shirt, the tension bands configured to secure the prosthesis to the leg and transfer impact forces from use of the prosthesis along the wearer's leg and the wearer's torso.

2. The body suit of claim 1, wherein the body suit comprises a cover material.

3. The body suit of claim 2, wherein the tension bands are one of integrally formed in the cover material and connected to the cover material.

4. The body suit of claim 2, wherein the cover material defines a plurality of openings disposed between at least some of the tension bands.

5. The body suit of claim 2, wherein the cover material includes a plurality of surface feature elements.

6. The body suit of claim 1, wherein the pant leg is a sleeve, comprising:
   a sleeve edge defining a sleeve opening; and
   an attachment element.

7. The body suit of claim 6, wherein the attachment element is configured to reduce the size of the sleeve opening to secure the sleeve edge around the encased portion of leg and the encased portion of the prosthesis.

8. The body suit of claim 6, wherein the attachment element includes at least one of a tension band, zipper, hook, button, and loop.
9. The body suit of claim 1, wherein the shirt includes a shoulder portion configured to encase the wearer's shoulders, and wherein at least some of the tension bands integrally extend from the pant leg to the shoulder portion and back to the pant leg.

10. The body suit of claim 9, wherein at least some of the tension bands further integrally extend from the shoulder portion along an arm portion of the body suit.

11. The body suit of claim 1, wherein the shirt comprises:
   a shirt waist portion configured to encase at least a portion of the wearer's torso;
   a shoulder portion configured to encase at least a portion of a wearer's shoulders;
   wherein at least some of the tension bands extend around the shirt waist portion and from the shirt waist portion to the shoulder portion and back to the shirt waist portion.

12. The body suit of claim 11, further comprising:
   another pant leg configured to encase a portion of the wearer's other leg; and
   a pants waist portion configured to encase at least a portion of the wearer's torso;
   wherein at least some of the tension bands extend from one pant leg around the pants waist portion and down the other pant leg.

13. The body suit of claim 12, wherein the shirt comprises:
   attachment means configured to attach the pants waist portion to the shirt waist portion, wherein the tension bands around the pants waist portion are configured to transfer impact forces to the tension bands around the shirt waist portion upon attachment.

14. A garment, comprising:
   tension bands configured to secure a prosthesis to a limb, wherein the tension bands partially encase the prosthesis and integrally extend along the limb to encircle at least one of a neck and a waist and a torso of the wearer.
15. The garment of claim 14, wherein the limb is a leg and wherein the tension bands integrally extend up the leg, encircle the waist of the wearer, and extend back down the leg to secure the prosthesis to the leg.
A. CLASSIFICATION OF SUBJECT MATTER
A61F 2/60(2006.01)i, A61F 2/66(2006.01)i, A61F 2/76(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61F 2/60; A61F 2/78; A41D 13/00; A61F 13/00; A61F 5/00; A61F 2/66; A61F 2/76

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: leg, prosthesis, garment, tension, band, attach, secure, amputee, elastic, fit, pants, compression, wrist, limb, suspension, sleeve, zipper, type

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>US 6592539 B1 (EINARSSON, P. et al.) 15 July 2003 See column 2, line 54 - column 7, line 23; claims 1-4, 6; figures 1-9.</td>
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<td>US 4790855 A (JOLLY, D. F.) 13 December 1988 See column 3, line 2 - column 6, line 64; claims 1-42; figures 1-8.</td>
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<td>US 5376130 A (COURTNEY, C.) 27 December 1994 See the whole document.</td>
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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents:
  "A" document defining the general state of the art which is not considered to be of particular relevance
  "E" earlier application or patent but published on or after the international filing date
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Date of the actual completion of the international search
10 November 2015 (10.11.2015)

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