US 20040215346A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2004/0215346 A1**

Rubie et al. (43) **Pub. Date: Oct. 28, 2004**

(54) **LOWER LEG PROSTHESIS**

(76) Inventors: **Eric W. Rubie**, Salt Lake City, UT (US); **Larry J. Hansen**, Salt Lake City, UT (US); **Nathan A. Williams**, Heber, UT (US); **David J. Wall**, Sandy, UT (US); **John B. Merlette**, Big Fork, MT (US)

Correspondence Address:
Lynn C. Cameron
FAEGRE & BENSON LLP
2200 Wells Fargo Center
90 South Seventh Street
Minneapolis, MN 55402-3901 (US)

(21) Appl. No.: **10/804,595**

(22) Filed: **Mar. 19, 2004**

Related U.S. Application Data

(63) Continuation of application No. 09/781,570, filed on Feb. 9, 2001, now Pat. No. 6,712,860.

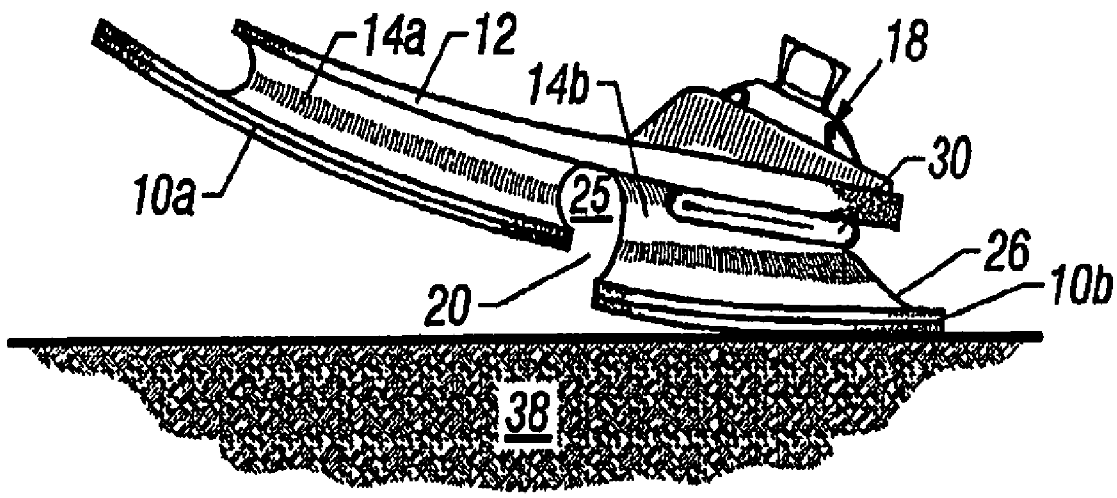
Publication Classification

(51) **Int. Cl.**[7] **A61F 2/62**; A61F 2/66

(52) **U.S. Cl.** **623/38**; 623/55

(57) **ABSTRACT**

An improved lower leg prosthesis is disclosed for providing an improved performance, including improved stability and improved multi-axial compliance. The prosthesis includes upper and lower foot plates and an elastomeric layer disposed between and attaching them together. The elastomeric layer extends substantially across an upper surface of the lower foot plate. The elastomeric layer preferably being narrower in width than the upper and lower foot plates in a middle portion of the layer. The prosthesis alternatively includes upper and lower foot plates and an attachment device coupled to the upper foot plate and adapted for connection to an external prosthetic component. The attachment device includes a lower surface that conforms to a sloping portion of the upper foot plate and preferably includes a generally horizontal mounting portion having a mounting protrusion, such as a pyramid adapter.



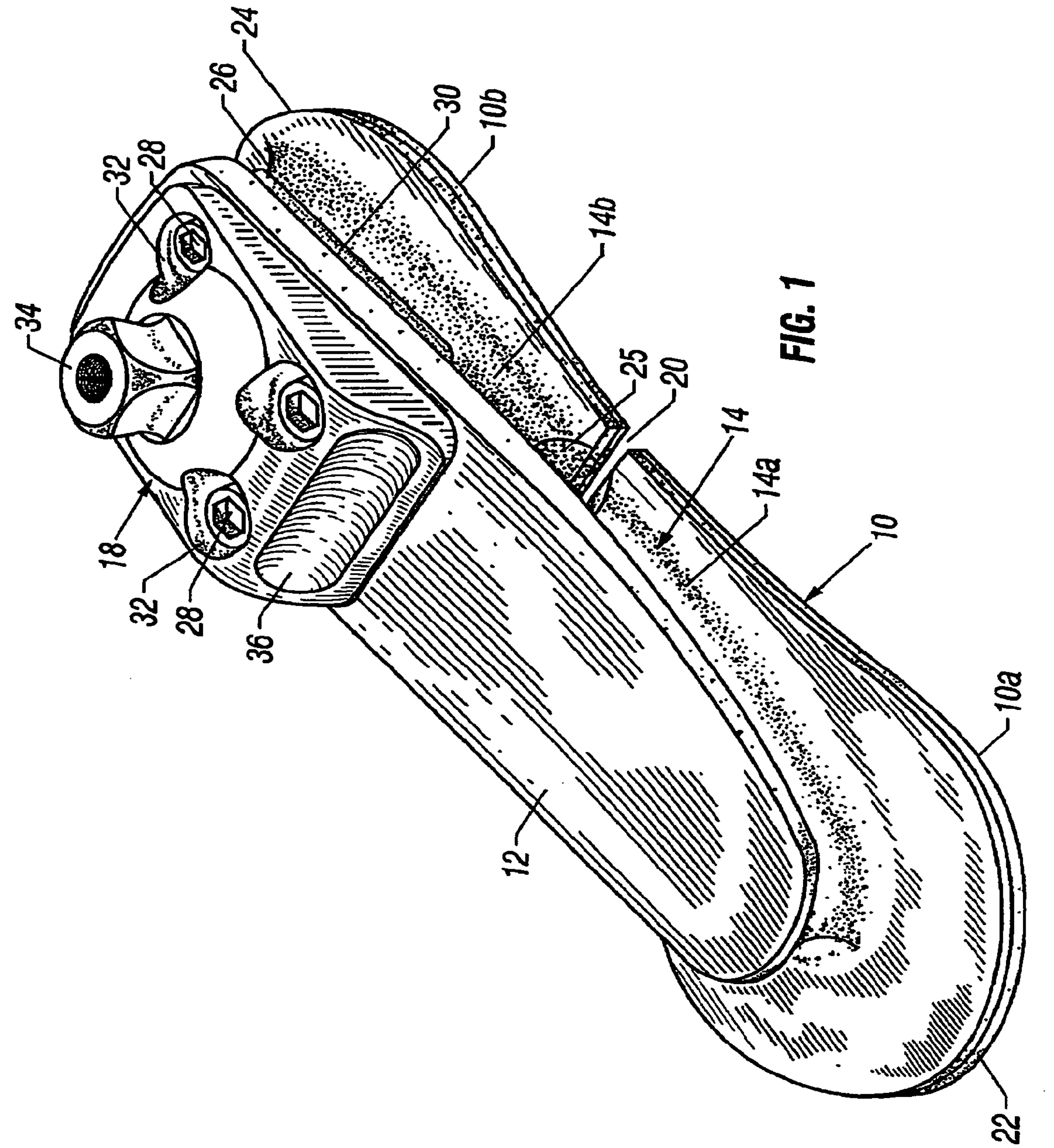


FIG. 1

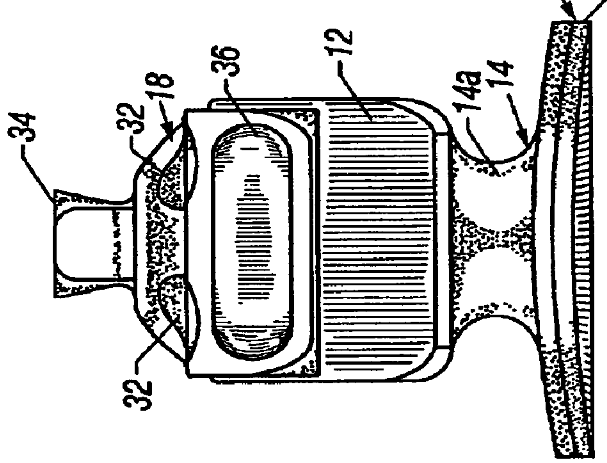

34
32
18
36
12
14a
14
10
10a
32

FIG. 2

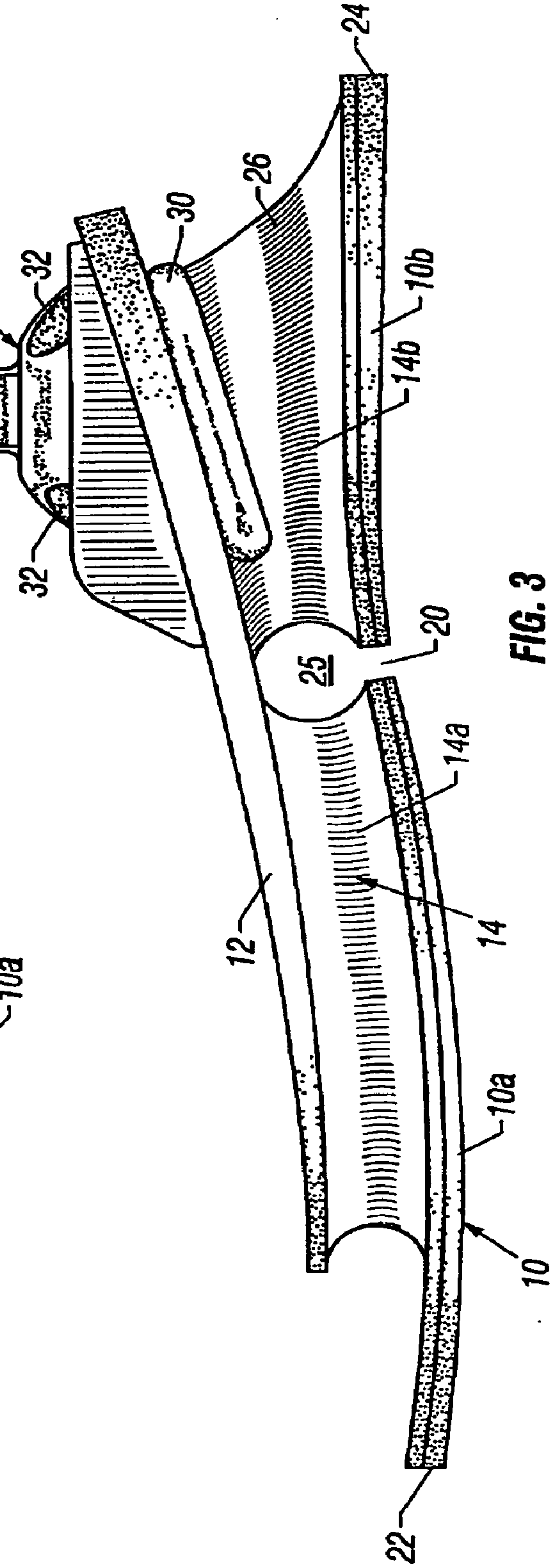

24
26
30
32
18
34
14b
10b
32
20
25
14a
12
14
10a
10
22

FIG. 3

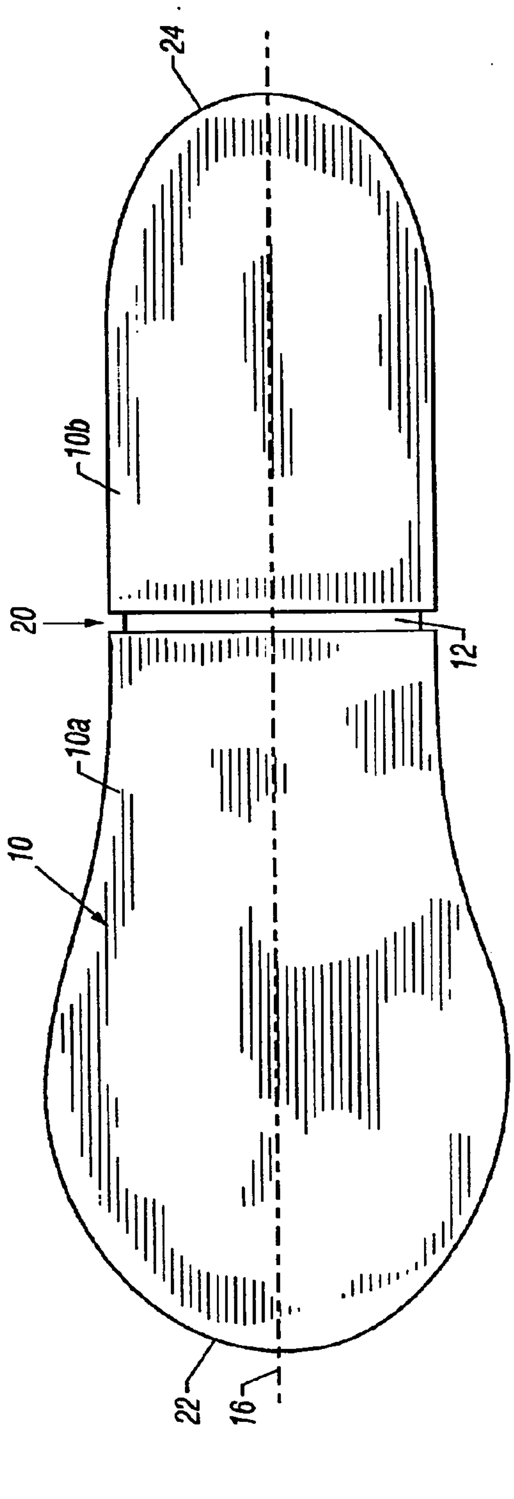


FIG. 4

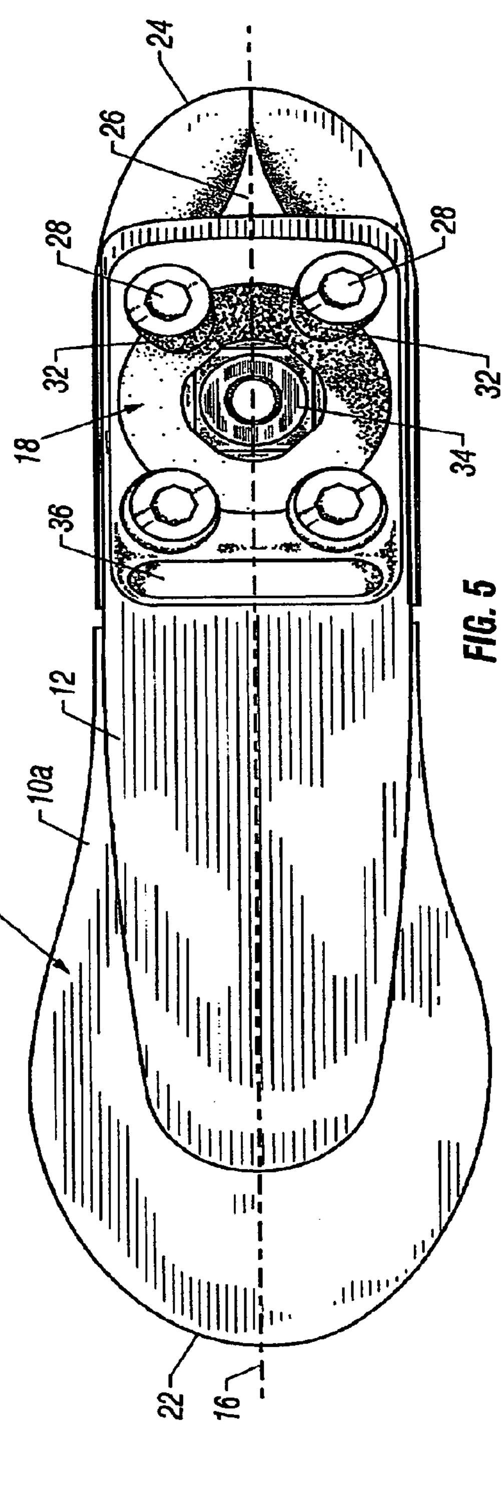


FIG. 5

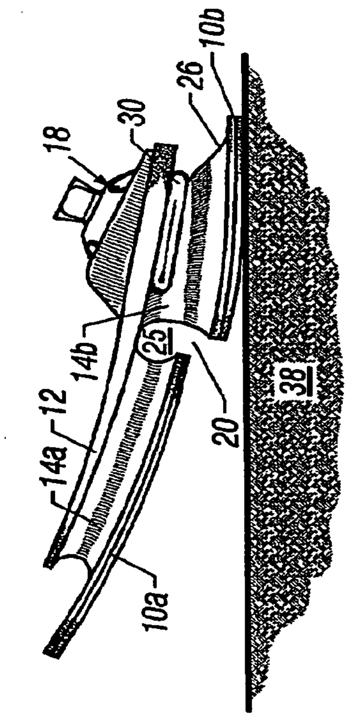


FIG. 6

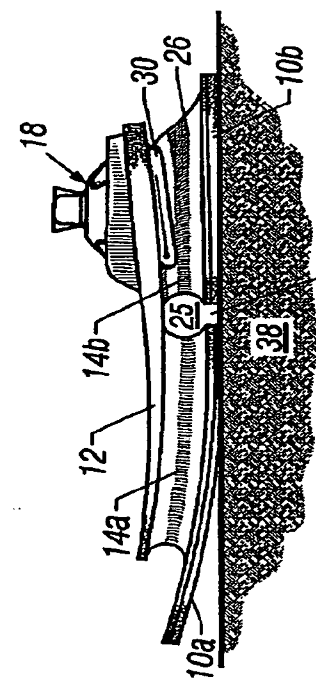


FIG. 7

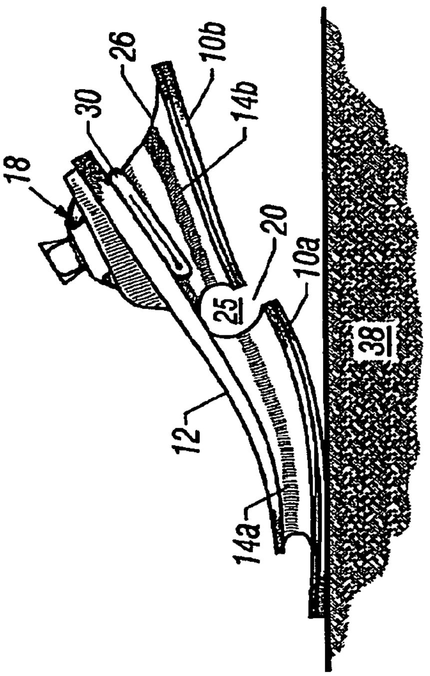


FIG. 8

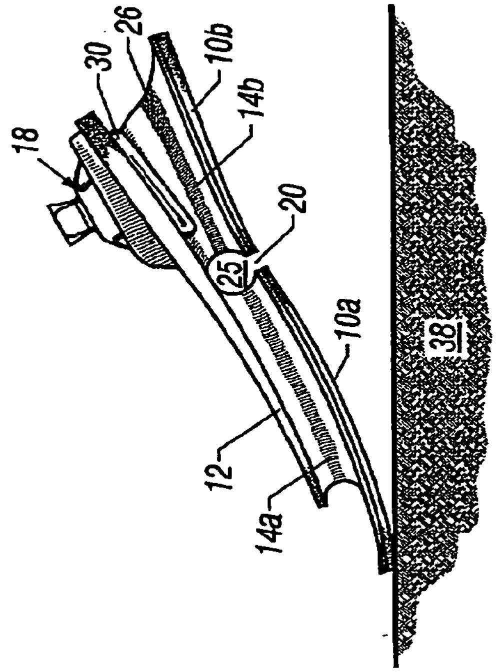


FIG. 9

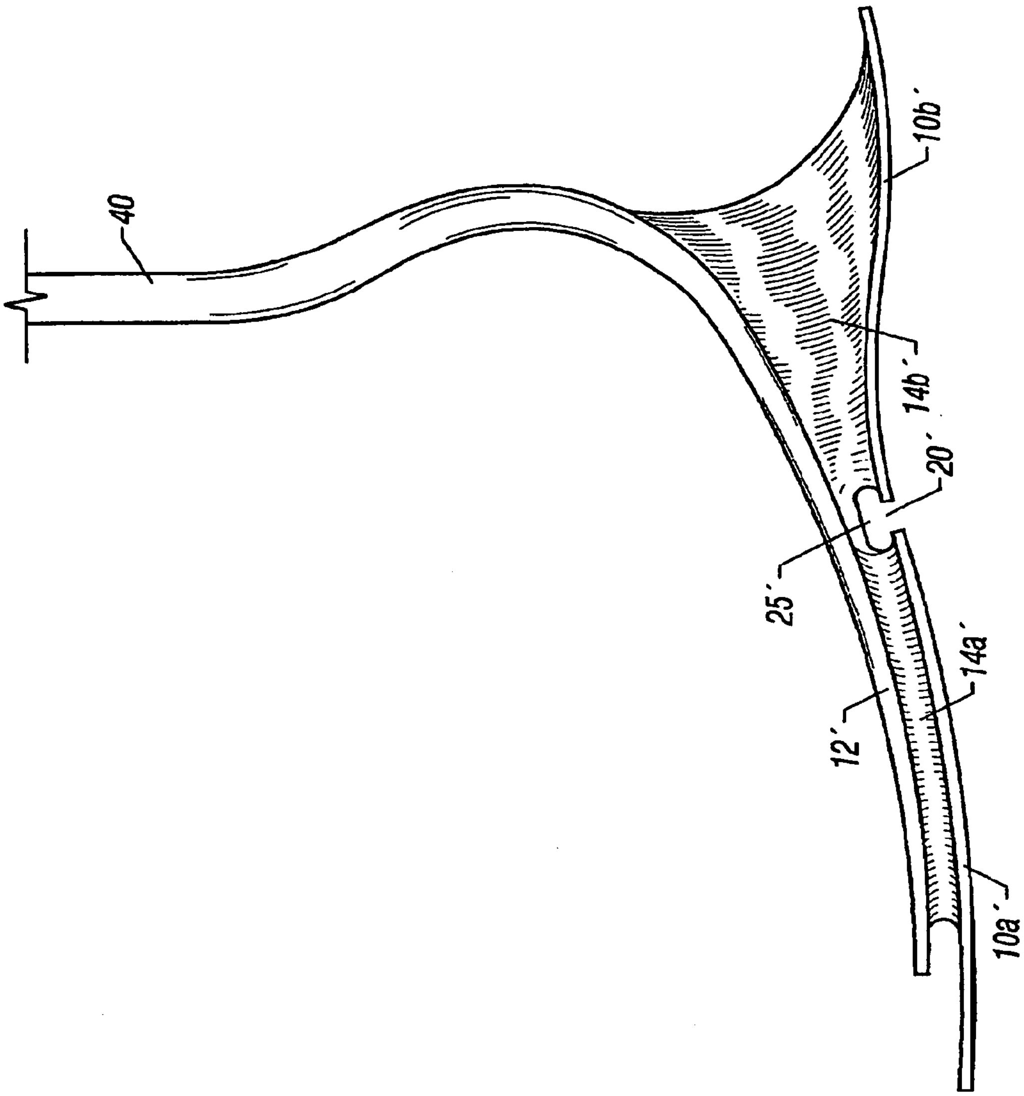


FIG. 10

LOWER LEG PROSTHESIS

[0001] This is a continuation of U.S. patent application Ser. No. 09/781,570 filed on Feb. 9, 2001, and published as U.S. Patent Application Publication US 2002/0116072 A1 on Aug. 22, 2002.

BACKGROUND OF THE INVENTION

[0002] This invention relates generally to lower leg prostheses and, more particularly, to lower leg prostheses configured to duplicate the performance characteristics of the natural human foot and ankle.

[0003] Significant advancements in the field of lower leg prostheses have been made in recent years, due largely to the development of composite materials technology. Lower leg prostheses incorporating fiberglass/epoxy and carbon fiber/epoxy composite materials have been developed, which closely duplicate the performance characteristics and feel of the natural human foot and ankle.

[0004] One such lower leg prosthesis is sold by CRP, Inc. d/b/a Springlite, under the name Advantage Low Profile. That prosthesis incorporates a flexible lower plate and a relatively rigid upper plate, which are attached together by an intermediate elastomeric layer. A toe portion of the lower plate projects beyond a forward end of the upper plate, and a heel portion of the lower plate projects beyond a rearward end of the upper plate. The lower and upper plates are formed of a high-strength, carbon fiber/epoxy composite material, and the elastomeric layer is formed of a high-density polyurethane material. An attachment pyramid is mounted on the upper plate, for attaching the lower leg prosthesis to a socket for receiving the amputee's residual limb or to an intermediate prosthesis such as a pylon. A crepe sole can be attached to the underside of the lower plate, and a foam foot shell or cosmesis can be placed over the plates, to provide the prosthesis with an appearance of a natural human foot.

[0005] The Advantage Low Profile prosthesis described briefly above has enjoyed substantial commercial success. Nevertheless, it is believed that the prosthesis can be improved upon by providing greater stability during use, particularly at heel strike and at toe-off, and also by providing a greater degree of multi-axial movement, thus coming closer to duplicating the performance and feel of the natural human foot and ankle. The present invention fulfills these needs and provides further related advantages.

SUMMARY OF THE INVENTION

[0006] The present invention provides a lower leg prosthesis having improved performance, including improved stability and improved multi-axial compliance. The prosthesis includes upper and lower foot plates and an elastomeric layer disposed between, which attaches them together. The elastomeric layer extends substantially across an upper surface of the lower foot plate. The elastomeric layer is preferably narrower in width than the widths of the upper and lower foot plates in a middle portion of the layer.

[0007] The prosthesis alternatively includes upper and lower foot plates and an attachment device coupled to the upper foot plate and adapted for connection to an external prosthetic component. The attachment device includes a lower surface that conforms to a sloping portion of the upper foot plate and preferably includes a generally horizontal mounting portion having a mounting protrusion, such as a pyramid adapter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] **FIG. 1** is a perspective view of a foot prosthesis in accordance with one preferred embodiment of the invention, this prosthesis including a two-part lower foot plate and an upper foot plate that are attached to each other by an intermediate elastomeric layer.

[0009] **FIG. 2** is a front elevational view of the foot prosthesis of **FIG. 1**.

[0010] **FIG. 3** is a side elevational view of the foot prosthesis of **FIG. 1**.

[0011] **FIG. 4** is a bottom plan view of the foot prosthesis of **FIG. 1**.

[0012] **FIG. 5** is a top plan view of the foot prosthesis of **FIG. 1**.

[0013] **FIGS. 6-9** are a series of side elevational views of the foot prosthesis of **FIG. 1**, showing the prosthesis in a sequence of stages of a normal step, including full weight on the heel (**FIG. 6**), mid-stance position (**FIG. 7**), full weight on the toe (**FIG. 8**), and toe-off (**FIG. 9**).

[0014] **FIG. 10** is a side elevational view of a lower leg prosthesis in accordance with an alternative embodiment of the invention, this prosthesis differing from the prosthesis of **FIG. 1** in that its upper foot plate incorporates an integral pylon.

DETAILED DESCRIPTION

[0015] With reference now to the illustrative drawings, and particularly to **FIGS. 1-5**, there is shown a foot prosthesis in accordance with a first embodiment of the invention. The prosthesis incorporates a two-part lower foot plate **10** and an upper foot plate **12**, which are bonded together in spaced relationship by an intermediate elastomeric layer **14**. The two-part lower foot plate includes a forefoot plate **10*a*** and a heel plate **10*b*,** which are aligned along a longitudinal axis **16**. The intermediate elastomeric layer likewise incorporates two sections aligned along the longitudinal axis, including an anterior section **14*a*** bonding the upper foot plate **12** to the forefoot plate **10*a*** and a posterior section **14*b*** bonding the upper foot plate to the heel plate **10*b***. An attachment device **18** is secured to the upper surface of the upper foot plate, at its posterior end, for use in attaching the prosthesis to a socket for receiving the amputee's residual limb or to an intermediate prosthesis such as a conventional tubular pylon. A conventional foam cosmesis (not shown) can be placed over the upper and lower foot plates, to provide the prosthesis with the appearance of a natural human foot.

[0016] As best shown in **FIGS. 1, 3** and **5**, the forefoot plate **10*a*** and the heel plate **10*b*** together have a size and peripheral shape that generally match that of a natural human foot, with heel, mid-foot and toe sections. A gap in the form of a slot **20** in the mid-foot section separates the forefoot plate **10*a*** from the heel plate **10*b***. This slot preferably has a uniform width in the range of 1 to 12 mm, most preferably about 5 mm. Other shapes for the gap alternatively could be used, including shapes that are asymmetric or otherwise non-uniform.

[0017] The transverse width of a mid-portion of the forefoot plate **10***a* preferably is slightly increased in a region corresponding generally to the ball of the natural human foot. The prosthesis of **FIGS. 1-5** is configured to be usable for both left and right feet. It will be appreciated, however, that the shapes of the forefoot plate **10***a,* heel plate **10***b,* and upper foot plate **12** alternatively could be configured specifically for use as a left foot or as a right foot.

[0018] The upper foot plate **12** is sized to be slightly smaller in length and width than the combined forefoot and heel plates **10***a* and **10***b*. Specifically, the anterior end of the upper foot plate terminates about 2.5 cm short of the toe tip **22** of the forefoot plate, and the posterior end of the upper foot plate terminates about 2.5 cm short of the heel tip **24** of the heel plate. The anterior end of the upper foot plate is defined by a circular arc that is generally concentric with a circular arc that defines the anterior end of the forefoot plate. Other configurations for the plates alternatively could be used, including configurations in which the forefoot plate and/or the heel plate do not extend beyond the periphery of the upper plate. The upper foot plate also could be configured to include multiple plates, as is preferred for the two-part lower foot plate.

[0019] The upper foot plate **12**, the forefoot plate **10***a,* and the heel plate **10***b* all preferably are formed of a conventional epoxy/carbon fiber composite material. Each preferably has a rectangular cross-section along its entire length. The upper foot plate's thickness is substantially uniform along its posterior half, but tapers to a minimum at its anterior end. The relatively greater thickness of the upper foot plate along its posterior half, together with the presence of the attachment device **18** at that location, render the posterior half of the upper foot plate substantially rigid and inflexible. As described below, however, the anterior half of the upper plate is configured to flex substantially during use of the prosthesis, storing and returning energy in a manner that enhances the prosthesis' performance.

[0020] Alternative materials also could be used for the upper foot plate **12**, the forefoot plate **10***a,* and the heel plate **10***b,* including metals and plastics. If necessary, straps, elastic bands, or other components, can be included, for limiting excessive movement or flexing of the plates in any particular direction. Further, the plates could be made from a material that is substantially inflexible, in which case the desired independent movement between the forefoot plate and heel plate would be provided solely by the elastomeric layer.

[0021] The intermediate elastomeric layer **14** preferably is formed of a high-density polyurethane material, although alternative elastomeric materials, including foams, also could be used. As mentioned above, the elastomeric layer's anterior section **14***a* bonds the upper foot plate **12** to the forefoot plate **10***a,* and its posterior section **14***b* bonds the upper foot plate to the heel plate **10***b.* A non-permanent attachment of the elastomeric layer to the plates alternatively could be used. A gap **25** separates the elastomeric layer's anterior and posterior sections. This gap preferably has a uniform, substantially circular cross-section, which provides excellent durability. It will be appreciated, however, that alternative cross-sectional shapes for the gap, e.g., oval, polygonal or accordion, also could be used. It also will be appreciated that the gap in the elastomeric layer could be eliminated altogether, and the elastomeric layer even could be configured to extend into the gap **20** defined between the forefoot and heel plates.

[0022] As best shown in **FIGS. 1-3**, the elastomeric layer **14** extends over the full height between the upper and lower plates **10** and **12** only in a region located inward of the upper plate's periphery. Outside that region, the elastomeric layer coats the entire upper surfaces of the forefoot and heel plates **10***a* and **10***b,* in a uniform thickness in the range of about 2 to 3 mm. Of course, this configuration for the elastomeric layer is only the preferred configuration; the elastomeric layer need not coat the entirety of this outer region, and it need not be of uniform thickness.

[0023] As best shown in **FIGS. 1-3**, the laterally facing sides of the portion of the elastomeric layer **14** that extends over the full height between the upper plate **12** and the forefoot and heel plates **10***a* and **10***b* are concave. These sides define a smooth transition to the planar portion adjacent the peripheries of the forefoot and heel plates and a similar smooth transition to the periphery of the upper plate. The anterior section **14***a* of the elastomeric layer is sized to space the upper foot plate above the forefoot plate by a uniform distance of about 2 cm, and the posterior section **14***b* is sized to space the upper foot plate above the heel plate **10***b* by a distance that ranges from about 2 cm adjacent to the slot **20** to about 3 cm at the upper foot plate's posterior end. It will be appreciated that the distance between the upper and lower plates could vary from these values. It also will be appreciated that the laterally facing sides of the elastomeric layer need not be concave; a convex configuration that projects beyond portions of the upper foot plate's periphery alternatively could be used.

[0024] The elastomeric layer **14** further defines a wedge section **26** that extends from the underside of the posterior end of the upper foot plate **12** to the tip **24** of the heel plate **10***b*. This aids in shock absorption at heel strike.

[0025] Extending the elastomeric layer **14** over the entire upper surfaces of the forefoot plate **10***a* and the heel plate **10***b* more effectively distributes stresses between the plates and the elastomeric layer. The plates thereby can be made slightly thinner, and they can provide increased flexibility and durability.

[0026] It will be noted in **FIGS. 1 and 3** that the forefoot plate **10***a* has a thickness profile that varies along its length, being its thickest at the toe tip **22** and thinnest adjacent to the slot **20**. Similarly, the heel plate **10***b* has a thickness profile that varies along its length, being its thickest at the heel tip **24** and thinnest adjacent to the slot. This configuration reduces the stress levels in the portions of the plates adjacent to the slot. It will be appreciated that other thickness profiles alternatively could be used.

[0027] The attachment device **18** is secured to the posterior end of the upper foot plate **12** using four screws **28** and a pair of threaded backing strips **30**. The screws are seated in individual recesses **32** formed in the attachment device, and the backing strips function to distribute the compressive forces from the screws over enlarged areas. Numerous conventional alternatives to the screws and backing strips also could be used. A pyramid **34** is located on the attachment device's upper side, for use in attaching the prosthesis to a socket for receiving the amputee's residual limb or to an intermediate prosthesis such as a pylon. It will be appreciated that other conventional attachment devices also could be used, including direct bonding or bolting to a socket.

[0028] The attachment device **18** is generally wedge shaped, such that its lower surface conforms to the sloping upper surface of the upper foot plate **12** but its upper surface is oriented generally horizontally. The device can be formed of any suitable material, including metals such as stainless steel or titanium, ceramics, composites, and plastics. A weight-reducing cutout **36** can be formed in the device's forward end.

[0029] Forming the lower foot plate **10** as separate forefoot and heel plates **10***a* and **10***b,* and forming the elastomeric layer **14** as separate anterior and posterior sections **14***a* and **14***b,* provides several important advantages. First, this configuration provides the prosthesis with substantially improved stability during use. For example, at heel strike, the anterior end of the heel plate deflects into contact with the ground **38** much sooner than it would if the lower foot plate were formed as a single, unitary plate. Similarly, at toe-off, the posterior end of the forefoot plate remains deflected into contact with the ground for much longer than it would if the lower foot plate were formed as a single, unitary plate. This ensures that a greater surface area on the underside of the prosthesis remains in contact with the ground for a greater time duration during each step, thus significantly improving the prosthesis' stability and correspondingly enhancing the user's sense of security when using the prosthesis.

[0030] This advantage of increased stability is evident from **FIGS. 6-9**, which depict the prosthesis at four successive stages of a walking gait. In particular, **FIG. 6** depicts the prosthesis at an early stage of the walking gait, where the user has applied substantial weight to the heel plate **10***b*. At this time, the plate's posterior end has deflected upwardly, to compress the posterior portion of the elastomeric section **14***b,* while at the same time the plate's forward end has deflected downwardly, to elongate the anterior portion of the elastomeric section. As depicted in **FIG. 6**, the heel plate's anterior end has deflected fully downwardly into contact with the ground **38**. At this time, enhanced plantar flexion stability is achieved even though the prosthesis' forefoot plate **10***a* has not yet touched the ground. The forefoot plate remains substantially unstressed.

[0031] **FIG. 7** depicts the prosthesis at a subsequent stage of the walking gait, when a mid-stance condition has been reached. At this stage, both the anterior section **14***a* and the posterior section **14***b* of the elastomeric layer **14** are slightly compressed, but the upper foot plate **12** and the forefoot and heel plates **10***a* and **10***b* are substantially unflexed. In the transition from the position of **FIG. 6** to the position of **FIG. 7**, energy stored in the heel plate, as well as energy stored in the posterior section of the elastomeric layer, is recovered and provided to help propel the user forward.

[0032] Subsequently, as depicted in **FIG. 8**, the user's weight has shifted forwardly onto the forefoot plate **10***a,* and the heel plate **10***b* has lifted off of the ground **38**. At this time, the forefoot plate and the anterior portion of the upper plate **12** are substantially deflected. The anterior portion of the elastomeric section **14***a* is compressed, and the posterior portion of this elastomeric section is elongated.

[0033] Eventually, as depicted in **FIG. 9**, the walking gait is completed as the toe tip **22** of the forefoot plate **10***a* makes final contact with the ground **38**. At this time, little weight is being borne by the prosthesis, and the various plates all are substantially unstressed and the elastomeric layer is uncompressed. In the transition from the position of **FIG. 8** to the position of **FIG. 9**, energy stored in the forefoot plate and the upper plate **12**, as well as energy stored in the anterior section **14***a* of the elastomeric layer **14**, is recovered and provided to help propel the user forward.

[0034] Another performance benefit that results from forming the lower foot plate **10** in two parts, as a forefoot plate **10***a* and a heel plate **10***b,* resides in the independent movement of the two parts. This enables the prosthesis to better conform to uneven terrain than a similar prosthesis having a single, unitary lower foot plate.

[0035] Yet another performance benefit that results from forming the lower foot plate **10** in two parts resides in reduced resistance to the user's turning about a vertical axis. This reduction is particularly evident when only the heel plate **10***b* or only the forefoot plate **10***a* contacts the ground **38**, as typically is the case when a turning motion is being made. More particularly, if the user desires to turn left or right as he steps off of the forefoot plate, this turning motion is coupled to the forefoot plate via just the upper plate **12** and the anterior section **14***a* of the elastomeric layer **14**. The posterior section **14***b* of the elastomeric layer and the heel plate **10***b* offer no resistance at this time to this turning motion.

[0036] Still another performance benefit for the prosthesis is provided by the configuration of the elastomeric layer **14**, and in particular by its substantial thickness along its entire length. This thickness facilitates enhanced inversion and eversion movement of the upper plate **12** relative to the forefoot and heel plates **10***a* and **10***b*. The prosthesis thereby better duplicates the motion of the natural human foot.

[0037] One convenient method for making the prosthesis is to initially form the forefoot plate **10***a* and the heel plate **10***b* as a single, unitary plate and to bond that single plate to the upper foot plate **12** using the elastomeric layer **14**. After such an assembly has been constructed, the unitary lower plate is cut to form the forefoot plate and the heel plate, separated by the slot **20**. This technique ensures that the forefoot and heel plates are properly aligned with each other.

[0038] The gap **25** between the anterior and posterior sections **14***a* and **14***b* of the elastomeric layer **14** conveniently can be provided at the time the elastomeric layer is formed by placing a dowel in a prescribed position between the upper plate **12** and the two lower plates **10***a* and **10***b* before the polyurethane material is poured or otherwise inserted between them. A silicone tool can be used to define the space into which the polyurethane material is inserted. The dowel preferably is sized so that the polyurethane material blends smoothly with the upper and lower plates. The resulting gap in the polyurethane layer has a substantially circular configuration and has a relatively large radius, which together function to enhance the layer's durability.

[0039] Sizing the gap **25** to extend fully between the upper plate **12** and lower plate **10** also allows maximum vertical displacement, or elongation, of the elastomeric layer **14** at heel strike and toe-off. This, in turn, provides increased shock absorption at heel strike, as compared to a similar prosthesis having a single, unitary lower foot plate. This increased shock absorption also is evident at less than full loads.

[0040] With reference now to **FIG. 10**, there is shown an alternative embodiment of a lower leg prosthesis in accordance with the invention. Elements of this alternative embodiment that correspond to elements of the embodiment of **FIGS. 1-5** are identified by the same reference numerals, but accompanied by asterisks. The alternative embodiment of **FIG. 10** differs from the embodiment of **FIGS. 1-5** in that it incorporates an upper plate **12**' that is integrated with a vertical pylon **40**. In this alternative embodiment, the rearward portion of the upper plate curves upwardly to form the pylon. A conventional attachment device (not shown) mounts to the pylon's upper end, for attaching the prosthesis to a socket. Many pylon shapes and configurations could be used in this embodiment.

[0041] In other respects, the prosthesis of **FIG. 10** is substantially similar to the prosthesis of **FIGS. 1-5**. It will be noted, however, that the gap **25**' between the anterior section **14***a*' and posterior section **14***b*' of the elastomeric layer **14** has an oval cross-section, and it does not extend fully up to the lower surface of the upper plate **12**'. It also will be noted that the anterior section **14***a*' has a substantially uniform thickness of about 0.5 cm and that the posterior section **14***b*' has a thickness that ranges from a minimum of about 0.5 cm, adjacent to the gap **25**', to a maximum of about 8 cm.

[0042] It should be appreciated from the foregoing description that the present invention provides an improved lower leg prosthesis that, in use, provides an improved performance, including improved stability and improved multi-axial compliance. The prosthesis includes a two-part lower foot plate, incorporating a forefoot plate and a heel plate, and an upper foot plate that is bonded to the forefoot and heel plates by a two-part intermediate elastomeric layer. Forming the lower foot plate and the elastomeric layer each in two parts ensures that the forefoot plate and heel plate function substantially independently of each other, which leads to substantially improved cushioning at heel strike and to improved stability throughout the gait cycle.

[0043] Although the invention has been described in detail with reference to the presently preferred embodiments, those of ordinary skill in the art will appreciate that various modifications can be made without departing from the invention. Accordingly, the invention is defined only by the following claims.

We claim:

1. A lower leg prosthesis comprising:

a lower foot plate and an upper foot plate disposed in spaced relationship to each other, wherein the lower and upper foot plates are elongated and are configured to be flexible in directions along a longitudinal axis; and

an elastomeric layer disposed between, and attaching together, the lower foot plate and the upper foot plate, wherein the elastomeric layer extends substantially across an upper surface of the lower foot plate.

2. The lower leg prosthesis of claim 1, wherein the elastomeric layer extends fully to a periphery of the lower foot plate.

3. The lower leg prosthesis of claim 1, wherein the elastomeric layer comprises an upper portion adjacent the upper foot plate, a lower portion adjacent the lower foot plate and a middle portion disposed between the upper and lower portions.

4. The lower leg prosthesis of claim 3, wherein the lower portion extends substantially to a periphery of the lower foot plate.

5. The lower leg prosthesis of claim 3, wherein the lower portion extends substantially to a periphery of the lower foot plate, the upper portion extends generally to a periphery of the upper foot plate and the middle portion extends generally less than the upper foot plate or the lower foot plate in a lateral direction.

6. The lower leg prosthesis of claim 5, wherein lateral facing sides of the elastomeric layer in the middle portion are generally concave.

7. The lower leg prosthesis of claim 5, wherein lateral facing sides of the elastomeric layer in the middle portion are generally convex.

8. The lower leg prosthesis of claim 3, wherein the lower portion is generally planar in an area extending beyond a periphery of the upper foot plate, and wherein the middle portion provides a smooth transition between the upper portion and the planar area of the lower portion.

9. The lower leg prosthesis of claim 3, wherein the middle portion defines a wedge section that extends from a posterior end of the upper foot plate toward a posterior end of the lower foot plate, protruding beyond the posterior end of the upper foot plate.

10. The lower leg prosthesis of claim 1, wherein the elastomeric layer bonds the upper foot plate to the lower foot plate.

11. The lower leg prosthesis of claim 10, wherein the elastomeric layer is the sole bonding between the upper and lower foot plates.

12. The lower leg prosthesis of claim 1, wherein the width of the elastomeric layer is generally narrower than the widths of the upper and lower foot plates.

13. The lower leg prosthesis of claim 12, wherein the elastomeric layer comprises an upper portion adjacent the upper foot plate, a lower portion adjacent the lower foot plate and a middle portion interposed between the upper and lower portions, and wherein the width of the middle portion is generally narrower than the widths of the upper and lower portions.

14. The lower leg prosthesis of claim 1, wherein the lower foot plate is formed of a composite material incorporating high-strength fibers.

15. The lower leg prosthesis of claim 1, wherein the lower foot plate includes a forefoot plate and a heel plate aligned along the longitudinal axis.

16. The lower leg prosthesis of claim 15, wherein:

the forefoot and heel plates together have a toe section, a mid-foot section, and a heel section; and

the forefoot and heel plates are separated from each other by a first gap located in the mid-foot section.

17. The lower leg prosthesis of claim 16, wherein the first gap has a substantially uniform width in the range of 1 to 12 mm.

18. The lower leg prosthesis of claim 16, wherein the elastomeric layer comprises an anterior section disposed between the upper plate and the forefoot plate and a posterior section disposed between the upper plate and the heel plate, wherein a second gap is defined between the anterior and posterior sections, adjacent the first gap.

19. The lower leg prosthesis of claim 18, wherein the second gap has a substantially circular cross-section.

20. The lower leg prosthesis of claim 18, wherein the second gap blends smoothly with a lower surface of the upper plate and with upper surfaces of the forefoot and heel plates.

21. The lower leg prosthesis of claim 18, wherein the first and second gaps both are substantially straight and oriented substantially perpendicular to the longitudinal axis.

22. The lower leg prosthesis of claim 16, wherein:

the forefoot plate and the heel plate both are formed of a composite material incorporating high-strength fibers;

the forefoot plate has a thickness that varies along its length, from a maximum at the forefoot plate's anterior end to a minimum at the forefoot plate's posterior end; and

the heel plate has a thickness that varies along the heel plate's length, from a minimum at the heel plate's anterior end to a maximum at the heel plate's posterior end.

23. The lower leg prosthesis of claim 1, wherein the elastomeric layer incorporates a solid, high-density polyurethane.

24. The lower leg prosthesis of claim 1, wherein the elastomeric layer has a thickness of at least about 2 mm over the outer portion of the lower foot plate.

25. A lower leg prosthesis comprising:

a curved upper foot plate configured to be flexible in a longitudinal direction;

a lower foot plate disposed below the upper foot plate, the lower foot plate including a heel portion for accommodating heel strike; and

an attachment device coupled to the upper foot plate and adapted for connection to an external prosthetic component, the attachment device including a lower surface that generally conforms to a sloping portion of the upper foot plate.

26. The lower leg prosthesis of claim 25, wherein the attachment device further comprises a mounting portion oriented generally horizontal for connection to an external prosthetic component.

27. The lower leg prosthesis of claim 26, wherein the mounting portion is opposite the lower surface of the attachment device, and wherein the lower surface and the upper foot plate slope downwardly toward a front portion of the upper foot plate.

28. The lower leg prosthesis of claim 26, wherein the mounting portion comprises a pyramid adapter oriented generally vertical.

29. The lower leg prosthesis of claim 25, wherein the attachment device comprises a wedge-shaped portion having a lower surface that conforms to the sloping portion of the upper foot plate and including a generally horizontal upper surface for mounting to an external component.

30. The lower leg prosthesis of claim 29, wherein the attachment device further comprises a mounting protrusion.

31. The lower leg prosthesis of claim 30, wherein the mounting protrusion is oriented generally vertical.

32. The lower leg prosthesis of claim 30, wherein the mounting protrusion comprises a pyramid adapter.

33. The lower leg prosthesis of claim 25, wherein the attachment device is bonded to the upper foot.

34. The lower leg prosthesis of claim 25, wherein the attachment device attaches to the upper foot plate using mechanical fasteners.

35. The lower leg prosthesis of claim 25, wherein the upper foot plate comprises an upper surface and a lower surface with the lower surface facing the lower foot plate, and the lower leg prosthesis further comprises a backing component configured for placement generally adjacent the lower surface of the upper foot plate and disposed generally below the attachment device, and wherein the attachment device attaches to the upper foot plate using a mechanical fastener coupled to the backing component.

36. The lower leg prosthesis of claim 35, wherein the backing component comprises at least one threaded opening and wherein the mechanical fastener threads into the threaded opening.

37. The lower leg prosthesis of claim 36, wherein the backing component comprises a plurality of threaded openings and wherein a plurality of mechanical fasteners thread into the plurality of threaded openings, respectively.

38. The lower leg prosthesis of claim 25, wherein the attachment device is formed from one or more of metals, ceramics, composites and plastics.

39. The lower leg prosthesis of claim 25, wherein the attachment device is configured for weight reduction.

40. The lower leg prosthesis of claim 39, wherein the attachment device comprises a weight reducing portion formed by removal of material.

41. The lower leg prosthesis of claim 40, wherein the weight reducing portion comprises a cutout formed in a forward facing portion of the attachment device.

42. The lower leg prosthesis of claim 25, further comprising an elastomeric layer disposed between the lower foot plate and the upper foot plate.

43. The lower leg prosthesis of claim 42, wherein the elastomeric layer extends across a substantial portion of an upper surface of the lower foot plate.

44. The lower leg prosthesis of claim 42, wherein the elastomeric layer extends over a substantial portion of a lower surface of the upper foot plate.

45. The lower leg prosthesis of claim 42, wherein the upper foot plate comprises an upper surface and a lower surface with the lower surface facing the lower foot plate, and the lower leg prosthesis further comprises a backing component configured for coupling with the attachment device, and wherein the elastomeric layer comprises at least one recess configured to receive the backing component so as to locate the backing component generally adjacent the lower surface of the upper foot plate and generally below the attachment device, the attachment device attached to the upper foot plate by coupling to the backing component.

46. The lower leg prosthesis of claim 42, wherein the upper foot plate comprises an upper surface and a lower surface with the lower surface facing the lower foot plate, and the lower leg prosthesis further comprises a backing component configured for placement generally adjacent the lower surface of the upper foot plate and disposed generally below the attachment device and generally within the elastomeric layer, and wherein the attachment device attaches to the upper foot plate using a mechanical fastener coupled to the backing component.

47. The lower leg prosthesis of claim 25, wherein the lower foot plate includes a forefoot plate and a heel plate aligned along a longitudinal axis.

48. The lower leg prosthesis of claim 47, wherein:

the forefoot and heel plates together have a toe section, a mid-foot section, and a heel section; and

the forefoot and heel plates are separated from each other by a first gap located in the mid-foot section.

49. The lower leg prosthesis of claim 48, wherein the elastomeric layer comprises an anterior section disposed between the upper plate and the forefoot plate and a posterior section disposed between the upper plate and the heel plate, wherein a second gap is defined between the anterior and posterior sections, adjacent the first gap.

50. The lower leg prosthesis of claim 49, wherein the first and second gaps both are substantially straight and oriented substantially perpendicular to the longitudinal axis.

* * * * *