US009895239B2

(12) **United States Patent**
Bartlett

(10) **Patent No.: US 9,895,239 B2**
(45) **Date of Patent: *Feb. 20, 2018**

(54) **LIMB PROSTHESIS SYSTEM AND METHOD**

(76) Inventor: **Brian Bartlett**, Seattle, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 846 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **12/925,997**

(22) Filed: **Nov. 4, 2010**

(65) **Prior Publication Data**

US 2011/0054634 A1 Mar. 3, 2011

Related U.S. Application Data

(63) Continuation-in-part of application No. 11/241,831, filed on Sep. 30, 2005, now Pat. No. 7,828,856.

(51) **Int. Cl.**

A61F 2/64	(2006.01)
A61F 2/60	(2006.01)
A61F 2/66	(2006.01)
A61F 2/78	(2006.01)
A61F 2/80	(2006.01)
A61F 2/50	(2006.01)

(52) **U.S. Cl.**

CPC ***A61F 2/60*** (2013.01); *A61F 2/64* (2013.01); *A61F 2/6607* (2013.01); *A61F 2/78* (2013.01); *A61F 2/80* (2013.01); *A61F 2002/5007* (2013.01); *A61F 2002/5072* (2013.01); *A61F 2002/5079* (2013.01); *A61F 2002/6614* (2013.01)

(58) **Field of Classification Search**

USPC 623/39–46

See application file for complete search history.

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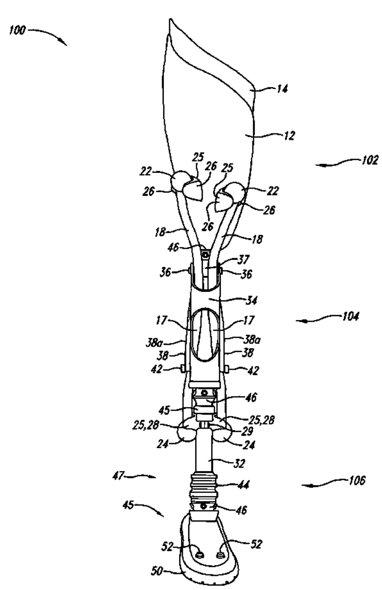
Primary Examiner — Bruce E Snow

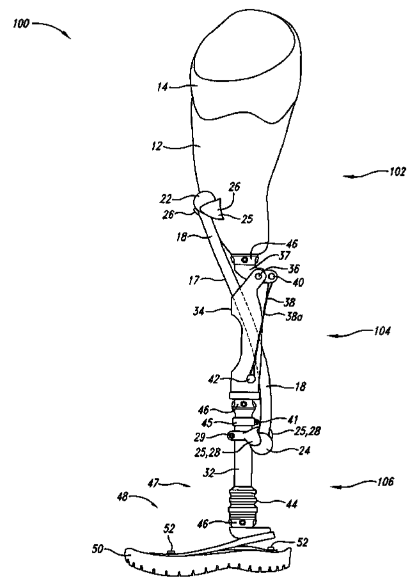
(74) *Attorney, Agent, or Firm* — Charles J. Rupnick

(57) **ABSTRACT**

A prosthesis system can have an advantageous use over conventional prostheses in certain activities, including, but not limited to certain sports activities: The system includes, elastic member(s) that can store and release energy. The storing and releasing of energy in the elastic members happens during the movements made by the user and with the application of the user's own body weight while performing an activity. Implementations can also include a variety of routing configurations for the elastic member(s), as well as a variety of mounting points to integrate the elastic member(s) into the system, and/or a variety of adjustable anti-hyperextension members, and/or a variety of interchangeable shoes used for applicable activities.

16 Claims, 34 Drawing Sheets





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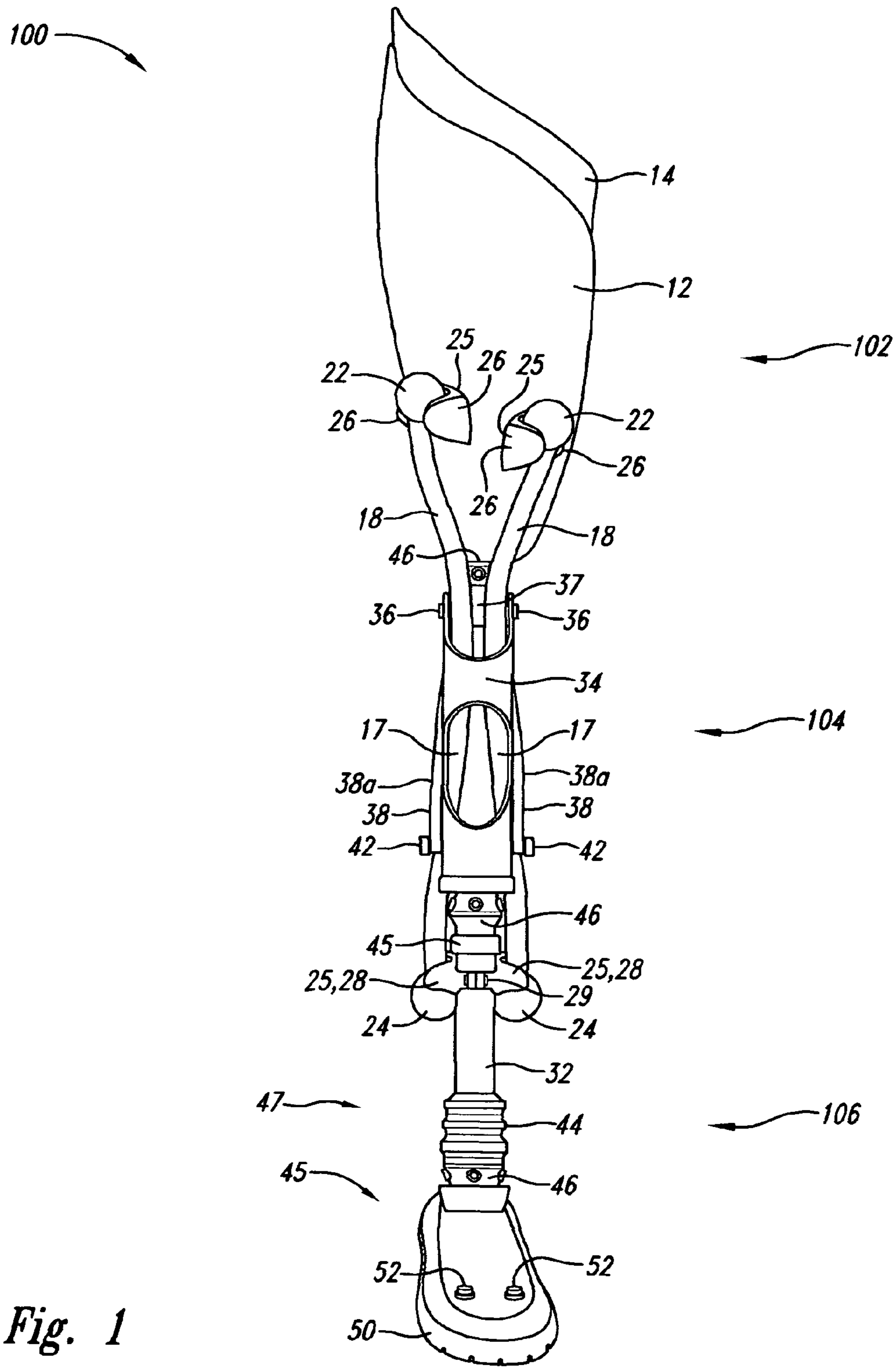
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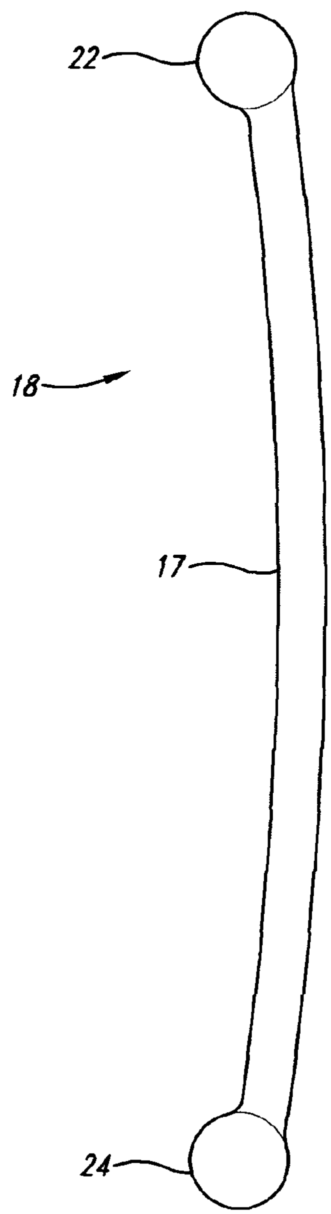
Fig. 1



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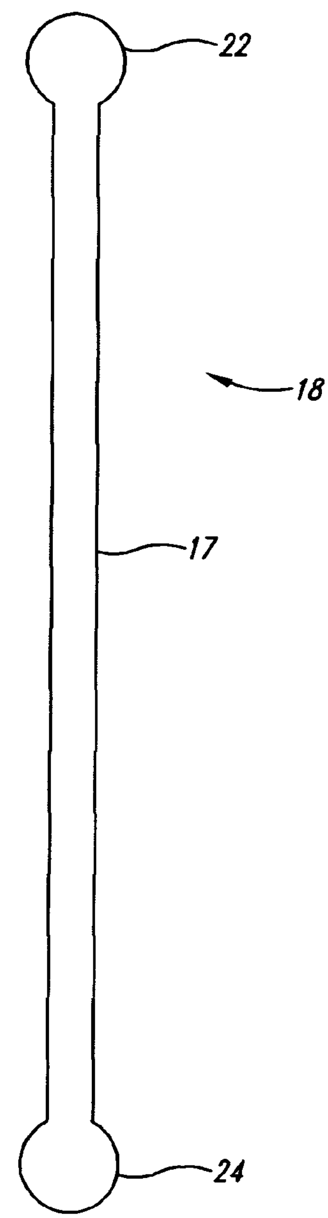

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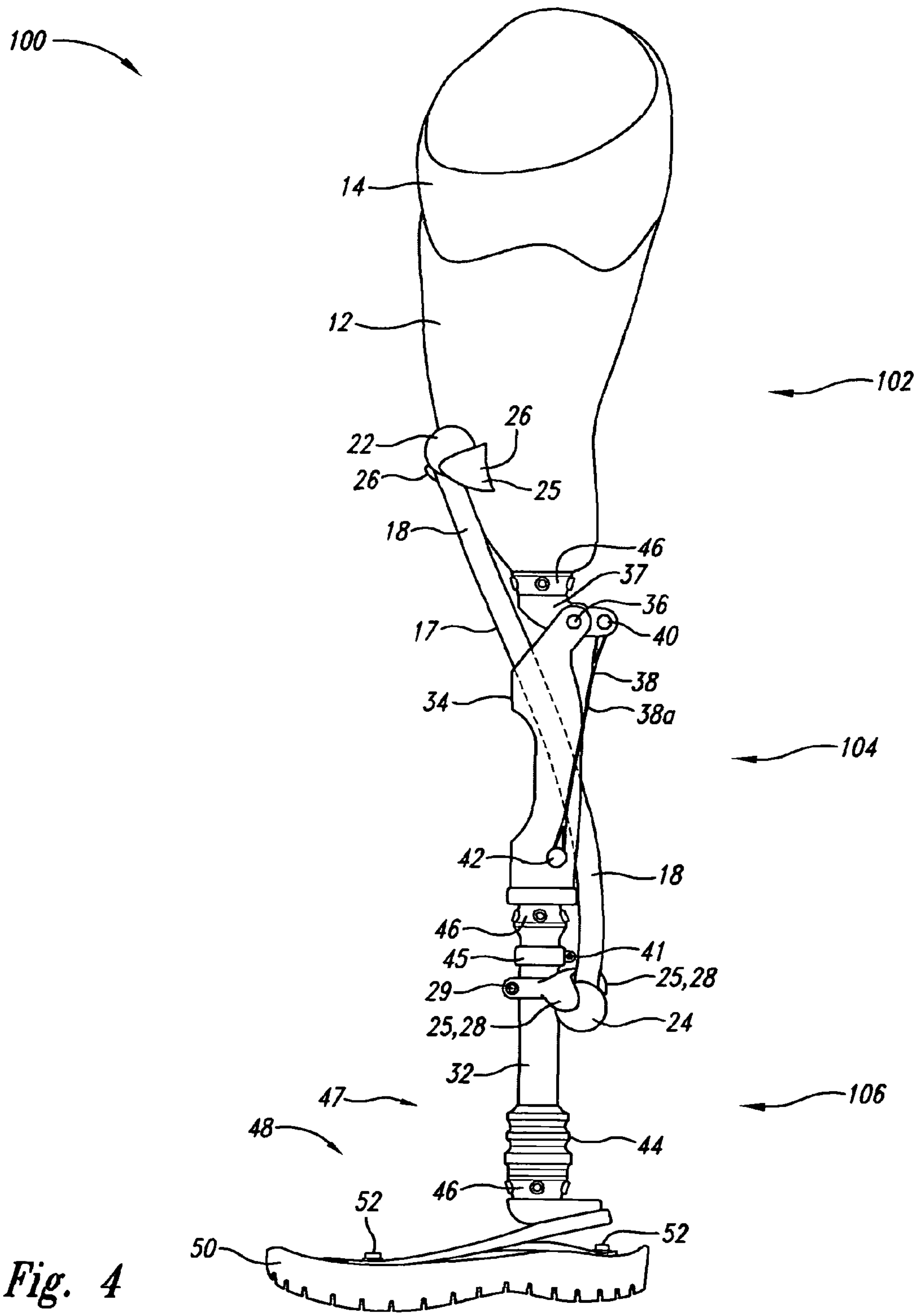
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Fig. 4

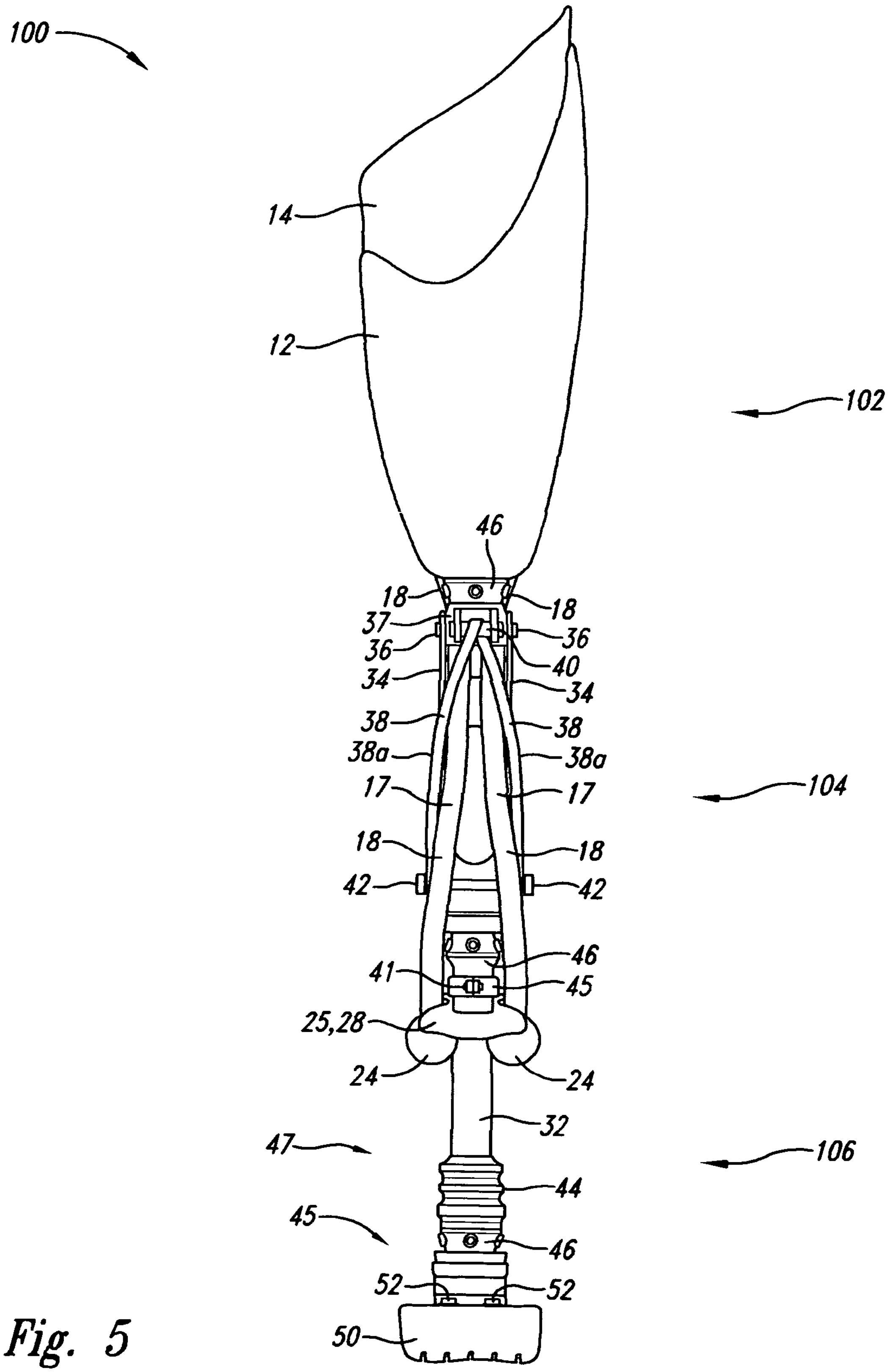
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Fig. 5

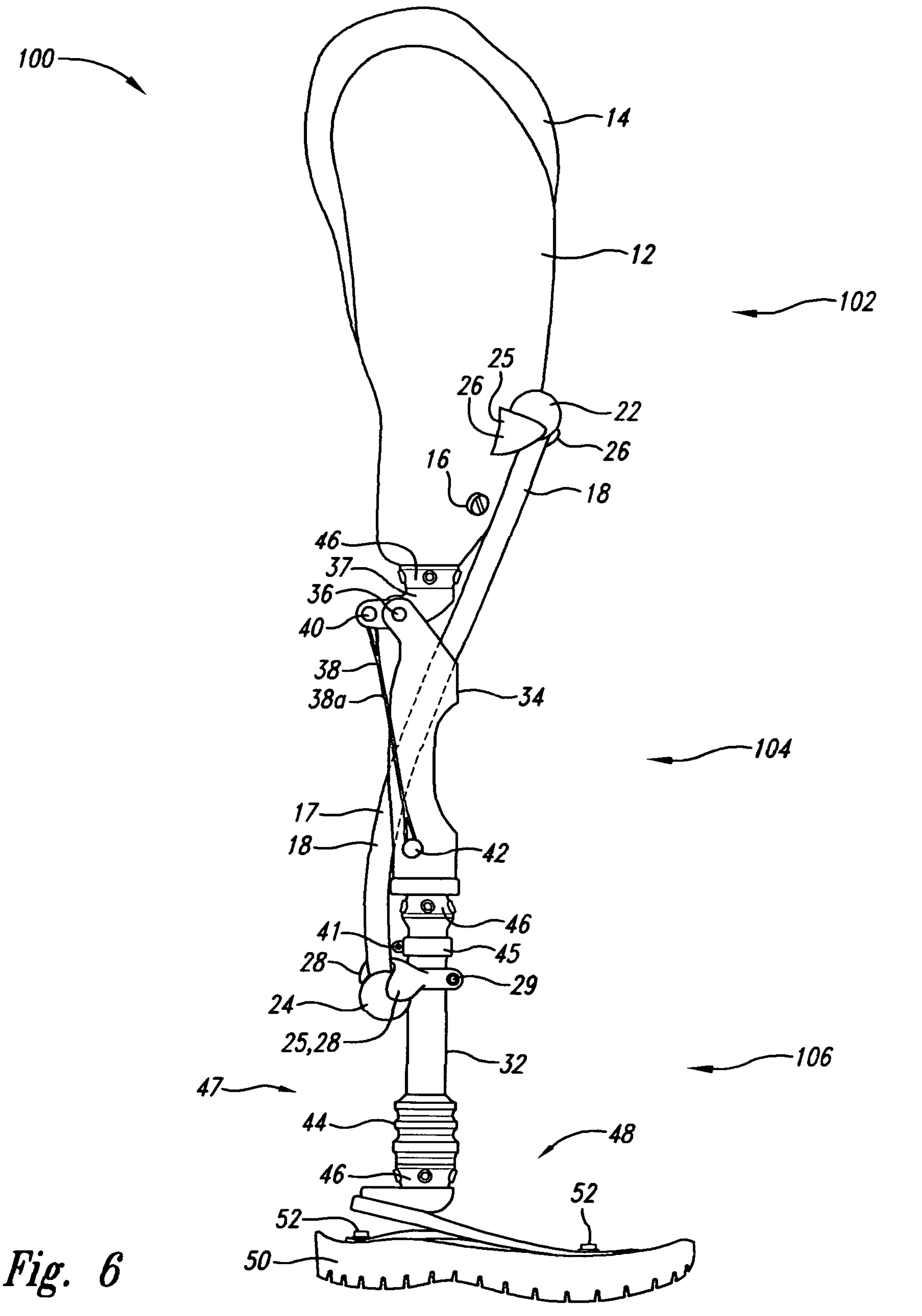
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Fig. 6

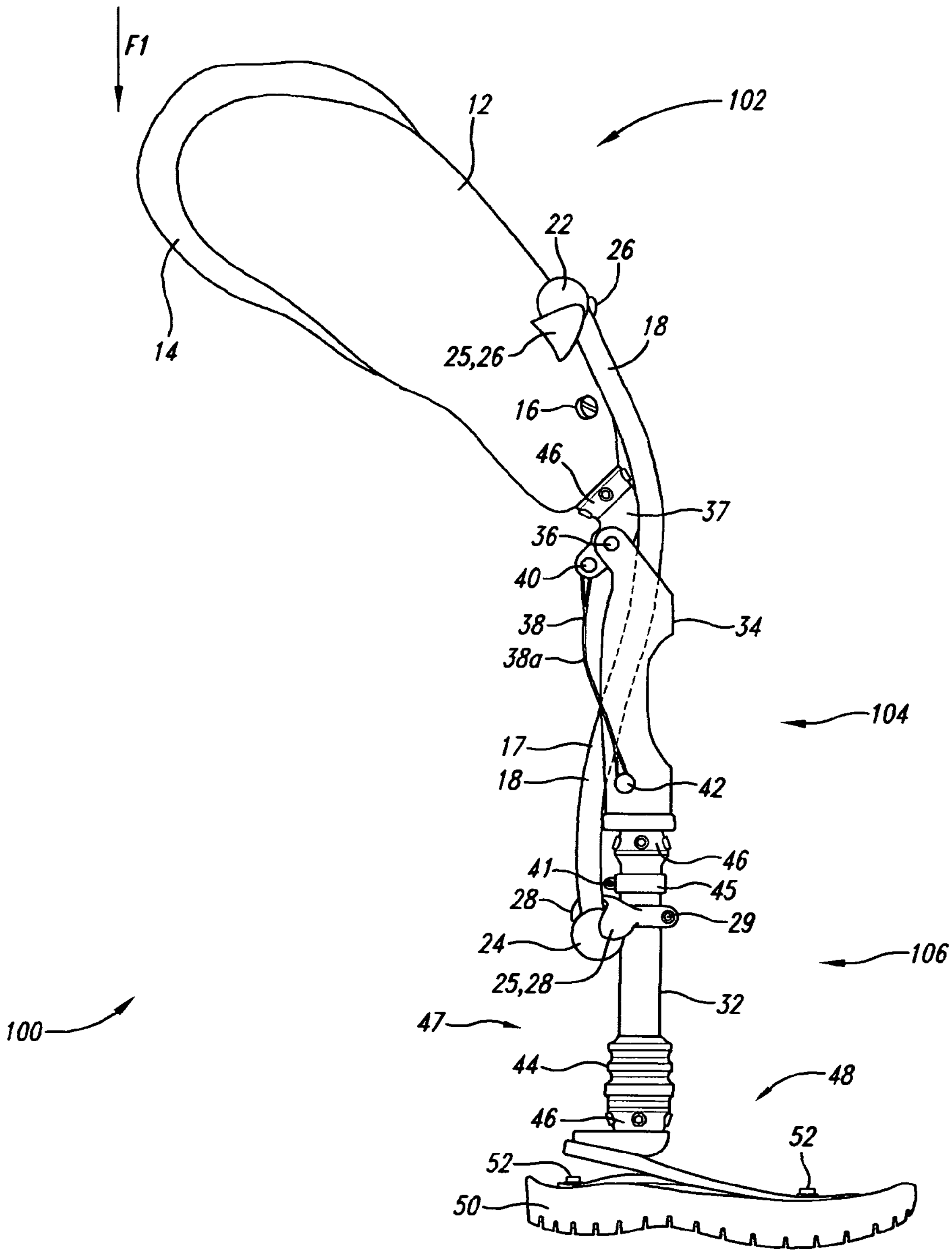
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Fig. 7

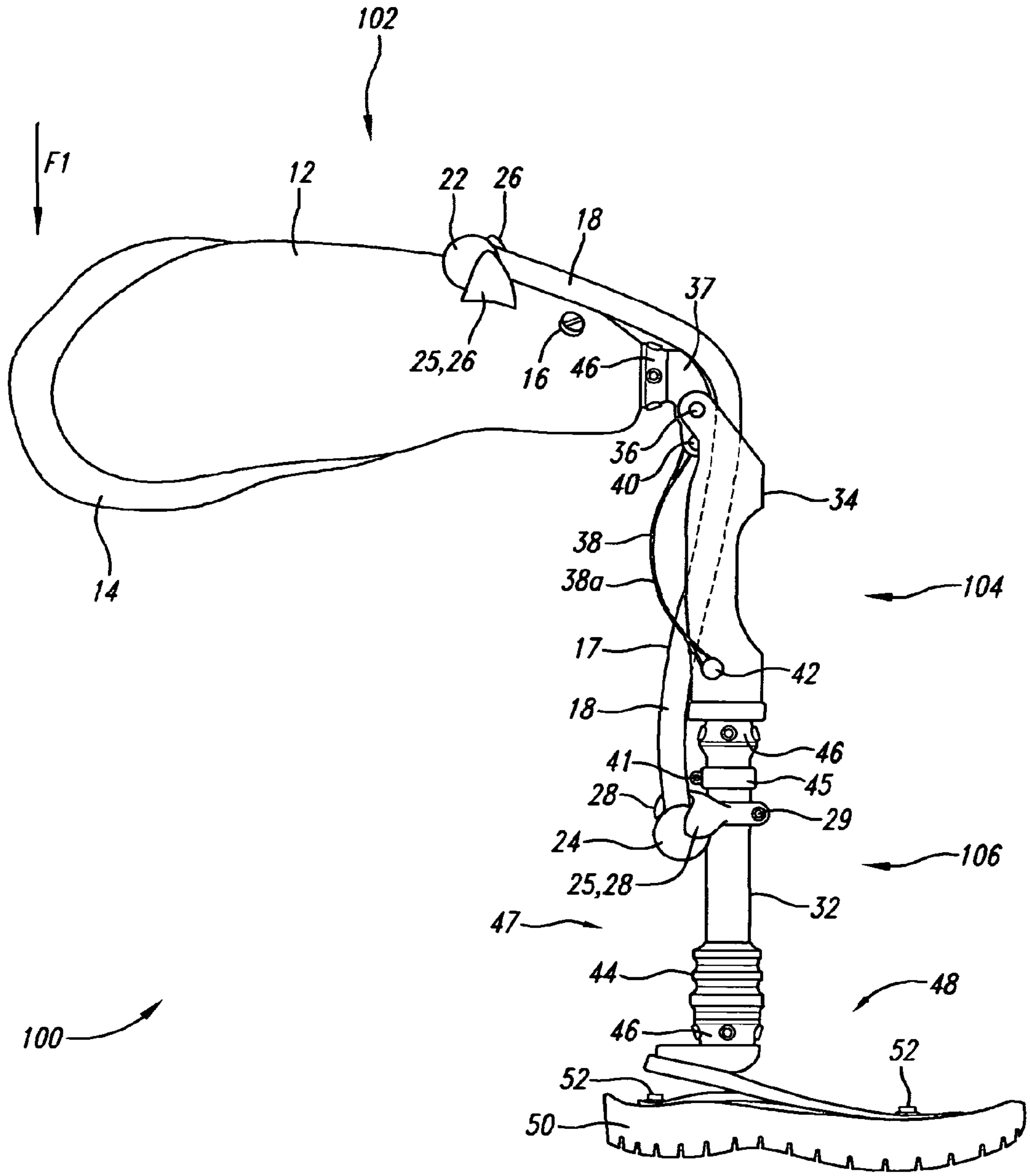
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Fig. 8

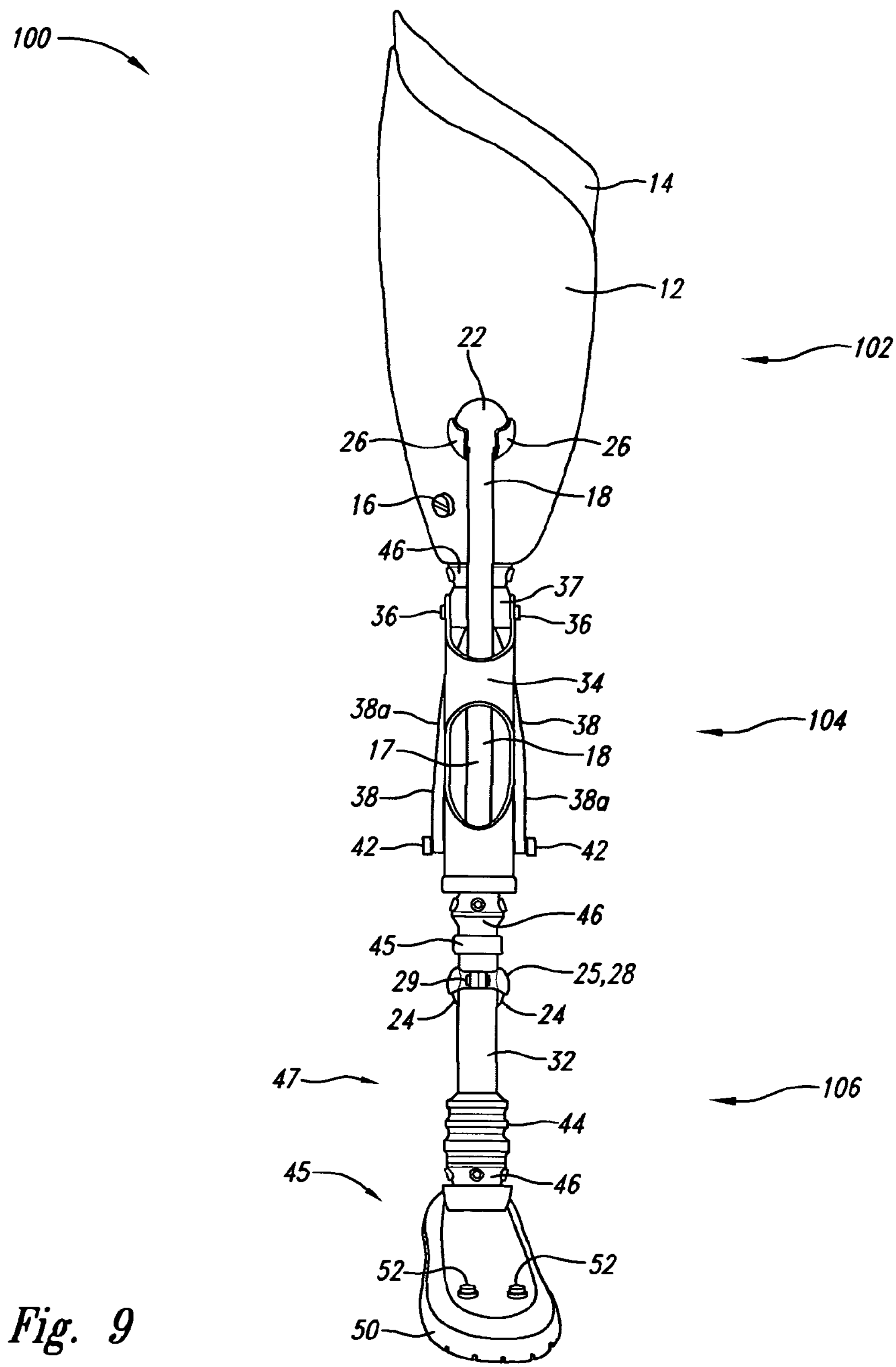
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Fig. 9

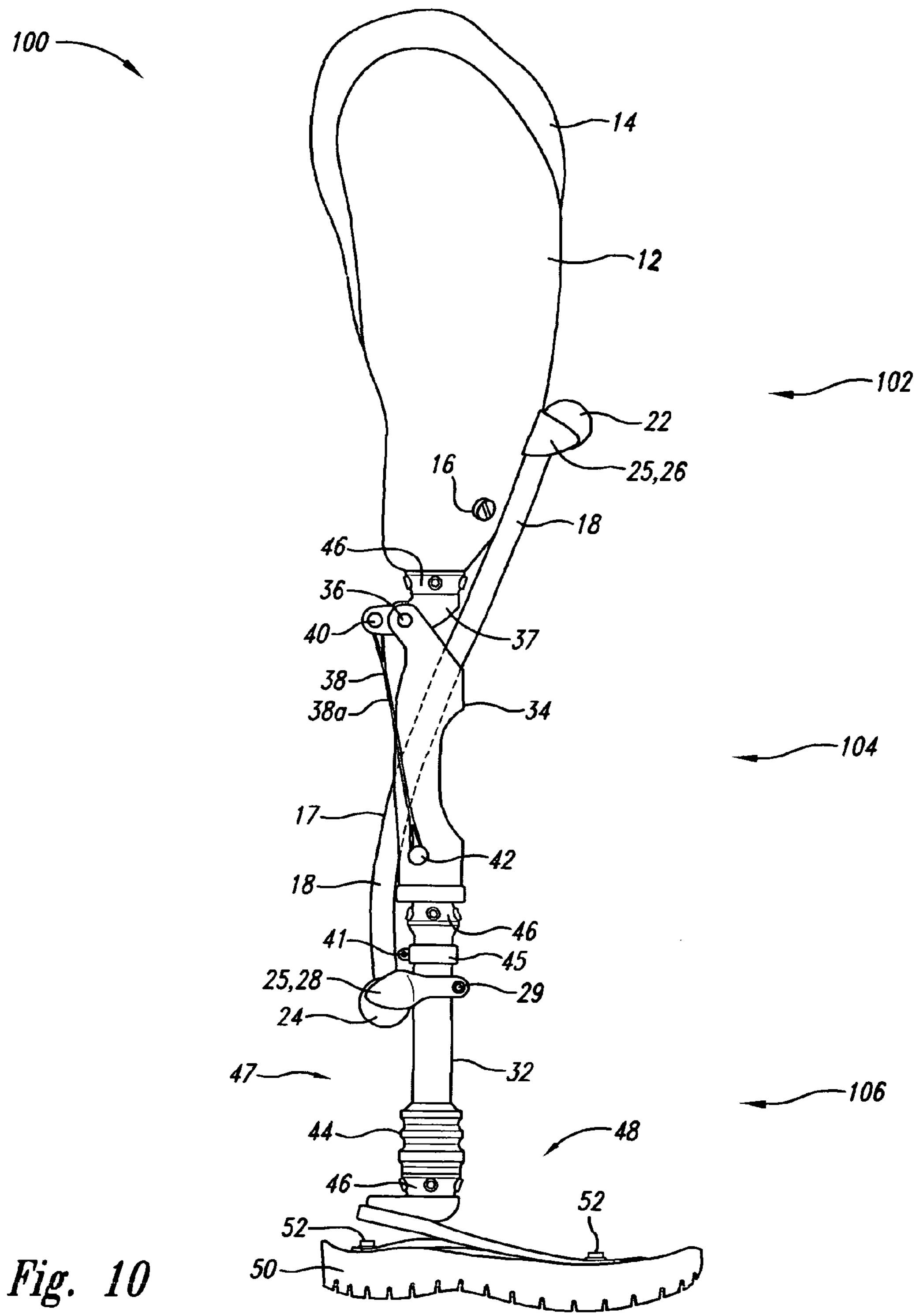
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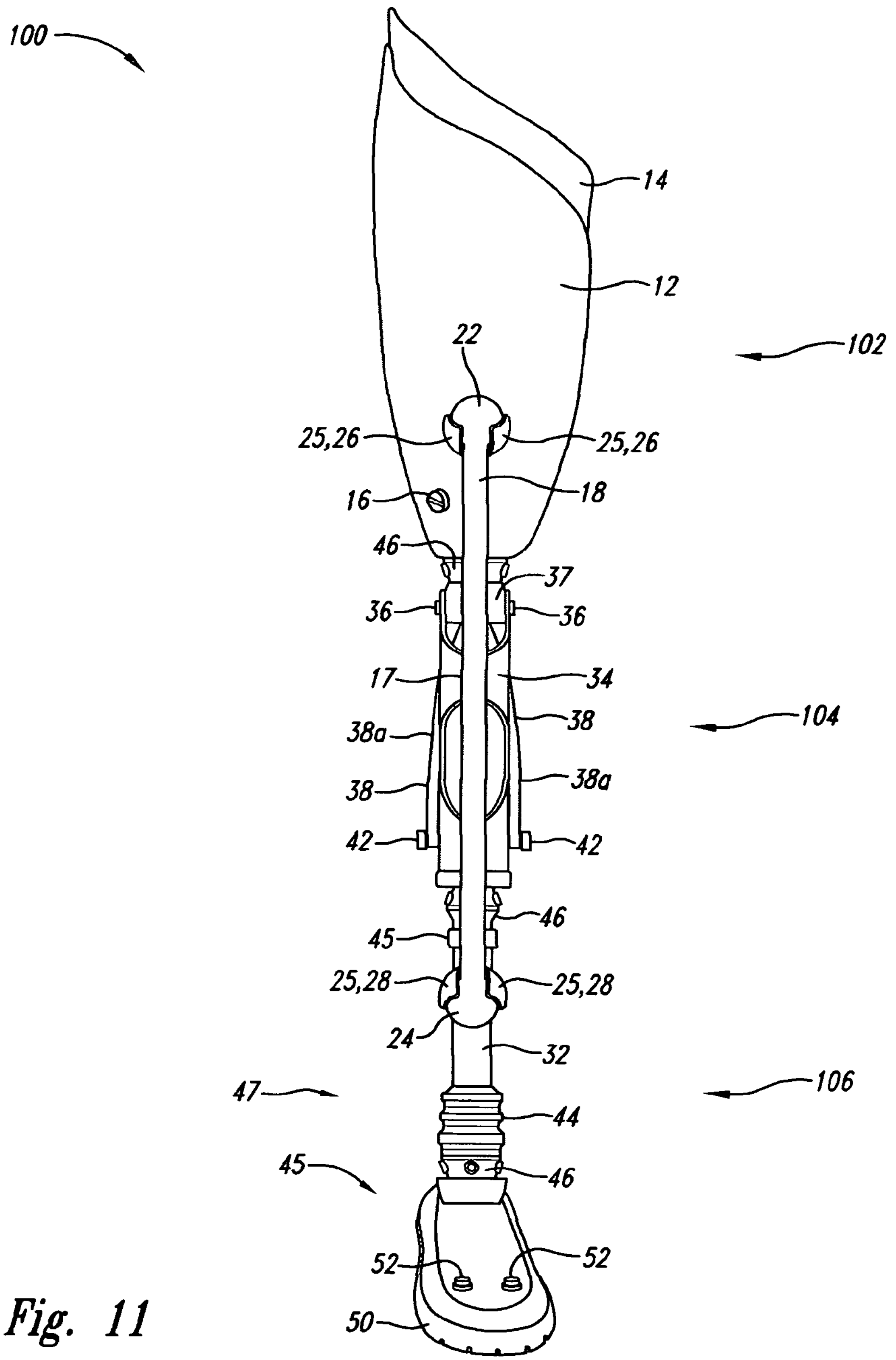
Fig. 10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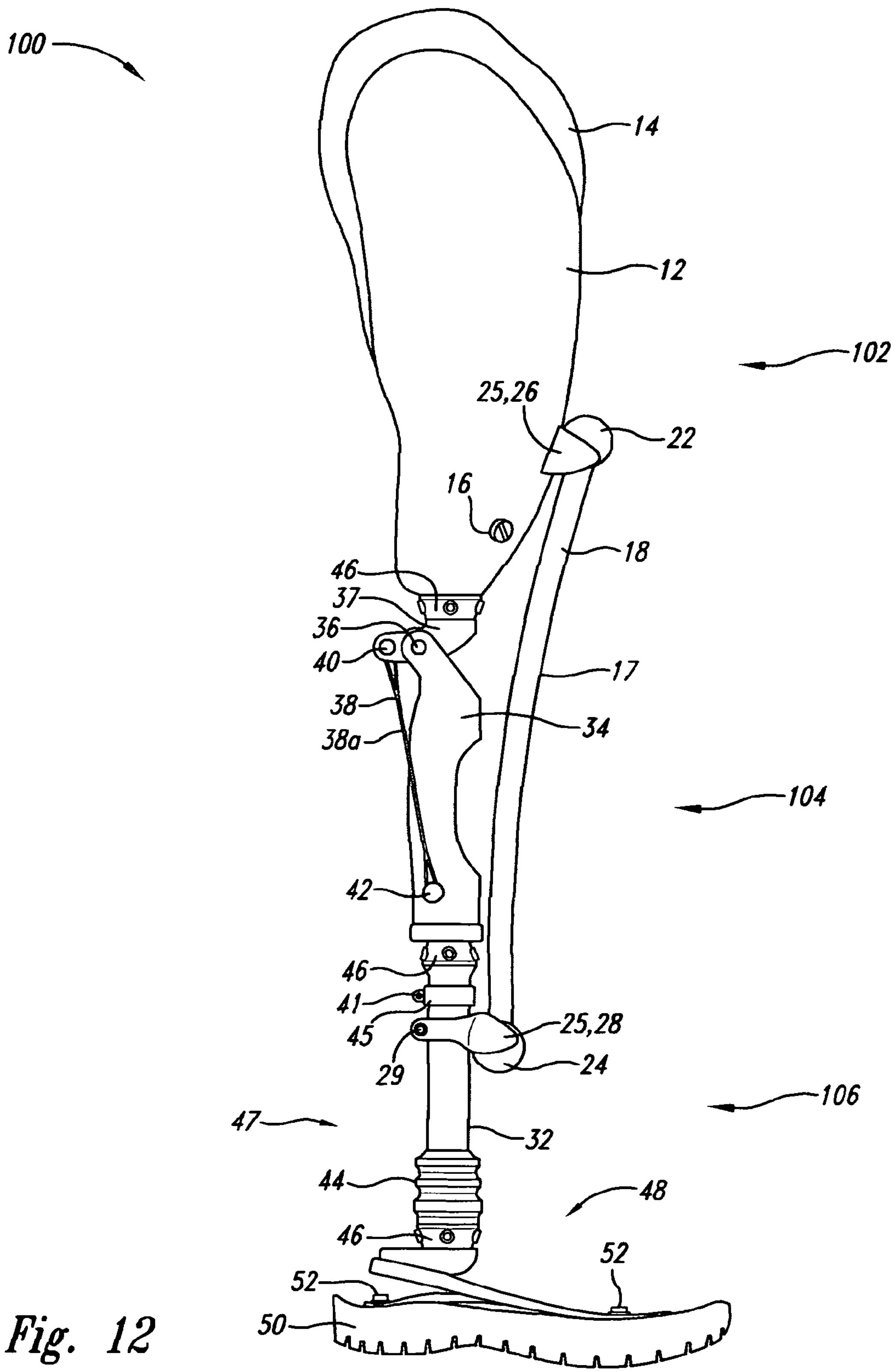
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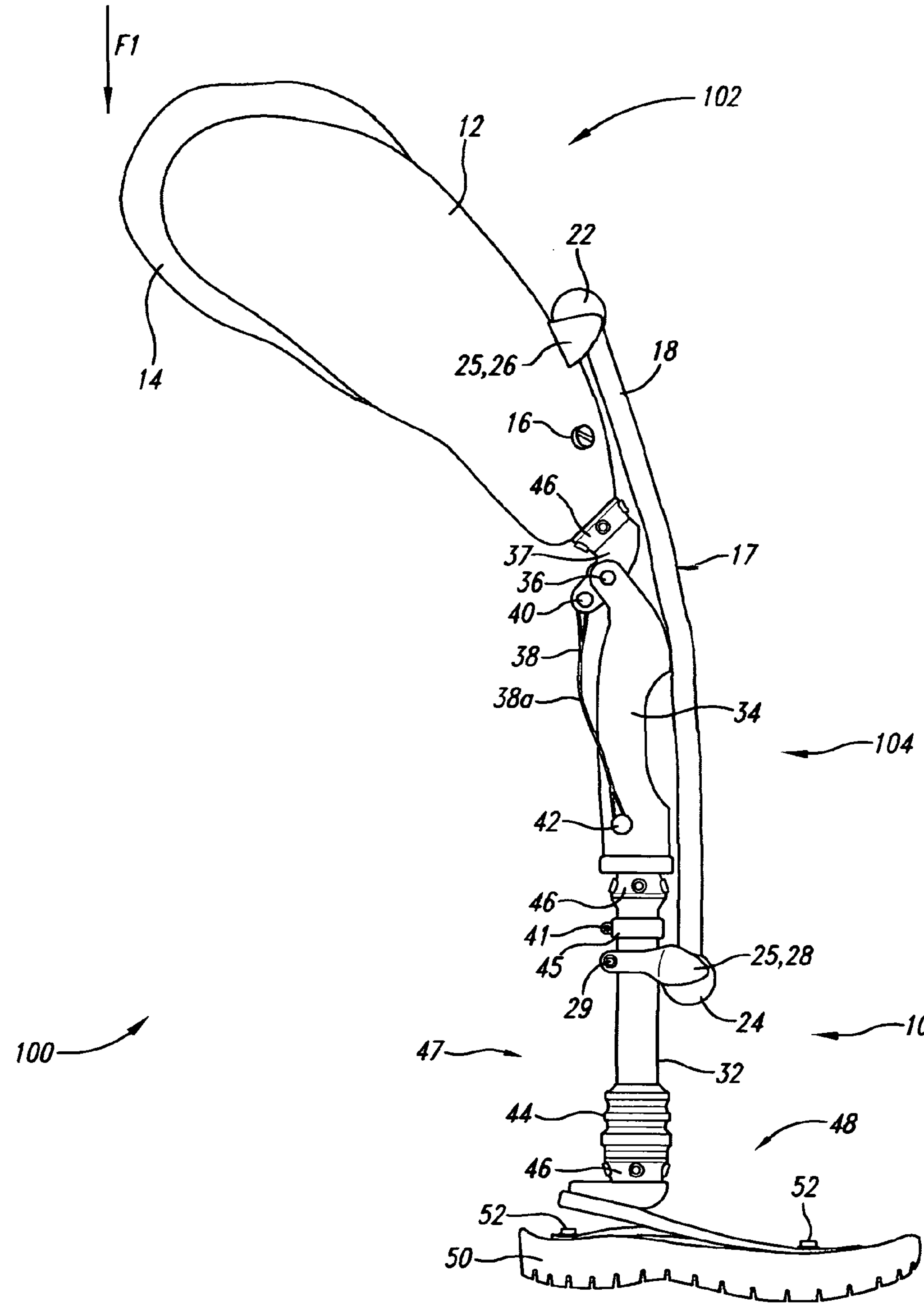
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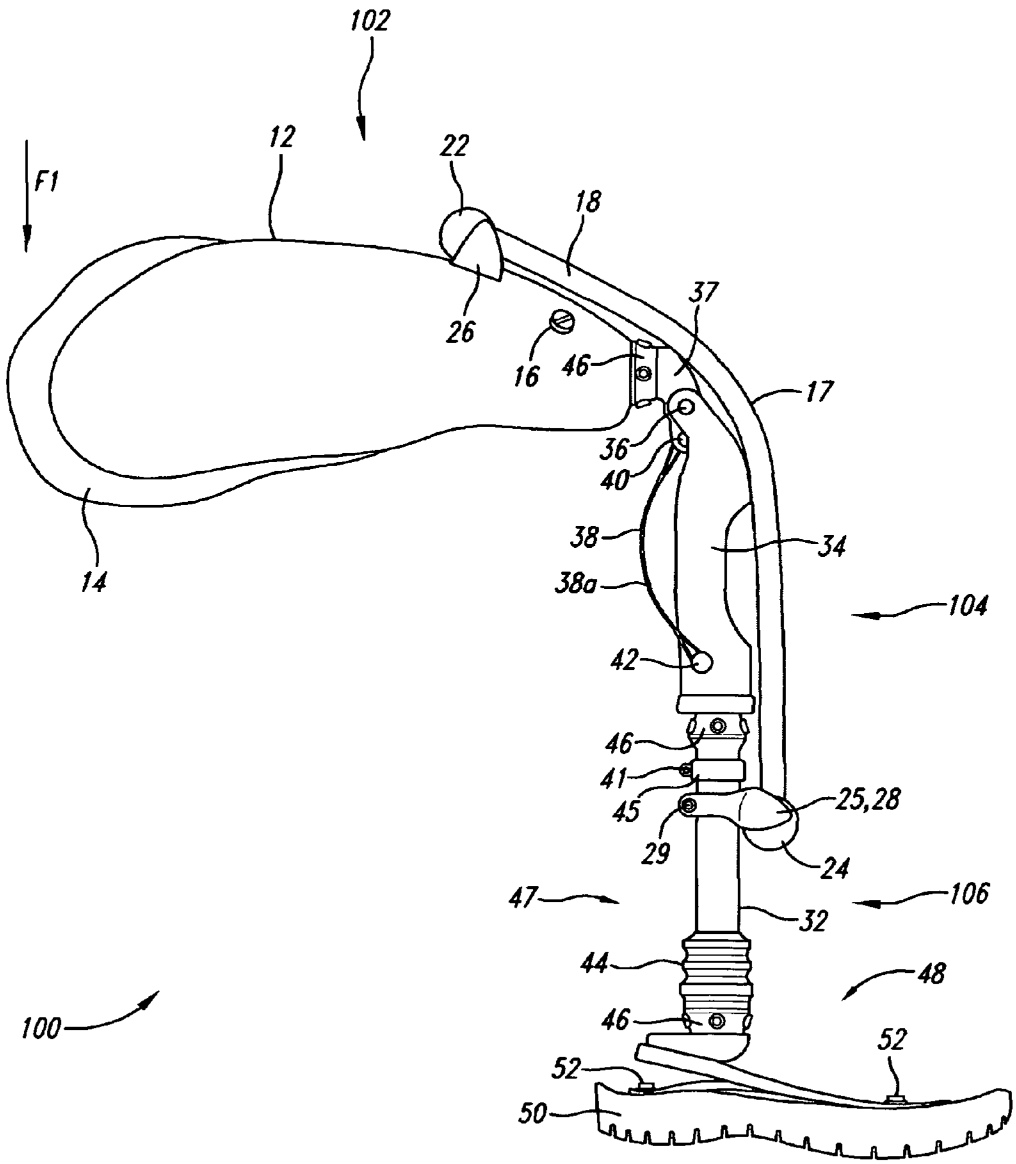
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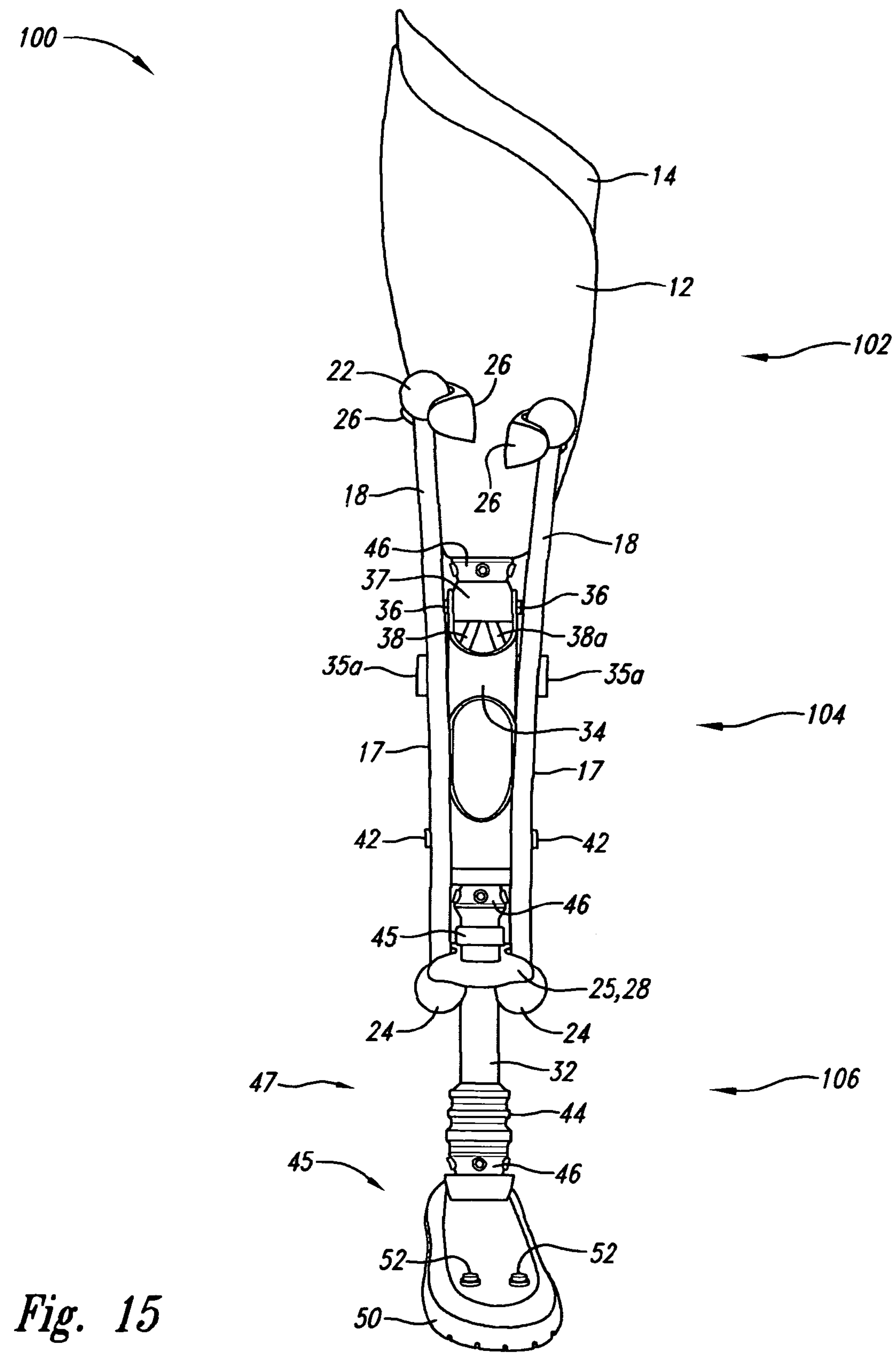
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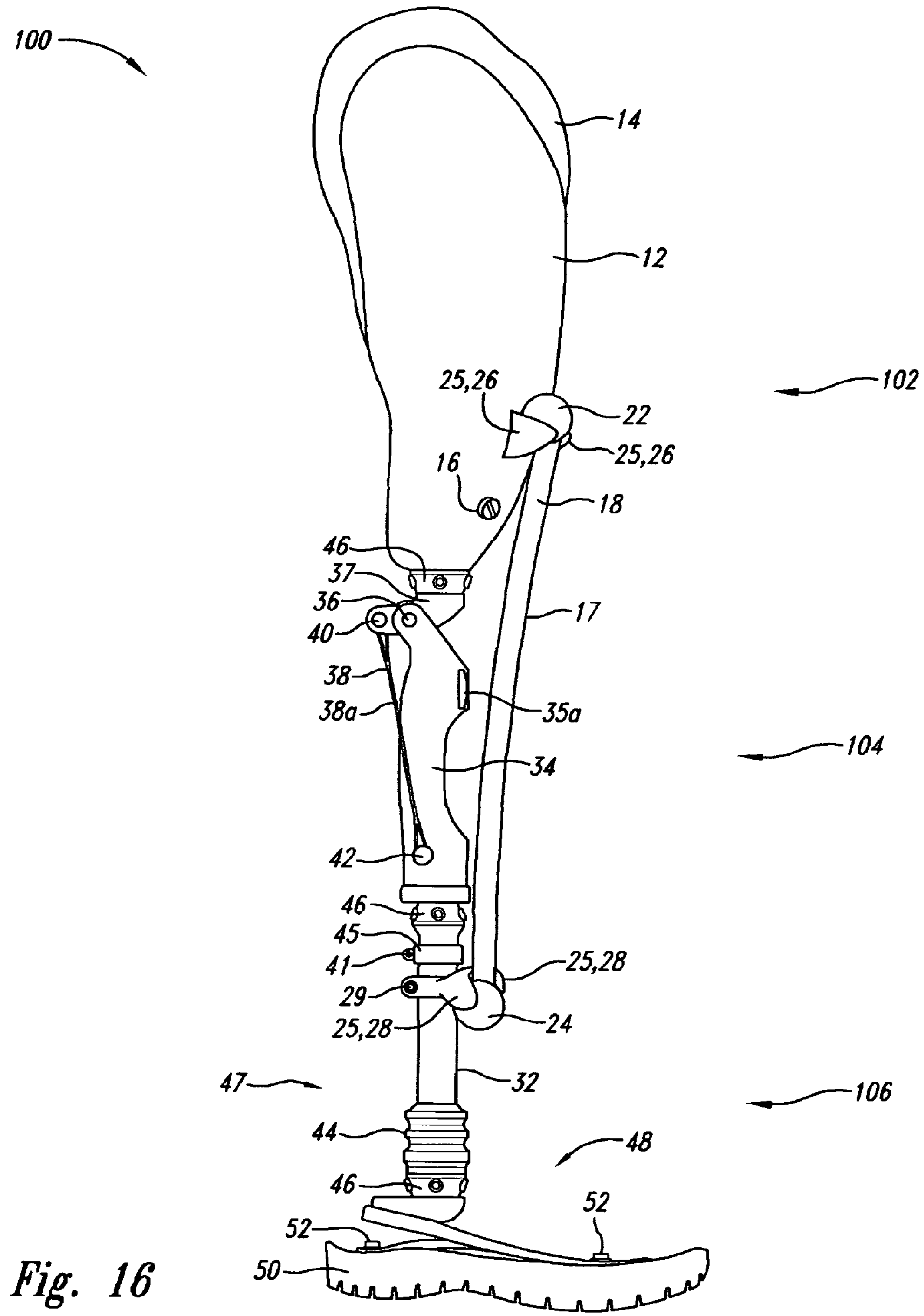
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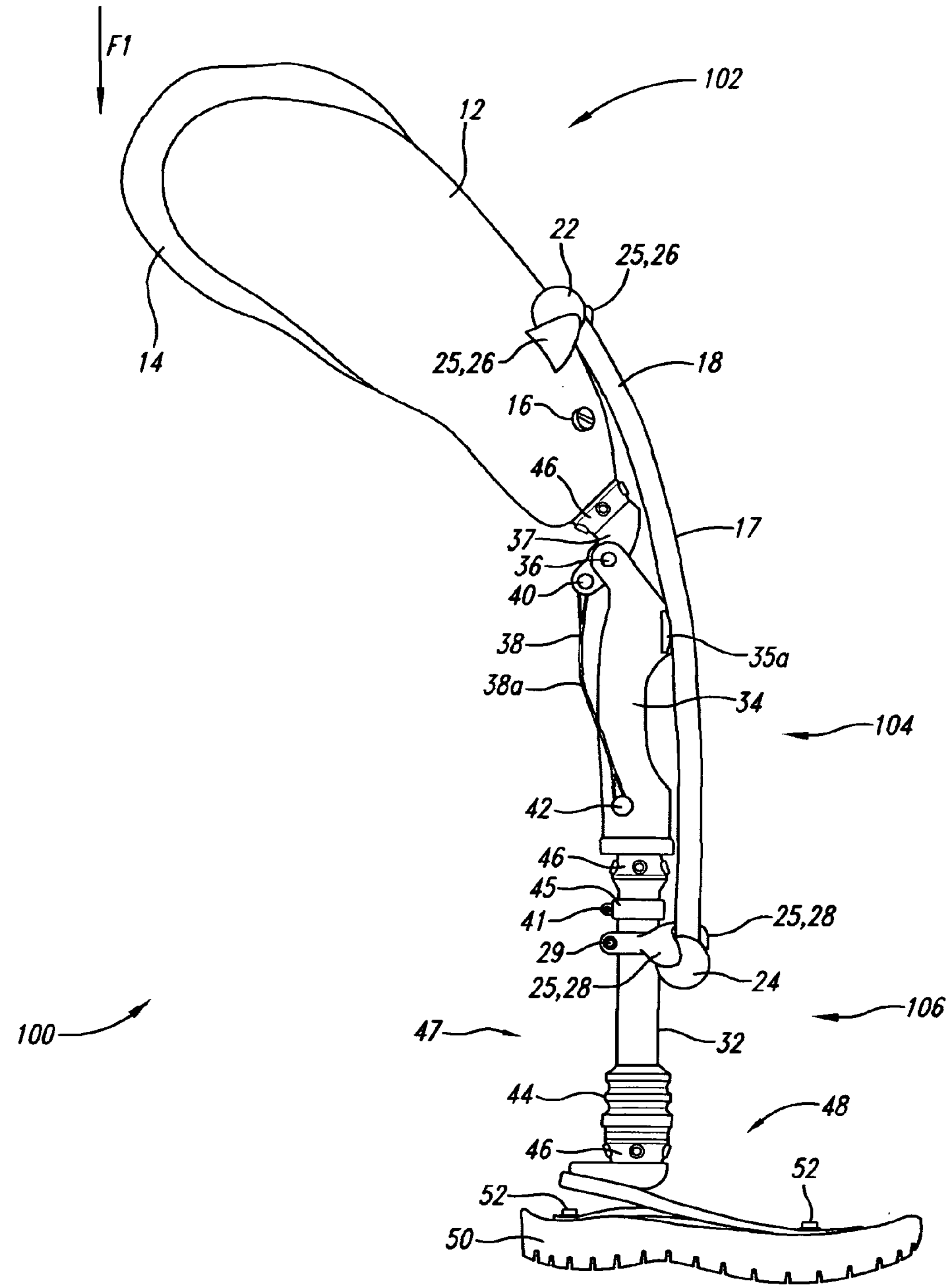
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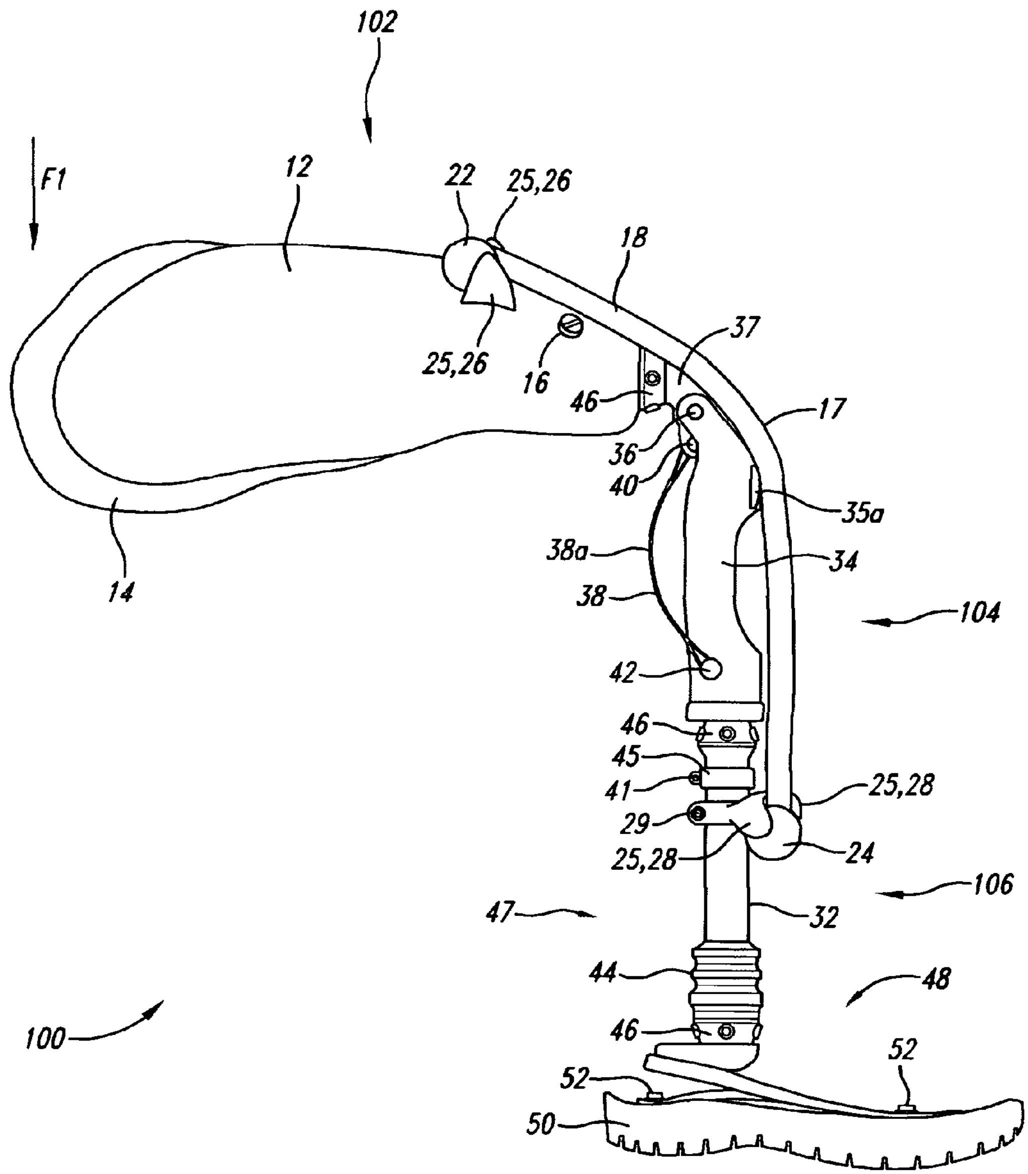
Fig. 17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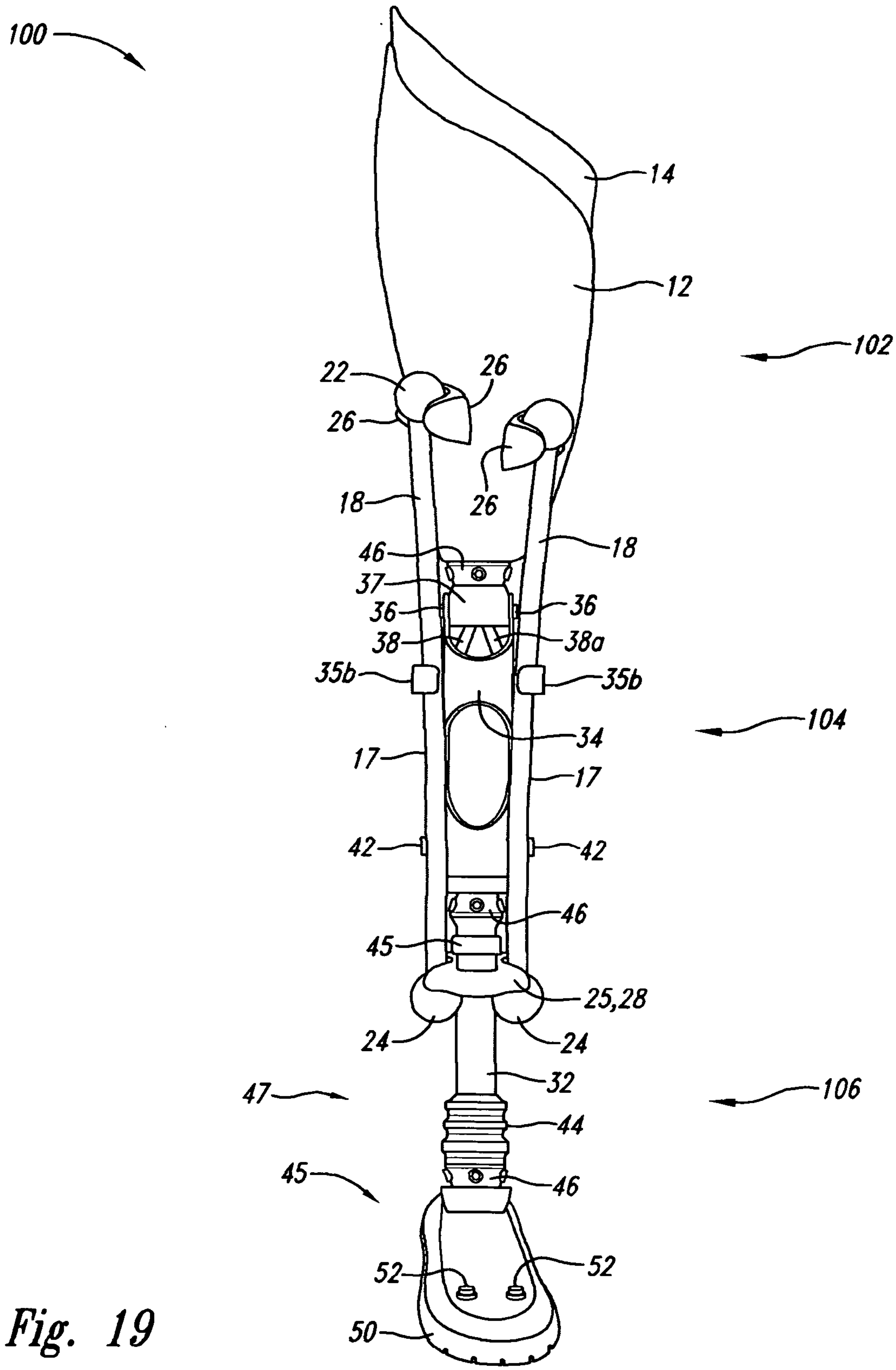
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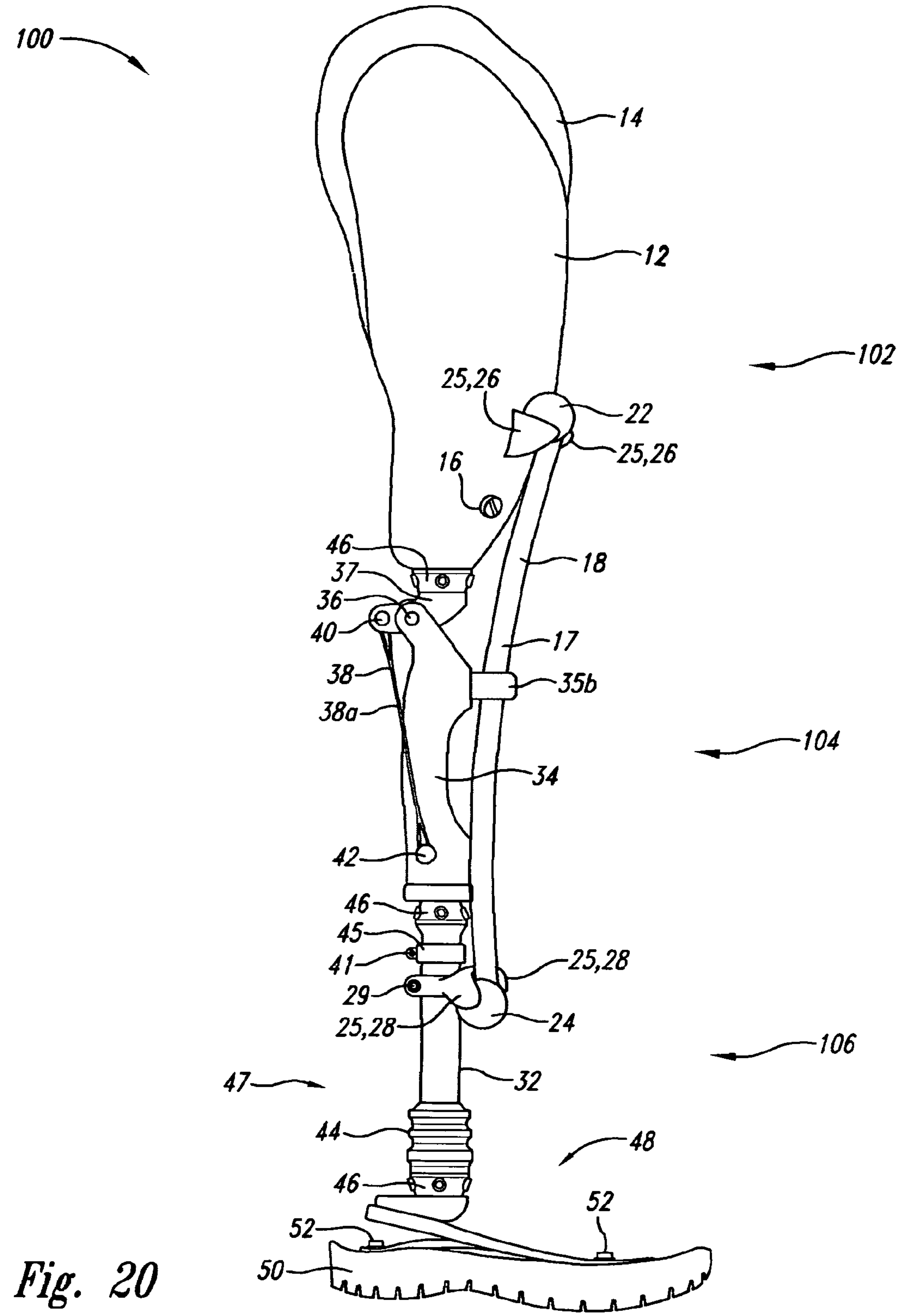
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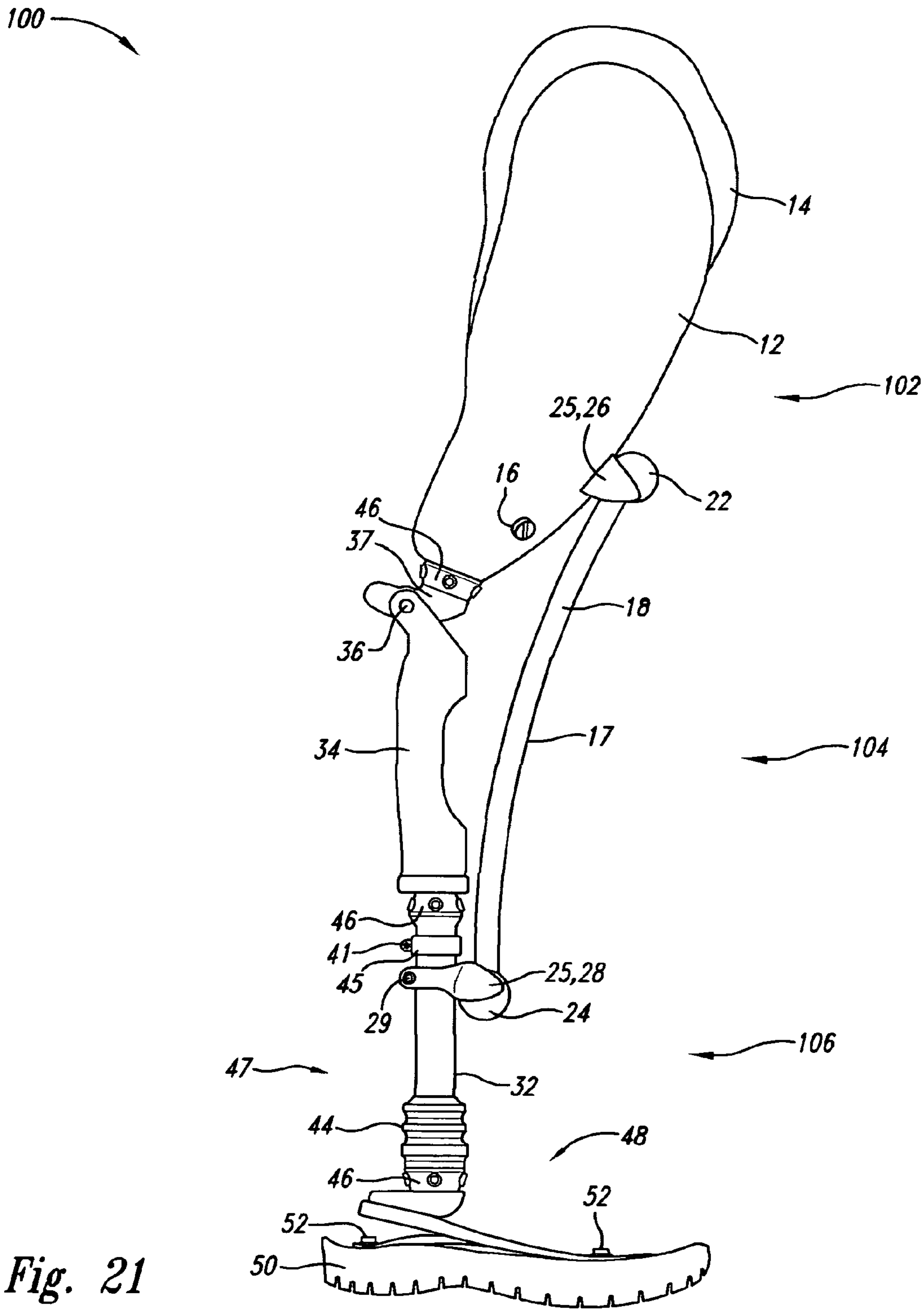
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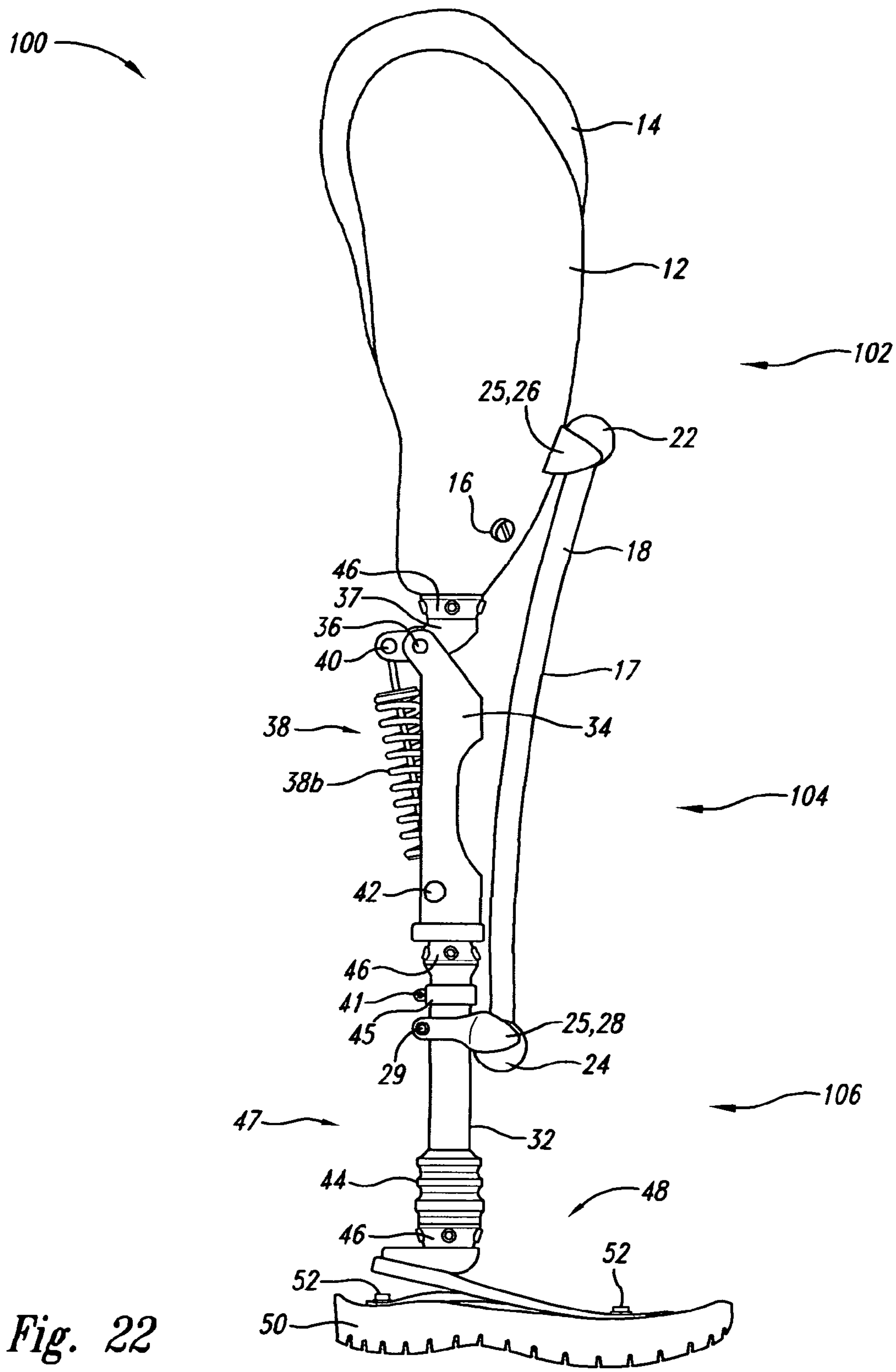
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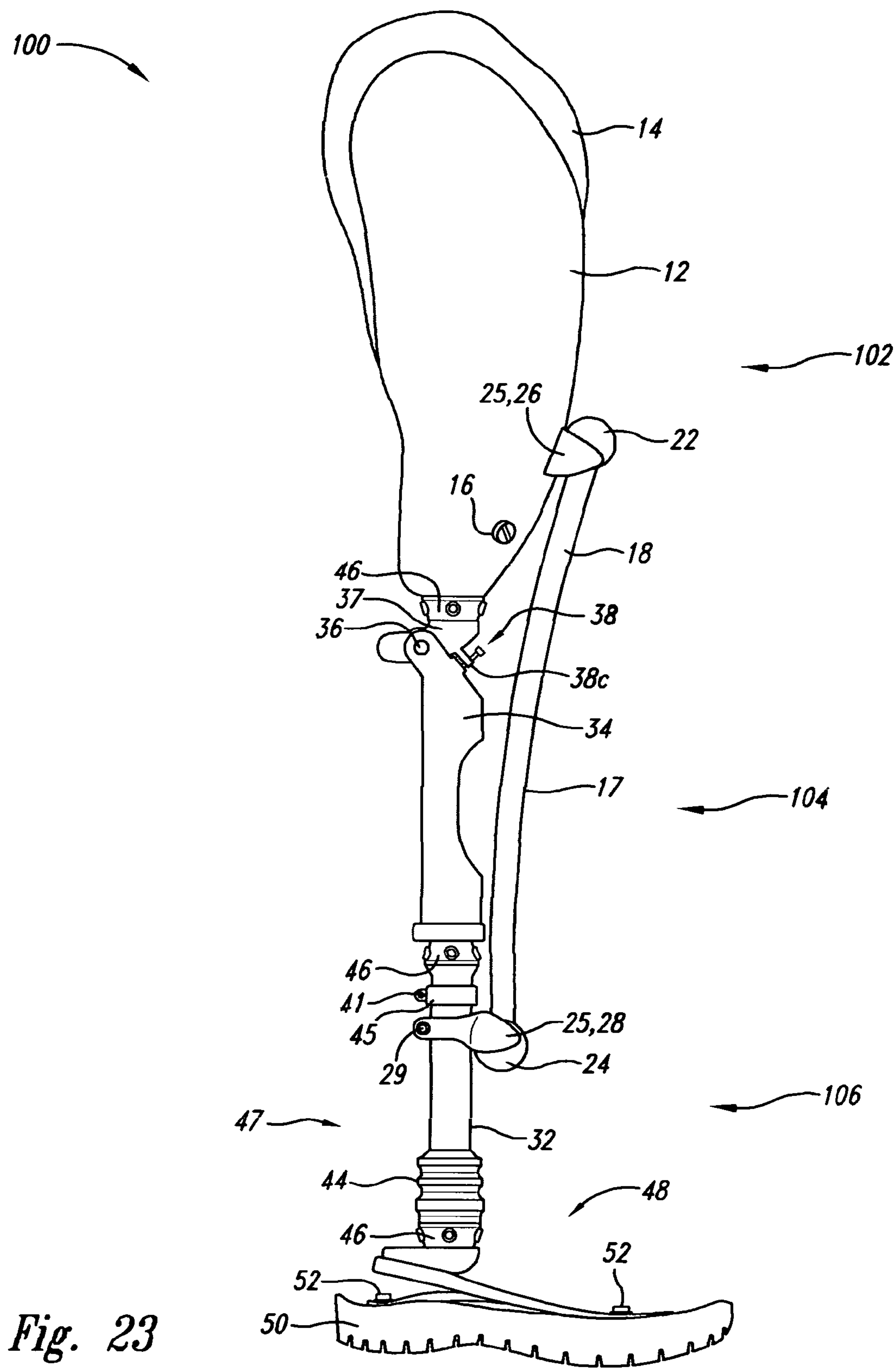
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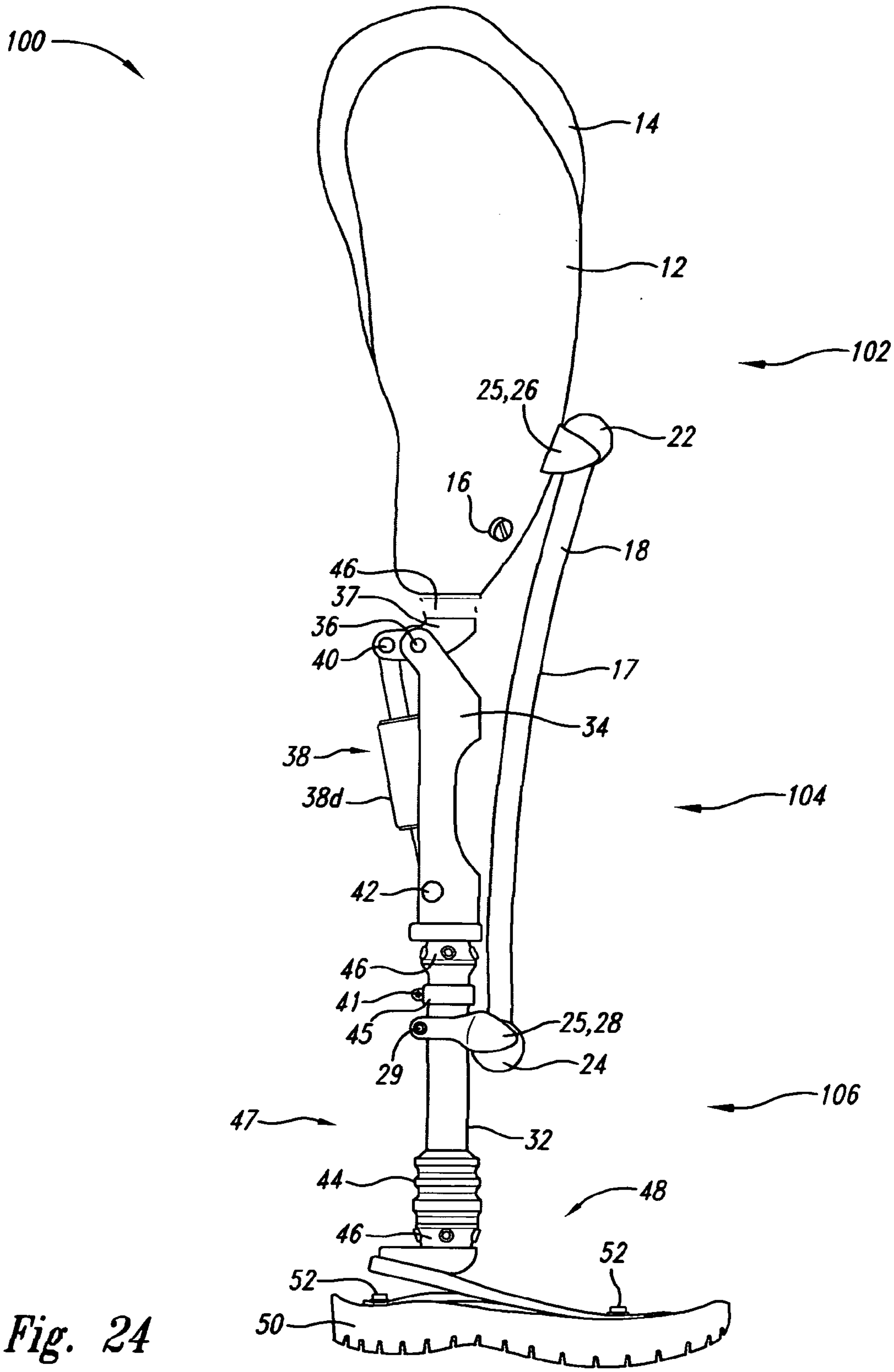
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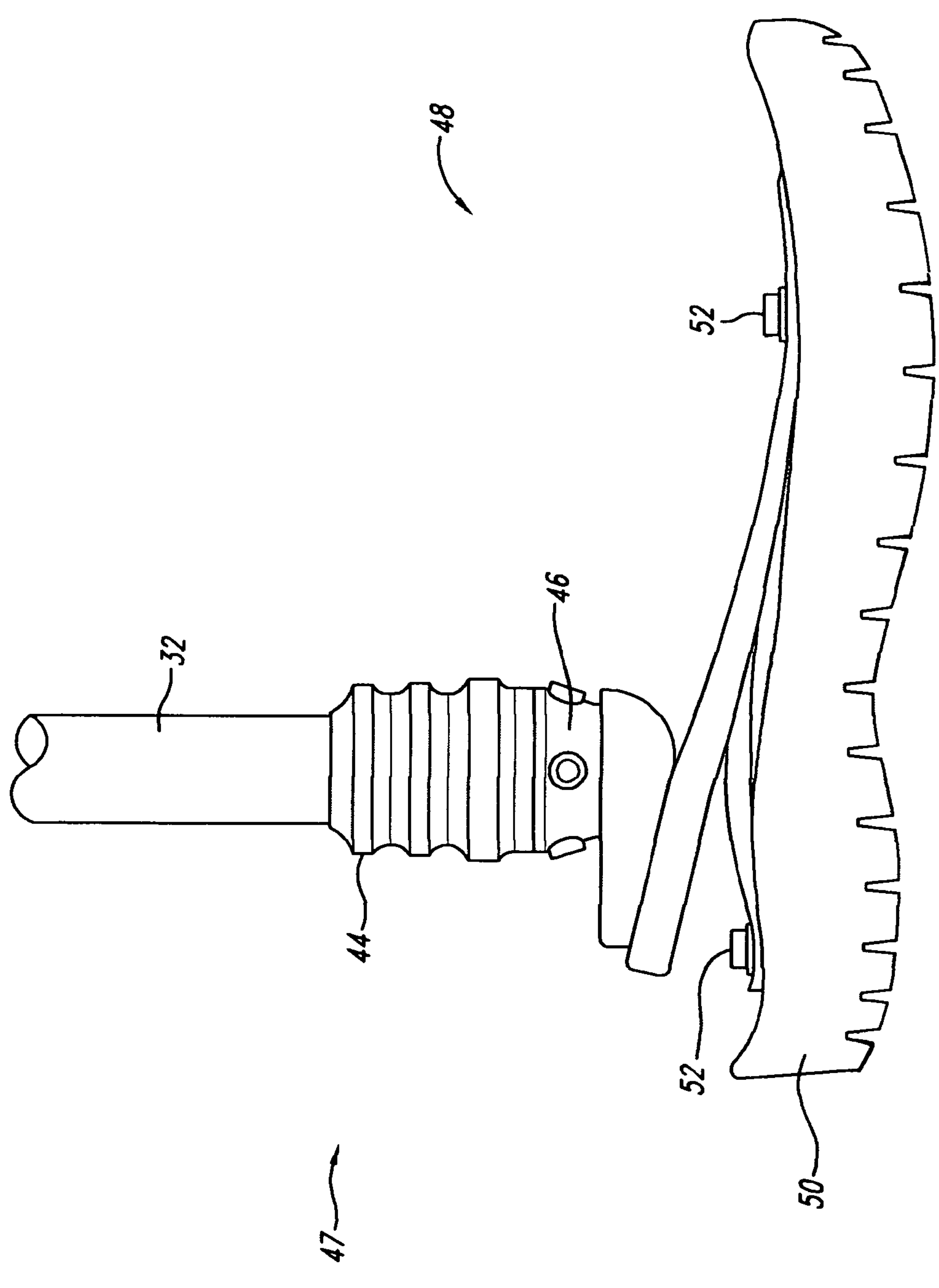
Fig. 24



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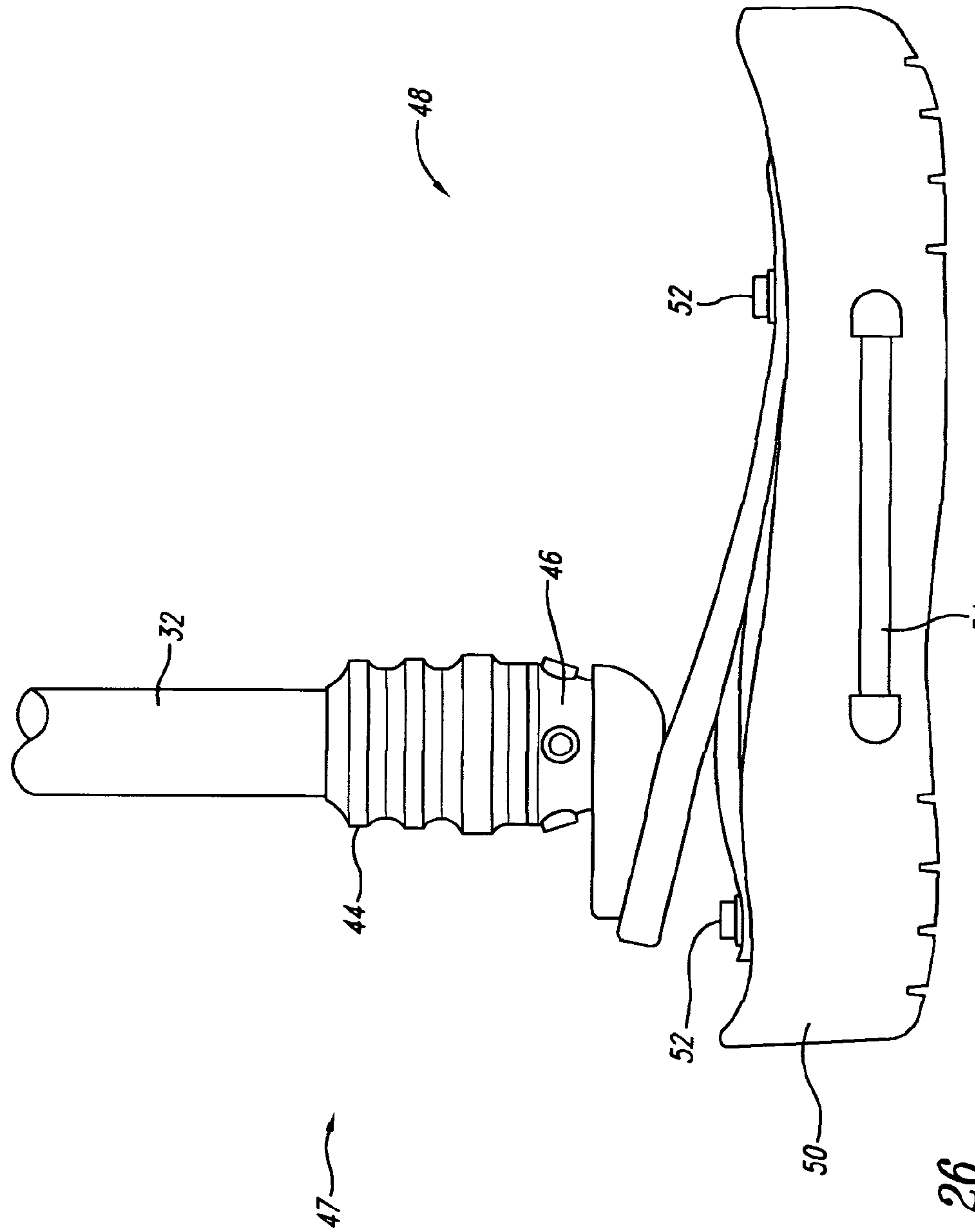

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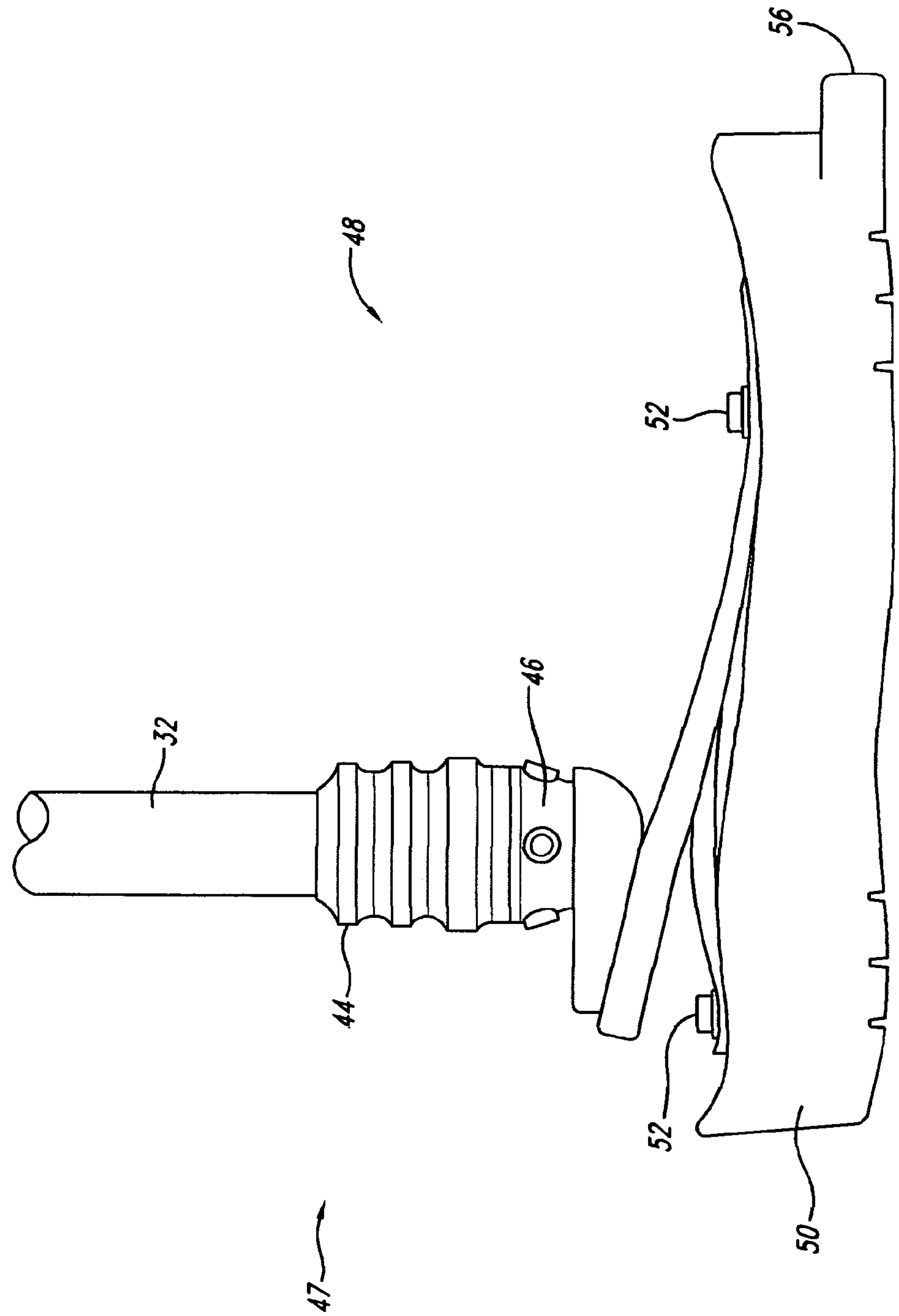

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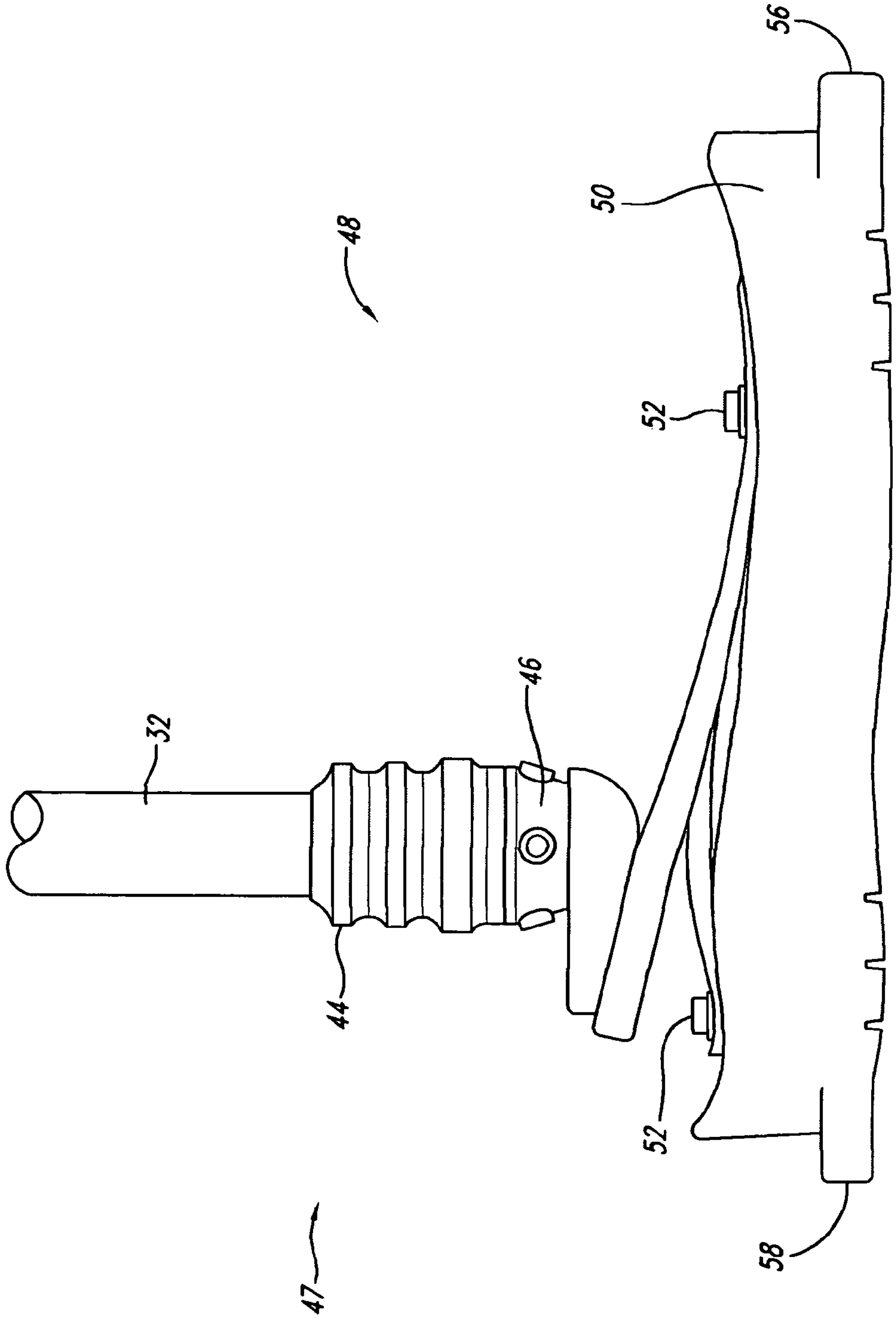

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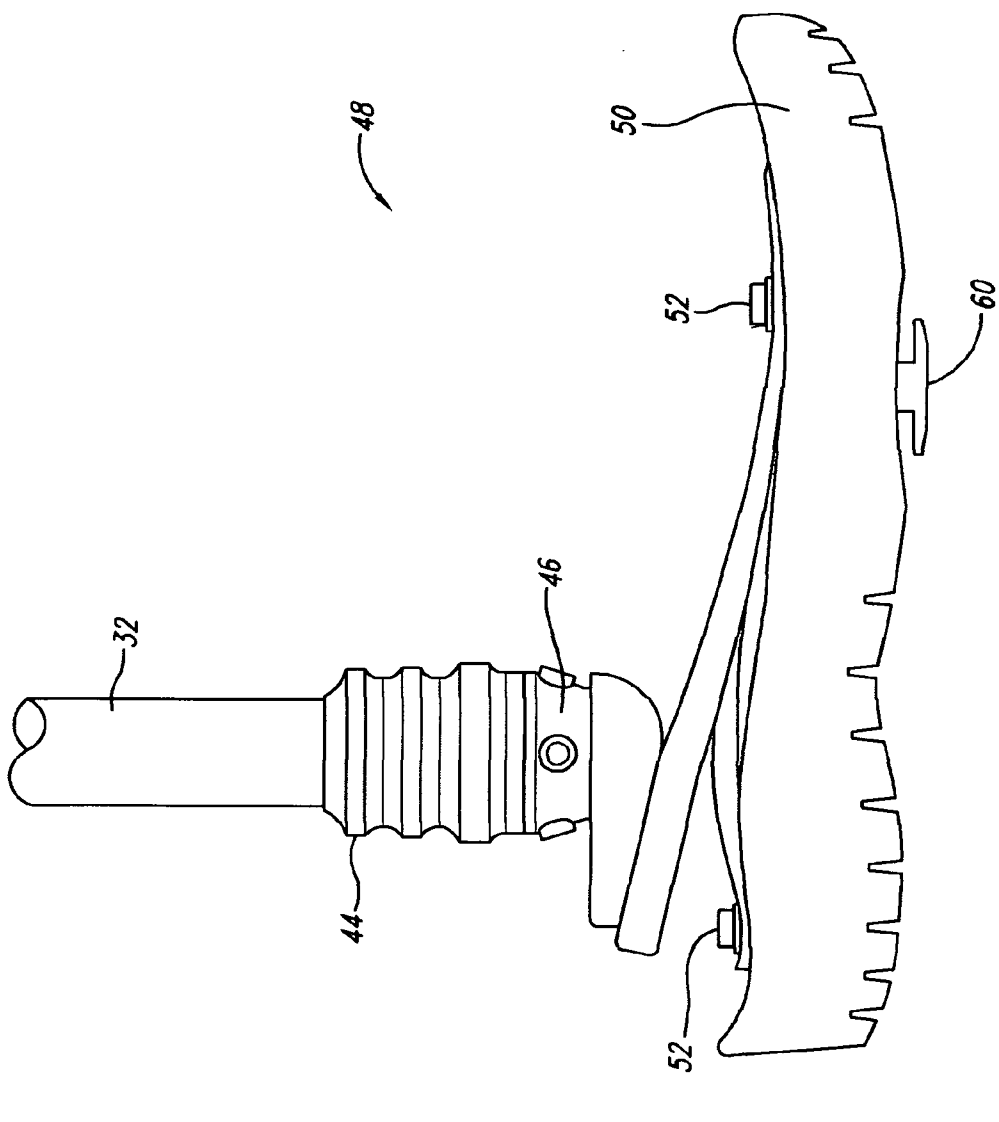

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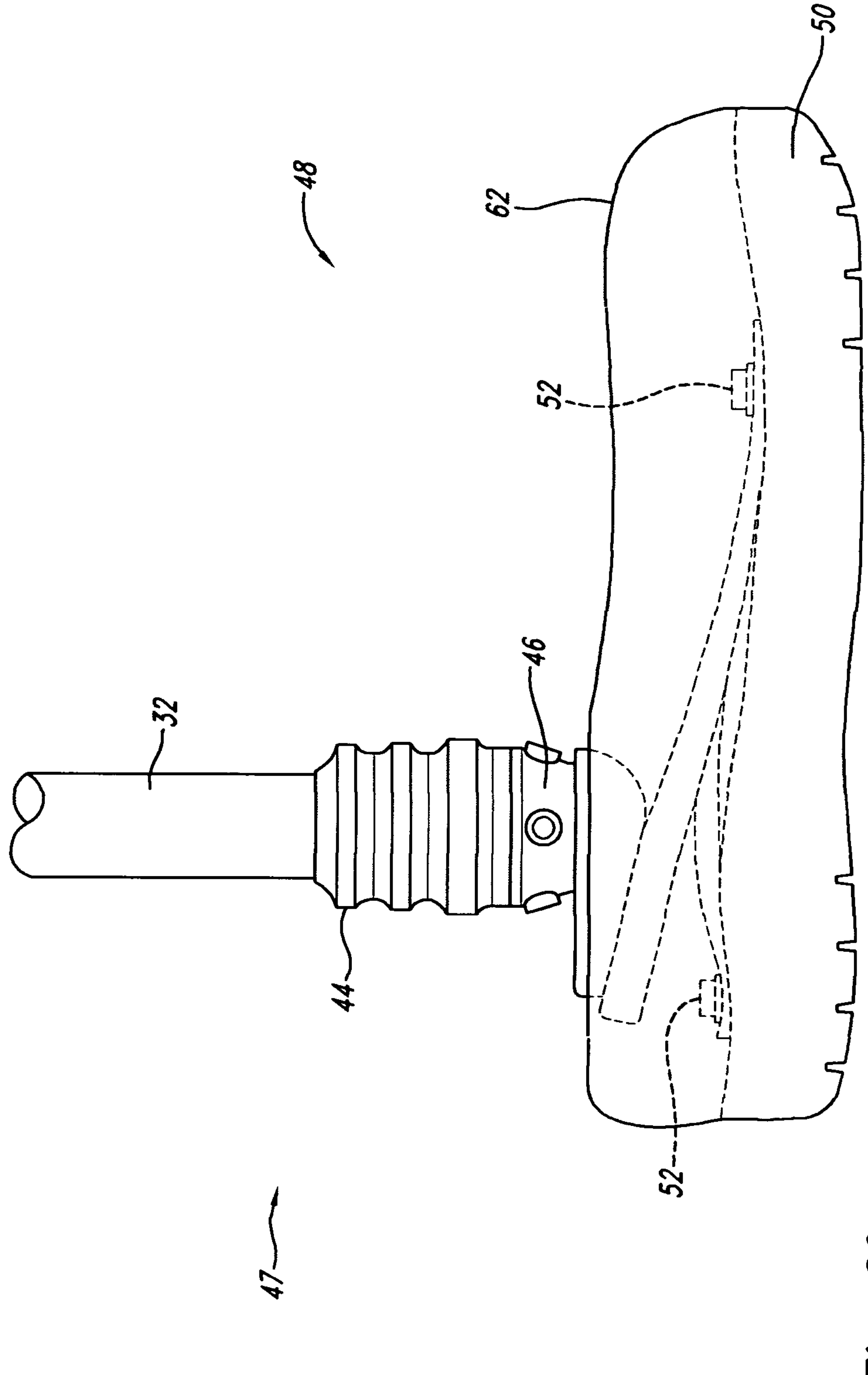

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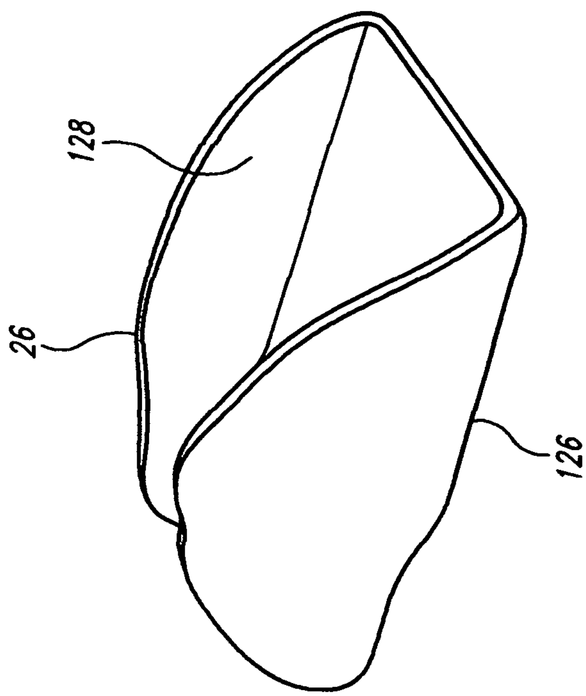

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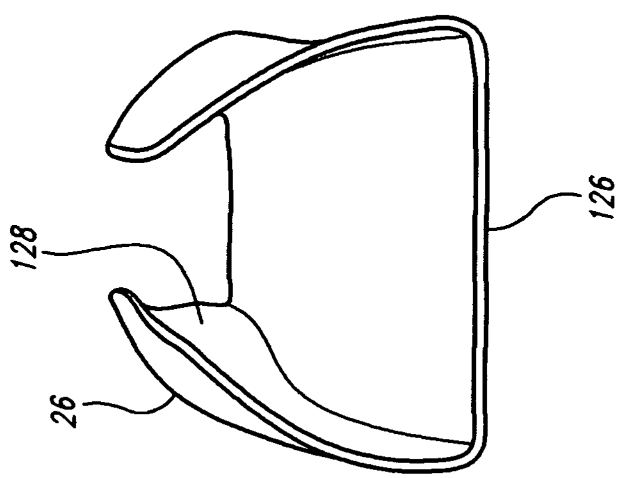

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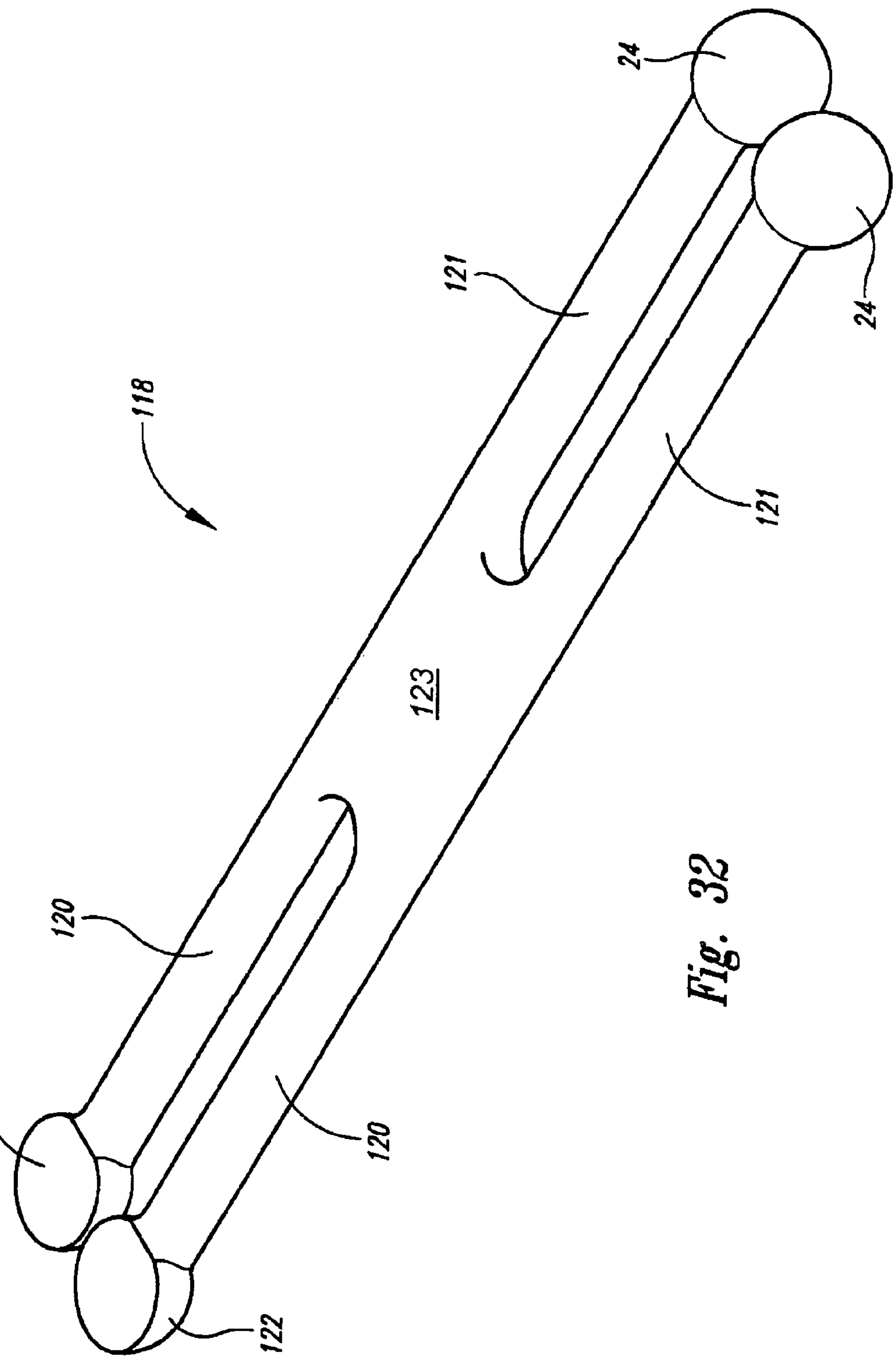

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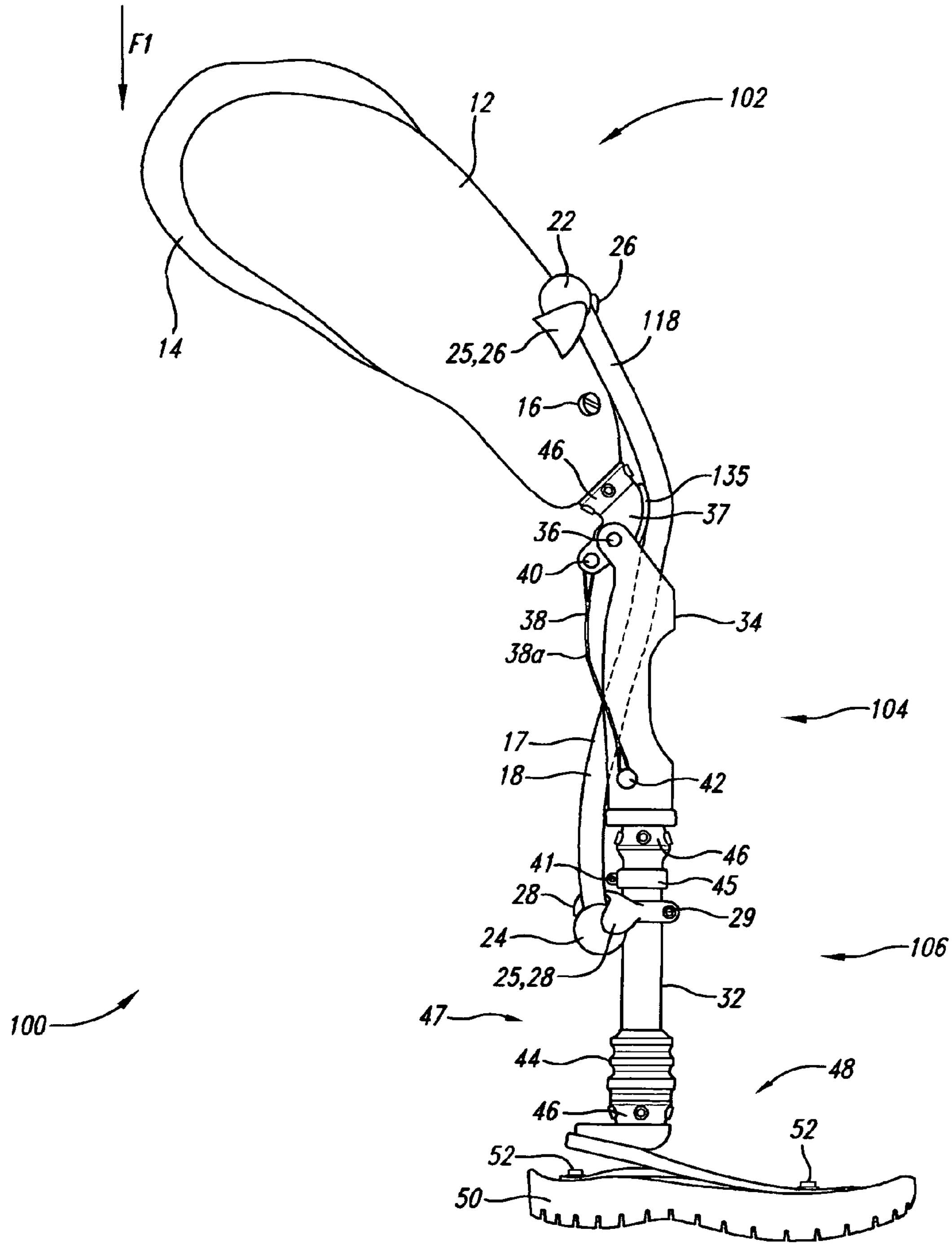
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Fig. 33

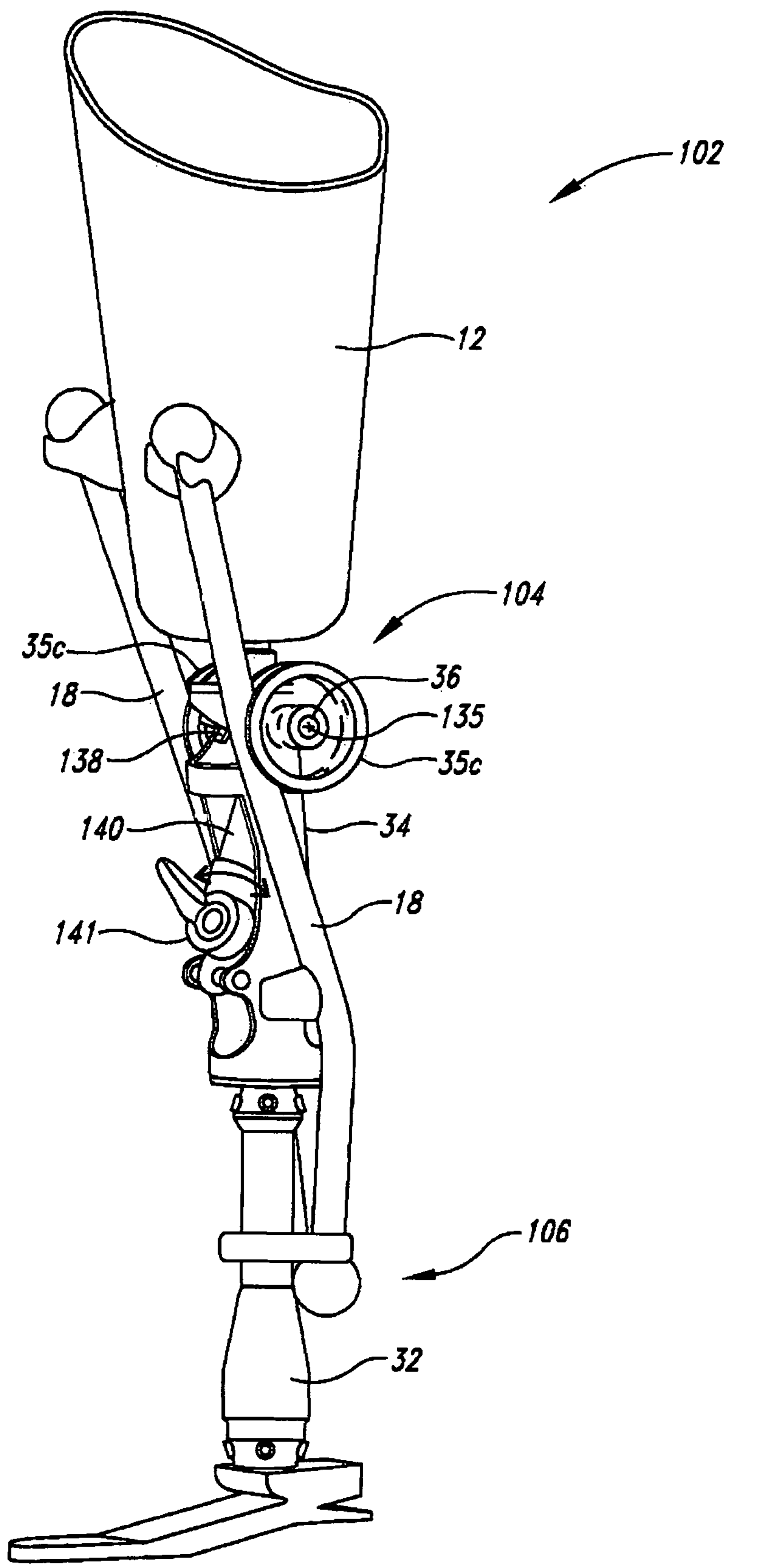

Fig. 34

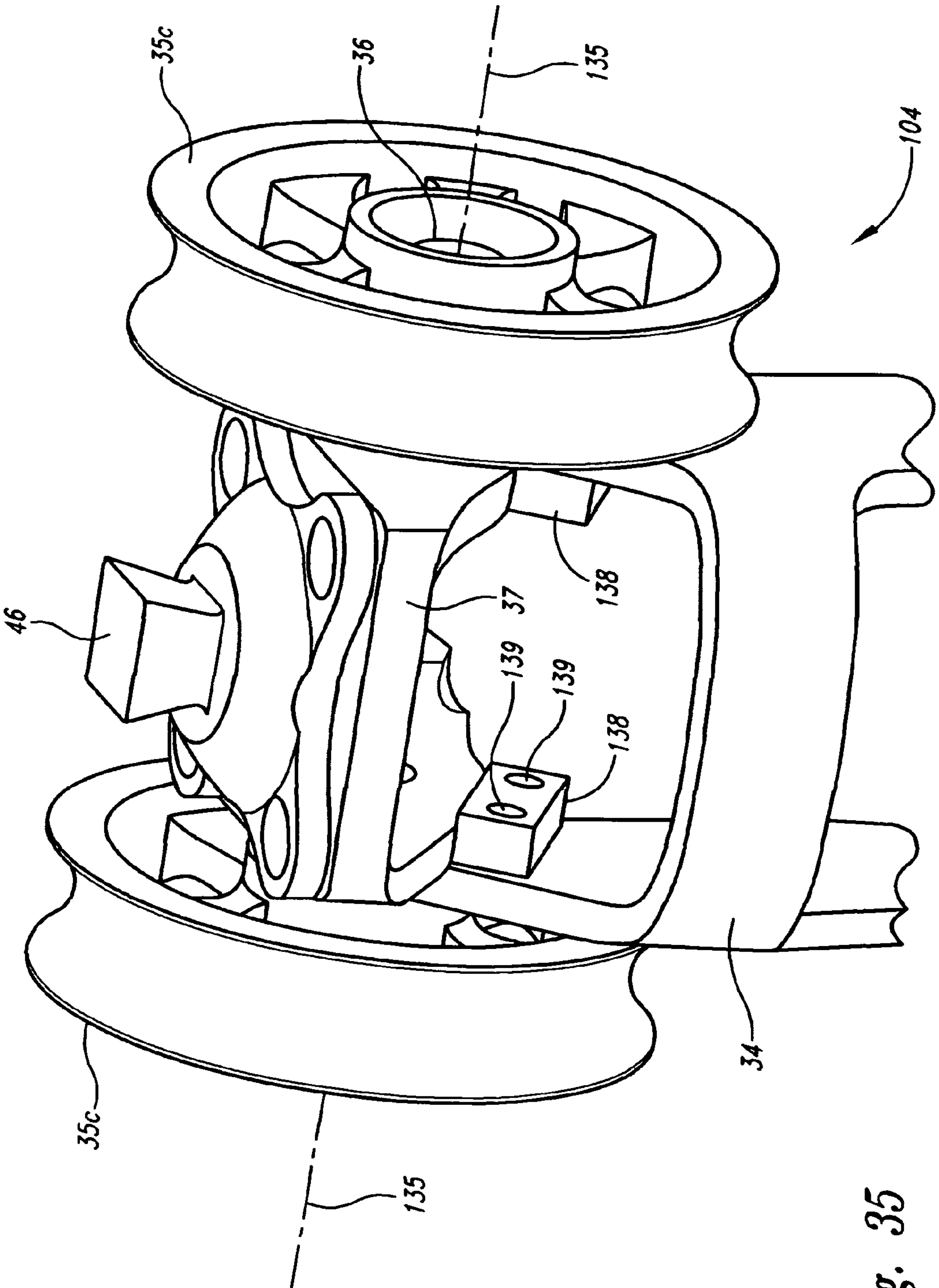

Fig. 35

LIMB PROSTHESIS SYSTEM AND METHOD

This application is a Continuation-In-Part and claims priority benefit of copending prior nonprovisional parent U.S. patent application Ser. No. 11/241,831 filed in the name of Brian Bartlett on Sep. 30, 2005, now U.S. Pat. No. 7,828,856 issued Nov. 9, 2010, the complete disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to prosthesis systems.

BACKGROUND OF THE INVENTION

Conventional prosthesis systems can be difficult to use for various activities including some involving certain sports.

SUMMARY OF THE INVENTION

The present invention is a prosthesis system for a human limb that allows for energy to be stored and released via one or more elastic member(s) for many activities, including, but not limited to sports activities such as bicycling, surfing, wakeboarding, snowboarding, downhill skiing, cross country skiing, and waterskiing.

According to one aspect of the prosthesis system, the prosthesis system includes a proximate or upper portion configured for coupling with the human limb; a distal or lower portion configured for coupling with an appendage; a joint portion with the proximate or upper portion hingedly coupled to the distal or lower portion via the joint portion such that the distal portion and the proximate portion are pivotally movable with respect to one another between an extended state and a bent state; and an elongated elastic cord member comprising a relatively elastic portion between relatively rigid first and second end portions and substantially continuous therewith, wherein the first end portion is coupled to a first retainer positioned on the proximate or upper portion, and the second end portion is coupled to a second retainer positioned on the distal or lower portion.

A method of making and operating the prosthesis system is detailed herein.

Other aspects of the invention are detailed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

FIG. **1** is a front elevational view of an implementation of a prosthesis system shown in the resting position, having two elastic members routed through the knee frame, and shown with an adjustable strap acting as an anti-hyperextension member.

FIG. **2** is a side elevational view of an elastic member.

FIG. **3** is a front elevational view of the elastic member depicted in FIG. **2**.

FIG. **4** is a left elevational view of an implementation of the prosthesis system depicted in FIG. **1**.

FIG. **5** is a rear elevational view of an implementation of the prosthesis system depicted in FIG. **1**.

FIG. **6** is a right elevational view of an implementation of the prosthesis system depicted in FIG. **1**.

FIG. **7** is a right elevational view of an implementation of the same prosthesis system depicted in FIG. **1**, but alternately shown in a forty-five degree bent position.

FIG. **8** is a right elevational view of an implementation of the same prosthesis system depicted in FIG. **1**, but alternately shown in a ninety degree bent position.

FIG. **9** is a front elevational view of an alternative implementation of a prosthesis system shown in the resting position, having one elastic member routed through the knee frame, and shown with an adjustable strap acting as an anti-hyperextension member.

FIG. **10** is a right elevational view of an implementation of the prosthesis system depicted in FIG. **9**.

FIG. **11** is a front elevational view of an alternative implementation of a prosthesis system shown in the resting position, having one elastic member frontally routed, and shown with an adjustable strap acting as an anti-hyperextension member.

FIG. **12** is a right elevational view of an implementation of the prosthesis system depicted in FIG. **11**.

FIG. **13** a right elevational view of an implementation of the same prosthesis system depicted in FIG. **11**, but alternately shown in a forty-five degree bent position.

FIG. **14** is a right elevational view of an implementation the same prosthesis system depicted in FIG. **11**, but alternately shown in a ninety degree bent position.

FIG. **15** is a front elevational view of an alternative implementation of a prosthesis system shown in the resting position, having two elastic members frontally routed.

FIG. **16** is a right elevational view of an implementation of the prosthesis system depicted in FIG. **15**, and shown with an adjustable strap acting as an anti-hyperextension member.

FIG. **17** is a right elevational view of an implementation of the same prosthesis system depicted in FIG. **15**, but alternately shown in a forty-five degree bent position.

FIG. **18** is a right elevational view of an implementation of the same prosthesis system depicted in FIG. **15**, but alternately shown in a ninety degree bent position.

FIG. **19** is a front elevational view of an implementation of the same prosthesis system depicted in FIG. **15**, but alternately shown with a hook style elastic member retainer.

FIG. **20** is a right elevational view of an implementation of the same prosthesis system depicted in FIG. **20**.

FIG. **21** is a right elevation view of a prosthesis system in a hyper extended state, and lacking an anti-hyperextension member.

FIG. **22** is a right elevational view of an alternative implementation of the prosthesis system depicted in FIG. **15**, but alternately shown with an adjustable tension spring acting as an anti-hyperextension member.

FIG. **23** is a right elevational view of an alternative implementation of the prosthesis system depicted in FIG. **15**, but alternately shown with an adjustable stop acting as an anti-hyperextension member.

FIG. **24** is a right elevational view of an alternative implementation of the prosthesis system depicted in FIG. **15**, but alternately shown with a fluidic shock absorber acting as an anti-hyperextension member.

FIG. **25** is a right elevational view of an implementation of the foot portion having a standard shoe.

FIG. **26** is a right elevational view of an alternative implementation of the foot portion having a clip-in style snowboard and/or wakeboard shoe.

FIG. **27** is a right elevational view of an alternative implementation of the foot portion having a cross-country and/or telemarking shoe.

FIG. **28** is a right elevational view of an alternative implementation of the foot portion having a downhill snow ski shoe.

FIG. **29** is a right elevational view of an alternative implementation of the foot portion having a bicycle clipless type shoe.

FIG. **30** is a right elevational view of an alternative implementation of the foot portion having a full upper shoe, for use in snowboard bindings, bicycle toe cages, snowshoes, crampons, water ski bindings, and/or other slip-in type bindings.

FIG. **31**A and FIG. **31**B are different views that illustrate one embodiment of upper ball retainers which are formed independently of an upper portion of the prosthesis system and coupled thereto in a desired position.

FIG. **32** illustrates an alternative part-spherical upper retaining ball on an alternative progressive elastic member or tendon having a plurality of upper and lower elastic cord portions extended in a spider Y-shape, X-shape or H-shape from a common hub portion.

FIG. **33** illustrates one embodiment wherein an artificial patella is provided adjacent to a knee joint of the prosthesis system and anterior thereof for protecting the hub portion of the alternative elastic member illustrated in FIG. **32**.

FIG. **34** is a pictorial anterior view of one alternative embodiment of the prosthesis system alternately shown with an adjustable pneumatic shock absorber.

FIG. **35** illustrates one adjustable anti-hyperextension member that is optionally integrated into the prosthesis system for preventing hyperextensions of the joint portion of the prosthesis system.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

As required, a detailed illustrative embodiment of the present prosthesis system and method is disclosed herein. However, techniques, systems and operating structures in accordance with the present prosthesis system and method may be embodied in a wide variety of forms and modes, some of which may be quite different from those in the disclosed embodiment. Consequently, the specific structural and functional details disclosed herein are merely representative, yet in that regard, they are deemed to afford the best embodiment for purposes of disclosure and to provide a basis for the claims herein which define the scope of the present prosthesis system and method. The following presents a detailed description of an illustrative embodiment (as well as some alternative embodiments) of the present prosthesis system and method.

In the Figures, like numerals indicate like elements.

A prosthesis system described herein allows for energy to be stored and released via one or more elastic member(s). Based upon this approach potential exists for performance advantages over a conventional prosthesis, such as when used in activities requiring the use muscles such as extensor muscles, for instance, the quadriceps. Present implementations can have an advantageous use over conventional prostheses in many activities, including, but not limited to sports activities such as bicycling, surfing, wakeboarding, snowboarding, downhill skiing, cross country skiing, and waterskiing. The system includes, elastic member(s) that can store and release energy. The storing and releasing of energy in the elastic members happens during the movements made by the user and with the application of the user's own body weight while performing an activity. Implementations can also include a variety routing configurations for the elastic member(s), as well as a variety of mounting points to integrate the elastic member(s) into the system, and/or a variety of adjustable anti-hyperextension members, and/or a variety of interchangeable shoes used for applicable activities.

Represented herein is a prosthesis system **100** comprised of an upper portion **102**, a joint portion **104**, and a lower portion **106**. Further included in the system is one or more elastic member(s) **18** for storing and releasing energy, an adjustable anti-hyperextension member **38** that prevents the elastic members **18** from hyper extending the system, a resilient ankle joint **44** in the ankle segment **47** that allows for three-dimensional movement of a foot or other appendage **48** relative to the lower portion **106**, and/or foot **48** in which a shoe **50** may be changed accordingly to accommodate any various activities the user may wish to engage in.

The implementations shown herein are representing a right leg. A left leg would simply be a mirror image of the right leg, and would incorporate all of the same components, forces, and workings of the right leg. Alternately, all of these same components, forces, and/or workings could also be applied to an elbow, a wrist, a shoulder, and/or an ankle.

The upper portion **102**, used for coupling of the system **100** to the user's leg, may be comprised of an outer socket **12**, an inner socket **14**, and/or a shuttle lock **16**, such as shown in FIG. **6**. Further included in the upper portion **102** may be one or more elastic member retainer(s) **25**, such as shown in FIG. **1**.

The joint portion **104** of the system **100** may be comprised of one or more pyramid adapter(s) **46**, a knee joint **37**, a knee frame **34**, a knee fulcrum **36**, an adjustable anti-hyperextension member **38**, an upper attachment point **40**, and/or a lower attachment point **42**, such as shown in FIG. **6**.

The lower portion **106** of the system **100** may be comprised of a coupler **45** for coupling the middle portion **104** to the lower portion **106**, a coupler clamp **41**, one or more elastic member retainer(s) **25** and **28**, a pylon **32**, an ankle segment **47**, and/or a foot **48**. The ankle segment **47** may further encompass a pyramid adapter **46** and/or a resilient ankle joint **44**. The resilient ankle joint, allowing a three-dimensional movement of the foot **48** relative to the lower portion **106**, will deter any torsional and/or lateral forces being transferred from the foot to the user. This can help alleviate stress on the user's body, and may reduce the potential for injury to the user. The foot **48** may be comprised of a shoe **50** and/or any number of shoe fastener(s) **52**. Additionally, the shoe **50** may be removed from the foot **48** via the fastener(s) **52**, providing the ability to change the shoe in order to suit any number of various activities such as bicycling, skiing, surfing, snowboarding, and so forth.

Additionally, incorporated into the system **100** is one or more elastic members **18**. The elastic member(s) are composed of a resilient material having a middle portion **17** with a decided level of elasticity for storing and releasing energy. The user chooses an elastic member **18** based on it's level of elasticity, the activity for which it will be used in, and according to his or her body weight. It should be noted that a higher level of elasticity would store and release more energy than a lower level of elasticity. The overall length and level of elasticity of the elastic member **18** determines the preloaded tension on the system. Further adjusting of the preload tension of the elastic member(s) **18** can be derived by positioning the lower ball retainer **28** along the longitudinal axis of the pylon **32**, via a retainer adjusting element **29**.

On opposing longitudinal ends of the elastic member **18** are an upper retaining ball **22** and a lower retaining ball **24**, both of which may be comprised of a harder material than the middle portion **17**, thereby hindering deformation of the retaining balls **22** and **24** while being retained in the ball retainers **25**. Mounting of the elastic member(s) **18** to the system is accomplished via an upper ball retainer **26** and a lower ball retainer **28** located on the upper portion **102** and lower portion **106**, respectively, which accept the retaining balls **22** and **24**, respectively. Furthermore, alternative mounting locations of the retaining balls **22** and **24** can be derived by determining the locations of the ball retainers **25**. The retaining balls **22** and **24** stay secured in the ball retainers **25** through the existing preload tension of the elastic member **18**.

Routing of the elastic member(s) **18** can take the form of various configurations described herein.

Two or more elastic members **18** may be mounted to the lower portion **106** via lower ball retainers **28**, having the middle portions **17** routed through the knee frame **34** of the joint portion **104**, and mounted to the upper portion **102** via upper ball retainers **26**, such as shown in FIG. **1**.

One elastic member **18** may be mounted to the lower portion **106** via a lower ball retainer **28**, having the middle portion **17** routed through the knee frame **34** of the joint portion **104**, and mounted to the upper portion **102** via an upper ball retainer **26**, such as shown in FIG. **9**.

One elastic member **18** may be mounted to the lower portion **106** via a lower ball retainer **28**, having the middle portion **17** routed frontally across the knee frame **34** of the joint portion **104**, and mounted to the upper portion **102** via an upper ball retainer **26**, such as shown in FIG. **11**.

Two or more elastic members **18** may be mounted to the lower portion **106** via lower ball retainers **28**, having the middle portions **17** routed frontally across the knee frame **34** of the joint portion **104**, and mounted to the upper portion **102** via upper ball retainers **26**, such as shown in FIG. **15**. In this implementation it may be necessary to incorporate an elastic member retaining element **35** for supporting the middle portion **17** of the elastic member **18**. The retaining element **35***a* may be configured as a simple seat, such as shown in FIGS. **15**, **16**, **17**, and **18**, or alternately configured as a hook type element **35***b* for a more secure retention of the middle portion **17**, such as shown in FIGS. **19** and **20**.

By allowing the user to apply the force F**1** of his or her own body weight, the system seeks a bent position. In other words, the upper portion **102** rotates around the knee fulcrum **36** and down towards the lower portion **106**, as shown if FIGS. **7** and **8**. This may in some respects mimic the bending of a knee. While in a bent position the elastic member(s) **18** are further stressed and applying a tensional force between the upper portion **102** and lower portion **106**, such as shown in FIGS. **7** and **8**. The tensional force applied by the elastic member(s) **18** will return the system to a resting position when the force F**1** of the user's body weight is diminished or removed, such as shown in FIG. **6**. In some respects this may mimic the function of the quadriceps muscles of the leg, acting as an extensor.

The tensional force applied by the elastic member(s) **18** can cause the system **100** to hyperextend beyond the resting position, such as shown in FIG. **21**. To prevent hyperextension, an adjustable anti-hyperextension member **38** may be integrated into the system **100**. This can be mounted between an upper attachment point **40** and a lower attachment point **42** within the joint portion **104**. The anti-hyperextension member **38** can also be adjusted so as to define the resting position of the system **100**. A simple strap **38***a* made of a resilient or non-resilient material could be used as the acting anti-extension member **38**, such as shown in FIGS. **16**, **17**, and **18**, and could further include examples such as: an adjustable tension spring **38***b* such as shown in FIG. **22**, an adjustable stop **38***c* such as shown in FIG. **23**, and/or an adjustable fluidic shock absorber **38***d* such as shown in FIG. **24**.

The ankle segment **47** may encompass a pyramid adapter **46** and/or a resilient ankle joint **44**. The resilient ankle joint, allowing a three-dimensional movement of the foot **48** relative to the lower portion **106**, will deter any torsional and/or lateral forces being transferred from the foot to the user. This can help alleviate stress on the user's body, and may reduce the potential for injury to the user.

The foot **48** may be comprised of a shoe **50** and/or any number of shoe fastener(s) **52**. Additionally, the shoe **50** may be removed from the foot **48** via the fastener(s) **52**, providing the ability to change the shoe in order to suit any number of various activities. The shoe **50** can vary in form and function, examples include: a standard shoe sole such as shown in FIG. **25**, a snowboarding or wakeboarding clip-in shoe with lateral clip bars **54** such as shown in FIG. **26**, a cross country ski shoe with a toe clip **56** such as shown in FIG. **27**, a downhill snow ski shoe with a toe clip **56** and heel clip **58** such as shown in FIG. **28**, a bicycling shoe with a clipless system **60** such as shown in FIG. **29**, and/or a shoe having a full upper portion **62** for use in various strap-in bindings such, as shown in FIG. **30**.

Additional Embodiments

FIG. **24** illustrates, for example, adjustable fluidic shock absorber **38***d* embodied as an adjustable pneumatic shock absorber.

Elastic middle portion **17** of elastic member(s) **18** represented herein is composed of a resilient material having a decided level of elasticity for storing and releasing energy. As discussed herein, the user chooses elastic member **18** based on it's level of elasticity, the activity for which it will be used in, and according to his or her body weight, wherein a stiffer level of elasticity stores and releases more energy than a softer level of elasticity. The overall length and level of elasticity of the elastic member **18** determines the preloaded tension on the system.

Upper retaining ball **22** and lower retaining ball **24** on opposing longitudinal ends of elastic member **18** are optionally composed of a stiffer or more rigid material than elastic middle portion **17**, which hinders deformation of retaining balls **22** and **24** for promoting retention in ball retainers **25**, while elastic middle portion **17** is composed of a different softer or less rigid material which provides elastic deformation for promoting storing and releasing of energy. End upper and lower retaining balls **22** and **24** composed of the stiffer or more rigid material are substantially continuous with elastic middle portion **17** composed of different softer or less rigid material. For example, different more and less rigid materials are injected into different portions of the die during injection molding of elastic member **18**.

Alternatively, retaining balls **22** and **24** and elastic middle portion **17** of elastic member **18** are optionally composed of the same material but having different hardness or durometer, wherein retaining balls **22** and **24** are relatively harder with a higher durometer, while elastic middle portion **17** is relatively softer with a lower durometer. End upper and lower retaining balls **22** and **24** composed of the relatively harder with a higher durometer material are substantially continuous with elastic middle portion **17** composed of different relatively softer with a lower durometer material. For example, different compositions of the same material having different higher and lower durometers are injected into different portions of the die during injection molding of elastic member **18**.

Additionally, upper ball retainers **26** located on upper portion **102**, which accept upper retaining ball **22** on end of elastic member **18**, such as shown by example and without limitation in FIG. **1**, are optionally formed independently of upper portion **102**. Upper ball retainers **26** are, for example, injection molded of an injection moldable material such as an epoxy graphite material that forms a substantially rigid structure for receiving upper retaining ball **22**. Independent molded upper ball retainers **26** are glued, adhesively adhered, mechanically fastened, or otherwise rigidly bonded in an appropriate position on upper portion **102**. Accordingly, upper ball retainers **26** are easily moveable to different positions on upper portion **102** to suit the current needs of the user.

Retaining balls **22** and **24** stay secured in ball retainers **25** through the existing preload tension of elastic member **18**.

FIG. **31**A and FIG. **31**B are different views that illustrate one embodiment of upper ball retainers **26** which are formed independently of upper portion **102** and coupled thereto in a desired position. Therefore, upper ball retainers **26** is a socket that is removable and replaceable on upper portion **102**. Upper ball retainers **26** located on upper portion **102** have mounting surfaces **126** shaped to conform to the surface of upper portion **102**. Accordingly, upper ball retainer sockets **26** can be coupled by adhesive bonding to the surface of upper portion **102**, else upper ball retainer sockets **26** can be coupled to the surface of upper portion **102** by fasteners.

Upper ball retainer sockets **26** are formed with receiver sockets **128** shaped to accept upper retaining ball **22** on end of elastic member **18**. For example, as illustrated in FIG. **2** and FIG. **3**, upper retaining ball **22** and lower retaining ball **24** on opposing longitudinal ends of elastic member **18** are substantially spherical in shape, and upper ball retainers **26** are substantially hemispherical in shape for receiving thereinto substantially spherical upper retaining ball **22**, as illustrated in FIG. **1**.

Alternatively, receiver sockets **128** of upper ball retainers **26** are part-hemispherical shaped for receiving an alternative part-spherical upper retaining ball **122** on end of elastic member **18**, as disclosed herein.

FIG. **32** illustrates alternative part-spherical upper retaining ball **122** on an alternative progressive elastic member or tendon **118** having a plurality of upper and lower elastic cord portions **120** and **121** extended in a spider Y-shape, X-shape or H-shape from a hub portion **123**. Here, alternative elastic member **118** is illustrated by example and without limitation as having a plurality of upper elastic cord portions **120** and a plurality of lower elastic cord portions **121** extended in a spider H-shape from hub portion **123**. However, spider shape of alternative elastic member **118** is optionally any of a X-shape or H-shape or Y-shape with more or fewer of either upper or lower elastic cord portions **120** and **121**, without deviating from the scope and intent of the present invention. Upper elastic cord portions **120** of alternative elastic member **118** are illustrated as being formed with alternative part-spherical upper retaining ball **122**, which cooperate with part-hemispherical upper ball retainers or upper ball retainer sockets **26** for providing a low profile alternative to substantially spherical upper retaining ball **22** for substantially undetectable use under conventional clothing.

Lower elastic cord portions **121** alternative elastic member **118** are illustrated as having substantially spherical lower retaining ball **24**. However, an alternative part-spherical lower retaining ball similar to alternative part-spherical upper retaining ball **122** is optionally substituted therefor without deviating from the scope and intent of the present invention.

As discussed herein regarding elastic members **18**, upper and lower retaining balls **122** and **24** are optionally composed of a stiffer or more rigid material than upper and lower elastic cord portions **120**, **121**, which hinders deformation of retaining balls **122** and **24** for promoting retention in ball retainers **25**, while elastic cord portions **120**, **121** are composed of a different softer or less rigid material which provides greater elastic deformation for promoting alternately storing and releasing of energy.

Alternatively, also as discussed herein regarding elastic members **18**, retaining balls **122** and **24** of elastic member **18** are optionally composed of the same material as upper and lower elastic cord portions **120**, **121** but having different hardness or durometer, wherein retaining balls **122** and **24** are relatively harder with a higher durometer, while elastic cord portions **120**, **121** are relatively softer with a lower durometer. Similarly to the stiffer or more rigid material composition, the higher durometer hinders deformation of retaining balls **122** and **24** for promoting retention in ball retainers **25**, while similarly to the softer or less rigid material composition, the lower durometer provides greater elastic deformation for promoting alternately storing and releasing of energy.

Here, hub portion **123** is formed with an increased cross-section relative to elastic cord portions **120**, **121**. This increased cross-section results in hub portion **123** being stiffer than elastic cord portions **120**, **121** such that hub portion **123** has a higher spring rate than elastic cord portions **120**, **121**, which hinders deformation of hub portion **123** and results in a different higher spring rate relative to softer elastic cord portions **120**, **121**.

Optionally, as discussed herein regarding progressive elastic members **18**, increased cross-section hub portion **123** is optionally composed of a relatively stiffer or more rigid material than upper and lower elastic cord portions **120**, **121**. Alternatively, also as discussed herein regarding elastic members **18**, hub portion **123** is optionally composed of the same material as upper and lower elastic cord portions **120**, **121** but having different hardness or durometer, wherein hub portion **123** is relatively harder with a relatively higher durometer, while elastic cord portions **120**, **121** are relatively softer with a relatively lower durometer. When composed of either relatively more rigid or relatively higher durometer material hub portion **123** is of relatively higher spring rate than lower spring rate, stretchier upper and lower elastic cord portions **120**, **121** which are composed of relatively less rigid or relatively lower durometer material. Accordingly, alternative elastic member or tendon **118** provides progressive increase in resistance to bending knee joint **37**, wherein stretchier upper and lower elastic cord portions **120**, **121** are initially active for providing a slower or gentler increase in bending resistance, until stiffer hub portion **123** latterly becomes active for providing a faster or stiffer increase in bending resistance. Latter introduction of the faster or stiffer increase in bending resistance provided by stiffer hub portion **123** effectively gently slows and finally substantially stops bending before hyper-rotation of knee joint **37** where hard stops are encountered.

During bending of knee joint **37**, alternative progressive elastic member or tendon **118** stores energy progressively in both stiffer hub portion **123** and stretchier upper and lower elastic cord portions **120**, **121**. In extension, alternative progressive elastic member or tendon **118** releases energy progressively from both stiffer hub portion **123** and stretchier upper and lower elastic cord portions **120**, **121**.

Alternative progressive elastic member or tendon **118** thus provides an initial high rate of energy release followed by progressive decrease in energy release during unbending and extension of knee joint **37**, wherein relatively stiffer hub portion **123** is initially active for providing a relatively faster release of energy, until relatively stretchier upper and lower elastic cord portions **120**, **121** latterly become active for providing a relatively slower or gentler energy release. Initial introduction of the relatively faster release of energy provided by stiffer hub portion **123** thus effectively provides an initial jolt of power on straightening, while latter introduction of the relatively slower or gentler release of energy provided by relatively stretchier upper and lower elastic cord portions **120**, **121** effectively gently slows and finally substantially stops unbending before hyperextension of knee joint **37** where hard anti-hyperextension member **38** are encountered.

Hub portion **123** is optionally positioned substantially at the middle of alternative elastic member **118** such that lower elastic cord portions **121** are of substantially identical length as upper elastic cord portions **120**. Alternatively, hub portion **123** is offset alternative elastic member **118** such that upper and lower elastic cord portions **120**, **121** are of different lengths, whereby hub portion **123** is positionable substantially directly over knee fulcrum **36**.

Routing of alternative elastic member(s) **118** can take the form of various configurations described herein.

FIG. **33** illustrates one embodiment wherein an artificial patella **135** is provided adjacent to knee joint **37** and anterior thereof for protecting hub portion **123** of alternative elastic member **118**. For example, artificial patella **135** is formed of a non-stick and wear-resistant material such as nylon, Teflon® or Delrin® that permits hub portion **123** to slide over knee joint **37** during bending and extension of upper and lower portions **102** and **106** about joint portion **104**. Artificial patella **135** also permits fabrics to slide over knee joint **37** during bending and extension for protecting user's clothing when elastic members **18** are substituted for alternative elastic member **118** having hub portion **123**.

FIG. **34** is a pictorial anterior view of one alternative embodiment of prosthesis system **100** alternately shown with an adjustable pneumatic shock absorber **140**. Hydraulic shock absorbers have been known in prior art prosthesis systems. However, such hydraulic shock absorbers fail to provide either a smooth stroke or a progressive compression and/or rebound. Pneumatic operation of alternative adjustable pneumatic shock absorber **140** provides both a relatively smoother stroke as compared with the typical sticky and uneven stroke of known prior art hydraulic shock absorbers, and also provides a relatively progressive compression and/or rebound as compared with the typical constant compression and abrupt stop of known prior art hydraulic shock absorbers.

Furthermore, hydraulic shock absorbers of known prior art prosthesis systems fail to provide ease of response adjustment. Response of such hydraulic shock absorbers is typically adjustable only by changing the fluid pressure in the hydraulic cylinder, else changing out a hydraulic cylinder of one pressure for a hydraulic cylinder of a different pressure. As compared with the limited ability of hydraulic shock absorbers for adjusting response, alternative adjustable pneumatic shock absorber **140** provides easy response adjustment by simple opening and closing (arrow) of an air restriction valve **141** between internal chambers, wherein restricting the air flow between internal chambers stiffens response, while opening air flow between internal chambers softens response.

Alternative adjustable pneumatic shock absorber **140** is similarly useful with either one or more elastic member(s) **18** or alternative progressive elastic member or tendon **118**.

FIG. **34** also illustrates joint portion **104** including a pair of alternative rotational retaining elements **35***c* each configured as a wheel or pulley rotatable about an axis **135** substantially parallel to or aligned with knee fulcrum **36**. Alternative rotational retaining elements **35***c* secure retention of middle portion **17** and guide elastic member **18** during bending and extension of upper and lower portions **102** and **106** about joint portion **104**. Alternative rotational retaining elements **35***c* are similarly useful for securing retention of either upper elastic cord portions **120** or lower elastic cord portions **121** and guiding alternative spider-shaped progressive elastic member or tendon **118** during bending and extension of upper and lower portions **102** and **106** about joint portion **104**.

FIG. **35** illustrates one adjustable anti-hyperextension member **138** that is optionally integrated into prosthesis system **100** for prevent hyperextensions of joint portion **104**. Here, adjustable anti-hyperextension member **138** is illustrated by example and without limitation as one or more rigid stops mounted on knee frame **34** in a position within joint portion **104** for interfering with hyperextensions of knee joint **37**. For example, a pair of anti-hyperextension stops **138** are removably mounted by one or more fasteners **139** on knee frame **34** adjacent to knee fulcrum **36** in positions for being encountered by knee joint **37** at the end of its extension. Anti-hyperextension member **138** is adjustable by removing and replacing the rigid stops mounted on knee frame **34** by fasteners **139**. Anti-hyperextension member(s) **138** is adjustable for varying a pre-bend of joint portion **104** for different activities, for example, for normal walking, or for extreme sports. For example, anti-hyperextension stops **138** are changed between different sizes of rigid stops for pre-bending of joint portion **104** in a substantially upright orientation at about four and one-half (4½) degrees for normal walking, or about eight and one-half (8½) degrees to ten (10) degrees for extreme sports. Other structures for anti-hyperextension member(s) **138** and means for mounting may take the form of various configurations and are also contemplated and may be substituted without deviating from the scope and intent of the present invention.

Anti-hyperextension stops **138** are optionally made of a non-marring slightly resilient sacrificial material, such as nylon, Teflon® or Delrin® that permits some shock absorption, or a non-resilient material, such as anodized or coated aluminum that provided long and durable life without significant shock absorption.

Prosthesis system **100** is represented herein by example and without limitation as a prosthetic leg. However, prosthesis system **100** is optionally an arm having upper portion **102** being an upper arm in a position proximate to the user's body, lower portion **106** being a forearm in a position distal from the user's body, and joint portion **104** being an elbow joint. When prosthesis system **100** is optionally an arm, ankle segment **47** is a wrist segment, and appendage **48** is a hand or other useful appurtenance or accessory.

From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

What is claimed is:

1. A prosthesis system for a human limb, the prosthesis system comprising:

a proximate portion configured for coupling with the human limb;

a distal portion configured for coupling with an appendage;

a rigid joint portion, the proximate portion hingedly coupled to the distal portion via the joint portion such that the distal portion and the proximate portion are pivotally movable with respect to one another between an extended state and a bent state; and

an elongated elastic cord member comprising a relatively elastic portion between relatively rigid first and second end portions that are continuous therewith, wherein the relatively elastic portion further comprises a relatively lower durometer material, and the relatively rigid first and second end portions each further comprises a relatively higher durometer material and wherein the relatively elastic portion is composed of a same material as the first and second end portions, and the cord member arranged for urging the distal portion and the proximate portion toward the extended state with the first end portion coupled to a first retainer positioned on the proximate portion, and the second end portion coupled to a second retainer positioned on the distal portion.

2. The system of claim **1**, wherein the distal portion is further configured for coupling with an artificial appendage.

3. The system of claim **1**, wherein the elongated elastic cord member further comprises a plurality of the relatively elastic portions extended from a common hub.

4. The system of claim **1**, further comprising an artificial patella positioned adjacent to the joint portion and anterior thereof.

5. The system of claim **1**, wherein the joint portion further comprises an adjustable pneumatic shock absorber coupled between a proximate attachment and a distal attachment.

6. The system of claim **1**, further comprising an adjustable anti-hyperextension member comprising one or more stops mounted within the joint portion between a proximate portion thereof and a distal portion thereof adjacent to a fulcrum thereof.

7. The system of claim **6**, wherein the one or more stops of the adjustable anti-hyperextension member further comprises a plurality of different sized stops, wherein one of the different sized stops is structured for stopping extension of the distal portion at a first pre-bent angle, and a different one of the different sized stops is structured for stopping extension of the distal portion at a second pre-bent angle different from the first pre-bent angle.

8. A prosthesis system for a human limb, the prosthesis system comprising:

an upper portion configured for coupling with the human limb, the upper portion further comprising one or more first retaining elements;

a lower portion configured for coupling with an artificial appendage, the lower portion comprising one or more second retaining elements;

a rigid joint portion hingedly coupling the upper portion to the lower portion such that the lower portion and the upper portion are respectively pivotally movable between an extended state and a bent state; and

one or more elongated elastic members arranged for urging the lower portion toward the extended state relative to the upper portion, wherein at least one of the elongated elastic members is further composed entirely of a single material, wherein each elongated elastic member comprises an elongated relatively elastic portion between first and second end portions of relatively stiffer material and continuous therewith, the first end portion coupled to one of the one or more first retaining elements of the upper portion and a second end portion coupled to one of the one or more second retaining elements of the lower portion, each of the elongated elastic members having a first length between the first portion and the second portion in the extended state and a second length between the first portion and the second portion in the bent state, the first length being shorter than the second length.

9. The system of claim **8**, wherein the first and second end portions of the one or more elongated elastic members further comprises a material having a relatively higher durometer, and the relatively elastic portion further comprises a material having a relatively lower durometer.

10. The system of claim **8**, wherein the elongated elastic member further comprises a plurality of individual ones of the relatively elastic portions extended from a common hub.

11. The system of claim **10**, wherein relatively elastic portion of the elongated elastic member further comprises a material having a lower durometer, and at least one of the first and second end portions further comprises a material having a higher durometer.

12. The system of claim **10**, wherein the plurality of the relatively elastic portions extended from a common hub further comprises a plurality of upper elastic cord portions extended from the common hub, and a plurality of lower elastic cord portions extended from the common hub.

13. The system of claim **8**, wherein the joint portion further comprises an adjustable pneumatic shock absorber coupled between a proximate attachment and a distal attachment, the adjustable pneumatic shock absorber further comprising an air restriction valve coupled for adjusting response.

14. A prosthesis system for a human limb, the prosthesis system comprising:

an upper proximate portion configured for coupling with the human limb and further comprising a first retainer positioned thereon;

a lower distal portion comprising a second retainer positioned thereon, and further comprising a structure for coupling with an artificial appendage;

a rigid joint portion, the upper proximate portion hingedly coupled to the lower distal portion via the rigid joint portion such that the lower distal portion and the upper proximate portion are pivotally movable with respect to one another between a extended state and a bent state; and

an elongated elastic member arranged for urging the lower portion toward the extended state relative to the upper portion, the elastic member comprising a resiliently stretchable portion between first and second relatively harder portions, wherein the first and second relatively harder portions of the elongated elastic member are further composed of a same material as the resiliently stretchable portion, wherein the first relatively harder portion is releasably coupled to the first retainer of the upper proximate portion, and the second relatively harder portion is releasably coupled to the second retainer of the lower distal portion, the elongated member having a first length between the first portion and the second portion in the extended state and a second length between the first portion and the second portion in the bent state, the second length being longer than the first length due to a stretching of the resiliently stretchable portion between the first relatively harder portion and the second relatively harder portion of the elongated member when the upper portion and the lower portion are pivotally moved between the extended state and the bent state.

15. The system of claim **14**, wherein the first and second relatively harder portions of the elongated elastic member further comprises a relatively higher durometer material, and wherein the resiliently stretchable portion further comprises a relatively lower durometer material.

16. The system of claim **14**, wherein the joint portion further comprises an adjustable pneumatic shock absorber coupled between a proximate attachment and a distal attachment, the adjustable pneumatic shock absorber further comprising an air restriction valve coupled for adjusting response.

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