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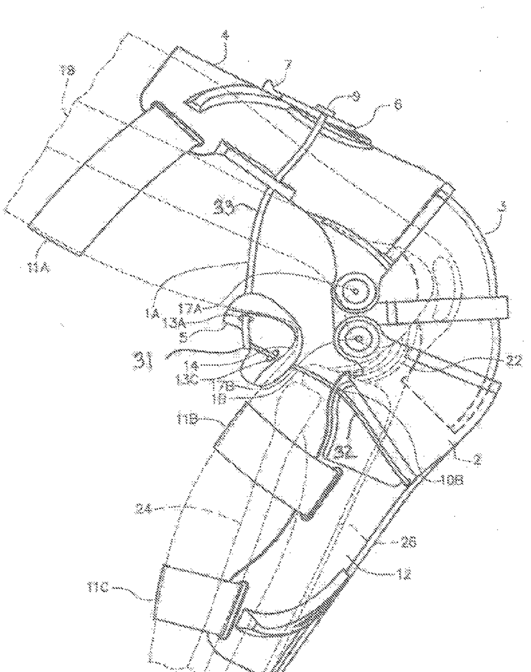

FIG. 5

(57) **Abstract:** It is the object of the invention to provide a knee bracing system that bolsters the body's natural ligaments, and accommodates user's with different natural Q-angles, to reduce the knees proneness to injury or re-injury. The invention is a cable system that acts much like the body's natural way that resists the forces that cause excessive joint movement and injury to the ACL and or MCL. As the leg travels through the range of motion the cables provide external hyper extension, bending, and rotation support preventing the tibia bone from moving forward (hyper extending) or twisting (lateral rotation) and or laterally bending with respect to the femur.

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CABLE KNEE BRACE SYSTEM

INVENTORS
Darren Fleming

PRIORITY CLAIM

[0001] This application claims priority from U.S. Application No. 16/436,716 filed June 10, 2019, which application is incorporated by reference in its entirety as if fully set forth herein.

INCORPORATION BY REFERENCE

[0002] The following documents are incorporated by reference in their entireties, U.S. Patent Application No. 13/867,910 filed on April 22, 2013, U.S. Patent Application No. 12/987,084 filed on January 8, 2011, and U.S. Patent Application No. 11/744,213 filed on May 3, 2007.

BACKGROUND OF THE INVENTION

[0003] The human knee is a complex mechanism that is highly vulnerable to injury in sports like football, hockey, skiing, snowboarding, and motocross. In these kinds of physically demanding sports the Anterior Cruciate Ligament (ACL) and Medial Collateral Ligaments (MCL) are commonly injured. The ACL controls forward movement of the tibia relative to the femur (hyper extension) and lateral rotation of the tibia with respect to the femur (over rotation). The MCL controls lateral movement of the tibia with respect to the femur. Hyper extending the leg and or laterally rotating or twisting or laterally bending of the leg can tear the ACL and/or MCL. The ACL regulates the amount of movement the tibia has with respect to the femur both in forward movement, and lateral rotation. When the leg reaches full extension the ACL becomes taut and limits the knee from hyper extending or over rotating laterally.

[0004] The MCL regulates how much the tibia can bend laterally with respect to the femur. The MCL becomes taut when a lateral force is applied to the leg preventing excessive bending. All too often in sports like motocross the leg is exposed to forces that exceed the ligament's ability to prevent excessive movement in the joint sometimes resulting in the tearing of the ACL and or MCL.

[0005] In order for a knee brace to be effective in resisting the excessive movement of the knee joint that tears the ACL and/or MCL, it must provide an effective differential force to the tibia relative to the femur. Because of the large amount of flesh surrounding the tibia bone and femur bone the only way to prevent the leg from over extending or over rotating would be to fix a rigid structure to the bones with some sort of mechanical means such as screws. Of course this would be impractical and undesirable. Not only should a knee brace be practical, it must be comfortable, and most of all effective at preventing knee injuries.

[0006] Most prior art (conventional) knee brace devices for ligament protection consist of a rigid femoral plate and tibial plate connected by hinges on either side of the knee. The plates are strapped to the leg tightly above and below the knee with straps that encircle the leg. The hinge locks as the leg reaches full extension and the rigid frame and straps act like a splint resisting hyperextension of the leg. There are many variations of the basic rigid hinged brace with differing hinge designs, strapping methods, and materials used. Conventional braces are limited in their effectiveness resisting excessive joint movement that causes injury to the knee. The biggest reason is that the flesh of the leg surrounding the femur and the strapping apparatus deform allowing the leg to hyperextend or rotate. Even when the strapping devices are tightened to the point of discomfort, they have limited effect preventing excessive movement of the knee joint when the leg is subjected to these forces.

[0007] It is the object of the invention to provide a knee bracing system that bolsters the body's natural ligaments to reduce the knees proneness to injury or re-injury.

[0008] The invention is a cable system that acts much like the body's natural ACL and MCL. The cables are routed around the knee joint in a way that resists the forces that cause excessive joint movement and injury to the ACL and or MCL. As the leg travels through the range of motion the cables tighten, preventing the tibia bone from moving forward (hyperextending) or twisting (lateral rotation) or bending laterally with respect to the femur.

[0009] The cable knee brace system of this invention can be tailored or adapted to prior art (conventional) braces increasing their effectiveness.

[0010] It is also anticipated by the Applicant that this cable knee brace system can be adapted to the elbow to prevent the arm from hyperextending. A humorous plate would substitute for the femoral plate 4, a radius plate would substitute for the tibial plate 2, and bicep plate would substitute for the femoral back plate 5 creating the differential resistive force across the elbow joint preventing hyperextension of the arm.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is an outside elevation/side view of a right leg showing normal fully extended and hyperextended (tearing ACL) views.

[0012] Figure 2 is a top/front view of the right leg fully extended showing normal and laterally rotated or laterally bent (tearing ACL and or MCL) views.

[0013] Figure 3 is an outside elevation/side view of the right leg fully extended showing the primary cable resisting hyperextension of the leg.

[0014] Figure 4 is a top/front view of the right leg fully extended showing the primary cable resisting lateral rotation of the leg.

[0015] Figure 5 is an outside elevation/side view of the right leg in the flexed position showing the primary cable knee brace system.

[0016] Figure 6 is an exploded isometric view showing the individual parts of the primary cable knee brace system.

[0017] Figure 7 is an outside elevation/side view of the left leg fully extended showing the secondary cable resisting hyper extension of the leg.

[0018] Figure 8 is a top/front view of the right leg fully extended showing the secondary cable resisting lateral rotation and or lateral bending of the leg.

[0019] Figure 9 is an outside elevation/side view of the left leg in the flexed position showing the secondary cable resisting lateral bending or lateral rotation.

[0020] Figure 10 is an exploded isometric view of the individual parts of the secondary cable knee brace system.

[0021] Figure 11 is an inside elevation/side view of the secondary cable guide plate that guides the secondary cable through the pivot points.

[0022] Figure 12 is an inside elevation/side view of an alternate cable guide plate that guides the secondary cable under and over the pivot points.

[0023] Figure 13 is an inside elevation/side view of another alternative cable guide plate that guides the secondary cable over and under the pivot points.

[0024] Figure 14 is a top view of a portion of a Q-adjustable tibial shell according to an embodiment of the present invention.

[0025] Figure 15 is a three-quarter view of a Q-adjustable leg brace according to an embodiment of the present invention.

[0026] Figure 16 is a top down view of a Q-adjustable leg brace according to an embodiment of the present invention.

[0027] Figure 17 is a top down view of a Q-adjustable leg brace according to an embodiment of the present invention.

DETAILED DESCRIPTION

[0028] To be effective preventing injuries to the ACL 22 and or MCL 23, a knee brace must prevent the tibia bone 26 from moving forward (hyperextending), see Figure 1, or laterally bending and or rotating (twisting), see Figure 2, with respect to the femur bone 18. The patella 20 and fibula bone 24 are shown for completeness. The knee brace of this invention as best shown in Figures 3-17, which like references refer to like elements throughout the several views, introduces a novel cable system that more effectively prevents hyperextension, lateral bending and or lateral rotation of the knee joint.

[0029] Figure 3 shows the primary cable system of this invention creating an effective differential force to the tibia 26 relative to the femur 18 and reinforcing the ACL 22. When the primary cable 1 of this system is properly tensioned, the brace acts like the body's own ACL 22 becoming taut as the leg extends resisting the forward movement of the tibia bone 26, with respect to the femur bone 18. Figure 4 shows the primary cable system of this invention resisting the lateral rotation of the tibia bone 26, with respect to the femur bone 18. Figure 5 shows the primary cable system of this invention when the leg is flexed. As shown in Fig. 3, because the tibial plate 2 moves further away from the femoral plate 4 as the leg extends, the primary cable 1 becomes progressively tighter as the leg approaches full extension. When a hyperextension force 28 is applied to the leg as shown in Figure 3, the tibial plate 2, patellar plate 3, and femoral plate 4 are compressed together as the primary cable 1 comes under progressively more tension. The tensile force in the primary cable 1 pulls down on the tibial plate 2, and up on the back plate 5, creating the differential resistive force across the knee joint preventing hyperextension of the leg. Figure 7 shows the secondary cable system of this invention creating an effective differential force to the tibia 26 relative to the femur 18, and reinforcing the ACL 22 and MCL 23. As the leg extends the secondary cable 40 resists the forward movement of the tibia bone 26, with respect to the femur bone 18. Figure 8, shows the secondary cable 40 resisting the lateral bending and or lateral rotation of the tibia bone 26, with respect to the femur bone 18. Figure 9 shows the secondary cable system of the invention when the leg is flexed and the secondary cable 40 resisting lateral bending and lateral rotation throughout the leg's range of motion. As the leg extends the patellar plate 3 acts like a hinge for the tibial plate 2 and femoral plate 4, rotating about pivot points 17a and 17b, respectively, approximating the knees flexion-extension movement.

[0030] When a lateral rotation force 30 is applied to the leg as shown in Figure 4 the tibial plate 2, patellar plate 3, femoral plate 4, and back plate 5 are held rigid by the tension developed in the primary cable 1. The tensile forces in primary cable 1 cross behind the leg, creating cable cross over point 31 as they pass through back plate 5, resisting rotation and bending across the knee joint and preventing the leg from laterally bending or rotating. When a lateral bending or lateral rotation force is applied to the leg as shown in Figure 8, the tibial plate 2, patellar plate 3, and femoral plate 4 are held rigid by the tension developed in the secondary cable 40. The tension in the secondary cable 40 prevents the brace from bending across the knee joint preventing the leg from laterally bending or rotating.

[0031] This invention comprises of a primary cable 1 and secondary cable 40 that can be made of any flexible material with a sufficiently high tensile strength. A tibial plate 2 that could be made of any rigid or semi-rigid material is shaped to conform to the tibia bone 26, beginning just below the knee and ending approximately at the midpoint of the tibia bone 26. The tibial plate 2 is held in position with straps 11b and 11c. Foam padding 12 is attached to the underside of the tibial plate 2 for comfort and to provide a firm grip on the individuals' tibia bone 26. A patellar plate 3 that could be made of any rigid or semi-rigid material connects the tibial plate 2 to the femoral plate 4. A femoral plate 4 that could be made of any rigid or semi-rigid material is located on top of the thigh from just above the knee to approximately mid-femur 18 and is held in position with strap 11a. Back plate 5 could be made of any rigid or semi-rigid material located behind the leg and just above the knee joint to keep the cable 1 in the proper location, firmly holding the femur bone 18 as the differential force of the primary cable 1 is transmitted across the joint. Foam padding 14 is attached to the inside of the back plate 5 to help spread the force of the primary cable 1 comfortably to the leg. A cable tensioner dial 6 and locking/release button 7 with spring 8 are attached to the femoral plate 4 with retainer screw 9. These could be made from any metal or rigid material that will withstand the forces required to keep the primary cable 1 locked in place during use. Other cable tensioning and locking mechanisms could be used, but the dial tensioning and locking system gives a very wide range of fine tuned cable adjustability and ease of use.

[0032] The fundamental element of this invention is the routing of the cables. As best shown in Figure 6, primary cable 1 begins attached to femoral plate 4 by cable connector 15a, crosses behind the leg through cable guide hole 13a and cable guide hole 13b in back plate 5, and runs through a cable guide hole on the opposite side of tibial plate 2. The primary cable 1 then loops over the leg through a cable guide hole and through the cable guide hole to the other side of tibial plate 2. From the cable guide hole in tibial plate 2, the primary cable 1 again crosses behind the leg through cable guide hole 13c, crossing over itself, creating cable cross over point 31, before going through cable guide hole 13d in back plate 5, and attaches to the opposite side of femoral plate 4 by second cable connector 15b.

[0033] In additional embodiments, primary cable 1 begins attached to femoral plate 4 by first cable connector 15a, crosses behind the leg through first cable guide hole 13a and second cable guide hole 13b in back plate 5, creating cable cross over point 31, and attaches to the opposite side of tibial plate 2 with clamping screw 10a. The primary cable 1 then loops over the leg attaching to the other side of tibial plate 2 with clamping screw 10b. From clamping screw 10b, the primary cable 1 again crosses behind the leg through third cable guide hole 13c and fourth cable guide hole 13d in back plate 5, and attaches to the opposite side of femoral plate 4 by the second cable connector 15b.

[0034] As best shown in Figure 10, secondary cable 40 begins attached to the outside, or collateral side, of the femoral plate 4 by the femoral cable connector 42a and runs through the femoral cable guide hole 44a. The secondary cable 40 crosses femoral pivot point 17a and tibial pivot point 17b through cable guide plate 48. From there, the secondary cable 40 runs through tibial plate guide hole 44b and attaches to the outside, or lateral side, of the tibial plate 2 by the tibial cable connector 42b, completing the route.

[0035] In some embodiments, a single cable is used as it passes through the various guides. In alternative embodiments, the cable could be made up of individual segments connected together to form the completed routing. For example, first primary cable segment 1a and second primary cable segment 1b can be formed by a single cable, or can be two separate cables connected together with tibial plate 2 to complete the loop. First primary cable segment 1a begins attached to femoral plate 4 by first cable connector 15a, crosses behind the leg through the cable guide hole 13a and cable guide hole 13b in back plate 5 and attaches to the opposite side of tibial plate 2 with clamping screw 10a.

Without having to loop over the leg, the second primary cable segment lb is attached to the opposite side of tibial plate 2 with clamping screw 10b. From clamping screw 10b the second primary cable segment lb crosses behind the leg through the cable guide hole 13c, and crossing over itself, creating cross over point 31, before going through cable guide hole 13d in back plate 5 and completes the loop by attaching to the opposite side of femoral plate 4 with cable connector 15b.

[0036] The segments of the cable extending from the cable cross over point 31 to the tibial plate portion of the brace and returning to the cable cross over point 31 form the tibial control loop portion 32 of the cable. The segments of cable extending from the cable cross over point 31 to the femoral plate portion of the brace and returning to the cable cross over point 31 form the femoral control loop portion 33 of the cable. Fig. 6, for example, illustrates these control loop portions 32 and 33. During use, for example when the knee is extended toward hyperextension, the tibial control loop will lengthen, causing an inverse tightening of the femoral control loop.

[0037] The primary cable 1 is adjusted by turning the cable tensioner dial 6 taking up the excess primary cable 1 length. The primary cable 1 is automatically locked into place by the ratcheting gears 16 on the cable tensioning dial 6 and spring 8 actuated locking/release button 7. The button 7 is also used to release the tension in primary cable 1 for installation and removal of the brace.

[0038] While an infinite number of secondary cable routings across the pivot points are possible, directly through the pivot points as shown in 46a is most desirable to achieve optimum tension on the secondary cable 40 throughout the leg's full range of motion. Figure 11 shows a cable guide plate which guides the cable directly through the pivot points, secondary cable routing 46a, as described above. Alternate secondary cable guide plate configurations as shown in Figures 12 and 13 could be used guide the secondary cable around the pivot points. For example, alternate secondary cable routing 46b could be achieved using the cable guide plate shown in Figure 13 which guides the secondary cable 40 over, or to the fore of, femoral pivot point 17a and under, or to the aft of, tibial pivot point 17b.

[0039] Fig. 15 depicts an alternative tibial shell arrangement. When configured in this manner, the tibial shell 2B mounts to the tibial shell 2A at point 51, forming the axis of rotation. The shell 2B is secured to the tibial shell 2A using tibial adjustment locking screw 52. The tibial shell 2B rotates about axis 51 in order to establish the desired Q-angle, as depicted in Fig. 16. The relative rotation of the tibial shell 2B about axis 51 is controlled using screws 53A-B on either side of the tibial shell 2B, as depicted in Fig. 14. By lengthening or shortening the adjustment screws, which push against corresponding bearing surface 55A-B, the tibial shell pivots accordingly about the axis 51.

[0040] Figure 14 best depicts the adjustment mechanism showing adjustment screws 53 A-B threaded through retention nuts 54 A-B in tibial shell 2B. As best shown in Figure 16, after loosening adjustment locking screw 52 and then shortening adjustment screw 53A, lengthening adjustment screw 53B pushes against bearing surface 55B on tibial shell 2A, forcing tibial shell 2B to rotate clockwise about axis 51 until adjustment screw 53A contacts bearing surface 55A on tibial shell 2A before tightening adjustment locking screw 52.

[0041] Cable guides accept the cable, the cable being comprised of one or more segments, which transfers energy to control knee movement and prevent hyperextension of the knee joint in the same manner as the other embodiments described above, for example, Figs. 2-6. In the same manner as the embodiments described above, the cable may be composed of one or multiple portions. While the routing of the cable is not depicted, in a preferred embodiment, the cable beginning from cross over point 31, extends to a first side of tibial shell 2A passing through one or more cable guide holes, then extends over tibial shell 2B through one or more cable guide holes, and then extends back down the opposite side of tibial shell 2A through one or more cable guide holes and then extends back to cable cross over point 31, forming the tibial control loop 32.

[0042] When the knee of the user extends, the cable portion extending from a cross over point 31 around the tibial shell 2B and returning to the cross over point, the tibial control loop 32, lengthens accordingly. This produces a direct response in the portion of the cable which extends from the cross over point 31 over and around the femoral plate, the femoral control loop. That portion of the cable tightens, bringing the femoral plate and the back plate 5 into the leg and behind the knee joint respectively, and stopping further extension of the knee by controlling the length of the tibial control loop.

[0043] Fig. 15 depicts both the femoral shell 4 and tibial shells 2A and 2B of a knee brace according to an embodiment of the present invention. Notably, the back plate, straps, and cable routing are absent in order to more clearly depict the arrangement of the adjustable tibial shell 2B. As depicted, the invention according to this alternative embodiment maintains many of the features described in alternative embodiments herein, including: 4, 6, 17C and 17D. Fig. 15 depicts the tibial shell 2B of Fig. 14 as well as its mounting surface 56 on tibial shell 2A. The axis of rotation 51 is clearly depicted as running through the point at which the tibial shells 2A-B are connected.

[0044] Foam padding may be strategically placed at various points on the inside portions of the brace depicted in Fig. 15. For example, on the sides near hinge point 17C and 17D, and underneath tibial shells 2A and 2B as well as femoral shell 4. This foam provides increased comfort to the user.

[0045] Fig 16 depicts the adjustability of the tibial shell 2B which creates a chosen Q-angle 57. The angle between the tibia and the femur forms the quadriceps angle, herein referred to as the Q-angle 57. This angle varies depending on the physiology of the user. The tibial shell 2B is adjustable in order to customize the Q-angle 57 to accommodate each user. By turning the adjustment screws 53A-B, the Q-angle 57 may be changed as the tibial shell 2B pivots 58. The Q-angle is adjustable in either direction. In preferred embodiments, the Q-angle 57 is adjustable up to 4 degrees in either direction, ΔQ. A Q-angle of less than average, is defined as Varus. In this embodiment, the Q-angle 57 may be referred to as negative, for example, the brace may be adjusted -4 degrees from average, ΔQ, forming a more acute Q-angle 57. A Q-angle greater than normal is referred to as Valgus, and may be formed by adjusting the brace to increase the Q-angle, for example +4 degrees from average. The depicted arrangement in Fig. 16 shows, for example, a Valgus arrangement, where the Q-angle of the brace, Q2, is greater than an average angle, Q1. In order to achieve this, the tibial plate 2B has been adjusted toward the outside of the user's leg (right side knee brace). Once the user is happy with their customized Q-angle, they can lock the brace using locking screw 52. This prevents the Q-angle from changing while the user is wearing the device.

[0046] Fig. 17 depicts an embodiment of the present invention with the femoral back plate 5 installed. As depicted, the back plate is positioned just above the knee joint, behind the user's knee. The back plate 5 guides the portions of the cable 1 to a cross over point 31, not shown, located on its back side. Each portion of the cable 1, is then guided back up toward the upper portion of the brace, for example to either side of the femoral plate 4, and the first tibial plate 2A. Cable guide holes along the perimeter of tibial plate 2A are also shown, these guide holes receive the cable from the femoral back plate 5, and guide the cable 1 along tibial plate 2A toward and to tibial plate 2B where the cable 1 enters another guide hole in tibial plate 2B before crossing over to the other side of tibial plate 2B and returning along the same path on the opposite side of the brace. This portion of the cable's path, from the cross over point 31 to the tibial plate 2B and back forming the tibial control loop 32. A similar path occurs where the cable 1 extends from the cross over point 31 on the femoral back plate 5 up to cable guides on either side of the femoral plate 4, connecting to the adjustment mechanism 6.

[0047] In additional embodiments of the present invention, the tibial plate may include additional portions which increase the hold on the wearer's tibia. Increased tibia control offers additional protection from hyperextension. As there is little tissue between the tibia and the external portion of the leg, this area is ideal for control of the leg. In some embodiments, the underside of the tibia plate, closest to the user's leg, may include an additional semi-ridged portion. As the cable system is tightened, for example, this semi-ridged portion conforms to the shape of the user's tibia. This provides an increased hold on the tibia.

[0048] In additional embodiments of the present invention, the tibia plate may be constructed such that the plate has varying flexibility across itself. For example, this varying flexibility would allow the tibia plate to conform to the shape of the user's leg, while also providing the necessary rigidity. In this example, a second semi-ridged portion may not be required, or, alternatively, may be offered in addition to the second semi-ridged portion.

[0049] In additional embodiments of the present invention, the user may, of course, use the brace as a preventative device, before any damage occurs, as opposed to after. In such a case, additional protection may be required. For example, user's engaged in extreme sports may require supplemental protection from impacts. Embodiments of the present invention may, therefore, include knee caps which protect the knee from strike forces. In some embodiments, the knee cap portion is disposed between the tibial and femoral plates such that when the plates pivot away from one another, the knee cap remains in place. In such an example, the tibial and femoral plates glide over or beneath the knee cap portion so as to allow necessary flexibility. Further, additional padding at the front of the knee may be added in order to both support the knee and protect it from strike forces.

[0050] While the invention has been described and illustrated with regard to the particular embodiment, changes and modifications may readily be made, and it is intended that the claims cover any changes, modifications, or adaptations that fall within the spirit and scope of the invention. Changes and modifications can readily be made to adapt this tibial shell Q angle adjustment invention to conventional knee braces. It is also anticipated that this invention can be adapted to an elbow brace by substituting the adjustable tibial shell with an adjustable radius shell. This allows a symmetrical elbow brace to be adjusted to fit the angle between the humerus and radius of the user's arm, and can be adjusted to fit a right or left arm.

CLAIMS

1. A functional knee brace to be worn on a leg comprising;

a semi-rigid femoral plate configured to receive a first thigh portion of the leg and including a thigh strap, the semi-rigid femoral plate being rotatable about a femoral point and having a cable guide;

a semi-rigid tibial plate configured to receive a shin portion of the leg, the semi-rigid tibial plate being rotatable about a tibial pivot point and having a cable guide;

a back plate capable of being located behind the leg and just above a knee joint, and wherein the back plate cooperates with the semi-rigid femoral plate and the semi-rigid tibial plate, the back plate having a cable guide;

a first substantially inelastic cable, wherein the first substantially inelastic cable is routed from the semi-rigid femoral plate, the first substantially inelastic cable traveling around the back plate, the first substantially inelastic cable traveling around and over the top of the semi-rigid tibial plate, the first substantially inelastic cable crossing over itself at a crossover point at the back plate, and then the first substantially inelastic cable traveling back to the top of the semi-rigid femoral plate, and wherein the first substantially inelastic cable is routed through a tensioning mechanism

and wherein a femoral loop portion of the first substantially inelastic cable, which extends from the crossover point over the semi-rigid femoral plate and back to the crossover point, and a tibial loop portion of the first substantially inelastic cable, which extends from the crossover point over the semi-rigid tibial plate and back to the crossover point, are configured such that a lengthening of the tibial loop portion of the first substantially inelastic cable results in a corresponding shortening of the femoral loop portion of the first substantially inelastic cable, and further wherein a corresponding tightening force resulting from the shortening of the femoral loop portion of the first substantially inelastic cable draws the semi-rigid femoral plate and the back plate closer together, and provides a radial force along the tibial loop portion of the first substantially inelastic cable directed toward the center of the tibial loop.

2. The knee brace of Claim 1 wherein the tensioning mechanism comprises a single mechanism mounted to the front of the semi-rigid femoral plate and wherein the first substantially inelastic cable enters and exits from opposing sides of the tightening mechanism.

3. The knee brace of Claim 1 further comprising a second cable coupled to the semi-rigid femoral plate and crosses the femoral and tibial pivot points and is coupled to the semi-rigid tibial plate, wherein tension in the second cable inhibits the semi-rigid tibial plate from laterally bending or rotating relative to the semi-rigid femoral plate around an axis generally perpendicular to the natural axis of knee rotation.

4. The knee brace of Claim 1 wherein the first substantially inelastic cable is attached to the semi-rigid tibial plate.

5. The knee brace of Claim 1 wherein the first substantially inelastic cable includes cable segments coupled together.

6. The knee brace of Claim 1 further comprising a locking system coupled to the semi-rigid femoral plate, the locking system configured to secure the first substantially inelastic cable to the semi-rigid femoral plate.

7. The knee brace of Claim 1 wherein a differential force urges the back plate closer to the semi-rigid tibial plate and closer to the semi-rigid femoral plate.

8. The knee brace of Claim 1 wherein the back plate comprises elongate members that guide the cable to the back plate crossover point and up to the top of the semi-rigid femoral plate and the semi-rigid tibial plate.

9. The knee brace of Claim 8 wherein the elongate members of the back plate form a cross or dog bone shape.

10. The knee brace of Claim 1 wherein the semi-rigid tibial plate has a varying flexibility across itself.

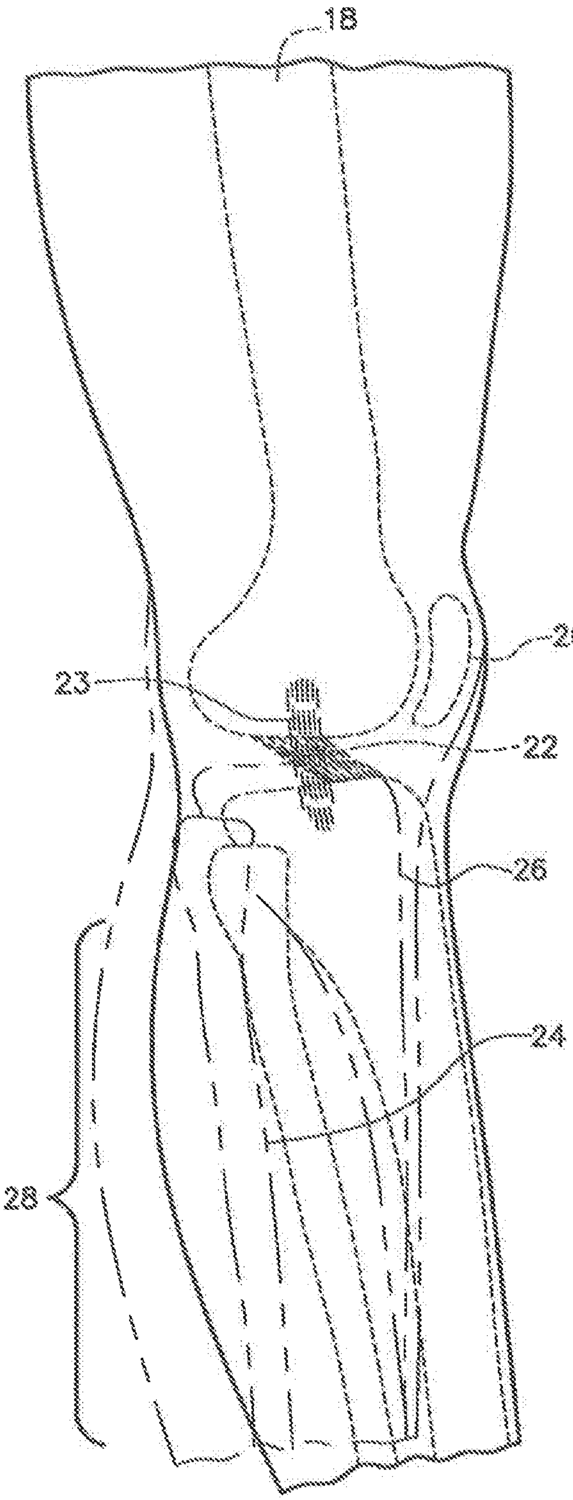


FIG. 1

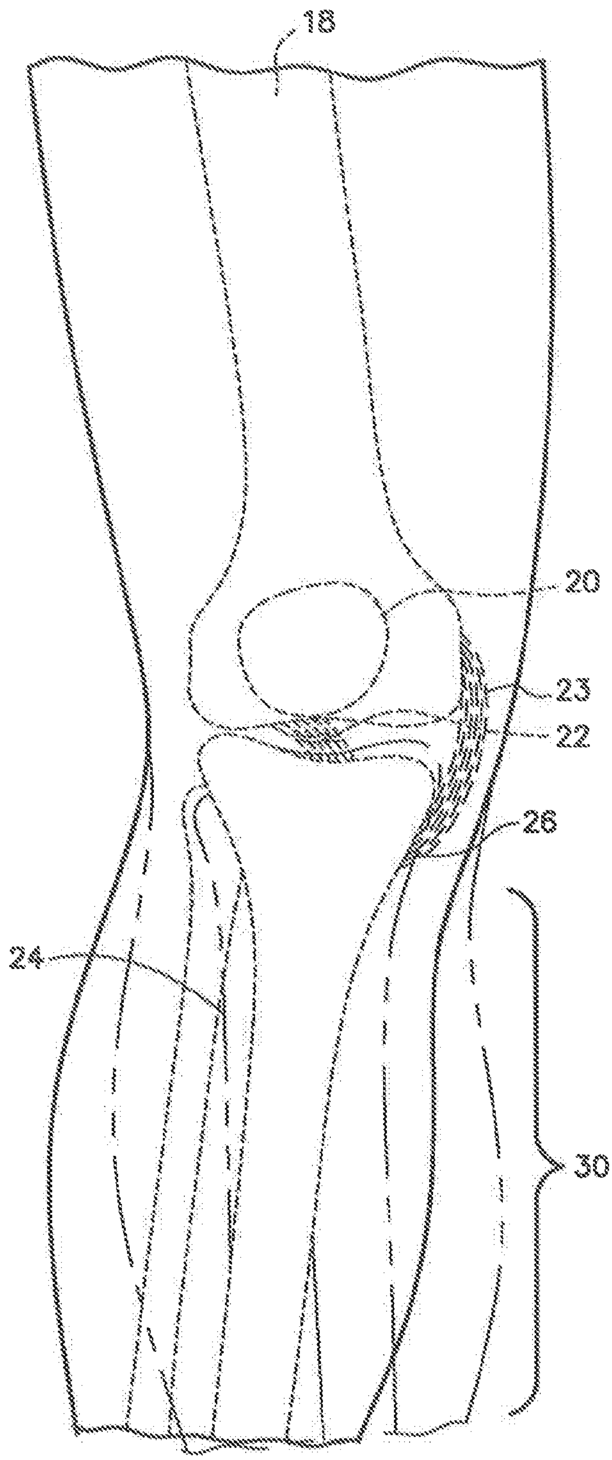
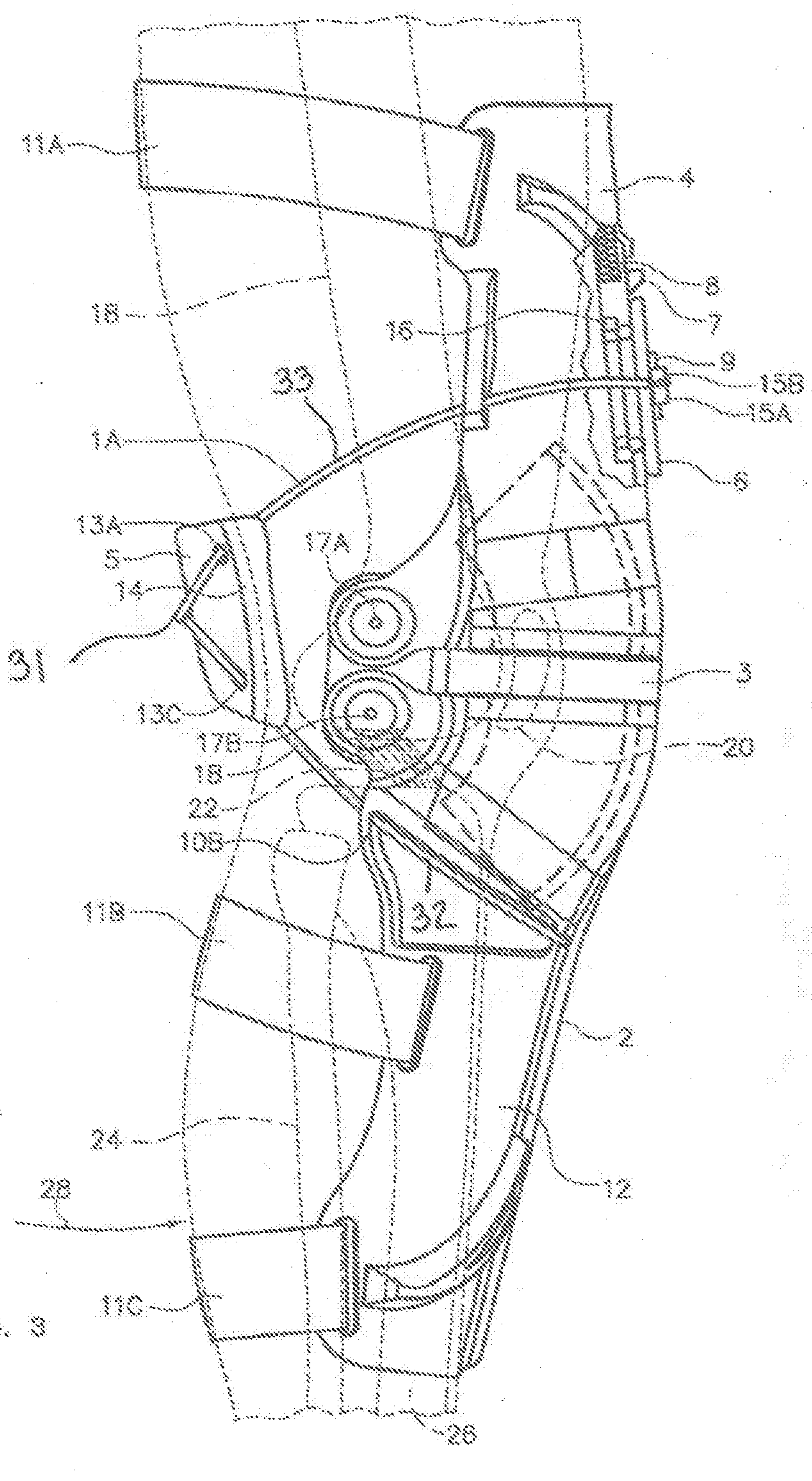


FIG. 2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4
8
7
18
16
9
15B
33
15A
1A
6
13A
17A
5
14
31
3
13C
17B
20
18
22
10B
32
11B
2
24
12
28
11C
26

FIG. 3

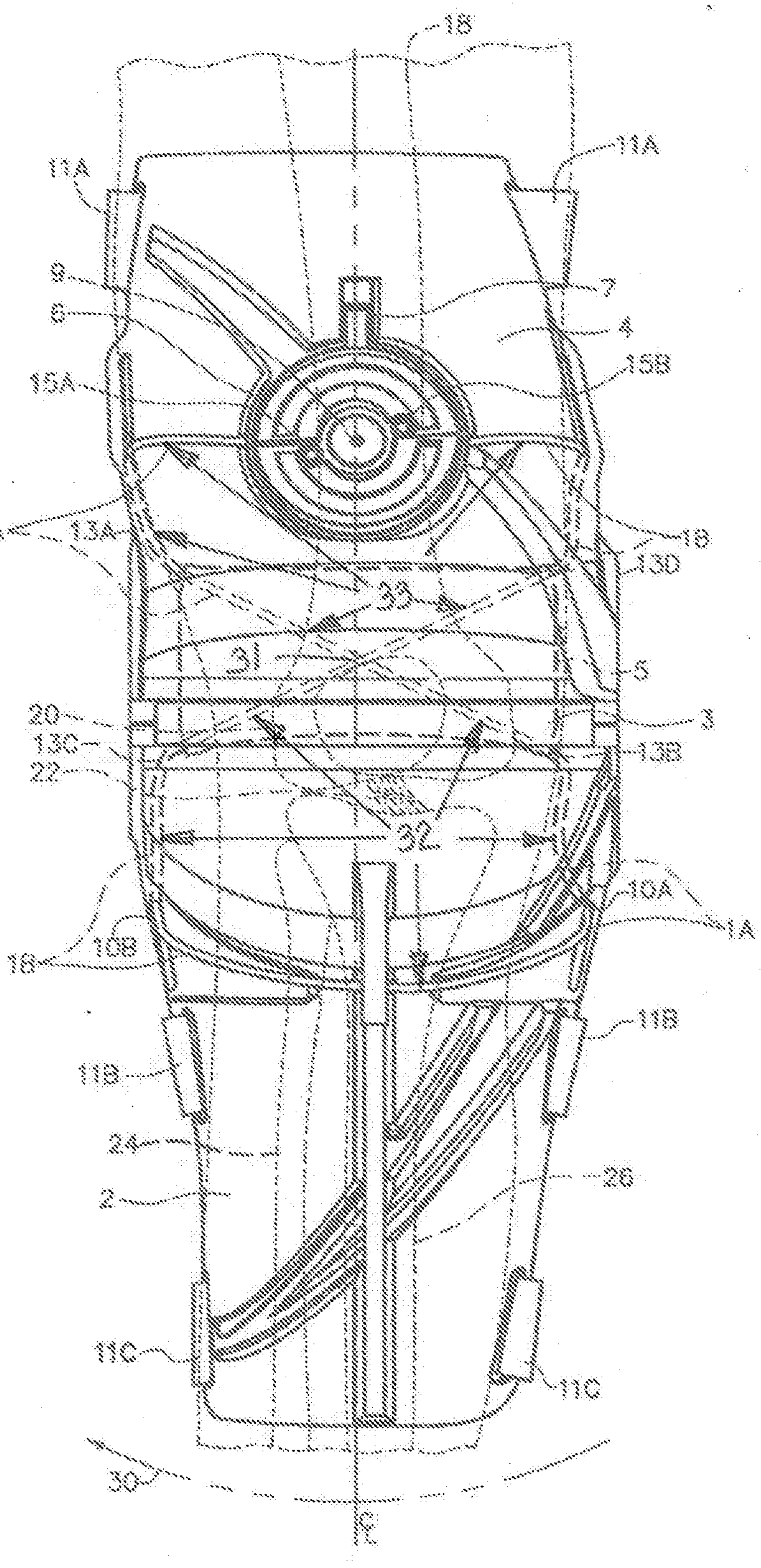

18
11A
11A
9
7
8
4
15A
15B
1A
13A
18
13D
33
31
5
20
3
13C
13B
22
32
10A
1A
18
10B
11B
11B
24
2
26
11C
11C
30
C
L

FIG. 4

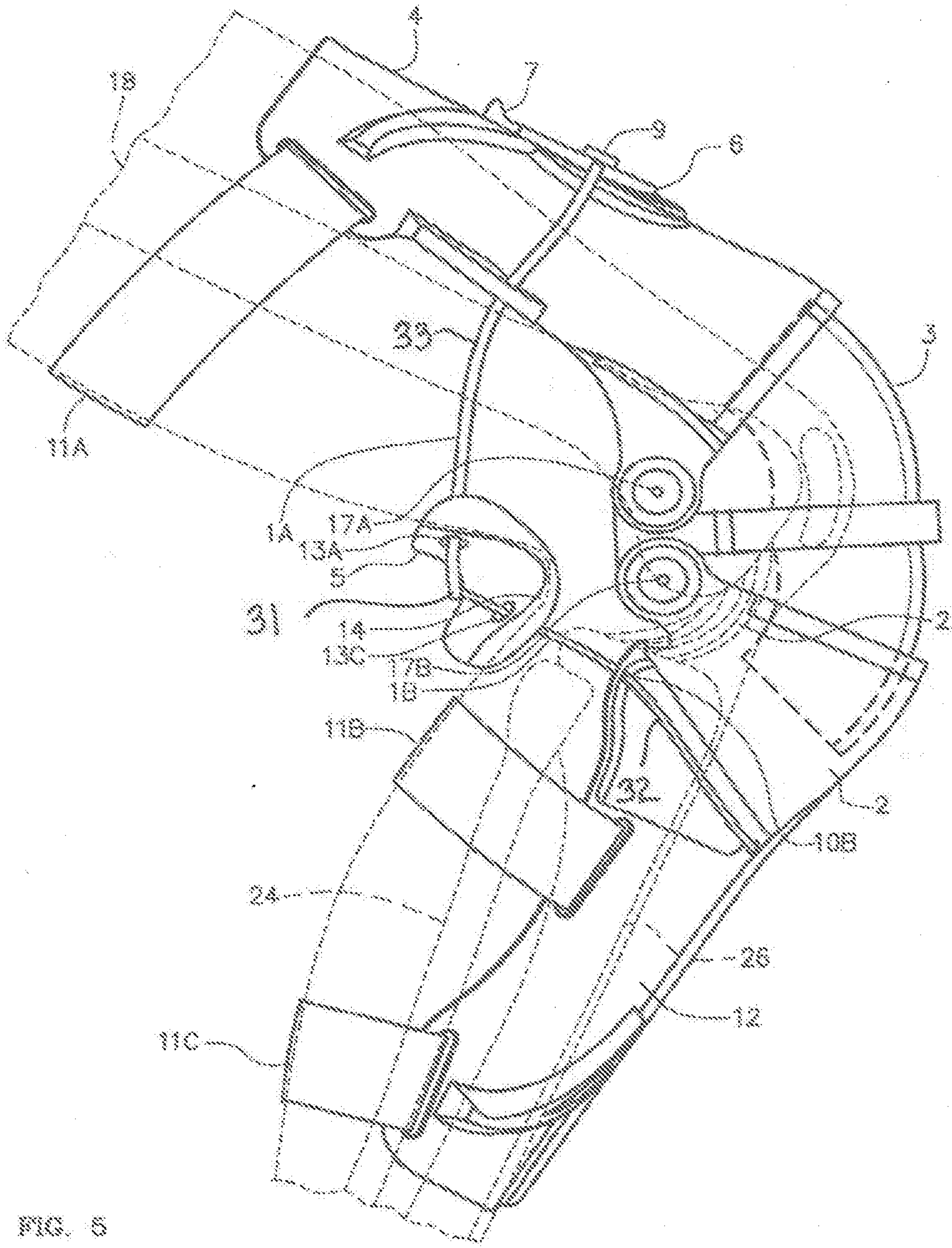
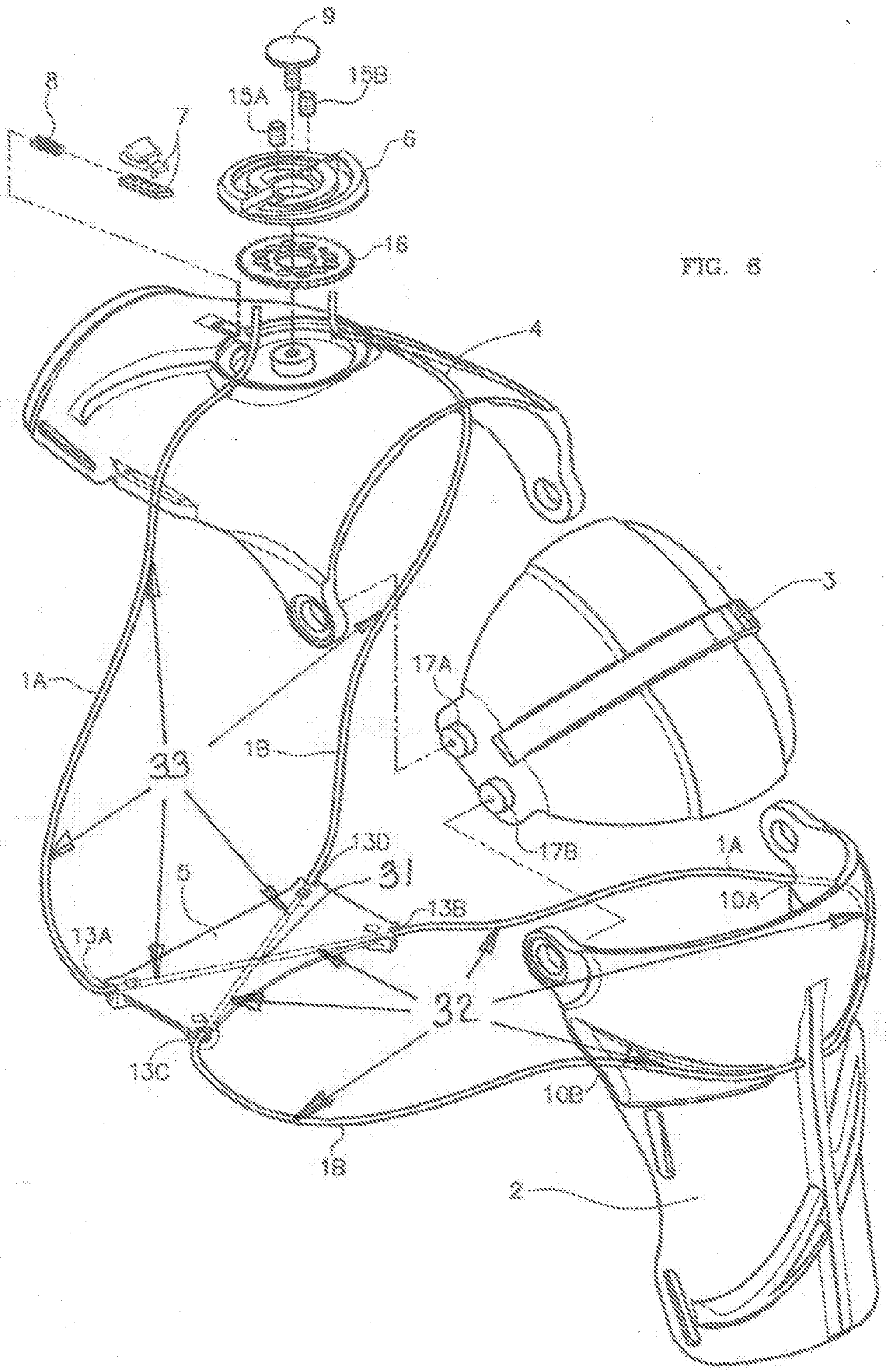

4
7
9
8
18
33
3
11A
1A
17A
13A
5
31
14
13C
17B
1B
22
11B
32
2
10B
24
26
12
11C

FIG. 5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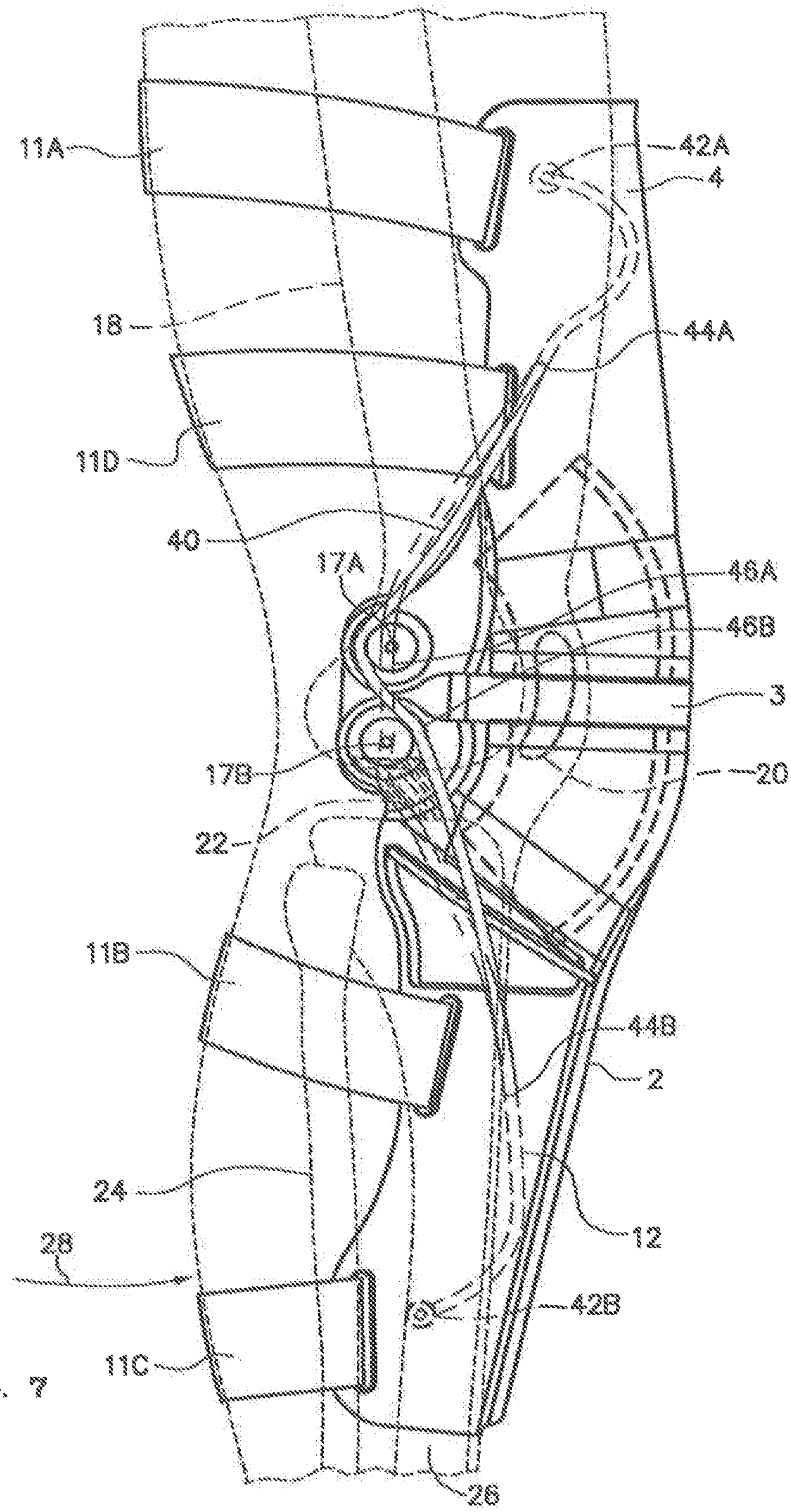
8
15A
15B
7
6
16
4
3
17A
1A
33
1B
17B
13D
31
5
13B
1A
10A
13A
32
13C
10B
1B
2

FIG. 6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42A
4
18
44A
11D
40
17A
46A
46B
3
17B
20
22
11B
44B
2
24
12
28
42B
11C
26

FIG. 7

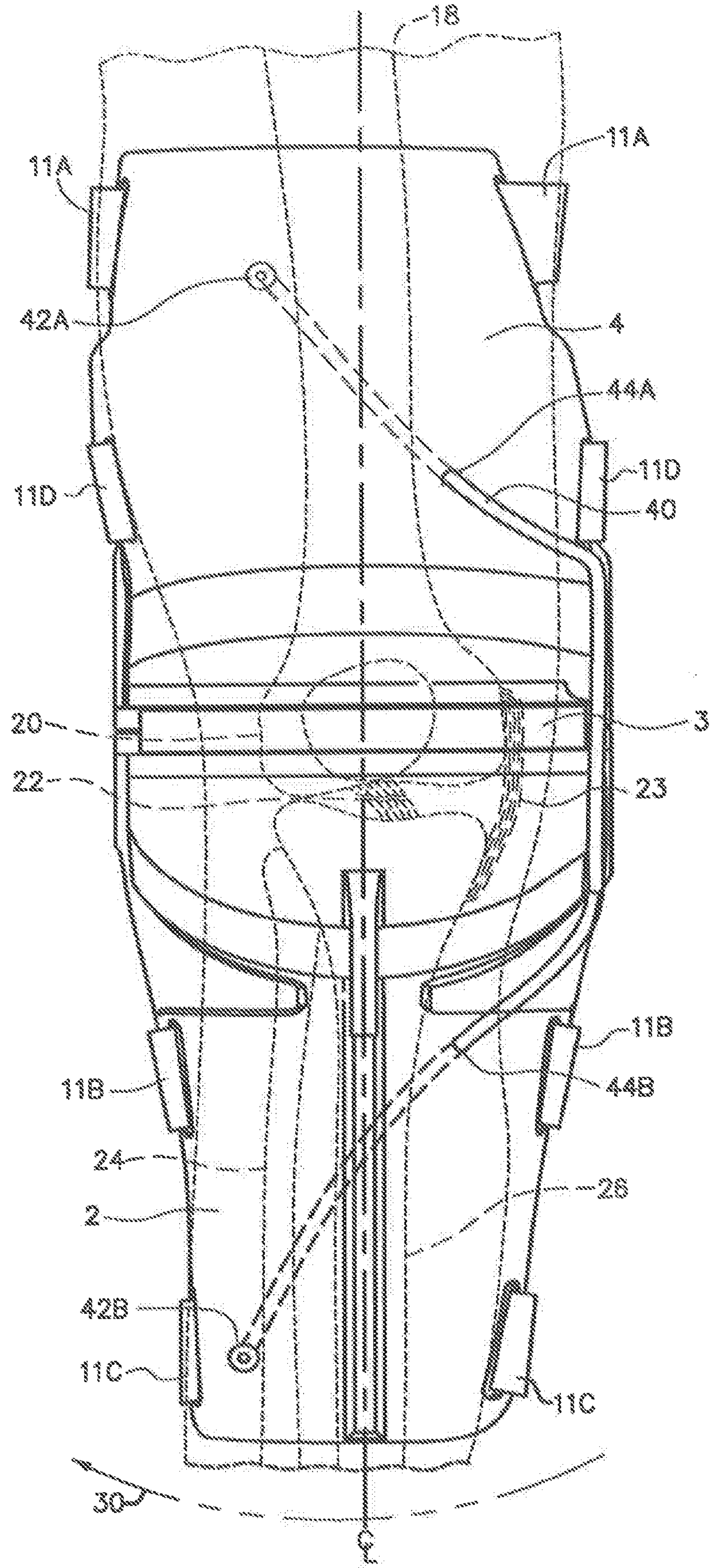
18
11A
11A
42A
4
44A
11D
11D
40
20
3
22
23
11B
11B
44B
24
26
2
42B
11C
11C
30
C
L

FIG. 8

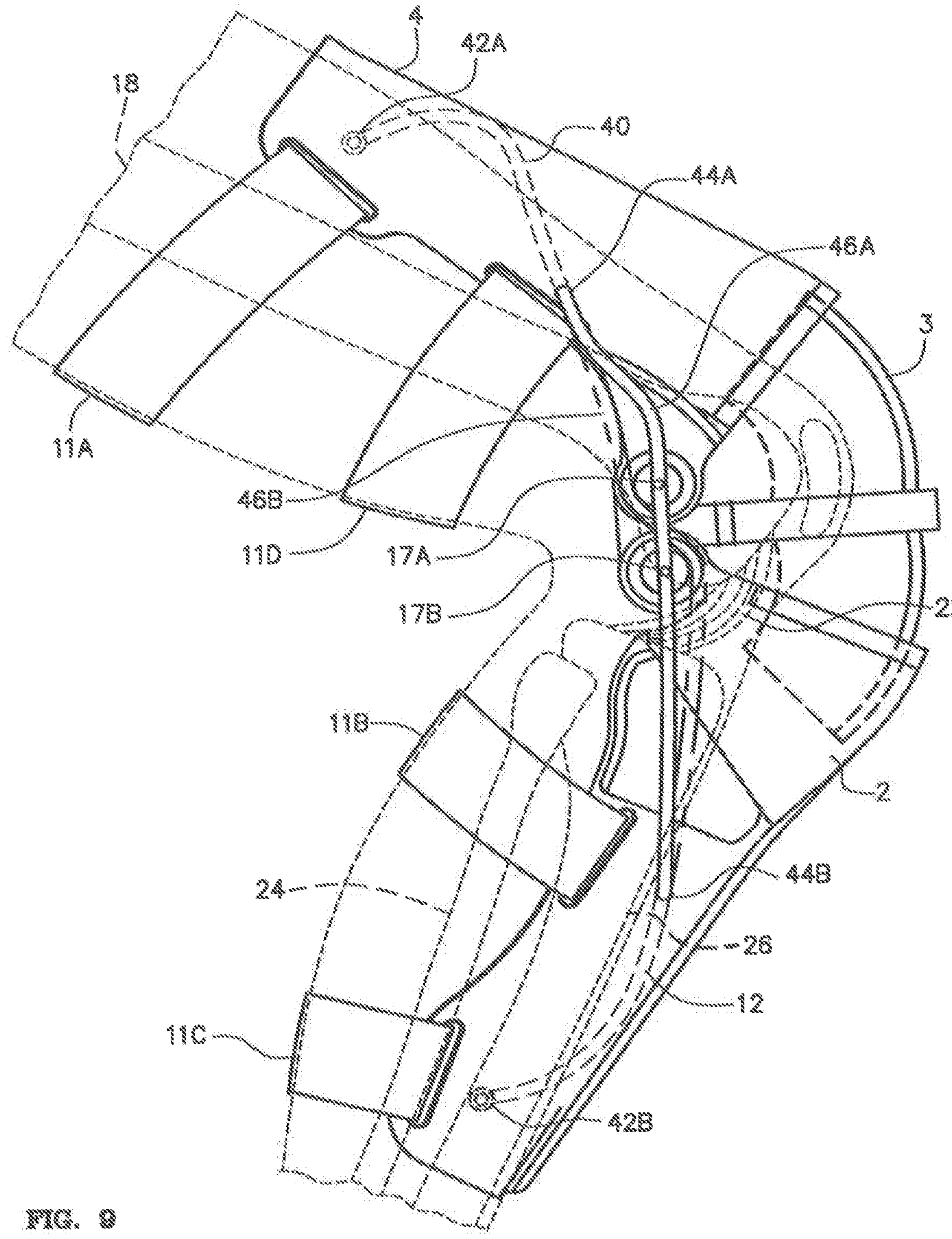
4
42A
18
40
44A
46A
3
11A
46B
11D
17A
17B
22
11B
2
44B
24
26
12
11C
42B

FIG. 9

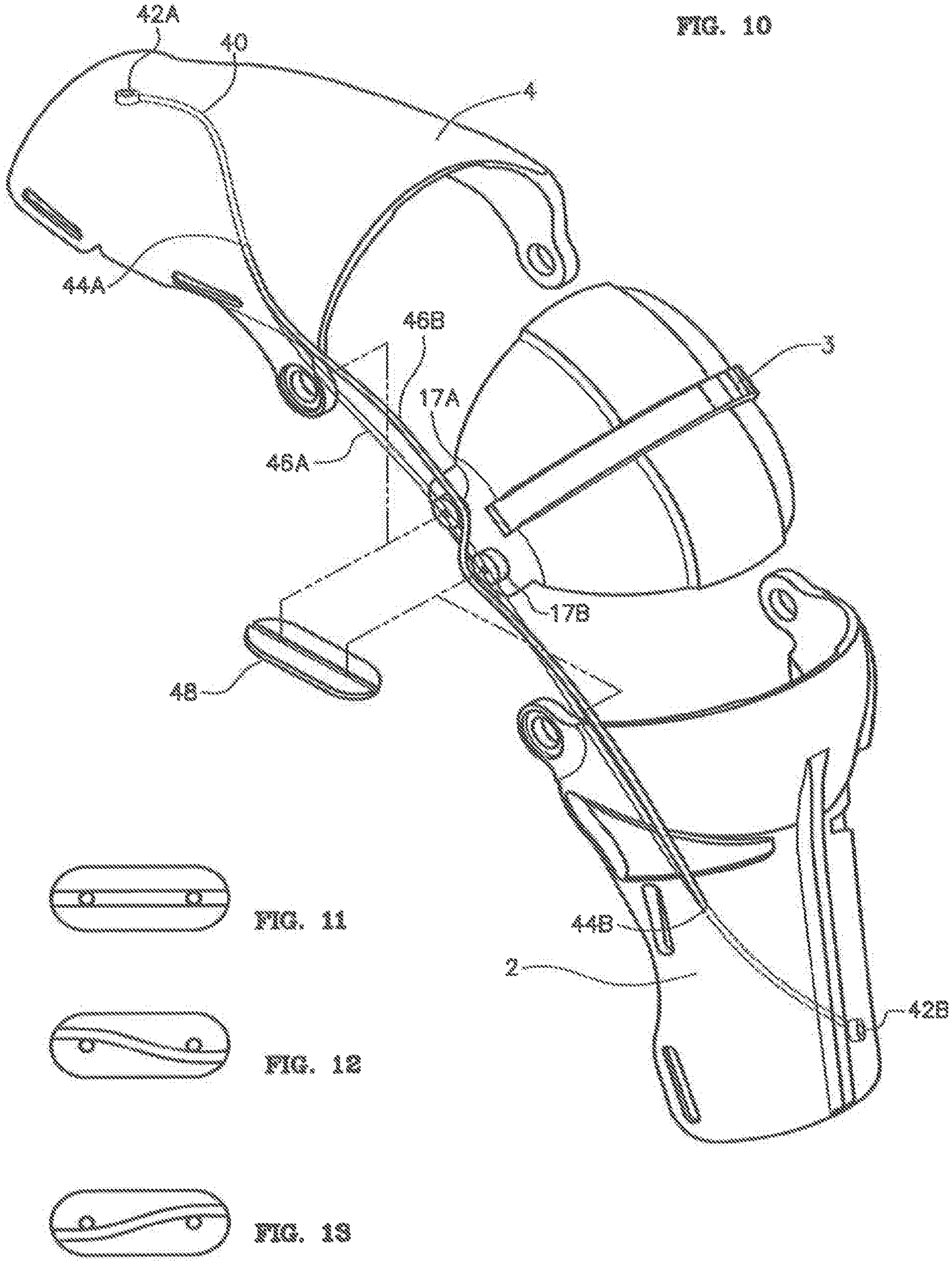

FIG. 10

FIG. 11

FIG. 12

FIG. 13

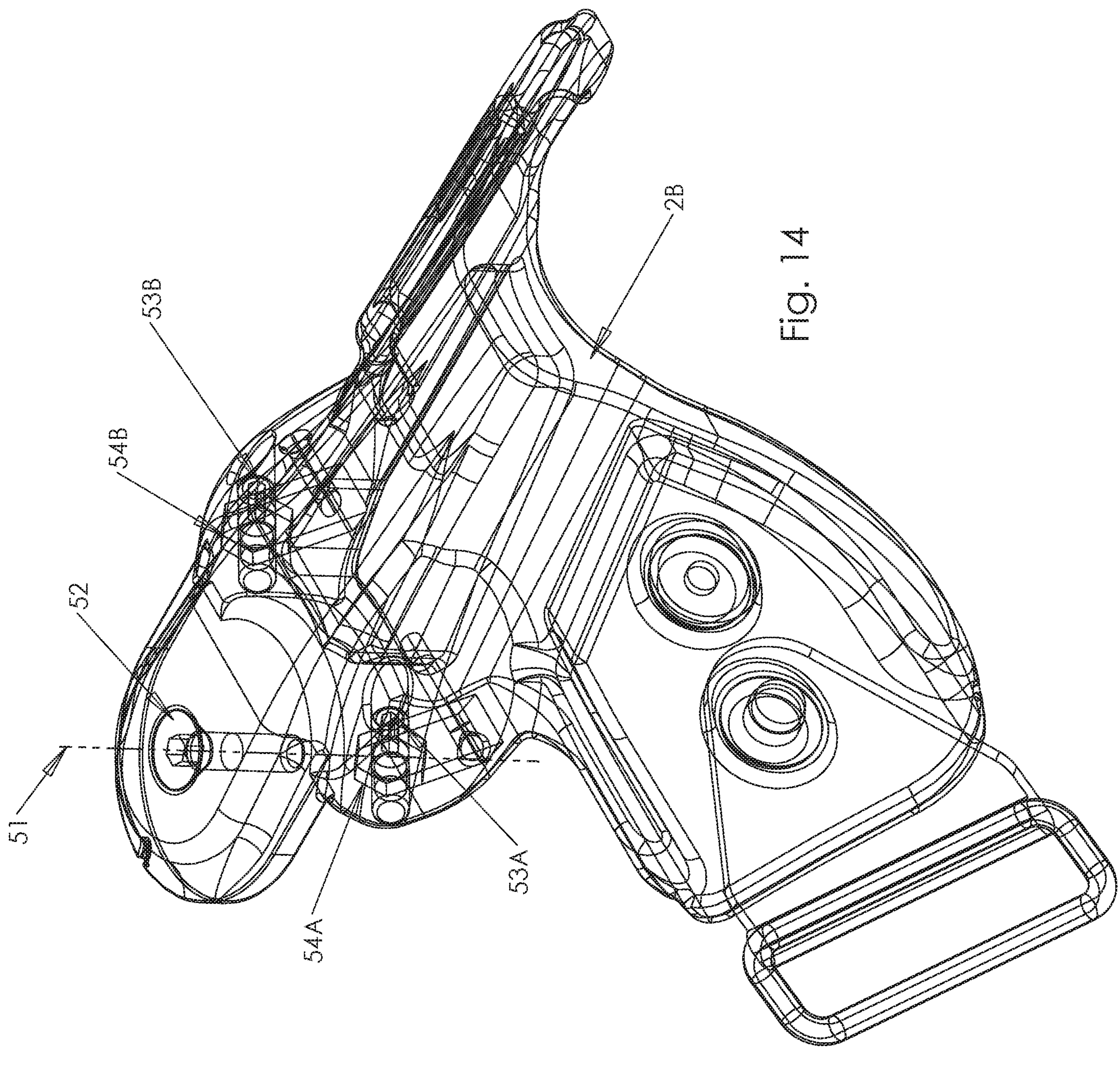

Fig. 14

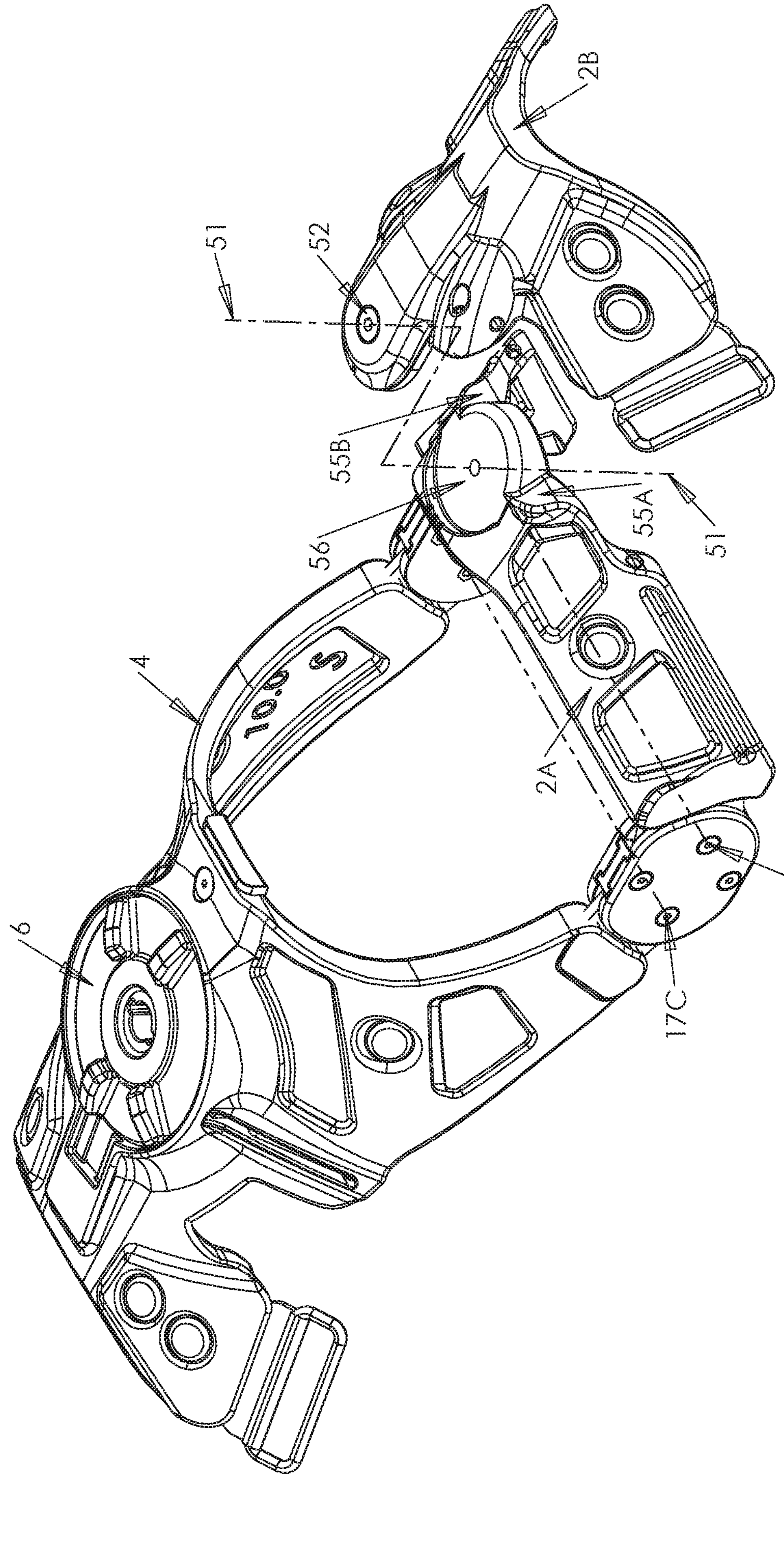

Fig. 15

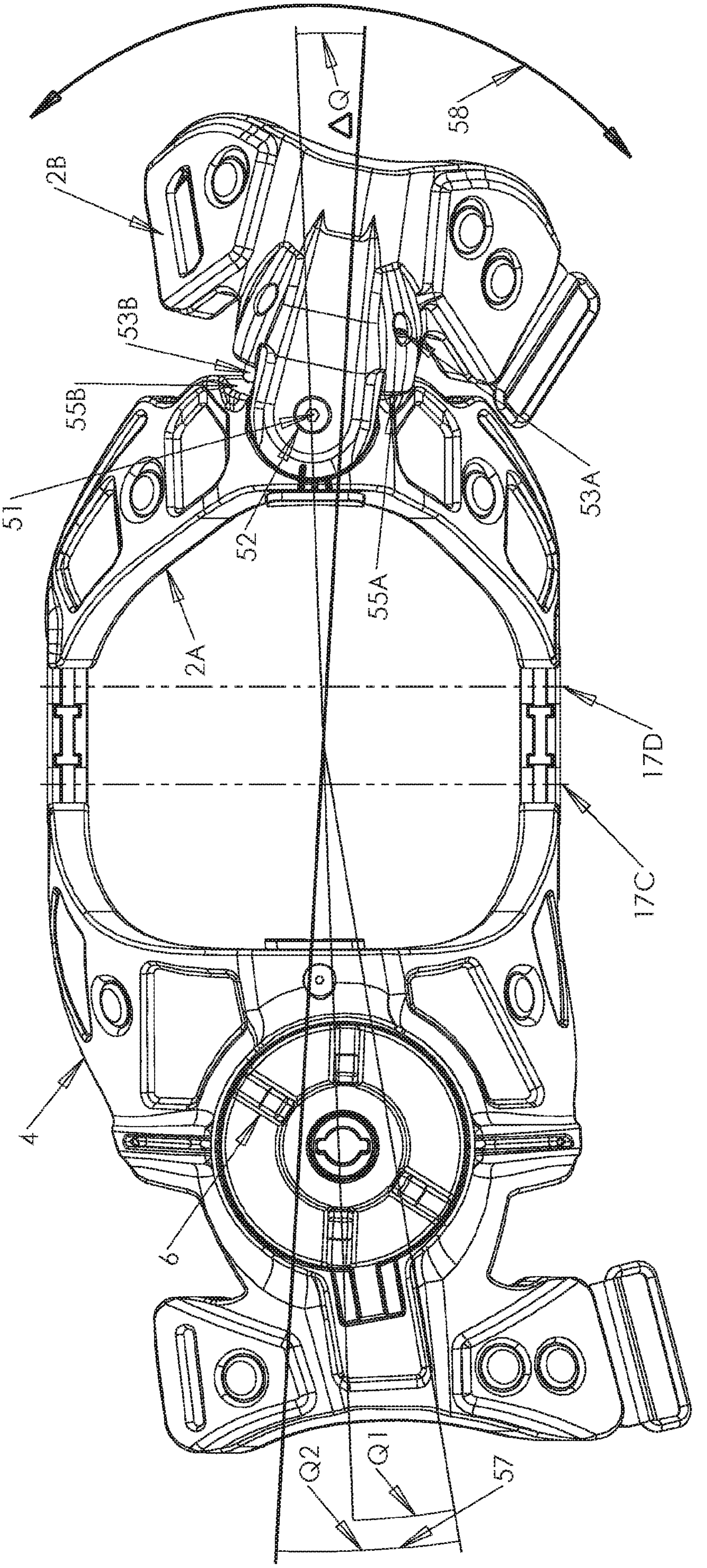

Fig. 16

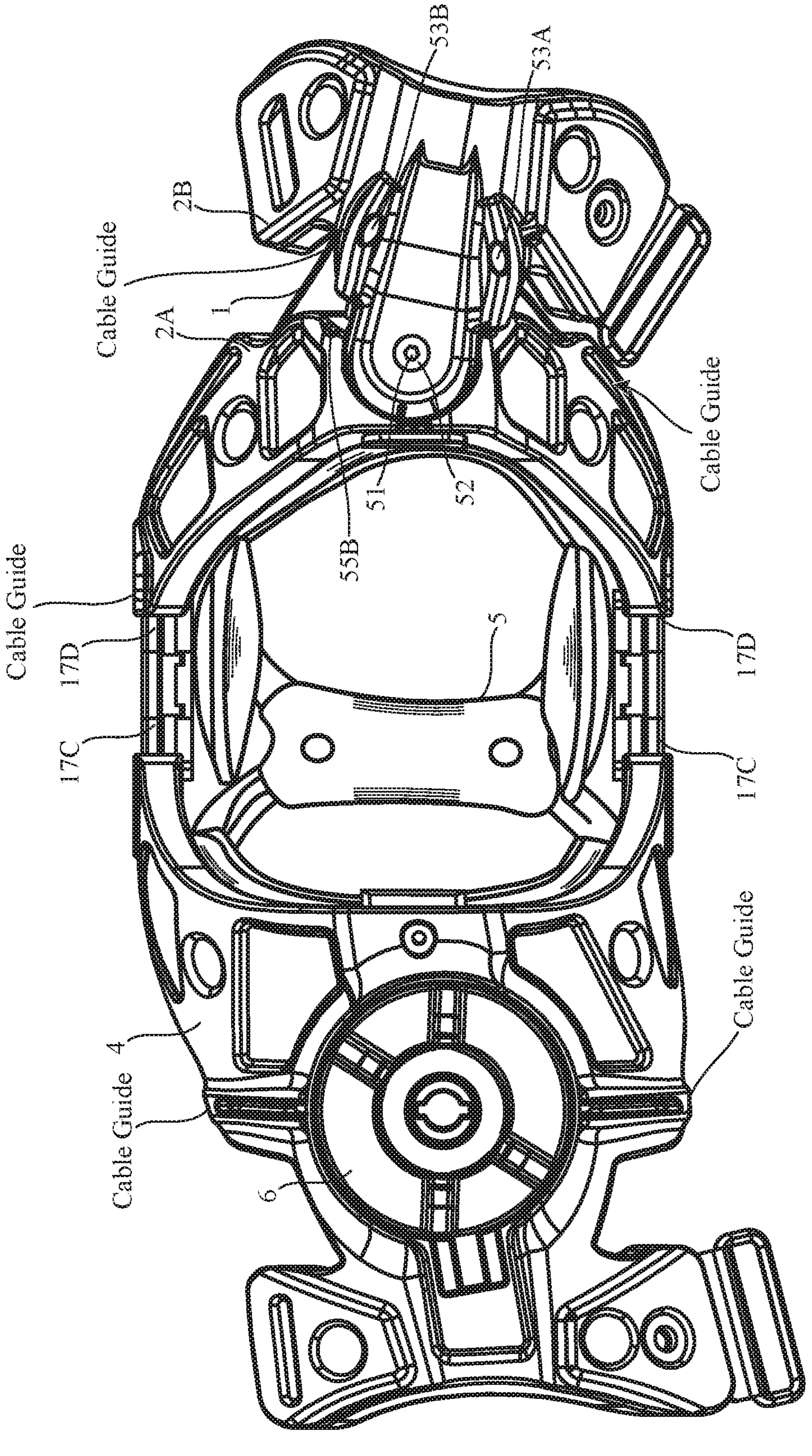
53B
53A
2B
Cable Guide
1
2A
Cable Guide
51
52
55B
5
Cable Guide
17D
17D
17C
17C
Cable Guide
4
Cable Guide
6

FIG. 17