

Multi-Terrain Damping Ergonomic Forearm Crutch System

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FIELD OF INVENTION

[Para 1] This invention relates to a novel device in the general field of human mobility supports and more specifically to a modular forearm crutch system centered around an ergonomically designed forearm handle from which is deployed an adjustable damping mechanism and a variety of interchangeable static or articulating or extreme multi-terrain tips.

BACKGROUND OF THE INVENTION

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[Para 2] Crutch walking, for the purposes of this disclosure, can be defined as the use of mobility supports necessitated by a temporary or permanent functional injury to, or the partial or complete loss of a lower limb. The nature of crutch walking is such that an exceptional burden is placed on the upper extremities. The highly repetitive and weight bearing nature of crutch walking is often associated with the development of upper limb pain and dysfunction. Common linear forearm crutches force the user into an unnatural posture, straining the shoulder joint, upper limb muscles and

tendons, merely in order to maintain perpendicularity with the ground. A more ergonomic configuration of forearm handle, able to support the user while resisting strain, pain, fatigue or additional dysfunction, is highly desirable.

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[Para 3] Crutch walking also entails repeated impact of the crutch with the ground, and various means of lessening this impact have been employed in the past. An 1841 U.S. patent #2297, titled Ferrule for Cane, employs a “steel spiral spring within the ferrule...” [which] “...prevents the usual jar to the hand or shoulder...” Crutches employing some form of coil spring suspension to absorb shock thus exist in the art, but are not an optimal solution because a spring responds to increased weight by bouncing back instead of absorbing the impact in a controlled and consistent manner. For this reason, spring-like crutch suspension systems, on their own, are ill-suited to “absorbing” impacts with the ground while retaining optimal control during mobility. Damping mechanisms quickly and consistently reduce the amplitude of oscillations in a suspension system. Therefore, improvements in crutch system design should include a means to dampen repeated impacts with the ground, only springing back when the weight of the user is released.

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[Para 4] While some prior art solutions employ hydraulic, pneumatic or elastomeric dampers, all have positioned the damping mechanism at the distal end of the crutch, cane, pole, etc, and are fitted onto the end of

commonly available, mass-produced, low quality crutch tubes. By positioning the damping mechanism at the end, instead of the middle of the crutch, less leverage, and therefore less damping is possible. A centrally positioned damping assembly moves the centre of mass closer to the centre of force (forearm and shoulder), thereby reducing effort for the user. No prior art damping crutch systems are designed to be integrated with an ergonomic forearm handle, nor with interchangeable tips which provide optimal multi-terrain traction only when employed in partnership with a centrally positioned damping system. Therefore, new crutch designs should include a damping mechanism located in the center of a crutch for more efficient damping and optimal traction control.

[Para 5] Crutch walking entails repeated impact with terrains of variable friction, density, viscosity and angle. Active crutch walkers do not want to limit their lifestyle to urban environments, and may be found perambulating along hiking trails, logging roads, mountainsides, glaciers, creek beds, snowfields, and other terrains that are often problematic for the fully-abled person. Therefore any improvements to crutch system design should ensure that those elements actually contacting the ground (crutch tips) are capable of maintaining optimal control and stability for each terrain encountered by the user. Also, crutch tips should be easily interchangeable, thereby providing appropriate traction, cushion and mobility in all circumstances.

BRIEF SUMMARY OF THE INVENTION

[Para 6] The multi-terrain damping ergonomic forearm crutch system is designed to reduce the physical impact and increase the safety for crutch
5 users traveling along a variety of urban and extreme terrains including, but not limited to urban streets, cambered or uneven roadways, hiking trails, rock slopes, ice fields, snowfields, glaciers, mountains, etc.

[Para 7] The disclosed crutch system provides a more ergonomic
10 configuration of forearm handle which is able to support the user while resisting strain, pain, fatigue or additional dysfunction. It provides a mechanism which reliably dampens repeated impacts with the ground, only springing back when the weight of the user is released. This damping
15 mechanism is located in the center of a crutch for more efficient damping and optimal traction control. The disclosed crutch system provides an integrated series of interchangeable and adjustable crutch tips capable of maintaining optimal control and stability for each terrain encountered by the
20 user.

[Para 8] The prior art does not appear to reveal any modular crutch walking
systems that employ all of the above features, including the means to swap
cuffs, handles or tips, or to utilize commonly available materials or

components from the biking or aerospace industry in order to allow use of local resources and maintenance options.

DETAILED DESCRIPTION

5 **[Para 9]** Figure 1a shows the side view of a representative ergonomic forearm crutch system 10 assembly. The core elements of said crutch system 10 are comprised of an ergonomic forearm handle 12, a damping assembly 28, and a removable tip at the distal end. Attached to the ergonomic forearm handle 12 is a cuff 18 with pivot bolt 20, and an ergonomic handle
10 grip 24. The ergonomic forearm handle 12 is connected to the damping assembly 28, including its coupling o-rings 36, and is then connected to the crutch tube 66. All tubular elements are connected by means of bolted 60 c-clamps 58, except the handle grip with its grip bolt 26. Clamp bolts 60 are tightened with a bolt key 62, in this case an appropriately sized Allen key,
15 which is housed in a key slot 64 in the cuff 18 for easy access and retention. Fig. 1a shows a representative general use (walking) tip 132 with a tip body 74, tube stop 72, a cushion 76, and a sole 78 material which is the foundation for a variety of traction solutions as described in more detail below.

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[Para 10] Figure 1b shows the side close-up sectional view of the ergonomic forearm handle 12 with its common attachments. The ergonomic forearm handle 12 is comprised of a handle tube 16 welded to a bent forearm tube

14. One desirable angular configuration of the forearm handle 12 is defined by the reference mark beside the drawing. A cuff 22 slides into the top of the forearm tube 14 by means of its pivot arm 22, which is attached by a pivot bolt 20. The bolt key 62 is shown partly inserted into the key slot 64 into the pivoting body of the cuff 22. An ergonomically shaped handle grip 24 is shown sliding onto the handle tube, and the top portion of the damping assembly 28 is shown attached to the bottom of the forearm tube by means of a c-clamp 58.

10 **[Para 11]** Note: for easier understanding of the following description, refer to both Figs. 2a and 2b together. Figure 2a shows the side cutaway view of the damping assembly 28 employing a hydraulic damper 48 and showing such external elements as the top housing 30 connected to the slide housing 38 by threading 94, then fitted into the coupling 40, which is cushioned from the crutch tube 66 by coupling o-rings 36. The coupling 40 is prevented from sliding too far down the crutch tube 66 by means of a slide flange 142. The bottom of the forearm tube 14 is clamped to the top of the top housing 30, and top of the crutch tube 66 is clamped to that portion of the coupling 40 below the slide flange 142, both by means of c-clamps 58 not shown in this drawing. Internal elements include a slide shaft 34 friction fitted into top of coupling 40, fitting through the slide housing 38 from the top, and contacting the bottom surface of the piston plate 56. The coupling 40 slides inside a Teflon® guide 46 along the direction A as weight is placed on or

removed from the above forearm tube 14. The top portion of the slide shaft 34 fits into a hexagonal plastic guide 44 which keys into the hexagonal bottom section of the top housing 30, in order to prevent the top housing 30 from rotating around the coupling 40, and thereby allowing the forearm
5 handle 12 to yaw around the crutch tube 66. A hydraulic dampener 48 threads into the piston plate 56 by means of its piston rod 54 and fits inside the top housing 30 as shown. A spring 42 is held in place by a spring retainer 32, with both sliding onto the piston rod 54 between the body of the hydraulic damper 48 and the piston plate 56. The coupling o-rings 36 act as
10 a backstop or cushion to prevent the bottom of the slide housing 38 from crushing the top of the crutch tube 66. A shaft o-ring 128 fitted under the top portion of the slide shaft 34 performs a similar protective function.

[Para 12] Figure 2b shows the side cutaway and sectional views of those
15 elements common to all damping assemblies, using the same hydraulic damper 48 from Figure 2a. In this figure it is easier to grasp how certain elements interlock to prevent unwanted rotation by means of the sectional views, and are shown by horizontal lines through each area sectioned. The only element added to Figure 2b is a representative c-clamp 58 with its
20 clamp bolt 60, whereas all other elements are the same as iterated in Figure 2a above.

[Para 13] Figure 3a shows the side cutaway view of an alternate damping assembly 28 employing an elastomeric damper 50, said element replacing the hydraulic damper 48, piston rod 54, piston plate 56, spring retainer 32 and spring 42 as shown in Figure 2a. Figure 3b shows the side cutaway view
5 of another alternate damping assembly 28 employing an internal spring hydraulic damper 52, which thereby eliminates the need for a spring retainer 32 and spring 42 as shown in Figure 2a.

[Para 14] Figures 4a and 4b respectively show the side cutaway & bottom
10 views of a general use (or walking) tip 132 comprised of a tip sleeve 70 sliding into the bottom end of the crutch tube 66, which inserts into the tip body 74, and terminates in a removable end cap 68. In order to prevent the bottom end of the crutch tube 66 from crushing the soft rubber of the tip body 74, a wider ring-like tube stop 72 is slid onto the bottom section of the
15 tip sleeve 70. This tube stop 72 may be press fitted, glued, set screwed or use other means of affixing it to the appropriate location. An alternate solution is to machine the tube stop 72 as part of the tip sleeve 70, thereby providing a fixed stop instead of a sliding stop. Affixed to the end of the tip body 74 are an additional layer of cushion 76 and a final layer of traction
20 material known as a sole 78. In addition, an annular indent 138 is formed or cut into the circumference of the tip body 74 as shown.

[Para 15] Figures 5a and 5b respectively show the side cutaway & bottom views of a hiking tip 134 comprised of the same elements as Figure 4a, except for pointed caulks 82 which are inserted through holes in the sole 78 and threaded 94 into an aluminum plate 80 affixed to the cushion 76.

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[Para 16] Figures 6a and 6b respectively show the side cutaway & bottom views of an ice tip 84 comprised of a tip sleeve 70 with a tip body 74, the distal end of which houses an ice pin 90, which is secured by set screws 92 fitted into indents in the circumference of the ice pin 90. Since the ice tip 84 is used as one part of the snow tip 136 (see Figs. 9a to c), the decking plate 88 with rivet holes 86 is used as a tube stop 72 in both tip designs.

[Para 17] Figures 7a and 7b respectively show the side cutaway close-up & bottom views of an articulating multi-terrain (AMT) tip 98 employing a sole 78 wherein each pad 110 holds a protruding stud 112. A socket body 108 attaches to the cushion 76 below, forms the socket for a ball joint 102 above, and is secured by a ball collar 104 by means of threads 94. The AMT sleeve 100 includes an integral tube stop 72 (as outlined above), and fastens to the ball joint 102 by means of a ball sleeve bolt 106. An AMT o-ring 130 both cushions and prevents the bottom edge of the tube stop 72 from damaging the sleeve orifice 140 in the top of the ball collar 104, as the AMT tip 98 is canted at different angles as it strikes non-perpendicular surfaces. Note: In Figs. 8a, 8c, 8e, and 8g to follow, the AMT tip 98 is the same as in Fig. 7a,

and only the foot configurations change. Note: for purposes of this discussion, the foot portion of a crutch tip are those features intended to contact the ground on a regular basis.

- 5 **[Para 18]** Figures 8a and 8b respectively show the side cutaway close-up & bottom views of an AMT tip 98 employing a general use or walking foot, which is comprised of a cushion 76 and a sole 78 as shown. Figures 8c and 8d respectively show the side cutaway close-up & bottom views of an AMT tip 98 with a cushion 76 and employing a sole 78 with exposed studs 112.
- 10 Figures 8e and 8f respectively show the side cutaway close-up & bottom views of an AMT tip 98 with a cushion 76 and employing a sole 78 with recessed studs 112, fitting into stud holes 114. Figures 8g and 8h respectively show the side cutaway close-up & bottom views of an AMT tip 98 with a cushion 76 and employing a sole 78 with recessed studs 112,
- 15 fitting into stud holes 114, where the studs are affixed to a metal plate 116 as shown.

- [Para 19]** Figure 9a shows the top view of a snow tip 136 which employs the ice tip 84 and which is attached to the flexible decking 120 with rivets 126
- 20 by means of its decking plate 88 (through rivet holes 86 shown in Figs 6a & 6b). The decking 120 material is attached by means of rivets 126 to connectors 122 which slot through the serrated frame 118 (see Figs. 9b & 9c)
- Figure 9b shows the side cutaway view of the snow tip 136 with the tip sleeve

70 portion of the ice tip 84 sliding into the bottom of the crutch tube 66. The form of the serrated frame 118 can now be seen, and the slots 124 through the frame 118 that hold the connectors 122 are demonstrated. Figure 9c shows the side view of the snow tip 136 with external views of the ice tip 84, 5 serrated frame 118, set screws 92, and ice pin 90.

[Para 20] One preferred embodiment of the multi-terrain damping ergonomic forearm crutch system 10 will now be described in detail. The integrated elements that make up the novel crutch system have been organized into the 10 following sections describing the attributes and functionality of: the ergonomic forearm handle 12, damping systems, tip designs, and miscellaneous support elements. Note that by focusing on individual elements or assemblies for purposes of explanation, one does not lessen their functional interdependence in practice.

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[Para 21] Ergonomic Forearm Handle Design:

[Para 22] Figure 1b shows the side close-up sectional view of the ergonomic forearm handle 12 which is comprised of bent forearm tube 14 and an 20 angled handle tube 16 welded to that bend. The angular configuration of the forearm handle 12 is defined by the reference mark beside the drawing. The angle of the forearm tube 14 and the handle tube 16 are an aspect of the invention because they enable the ergonomic positioning for wrist and

hand during the highly repetitive and weight bearing nature of crutch walking.

[Para 23] One of the inventors is a Registered Occupational Therapist, and in her professional experience, the optimal biomechanical angle for a crutch forearm handle 12 is one which allows a more open wrist position angle, for example 100 degrees instead of the almost universally employed 90 degrees. This angle reduces wrist hyper-extension and permits greater weight bearing on the ulna side (strength side) of the hand. This position also relieves stress and reduces uneven loads on the surrounding arm and shoulder muscles, as well as related connective tissues and structures. The ergonomic forearm handle 12 supports both lower and upper arm in a more natural and therefore a stronger biomechanical position. The more ergonomic the position of the biceps and shoulder joint, the more relaxed and responsive is the posture while moving with the ergonomic forearm crutch system 10. This configuration results in reduced fatigue or risk of chronic pain or injury during endurance or extreme outdoor activities such as hiking, mountain climbing, ice travel, skiing etc.

[Para 24] An additional functional attribute of the ergonomic forearm handle 12 is that it is constructed of tubular dimensions that allow it to interface with common mountain bike handle components such as a multiplicity of ergonomic handles designed to prevent similar ulnar and forearm repetitive

injuries. By this means, the present design permits more selection of, and less expensive alternatives for, replacement handles to be found and used, irrespective of the user's location.

5 **[Para 25]** Damping Systems:

[Para 26] Damping is the capacity built into a mechanical device to prevent excessive correction, which results in instability or oscillatory conditions.

Damping is any effect, either deliberately engendered or inherent to a system
10 that tends to reduce that system's amplitude of [oscillations](#). Unlike a spring, or a common shock absorber, a damper absorbs weight to a certain point, and then slowly releases the weight back to the starting point in a controlled fashion. The kind of hydraulic damper 48 used with this invention is an extension damper which is adjustable in the return force supporting the
15 weight of the user. The user can manually adjust the amount of return force provided by the damper by turning the piston 54 a number of turns in a specified direction, as per the manufacturer's instructions. Therefore any damping assembly 28 employing a hydraulic damper 48 can be adjusted to support users of different weights, thereby providing the optimal stroke
20 motion and return duration for maximum comfort and safety. The preferred embodiment of the ergonomic forearm crutch system 10 employs a hydraulic damper 48 as the core element of the damping assembly 28 which will now be described in detail.

[Para 27] Hydraulic Damper Assembly:

[Para 28] As shown in Figs. 2a & 2b, the damping assembly 28 employing a
5 hydraulic damper 48 is a tubular mechanism that absorbs the weight of a
user as they move with the crutch. Hydraulic dampers 48 are cylindrical
cartridges filled with a compressible gas such as nitrogen, such that when
weight is placed on the piston 54, it retracts into the cartridge at a given
rate. Hydraulic dampers 48 may also employ oil seal chambers, which when
10 vented between chambers, control or moderate the rate of piston travel.
Damping assemblies 28 may also employ elastomeric dampers 50 in place of
the hydraulic damper 48, or may employ a hydraulic damper with an internal
spring 52, but these alternate embodiments will be described further in the
appropriate section below.

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[Para 29] As shown in Figs. 2a & 2b, the damping assembly 28 slides partway
into the bottom of the ergonomic forearm handle 12 and partway into the
top of the crutch tube 66, and both are fastened by means of c-clamps 58 at
the top housing 30 and coupling 40 respectively. In both cases there is a
20 means to prevent damage to components if the c-clamps 58 are loosened for
any reason, namely the forearm tube 14 is stopped by the ledge at the top of
the top housing 30, and the top of the crutch tube 66 is stopped by the slide
flange 142 of the coupling 40. The hydraulic damper 48 is held inside the

top housing 30 so that the piston plate 56 threaded 94 to the piston 54 is pressing on the top of the slide shaft 34. In this embodiment, a compression spring 42 and spring retainer 32 are fitted over the piston 54, behind the piston plate 56, so that when weight is applied to the hydraulic damper 48, the spring 42 provides an increasing force to absorb the weight of the user, easing them down gently. When the user's weight is removed however, the hydraulic damper 48 prevents the spring 42 from returning to its maximum extension too rapidly, and thereby prevents the "pogo stick" action common in prior art solutions. Springs 42 of the same length can be selected for different compression ranges (tension) by using a denser or thicker-wire size. Spring 42 tensions will be selected according to weight of user so as to provide a safe margin of support.

[Para 30] While the damper 48 and spring 42 provide optimal suspension for crutch walking, they also require a means to ensure both smooth and reliable operation during many repetitions, as well as a means to prevent unwanted horizontal rotation of components during use. The sliding elements of the damping assembly 28 are the solution to both these requirements. The sliding elements start from the internally hexagonal lower section of the top housing 30, wherein is fitted a hexagonal plastic guide 44, into which slots the hexagonal top portion of the slide shaft 34, and which is normally in contact with the piston plate 56. By this means, the slide shaft 34 is prevented from horizontal rotation, and when its bottom portion, which

slides through the top of the slide housing 38, is secured into the top of the coupling 40, and that is secured to the crutch tube 66 by a c-clamp 58, the entire upper section of the crutch is now prevented from any unwanted horizontal rotation or yawing. Vertical movement of the damping assembly 5 28 is necessary however, and should be as frictionless as possible, therefore a cylindrical Teflon® guide 46 is inserted between the coupling 40 and the inside wall of the slide housing 38.

[Para 31] Elastomeric o-rings allow for adjustment of travel range, provide a gentle final stop, and also act as a crash barrier if suspension components fail. The number of coupling o-rings 36 stacked onto the coupling 40 depends on the required stroke length (see A in Figs. 2a, 3a & 3b), which usually varies depending on the weight of the user. The shaft o-ring 128 at base of top housing 30 is used to decrease noise during the return stroke.

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[Para 32] Tip Designs:

[Para 33] All tips designs employ tip sleeves 70 (or 100) which slide into the bottom of the crutch tube 66 and are secured by tightening the clamp bolt 20 60 of the c-clamp 58. All tips also normally require a means to arrest the crutch tube 66 at a specific point on the tip sleeve 70, in case the c-clamp 58 should fail. In most tips, this is done by means of the tube stop 72, and in the case of the ice 84 and snow 136 tips, by their decking plate 88, which

acts as a tube stop 72. Tube stops 72 are either a cylindrical ring which slides on the tip sleeve 70 or a widened diameter of the tip sleeve 70 just above the softer tip body 74. Whether they are used depends on the structural resilience of the tip body 74 material. If the tip body 74 can

5 support the combined body weight of the user and the force of impact while moving with the crutch, then a tube stop 72 is not necessary. The tube stop 72 distributes the forces from the bottom of the crutch tube 66 over a wider surface area of the top of the tip body 74. The object is to prevent the crutch tube 66 from crushing through the tip body 74, thereby damaging the tip,

10 and potentially becoming a safety hazard to the user.

[Para 34] For purposes of this disclosure, interchangeable tips are classified as static, articulating multi-terrain (AMT), or extreme (ice & snow). Specific sub-classifications define how each tip works best in its primary

15 environment, but these classifications are broadly descriptive, and not limiting if other functionalities are discovered.

[Para 35] Static Tips:

20 **[Para 36]** Two static tips are illustrated, namely the General Use (Walking) Tip 132, and the Hiking Tip 134. Both static tips have a similar tip body 74 design, and employ a soft rubber cushion 76 that both absorbs impact, and allows the sole 78 additional flexibility to maintain maximum contact with

the ground. Both static tips have an annular indent 138 around the mid-section of the tip body 74 just above the soft rubber cushion 76 that increases flexion of the tip up to a 30 degree angle, and thereby allows the sole 78 of the tip to remain on the floor longer during the swing phase of crutch walking. As shown in Figs. 4a & b, the sole 78 of the general use (walking) tip 132 is made of Vibram® rubber or similar material for optimal traction on commonly encountered surfaces in urban or rural streets such as asphalt, concrete, or cobblestones. As shown in Figs. 5a & b, the sole 78 of the hiking tip 134 employs additional screw-in caulks 82 threaded 94 into an aluminum plate 80 which is bonded between the soft rubber cushion 76 and the Vibram® rubber sole 78. The caulks 82 provide additional traction on hiking trails, undeveloped roadways, wooden bridges, or any surface where a rubber sole 78 might lose traction due to softer, slippery or uneven terrain.

[Para 37] The annular indent 138 around both the general 132 and hiking tip 134 bodies is meant to increase the flexibility of the bottom portion of these tips, and to allow the foot of the tip to remain in contact with the ground longer than with more rigid tip body designs. When a tip does not have sufficient surface area in contact with the ground, it cannot provide sufficient traction. Without a means to allow the tip to flex with any contacting surface, the tip is likely to skid along the ground on its edge, which is unsafe for the user, and damaging to the tip. The static tips solve this problem by means of the annular indent 138, whereas the articulating tips 98 solve it with their

ball joint 102 and socket body 108 assemblies. As evident from Figs. 4a or 5a, if the bottom portion of these tips hits an inclined surface, the closest sector of the annular indent 138 will allow that area of the tip body 74 to compress, and thereby allow the sole 78 to maintain optimal contact with the ground. Therefore an object of the annular indent 138 on these tip bodies 74 is to allow sole 78 to maintain connection with the surface of the ground even when it is angled to the direction of impact of the crutch tip.

[Para 38] Articulating Multi-Terrain (AMT) Tips:

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[Para 39] As shown in Figs. 7a to 8h, all AMT tips 98 employ the same body design, but employ one of five different sole 78 designs, namely general use (walking), protruding studs, exposed studs, recessed studs, or recessed studs with metal plate. Figure 7a shows a close-up of the AMT tip 98 body design where the ball joint 102, a low friction plastic sphere, is fastened to the bottom of the AMT tip sleeve 100, and rides in a correspondingly spherical socket embedded in the socket body 108. The ball collar 104 compresses the ball joint 102 against the socket body 108, by means of threading 94 on both parts, and this determines how freely the ball joint 102 is able to move within the socket body 108. The resultant rotational freedom of the crutch tip from the crutch body allows the user's shoulder to slightly rotate externally, while swinging through each stride. This has the potential

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to reduce user fatigue, by allowing a more natural positioning of the shoulder in relation to the body – during the swing portion of the stride.

[Para 40] A primary object of any AMT tip 98 is its ability to change its angle
5 when contacting unevenly angled terrain so that the sole 78 of the tip
presents the largest surface area at every contact with the ground, and
thereby provides optimal traction for the user. The AMT tip 98 allows each
foot a nominal 60 degree range of articulation around the axis of the AMT tip
10 sleeve 100. In order to permit this range of articulation, the sleeve orifice
140 in the top of the ball collar 104 is widened and beveled as shown in Fig.
7a. To prevent the metal AMT tip sleeve 100 from damaging the sleeve
orifice 140 of the plastic ball collar 104 as it articulates, a cushioning AMT o-
15 ring 130 is inserted as shown. The AMT o-ring 130 can vary in size to
increase or decrease the range of foot articulation, and also acts as a seal to
prevent water, contaminants, or abrasive materials from entering and
possibly damaging the inside of the socket body 108 assembly.

[Para 41] Other objects of the AMT tip 98 include soles 78 designed to
provide traction on multiple terrains, and which provide nominally wider
20 surface areas contacting the ground than soles 78 found on static tip
designs. AMT tips 98 use metal studs 112 instead of caulks 82 of the hiking
tip 134, and perform a similar function in that they provide optimal traction
on slippery or uneven terrain by biting into the surface of the ground. Studs

112 in the preferred embodiment are hexagonal flat headed stainless machine screws which are driven into and secured in the sole 78 material. The general use (walking) foot employed with the AMT tip 98 does not use studs 112, but employs a Vibram® sole 78 as shown in Figs. 8a & b. Four
5 studded sole designs are available: with studs 112 affixed to protruding pads 110 (Figs. 7a & b); studs 112 affixed flush to the sole 78 material (Figs. 8c & d); studs 112 affixed into stud holes 114 in the sole 78 material, thereby providing the potential to use this foot indoors without damaging flooring because the studs 112 are level with the sole 78 (Figs. 8e & f); and studs 112
10 affixed into stud holes 114 in the sole 78 material, through a reinforcing metal plate (Figs. 8g & h). Note that studs 112 may also be embedded into the sole 78 material as part of its forming process, but this may preclude the option to replace damaged studs 112. Studs 112 embedded in stud holes 114 decrease the noise made when walking over harder surfaces such as
15 cobblestones, logging roads, hardwood floors. The embedding depth of threaded machine screws or anchoring pins securing the studs 112 to the sole 78 material or beyond, are optimally greater than the height of the studs 112 projecting beyond the anchoring surface.

[Para 42] Extreme Tips:

[Para 43] Two extreme tips are available, namely the ice tip 84 (Figs. 6a & b), and the snow tip 136 (Figs. 9a to c), with the latter being assembled around
5 the former.

[Para 44] The ice tip 84 allows the user to crutch walk on glaciers, ice fields, or even urban streets covered with frozen water. It is primarily comprised of cylindrical tip sleeve 70 and tip body 74 sections (see Fig. 6a), the latter
10 housing a replaceable ice pin 90 in the end contacting the ground. Since the ice tip 84 can be used to assemble a snow tip 136, and since it needs some form of tube stop 72, for the reasons outlined above, the decking plate 88 is retained in both tips and serves this purpose. The decking plate 88 is welded
15 in place or is affixed by other means approximately halfway down the ice tip 84, and retains the rivet holes 86 to be used for the snow tip 136. The ice pin 90 is fixed in place by means of at least two set screws 92, the ends of which are screwed into corresponding indents 96 in the ice pin 90 body. By this means, the ice pin 90 is firmly secured in the end of the ice tip 84, and by
20 loosening the set screws 92, one may replace the ice pin 90 if blunted or bent during extreme use.

[Para 45] The snow tip 136 shown in Figs. 9a to c is used as a crutch walking snow shoe and may be used as an expedient sand shoe. As mentioned

above, the snow tip 136 is assembled around the ice tip 84 by affixing a flexible, strong, weatherproof decking 120 material to the decking plate 88 by means of rivets 126 through existing rivet holes 86 (see Figs. 6a & b). The decking 120 is then attached with rivets 126 at equidistant points around its circumference to rigid connectors 122 fitting through slots 124 in the circular serrated frame 118. The object of the decking 120 is to create a sufficiently large contact area to distribute and support the weight of the user as they crutch walk on the surface of the snow (or sand). The object of the serrated edge of the frame 118 is to enable the user to punch through snow with an icy crust which otherwise may prevent sufficient frame 118 insertion into a variable density surface. The object of retaining an ice tip 84 as part of the snow tip 136 assembly is the necessity to punch through an icy crust, only to encounter a deeper unyielding ice or ground layer. In this circumstance, without the tip body 74 section of the ice tip 84, the frame 118 of the snow tip 136 would likely not have enough stability to maintain traction or support.

[Para 46] Support Elements:

[Para 47] The following section details various support elements that are necessary to full operation of the ergonomic forearm crutch system, namely the cuff 18, handle grip 24, crutch tube 66, and modular component clamping solutions.

[Para 48] As shown in Figs. 1a & b, the cuff 18 slides into the top of the forearm tube 14 by means of its pivot arm 22. The pivot arm 22 allows the ring of the nylon cuff that wraps around, cushions, and cradles the upper arm, to pivot around its pivot bolt 20. By this means, the user may adjust their upper arm to varying loads, terrains and inclines. The diameter of the forearm tube 14 is designed to accept, available cuffs with similar diameter insertion means or cuffs 18 which may be specifically retrofitted to fit the novel crutch system 10.

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[Para 49] The top back area of the arm ring portion of the cuff 18 may also be used to house the (Allen) bolt key 62 in its key slot 64. By this means the bolt key 62 used to adjust and tighten the four c-clamps 58 is readily accessible for use, and is readily stowable so that such a tool for the safe operation of the crutch system 10 is available when needed to help one navigate variable terrain. A groove may be incorporated in the body of the cuff 18 to receive the angled portion of the bolt key 62 so that it is flush with the top surface of the cuff 18 in order to prevent the end of the bolt key 62 from being inadvertently pulled from its key slot 64 and potentially lost.

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[Para 50] The handle grip 24 that slides onto the handle tube 16 can be any ergonomic or regular bike handle that fits commonly used 7/8 inch diameter tubing. This allows the user to employ the custom handle grip 24 they prefer

from a multiplicity of readily available handles designed for cycles or crutches. Also, the user can readily replace a damaged handle in the field, or in another country, by employing readily available cycle handle grips. The ergonomic handle grip 24 shown in Figs. 1a & b is designed to completely and comfortably fill the space in a user's palm with the enlarged handle grip 24 so that full control of the handle tube 16, and therefore of the crutch system 10, is easily possible. The handle grip 24 is secured on the handle tube 16 by means of a grip bolt 26, which prevents unwanted and potentially unsafe rotation of the grip 24 around the handle tube 16.

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[Para 51] The crutch tube 66 may be made from aircraft aluminum hollow tubing, its top sliding onto the end of the damping assembly 28, and bottom over the tip sleeve 70, and its securement position in the latter case can be partly extended up the tip sleeve 70 by varying where one fastens the c-clamp 58.

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[Para 52] Clamping of modular components is achieved by means of c-clamps 58 which, when tightened by their clamp bolts 60 with the bolt key 62, compress the tubing (crutch tube 66 or forearm tube 14) around each component. Reliable securement is only made possible when the component to tube distance (tolerance) is small enough (see Fig. 2a: forearm tube 14 to top housing 30) so that c-clamp 58 compression of the tubing completely around (see Fig. 2b: sectional view of c-clamp 58) each component clamping

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area is effective. In the present embodiment, all bolts used to fasten c-clamps 58 or other elements employ Allen key heads, so that only one bolt key 62 is required to maintain the crutch system 10. The bolt key 62 is sized to be compatible with common cycling components, so that if one loses their
5 key, they may be able to borrow the compatible Allen key to adjust and or secure their crutch system 10.

[Para 53] Other embodiments of the ergonomic forearm crutch system 10 will now be described in detail. Further similar embodiments and similar methods
10 leading to the same result will occur to those skilled in the art and are considered to be in accordance with the spirit and general teachings of the present invention.

[Para 54] As shown in Figure 3a the hydraulic damper 48 employed in the
15 illustrated embodiment may be replaced with an expedient elastomeric damper 50, such as those commonly used in front fork suspensions for mountain bikes. This allows the crutch walker traveling in less developed countries to secure a readily available substitute for an inoperable hydraulic damper 48, allowing her to continue her journey until she can find the proper
20 replacement part. The elastomeric damper 50 may also be used as a less expensive alternative to the preferred embodiment.

[Para 55] As shown in Figure 3b, another alternate embodiment employs an internal spring hydraulic damper 52 which acts in the same manner as the hydraulic damper 48, but with a spring or an equivalent functional mechanism inside the damper cartridge. For this reason, an external spring
5 42 and its retainer 32 are not needed in this embodiment.

[Para 56] The c-clamp 58 may also include a version with low profile quick release lever instead of an allen head bolt as a securement means. However, the advantage of the latter is more reliable clamping, whereas a quick release
10 may become disengaged inadvertently if the lever is caught on something. The advantage of the quick release is convenience when changing components, so that if there were a means to prevent unlocking during travel, this method may be employed in place of some or all c-clamps.

[Para 57] Crutch tubes 66 made of carbon fiber (see below) allow one to
15 manufacture a floating marine crutch system 10, with all components made from synthetic waterproof high-strength plastics, tubing filled with foam for floatation if needed, use of the lighter weight elastomeric damper 50, or none at all, and with the object that the crutch system 10 could be used in a
20 marine environment, such as from a kayak, and would float on water. Note that variations employing the use of an elastomeric damper or no damper also apply to the use of skiing attachments such as a skiing foot.

[Para 58] The appropriate and alternate materials used to manufacture the Multi-Terrain Damping Ergonomic Forearm Crutch System 10 will now be described, if not mentioned elsewhere in this document.

5 **[Para 59]** The caulks 82 or studs 112 used on the soles 78 of static and articulating feet may also be made of appropriate non-metallic materials such as rigid hard rubber, Fastex® style plastics, or any material that would increase traction on a wider variety of base surfaces. The object of using non-metallic caulks 82 or studs 112 as traction elements is to provide both
10 the required outdoor grip, yet allow the user to move across interior flooring without causing damage to said flooring and without being forced to change to a softer tip to prevent such damage.

[Para 60] Tip bodies 74 of both static tips: General Use (walking) (Fig. 4a),
15 and Hiking (Fig. 5a), are formed with rigid light-weight resilient rubber such as polyurethane, or any material with similar properties. Cushion 76 materials should be light weight, pliant, and resilient and can be made from natural or synthetic rubber, urethane ethylene, propylene, silicone, EVA, or similar materials. Soles 78 may be made from Vibram® TC-1 rubber outsole
20 material, as well as 5.10 Stealth® soles or any similar outdoor tread material that can endure the chosen terrain. Vibram is an elastomeric material (vulcanized natural and or synthetic rubber) with a hardness of 30-80 Shore A (Durometer), and reduces the physical impact on joints and the noise of

contact with hard surfaces. Vibram® soles are more durable, but Stealth® soles are stickier, so the user must select the sole 78 material most appropriate to their chosen terrain.

5 **[Para 61]** The cuff 18 is made primarily from a 606 nylon/ Dupont Zytel® blend of plastics, for strength, durability, and waterproofing. Other cuffs would be chosen by the user, but must fit the diameter of the forearm tube 14, and permit similar ergonomic advantages as the original cuff 18.

10 Tubing, namely the crutch tube 66 and ergonomic forearm handle 12, are made from high grade 6061 aluminum, chosen for its strength, durability, and availability (used to make most mountain bike frames now). Tubing may also be made from titanium for its strength & durability, or carbon fiber for its lightness. (see marine version above)

15

[Para 62] The hydraulic damper 48 employed in the preferred embodiment is an extension damper from Ace Controls, part number HB-15-25-88-M, with a stroke length of 25mm (which may be reduced to approximately 8mm with the use of coupling o-rings 36), and is able to support a maximum force of
20 800 newtons. The spring 42 employed with the hydraulic damper 48 is made from stainless steel for rustproofness and responsiveness, i.e. stainless steel responds with less speed and rebound force, preventing the “pogo-stick” effect mentioned above. The spring 42 is from Ammtech, part number 80-

604-8000-1500c-ceg-l-ss, and is eight left-hand wound 0.08 inch coils made from T302 stainless steel, with an approximate 62.87 lb/inch rate of deflection (travel), and a recommended load capacity of 30 pounds (US).

5

[Para 63] The ice pin 90 is made from tungsten carbide alloy or hardened stainless steel or any material with similar strength & resilience. Decking 120 for the snow tip 136 can be made from PVC or urethane coated material with a minimum density of 45 oz/sq. yd. The serrated frame 118 may be
10 constructed in aluminum or stainless steel, with the former material lighter, but not stronger than stainless. An aluminum frame 118 is powder coated so that ice does not build up on the snow tip 136 during extended use.

[Para 64] Other advantages of using the ergonomic forearm crutch system 10
15 over other methods or devices are described herein. The adaptability of a modular crutch system 10 allows one to employ existing cuff designs and mounting methods, off the shelf handlebar grips from most contemporary bicycles, and tubing of the same specifications as that used for bicycle handlebars. The modularity of the system 10 is adaptable to activities such
20 as mountaineering, kayaking, skiing, long distant walking, biking/motorcycle travel (bike model would break down into travel size pieces), etc. Modular components can be disassembled and attached to a kayak, motorcycle, or bicycle during travel, or compactly stored in a suitcase, backpack or briefcase. For this latter functionality, the crutch tube 66 may be constructed

as two separate tubes connected together by means of an internal cylindrical rigid sleeve joint which is compressed by means of a c-clamp 58. By this means, the crutch tube 66 may be broken down into two parts approximately equal in length for storage or travel. Multi-terrain tips allow safe travel along
5 gravel (logging roads), asphalt, cambered roads, sand, concrete, mud, water, skiing trail, mountain trail, desert trail, cobblestones, bailey bridges, log bridges, etc. The damping assembly can be also retrofitted to all tubular support devices such as walking sticks, crutches, canes, walkers, ski poles, etc.

10

[Para 65] The foregoing description of illustrative embodiments of the apparatus and methods of operation and construction should be considered as descriptive only, and not limiting. Other manufacturing techniques, configurations, and materials may be employed towards similar ends. Various
15 changes and modifications will occur to those skilled in the art, without departing from the true scope of the invention.

DRAWINGS

BRIEF DESCRIPTION OF THE DRAWINGS

[Para 66] Fig1 a – Side view of the Forearm Crutch System assembly.

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[Para 67] Fig1 b – Side closeup cutaway view of the Forearm Handle with common attachments.

[Para 68] Fig2a – Side cutaway view of a Hydraulic Damper assembly.

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[Para 69] Fig2b – Side cutaway and sectional views of common Damper related elements.

[Para 70] Fig3a – Side cutaway view of an Elastomeric Damper assembly.

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[Para 71] Fig3b – Side cutaway view of an Internal Spring Hydraulic Damper assembly.

[Para 72] Fig4a/b – Side cutaway & bottom view of a General Use (Walking)

20 Tip.

[Para 73] Fig5a/b – Side cutaway & bottom view of a Hiking Tip.

[Para 74] Fig6a/b – Side cutaway & bottom view of an Ice Tip.

[Para 75] Fig7a/b – Side cutaway closeup & bottom view of an Articulating Multi-terrain Tip (AMT) with a Protruding Studded Foot.

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[Para 76] Fig8a/b – Side cutaway closeup & bottom view of an AMT with a General Use (Walking) Foot.

[Para 77] Fig8c/d – Side cutaway closeup & bottom view of an AMT with an Exposed Studded Foot.

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[Para 78] Fig8e/f – Side cutaway closeup & bottom view of an AMT with a Recessed Studded Foot.

[Para 79] Fig8g/h – Side cutaway closeup & bottom view of an AMT with a Recessed Studded Foot using a metal plate.

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[Para 80] Fig9a – Top view of a Snow Tip.

[Para 81] Fig9b – Side cutaway view of a Snow Tip.

20

[Para 82] Fig9c – Side view of Snow Tip.

Fig. 1a

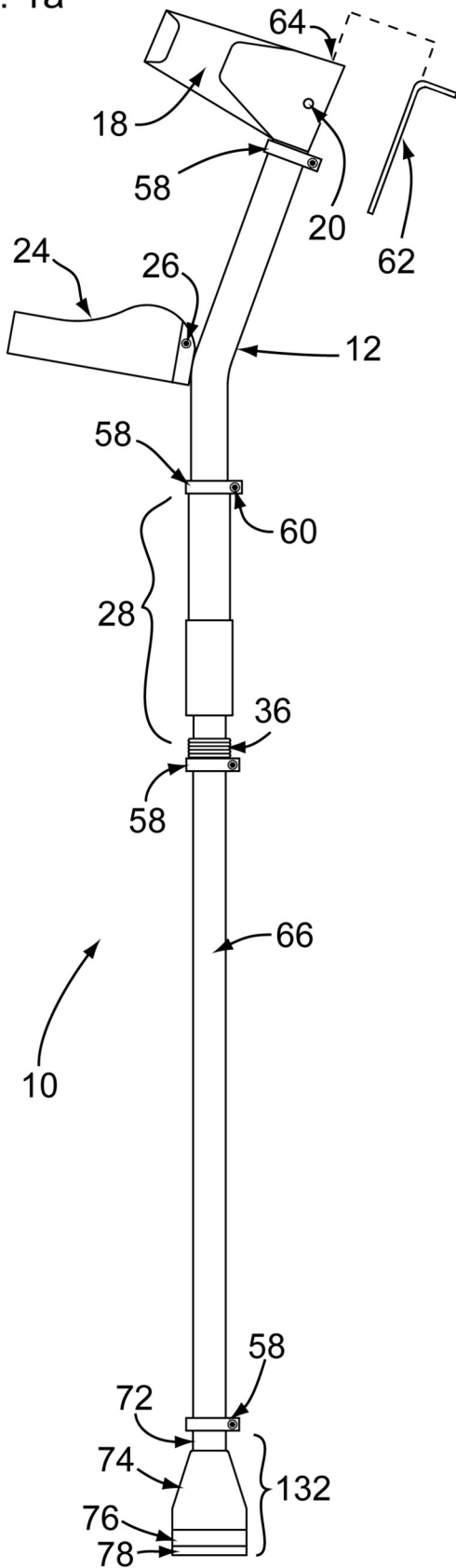


Fig. 1b

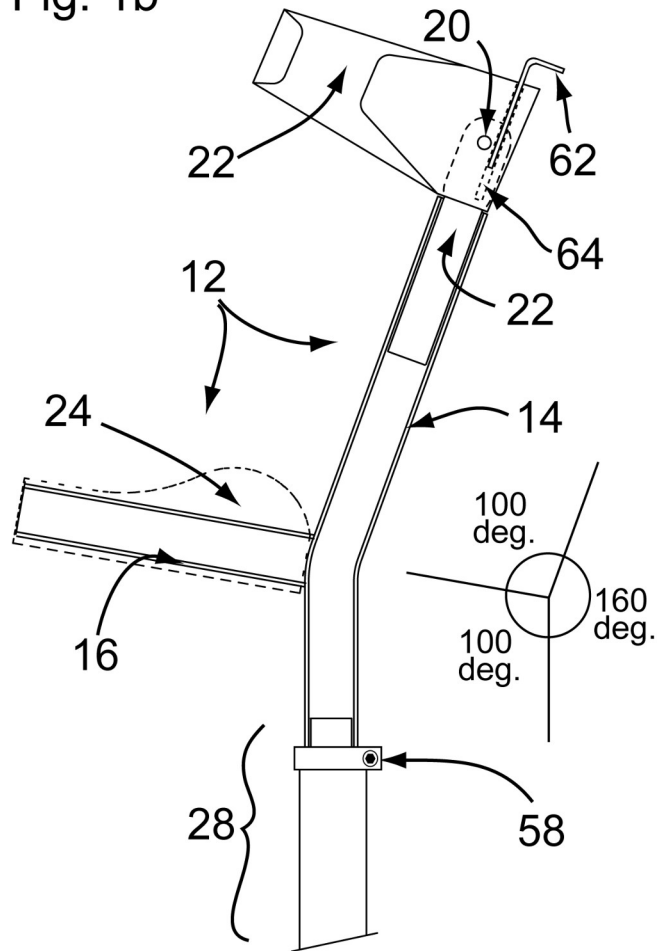


Fig. 2a

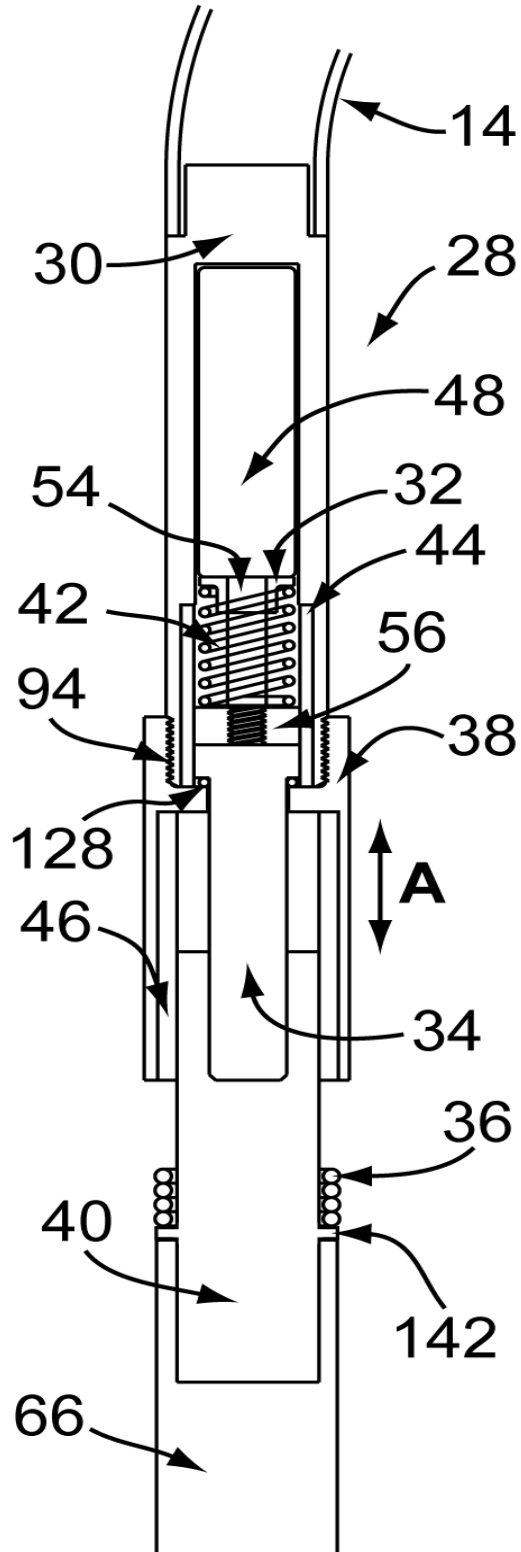


Fig. 2b

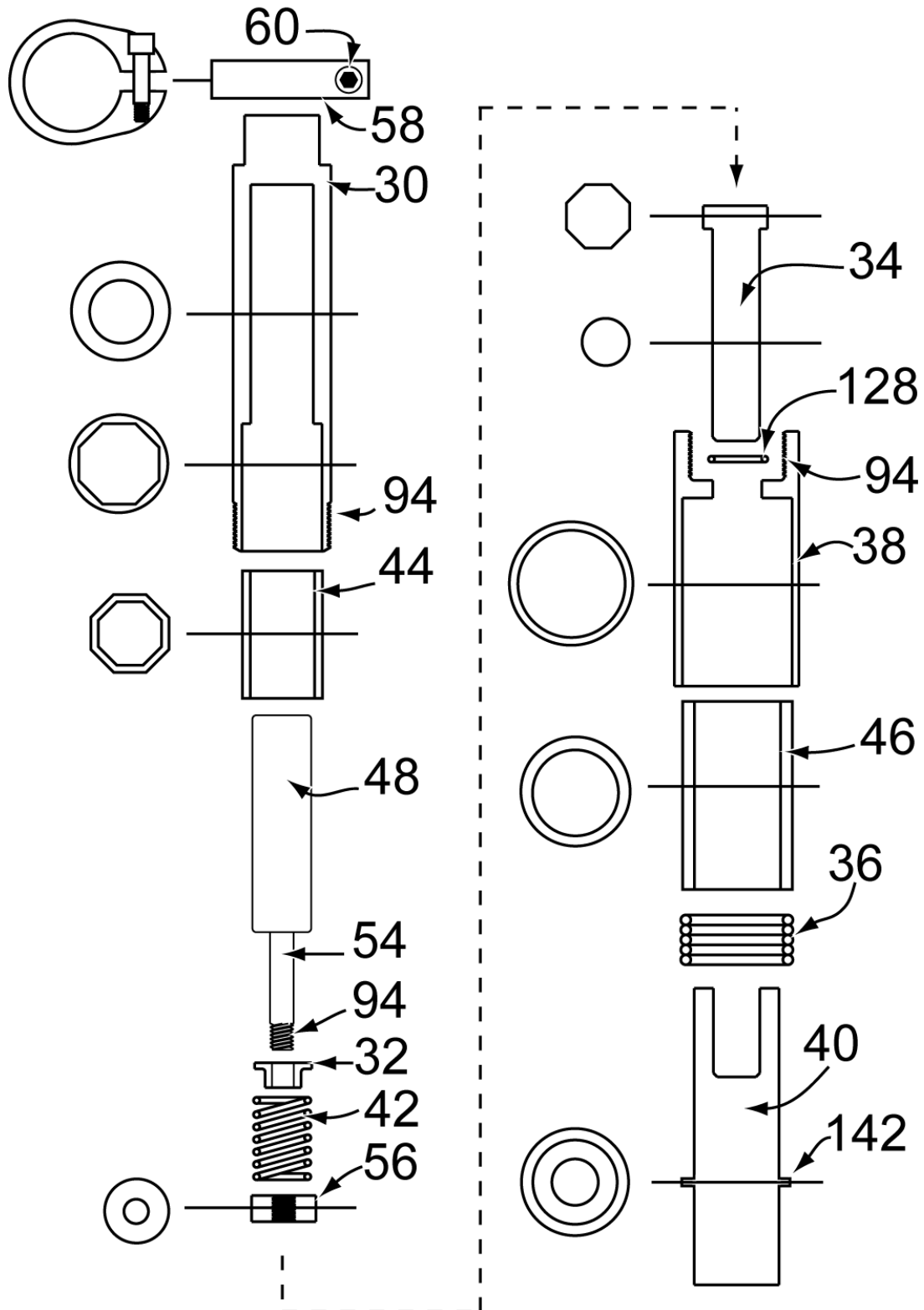


Fig. 3a

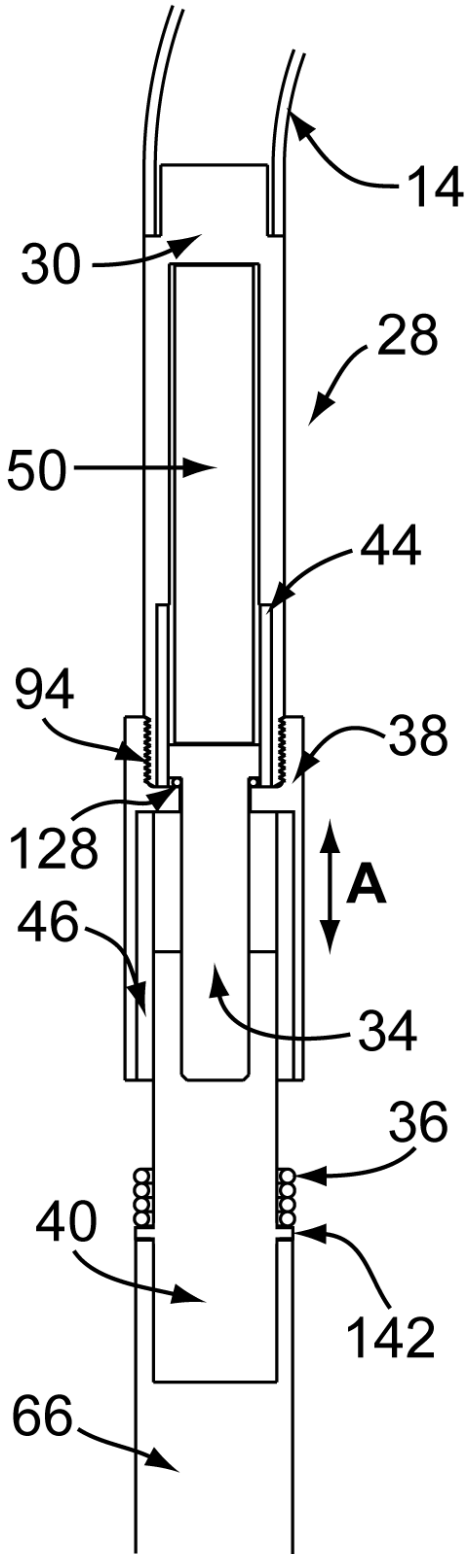
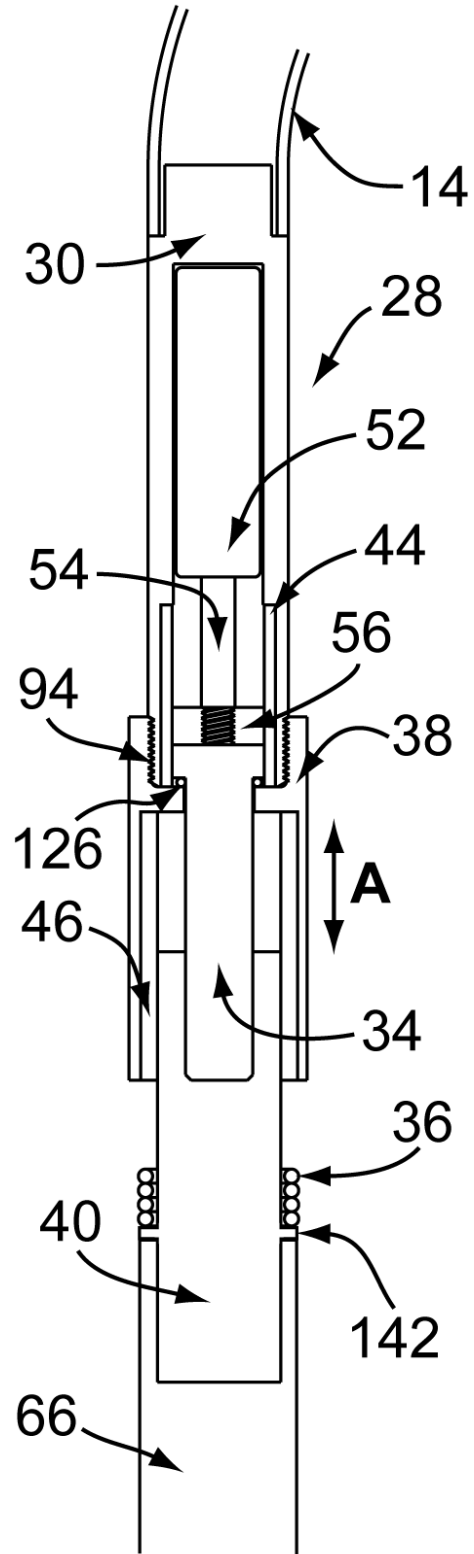


Fig. 3b



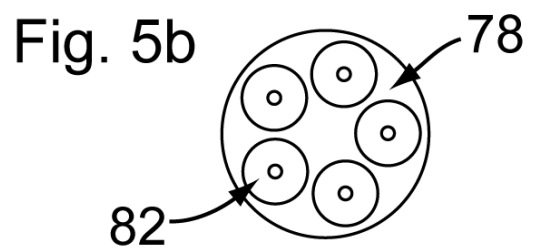
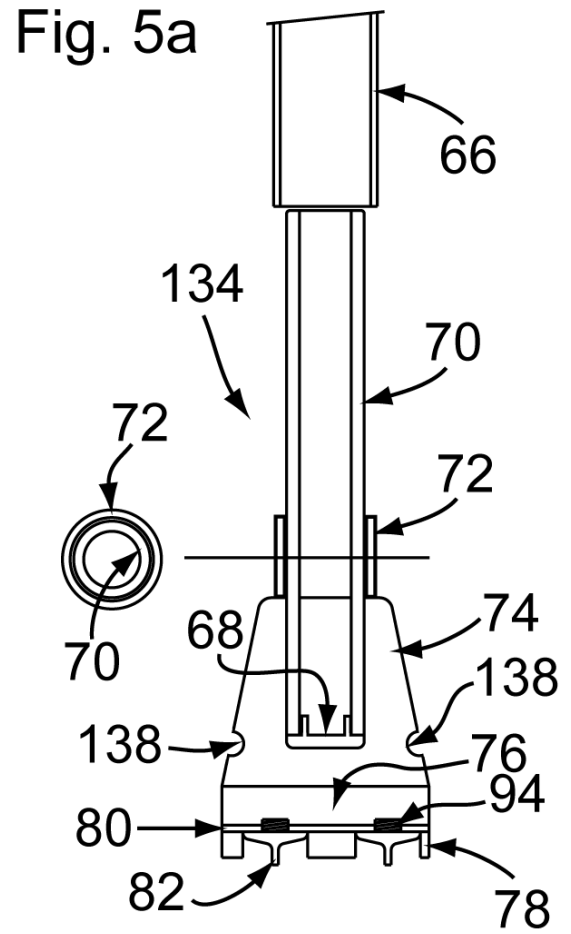
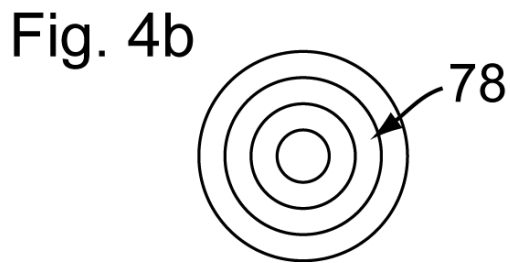
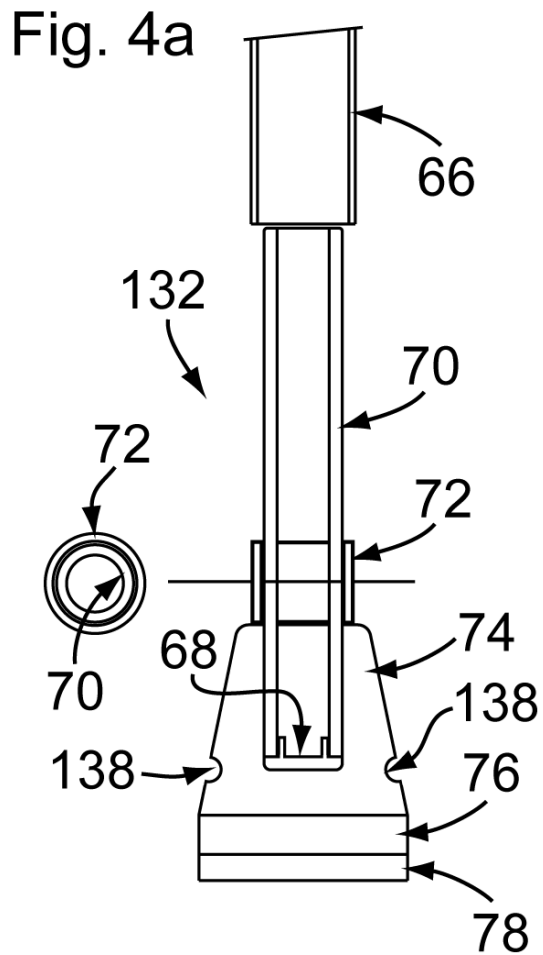


Fig. 6a

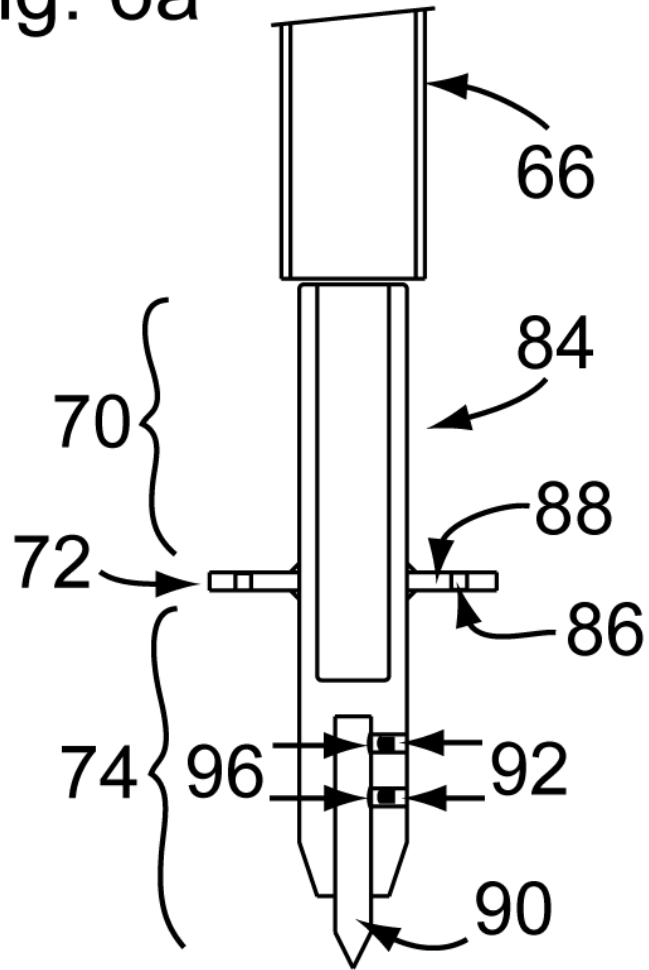


Fig. 6b

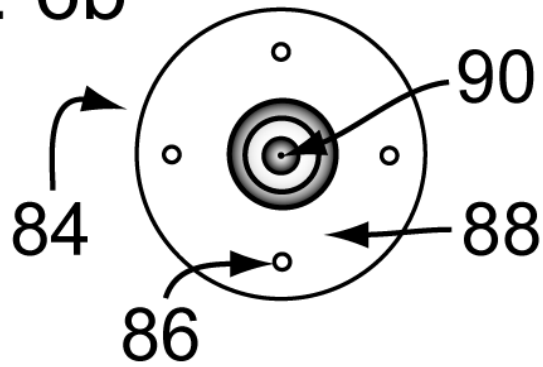


Fig. 7a

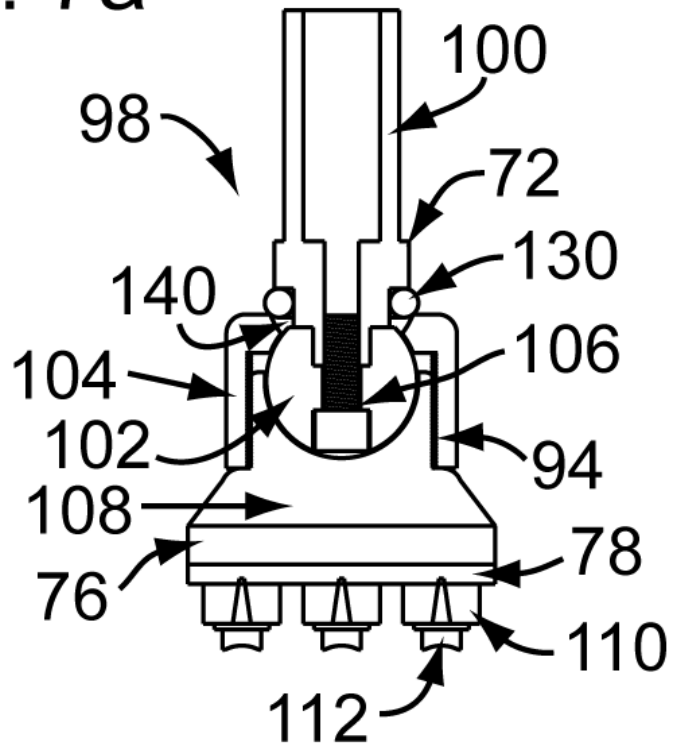


Fig. 7b

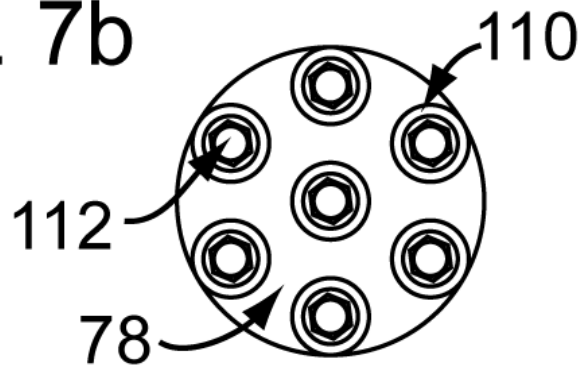


Fig. 8a

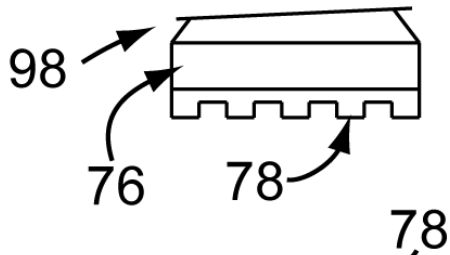


Fig. 8c

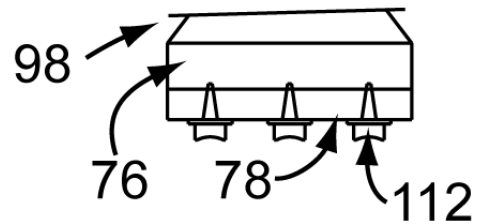


Fig. 8b

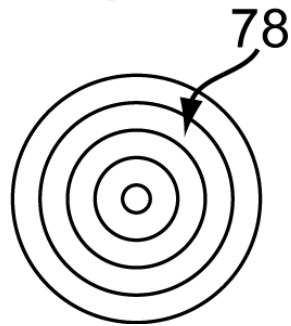


Fig. 8d

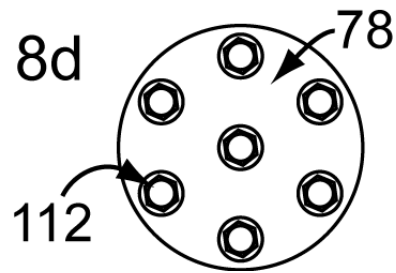


Fig. 8e

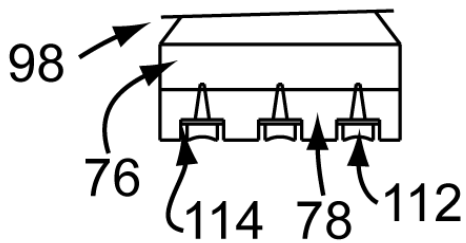


Fig. 8g

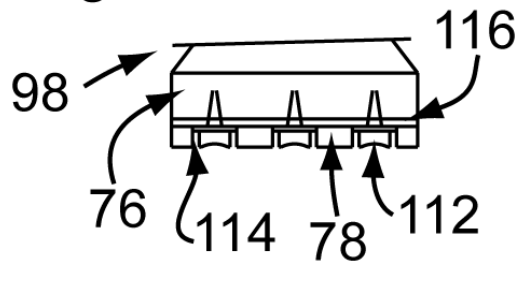


Fig. 8f

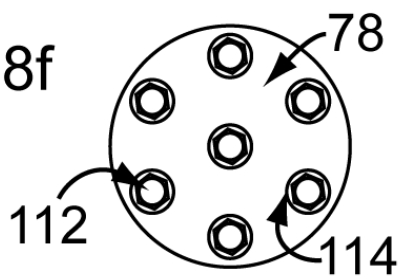


Fig. 8h

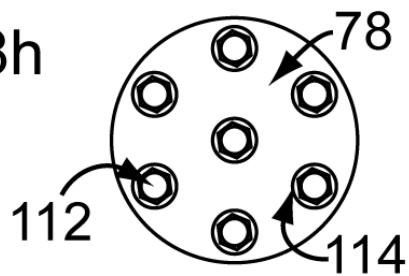


Fig. 9a

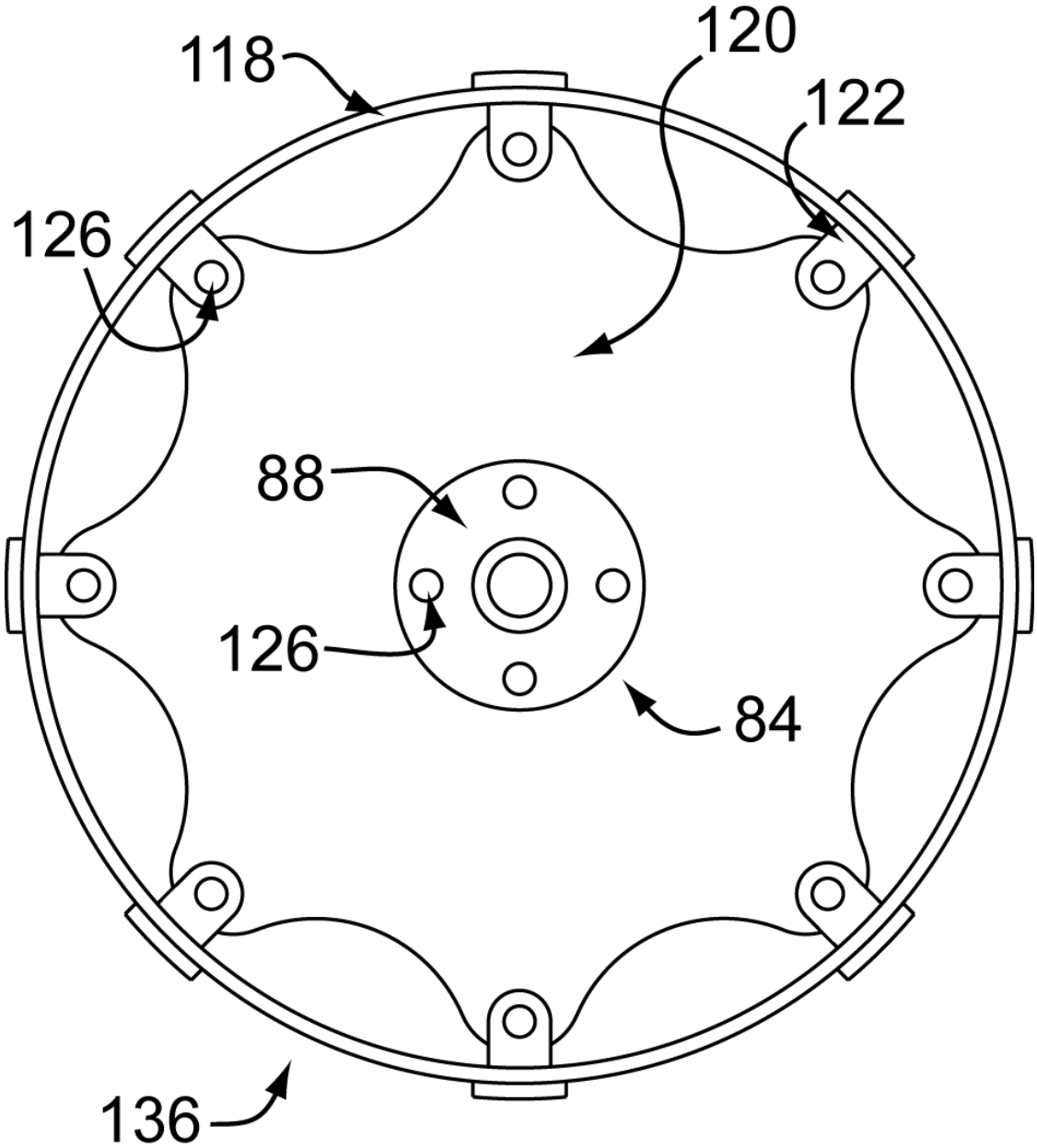


Fig. 9b

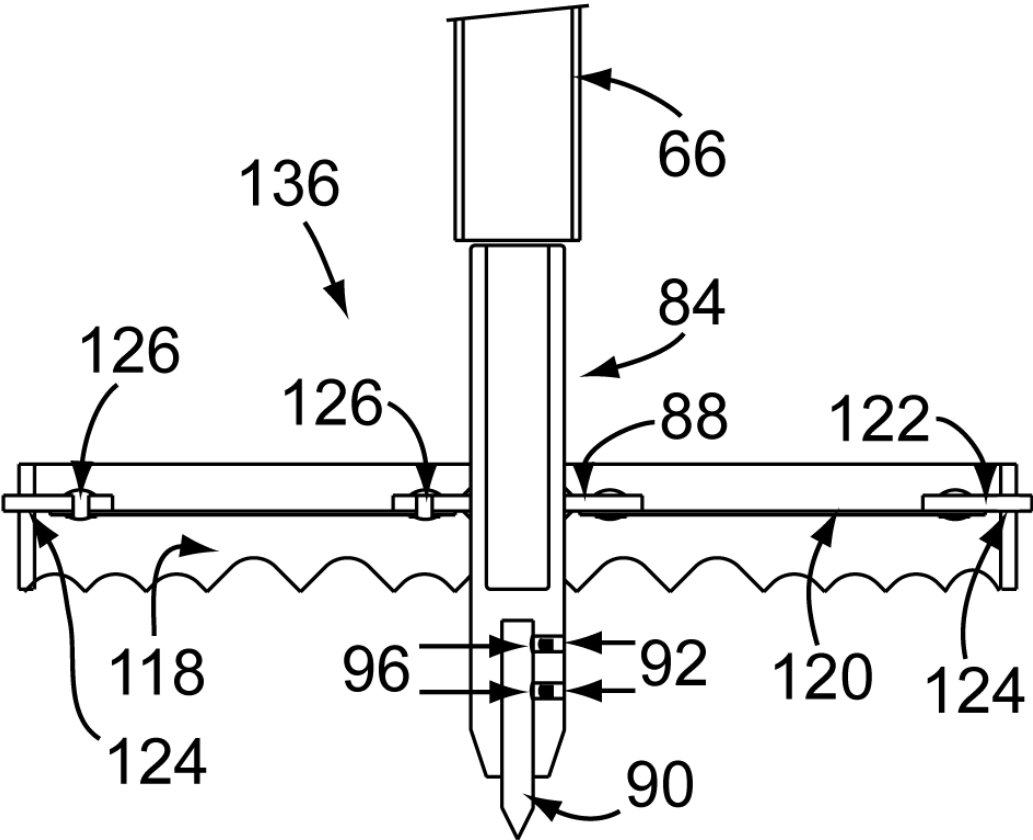
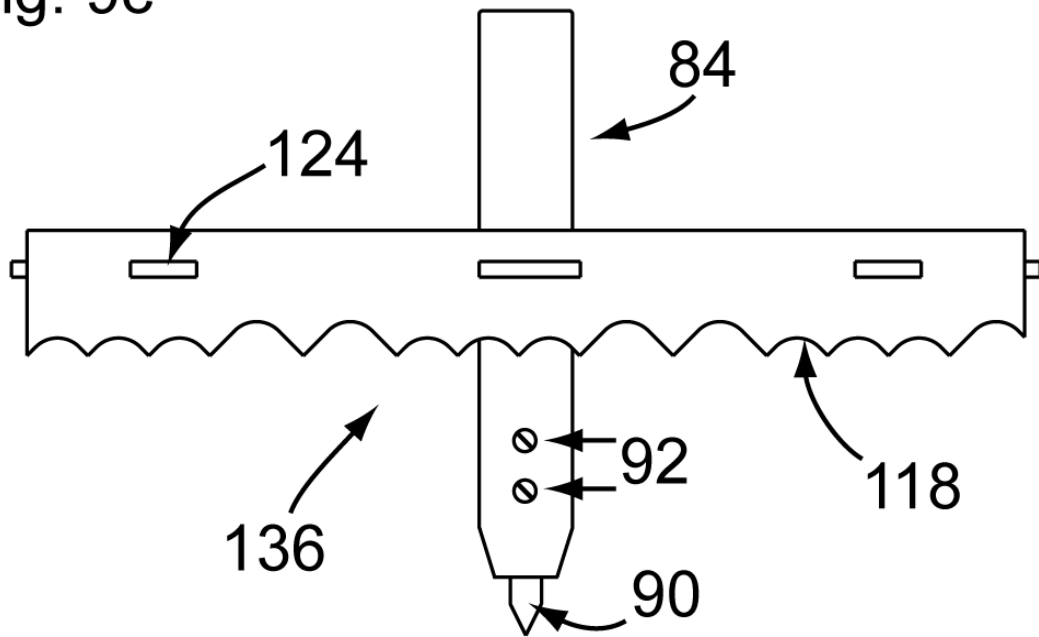


Fig. 9c



[Para 83] Part Numbers:

10	Ergonomic Forearm Crutch System
12	Ergonomic Forearm Handle
14	Forearm Tube
16	Handle Tube
18	Cuff
20	Pivot Bolt
22	Pivot Arm
24	Handle Grip
26	Grip Bolt
28	Damping Assembly
30	Top Housing
32	Spring Retainer
34	Slide Shaft
36	Coupling O-Ring
38	Slide Housing
40	Coupling
42	Spring
44	Plastic Guide
46	Teflon Guide
48	Hydraulic Damper
50	Elastomeric Damper
52	Internal Spring Hydraulic Damper
54	Piston
56	Piston Plate
58	C-clamp
60	Clamp Bolt
62	Bolt Key
64	Key Slot
66	Crutch Tube
68	End Cap
70	Tip Sleeve
72	Tube Stop
74	Tip Body
76	Cushion
78	Sole
80	Aluminum Plate

82	Caulk
84	Ice Tip
86	Rivet Hole
88	Decking Plate
90	Ice Pin
92	Set Screw
94	Threading
96	Indent
98	Articulating Multi-terrain Tip (AMT)
100	AMT Tip Sleeve
102	Ball Joint
104	Ball Collar
106	Ball Sleeve Bolt
108	Socket Body
110	Pad
112	Stud
114	Stud Hole
116	Metal Plate
118	Serrated Frame
120	Decking
122	Connector
124	Slot
126	Rivet
128	Shaft O-Ring
130	AMT O-Ring
132	General Use (Walking) Tip
134	Hiking Tip
136	Snow Tip
138	Annular Indent
140	Sleeve Orifice
142	Slide Flange
144	
146	
148	
150	