



US 20110030666A1

(19) **United States**

(12) **Patent Application Publication**
Darlington

(10) **Pub. No.: US 2011/0030666 A1**

(43) **Pub. Date: Feb. 10, 2011**

(54) **COMPOUND ARCHERY CROSSBOW**

Publication Classification

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(51) **Int. Cl.**
F41B 5/12 (2006.01)
F41B 5/10 (2006.01)

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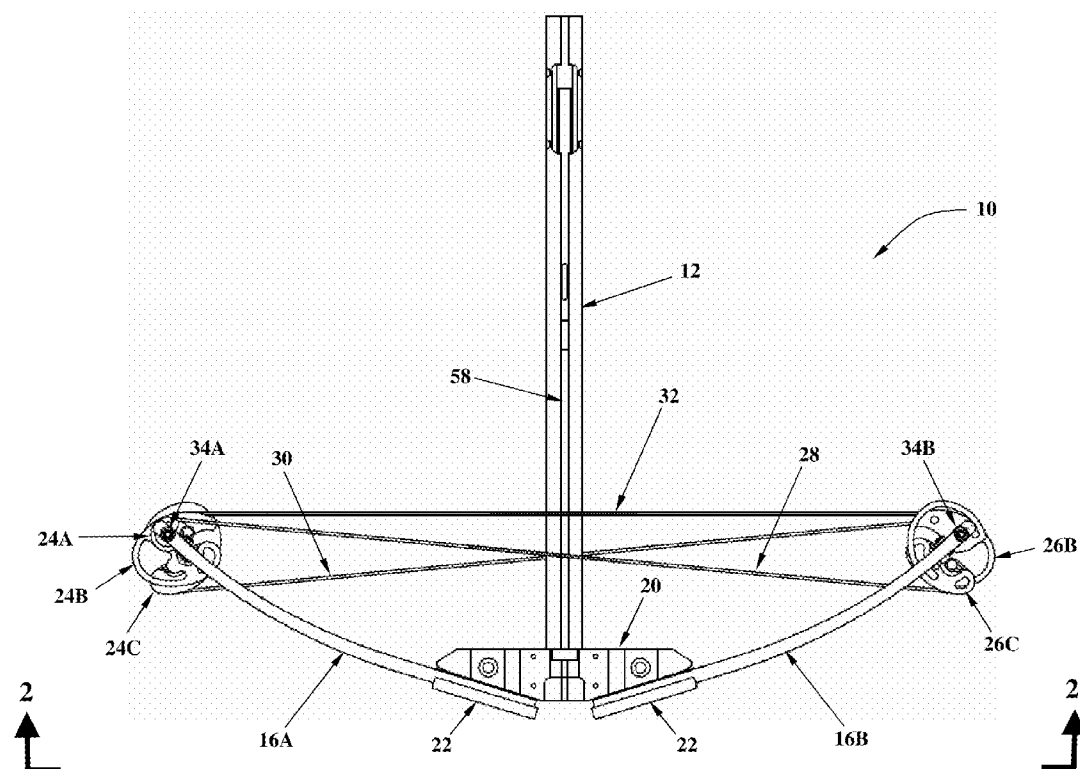
(52) **U.S. Cl. 124/25; 124/25.6**

(57) **ABSTRACT**

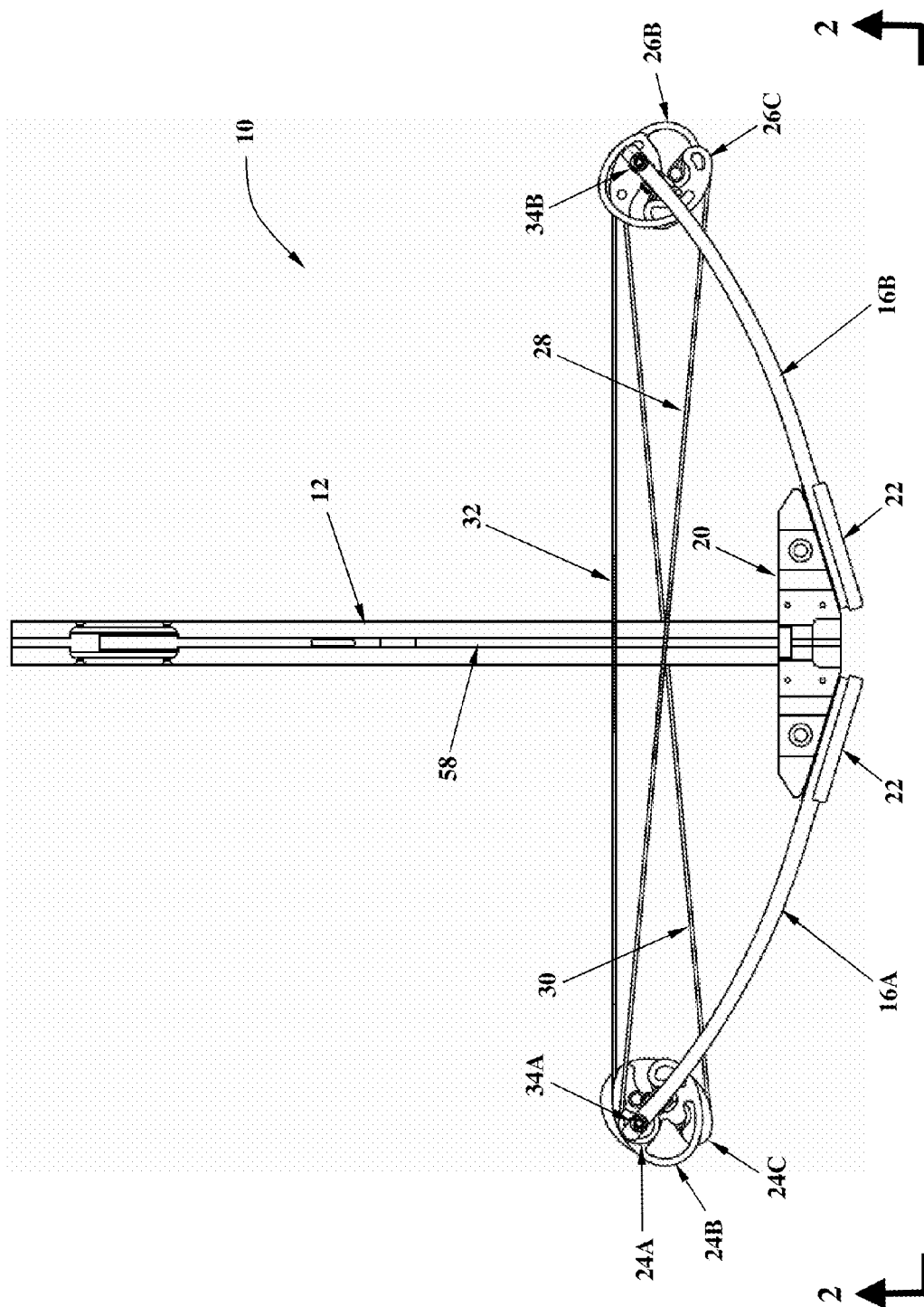
The invention is directed to a compound archery crossbow wherein the power cables and the bowstring remain substantially parallel allowing the bowstring to be positioned for increased power and accuracy of an arrow and/or wherein the power stroke has been extended by positioning the bowstring farther from the string catch.

(21) **Appl. No.: 12/535,290**

(22) **Filed: Aug. 4, 2009**



Hunter's Manufacturing Company, Inc.
Ex. 1013



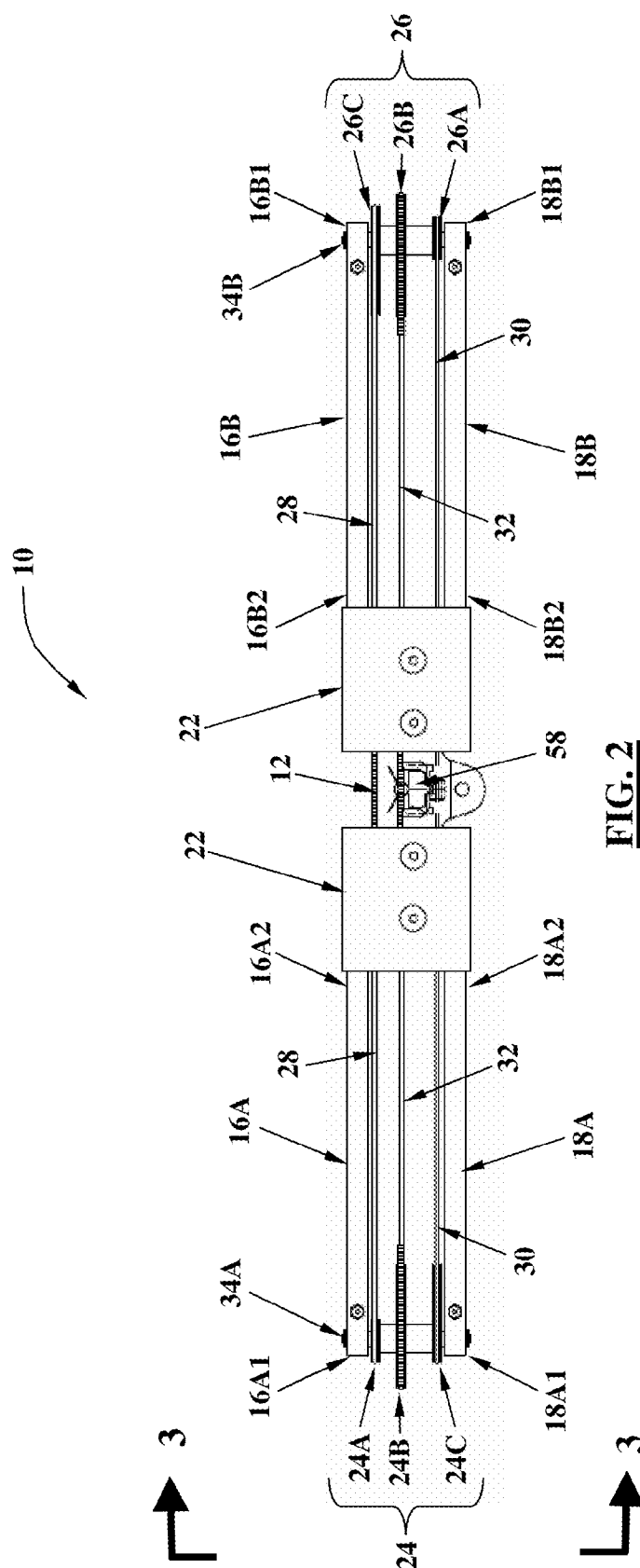
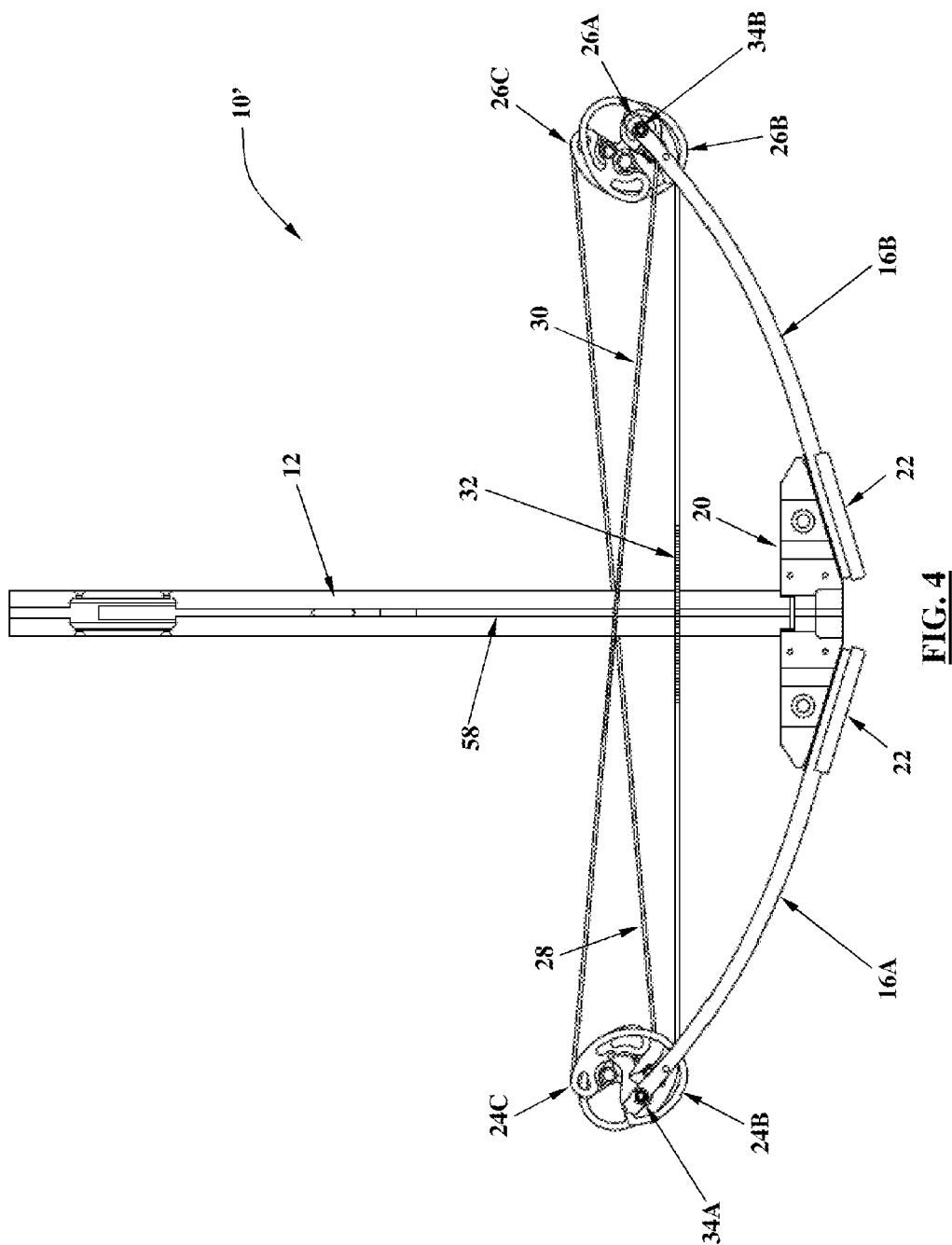


FIG. 2



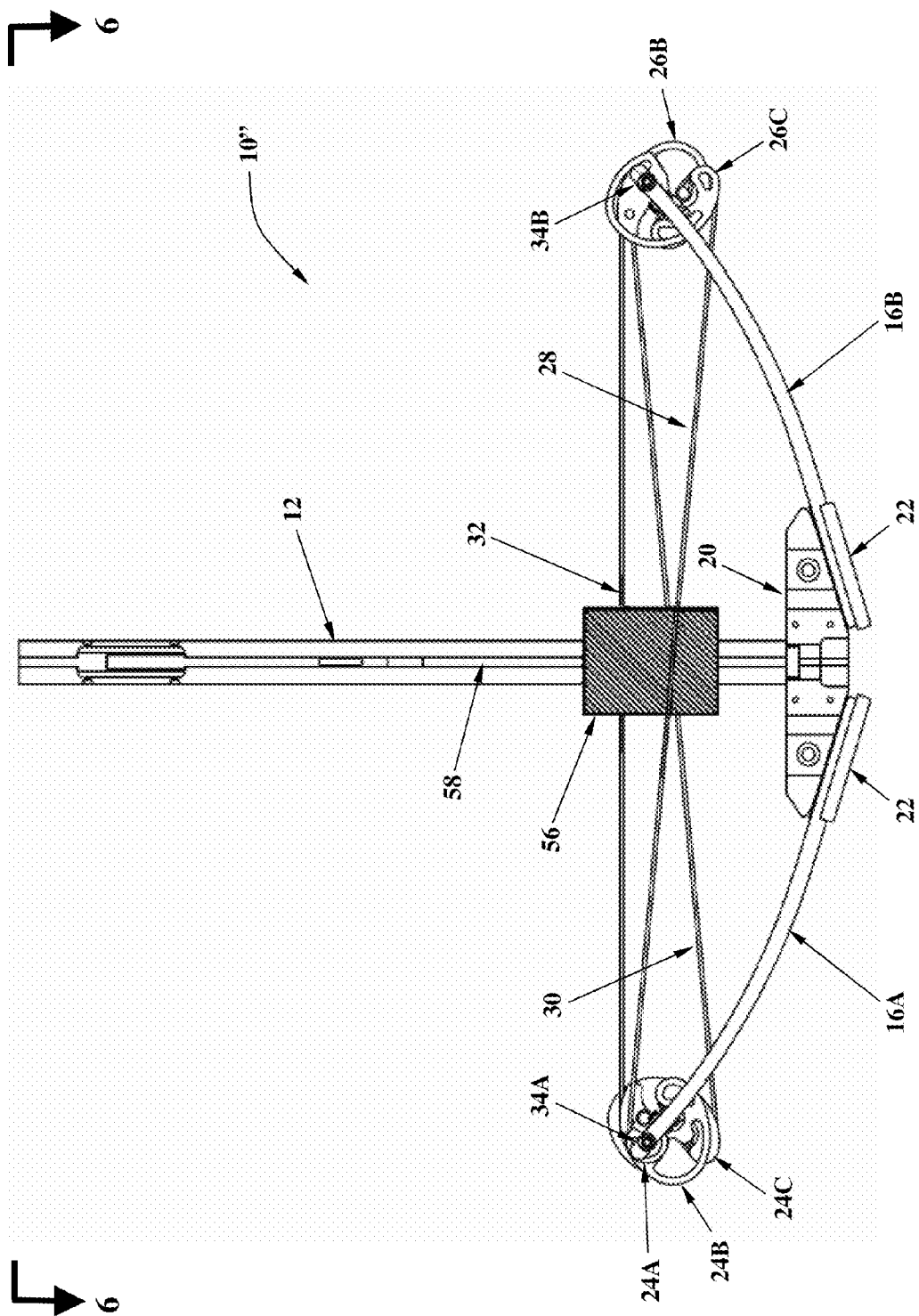
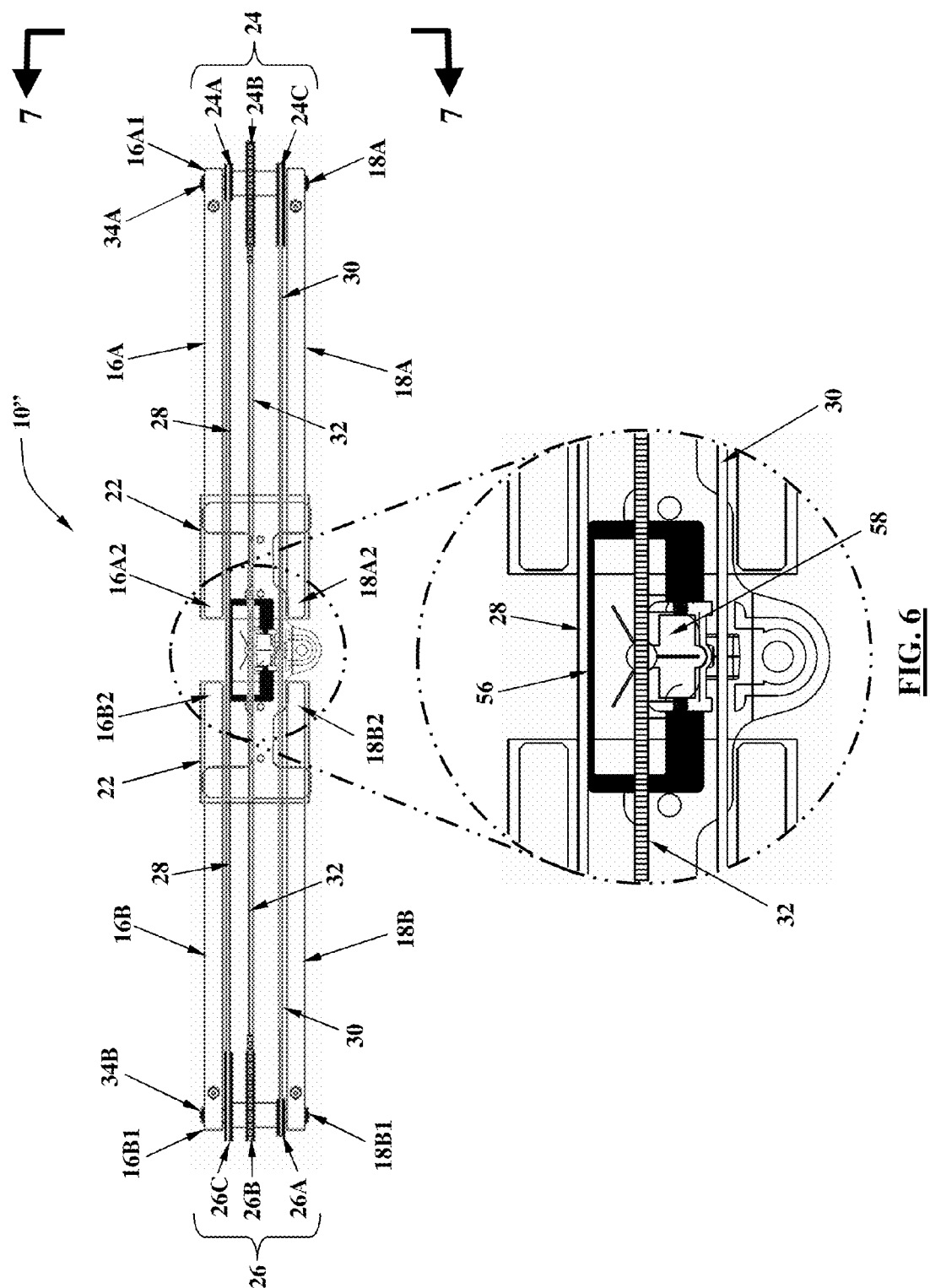


FIG. 5



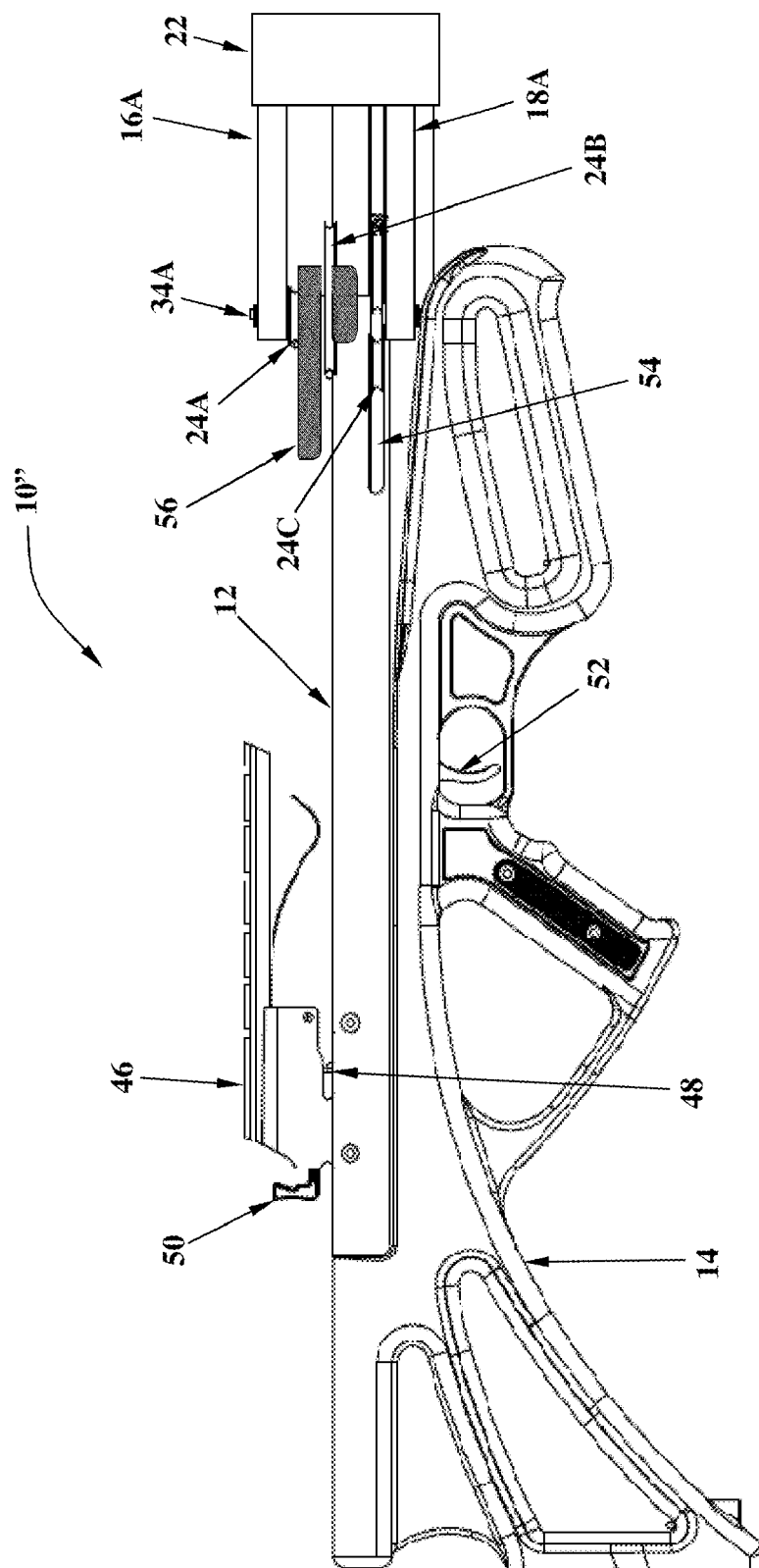


FIG. 7

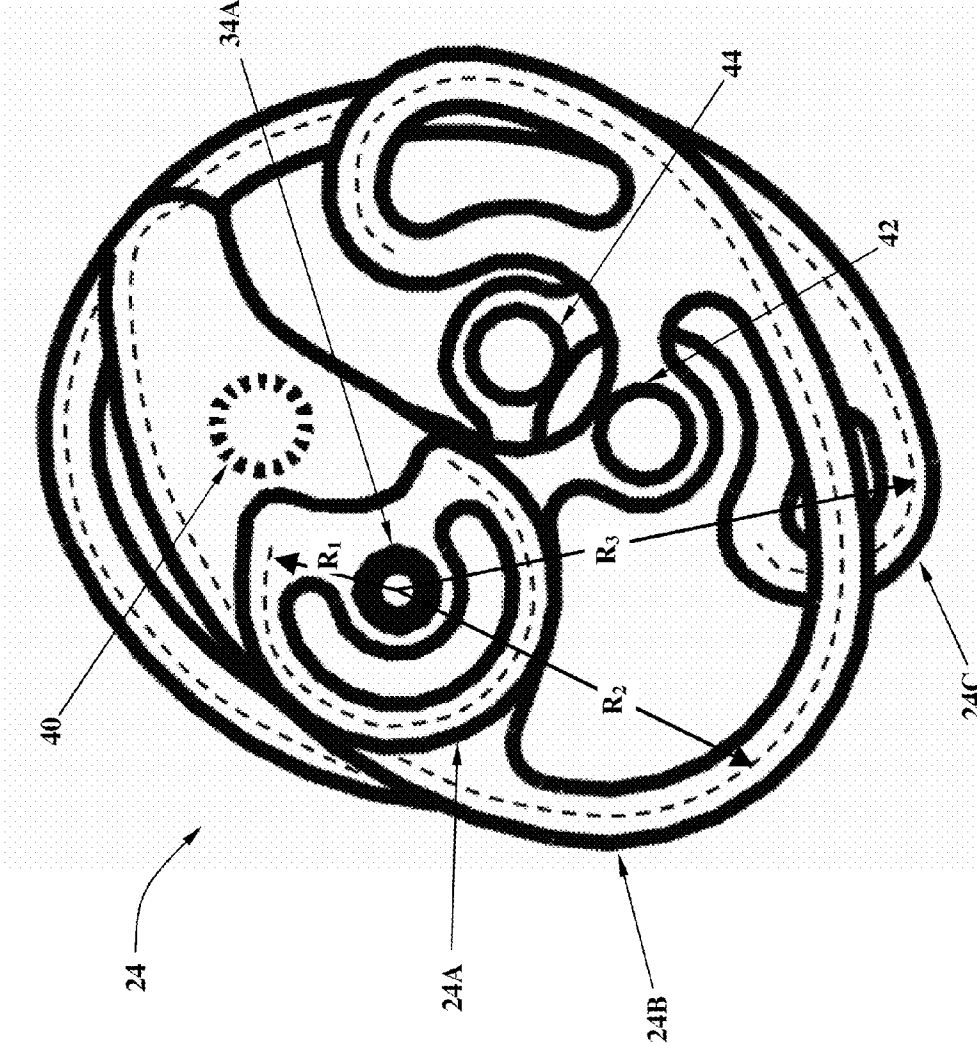
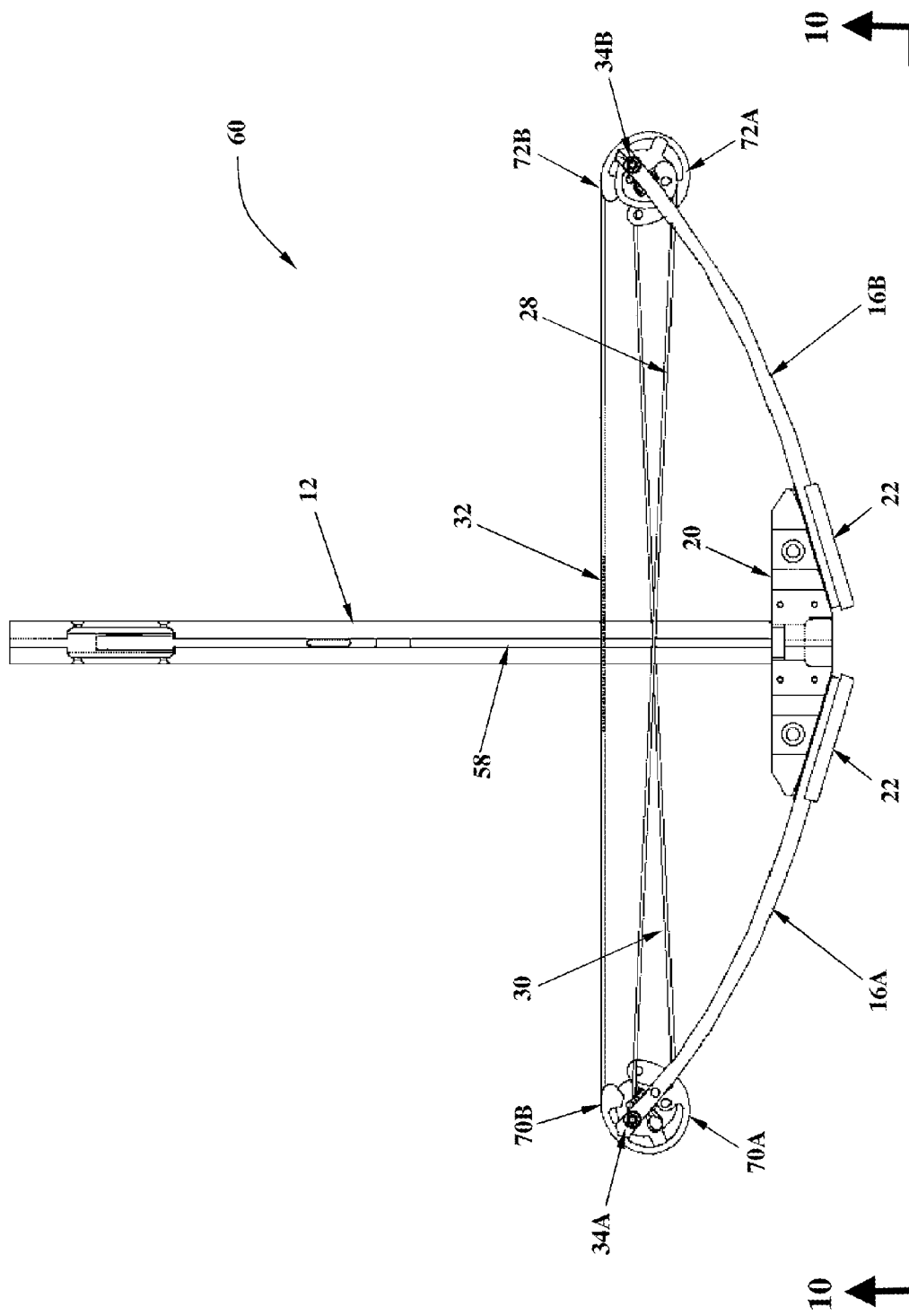


FIG. 8



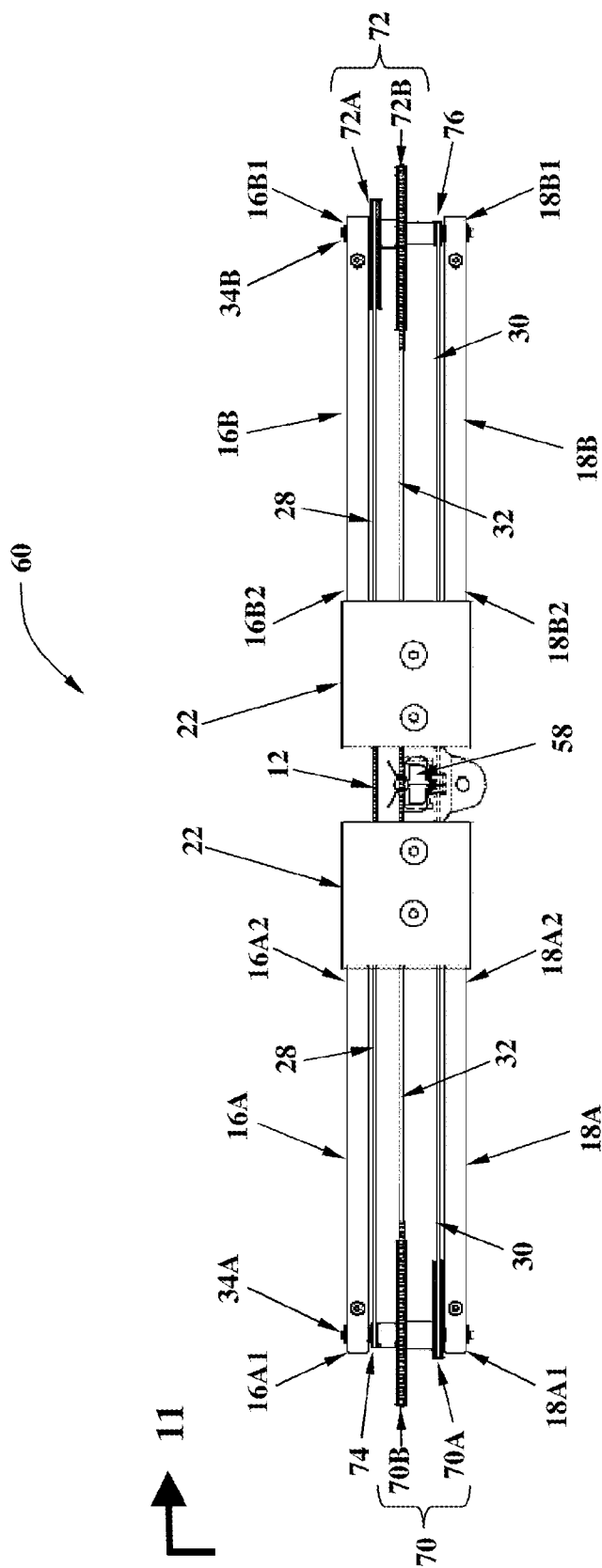


FIG. 10

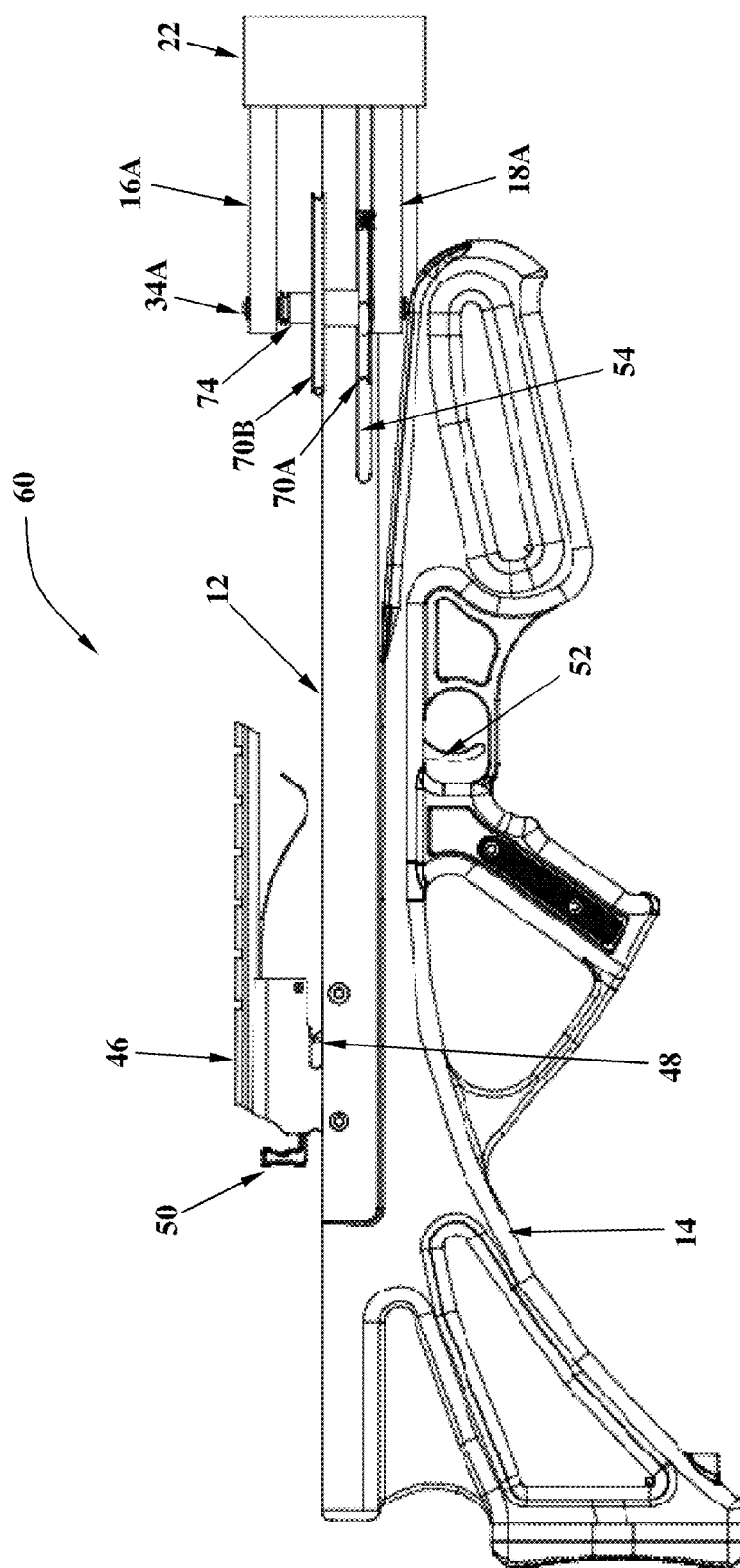
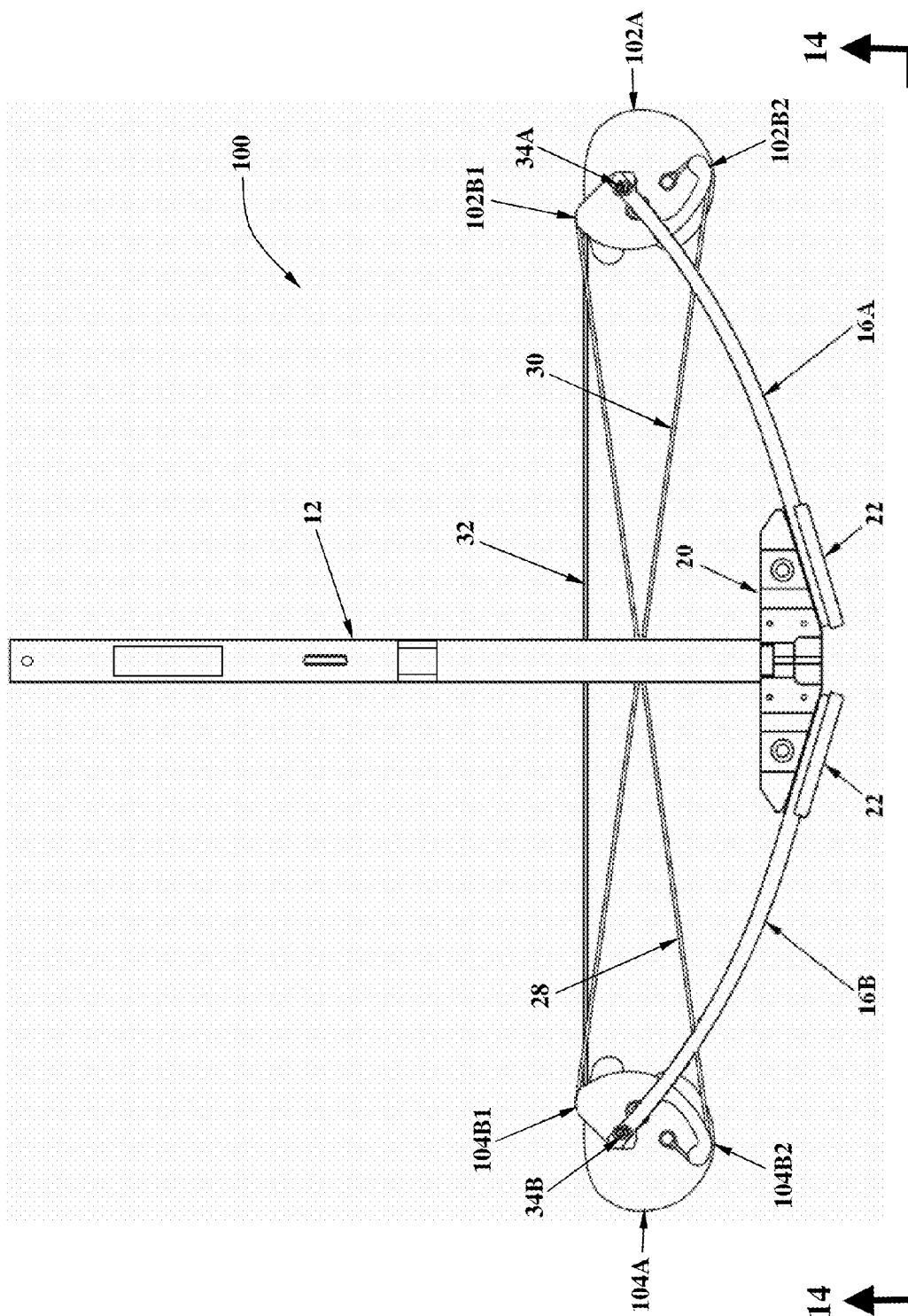


FIG. 11



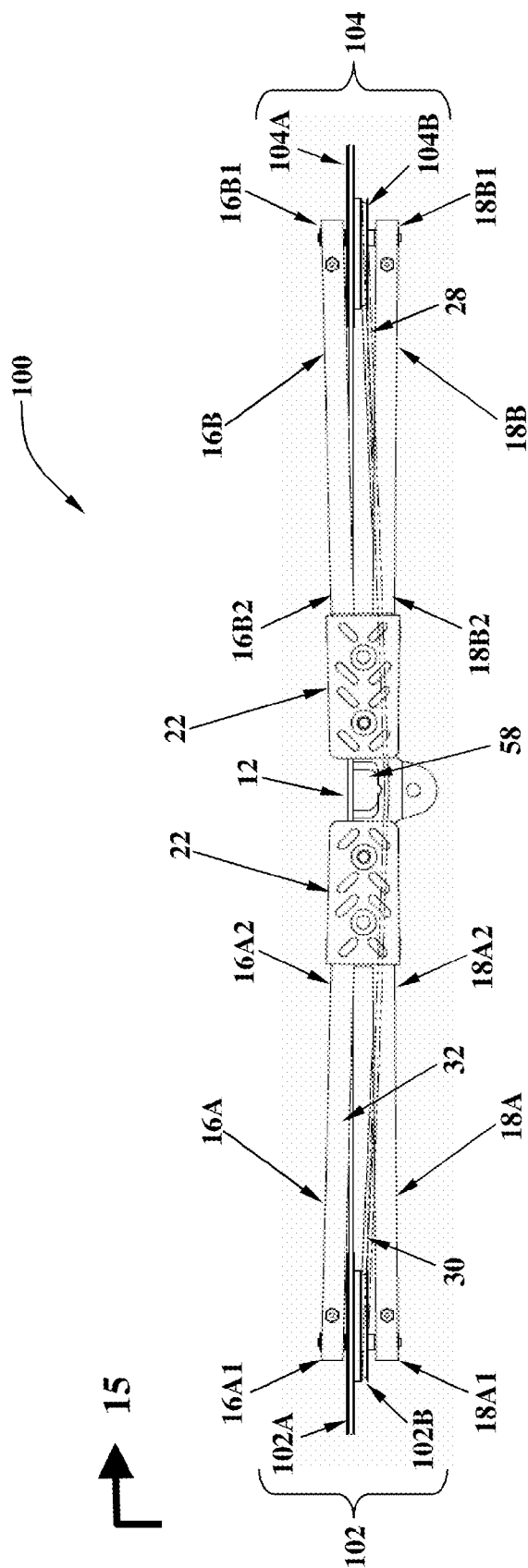


FIG. 14

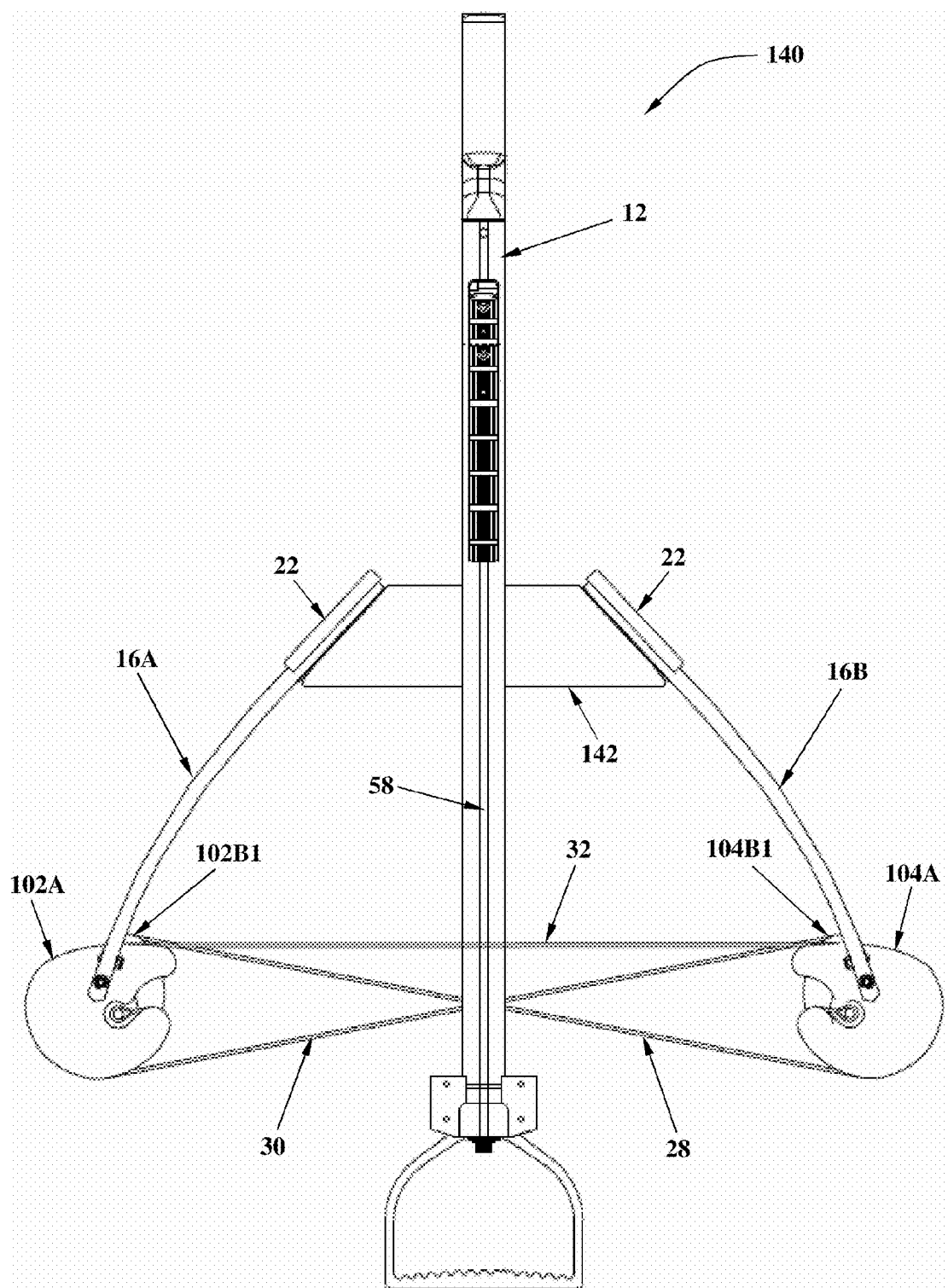


FIG. 17

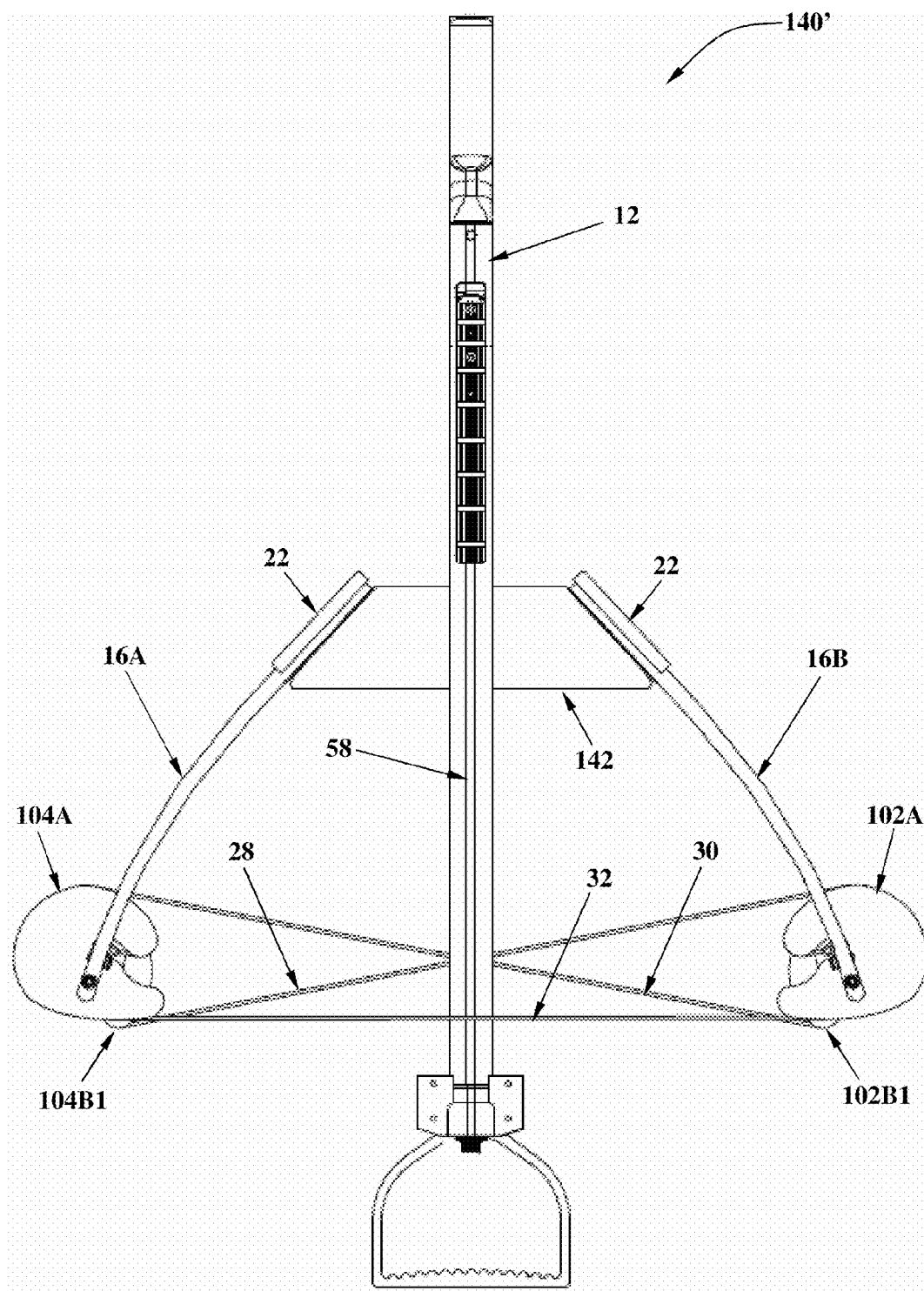


FIG. 18

COMPOUND ARCHERY CROSSBOW

FIELD OF THE INVENTION

[0001] This invention relates to an improved compound archery crossbow.

BACKGROUND OF THE INVENTION

[0002] Crossbows conventionally include an elongated barrel of wood, metal or composite composition that forms a mounting base for the remainder of the crossbow hardware. A pair of resilient limbs of wood, steel, aluminum, and/or composite composition project in opposite directions from one end of the barrel, with the free ends of the limbs being joined by a bowstring cable. A support is provided on the upper surface of the barrel for holding an arrow. A trigger mechanism is carried by the barrel for engaging, and holding the bowstring cable in the drawn or cocked position, and for selectively releasing the cable so as to propel the bolt from the bow.

[0003] Conventional dual-cam compound crossbows have a power cam mounted at the end of each of the two bow limbs to control the draw force on the bowstring and the bending of the limbs as the bowstring is drawn back to cock the crossbow. Each power cam includes grooved segments to control let-out of the bowstring cable and take-up of the power cables. Those cams typically include two grooved segments (hereinafter, “two-groove cams”). But, with two-groove cams, the cams can get out of sync when the bowstring is drawn back to cock the bow, which can offset the nock travel so it is no longer straight with the barrel, thereby causing the arrow to launch incorrectly. Latching the bowstring off center from the correct nocking point when cocking the bow can also cause erratic arrow flight. Those issues do not occur, however, when cams with two let-out grooves and a take-up groove are used (hereinafter, a “three-groove cam”). In a dual cam bow with three-groove cams, the distal ends of both power cables are each attached to opposite cams so that each cam becomes a slave to the other, thereby forcing the cams to rotate in unison, which helps maintain straight nock travel and makes it possible to get a higher level of stored energy to peak weight from the bow.

[0004] Commonly in dual-cam crossbows, the power cables or cable segments are anchored near the end of one or both bow limbs, typically at the mounting axles of the pulleys and/or cams. Accordingly, a continuous problem with compound bows is the inherently unequal application of force to opposite sides of the mounting axles of the pulleys and/or cams as the bowstring is drawn. Moreover, placing the power cables all on one cam creates more load on one side of the limb.

[0005] In an effort to overcome that out of balance system, configurations have been proposed that distribute the force load applied to the mounting axles. For example, a “yoke” or “Y harness” configuration was proposed wherein the terminal, or anchor end, of a cable is divided into two strands that extend to opposite sides of a pulley or cam, thereby evenly distributing the force applied by that cable to its respective attachment points. A “yoke” or “Y harness” configuration is described in commonly-owned U.S. Pat. No. 6,990,970, the subject matter of which is incorporated by reference in its entirety. A yoke system, however, is not effective to balance the load on the limbs with a front mounted (i.e., reverse draw) bowstring because it is not possible to draw the bowstring past

the split in the cables because they are anchored at the axle on each side of the pulleys and/or cams. And, anchoring the power cables to the limb still affects the timing of the cams and causes problematic twisting of the limbs. In addition, riggings that position all of the power cables on one side of the bowstring can generate cable forces on one side of the pulley or cam, which results in a design that tends to lean, tip, or twist the limbs of a bow with respect to the plane of the bowstring, thereby causing an arrow to launch incorrectly. Accordingly, there is a need for a dual-cam crossbow with synchronized cams and with minimal twisting of the limbs.

[0006] Hybrid dual-cam two-groove “slave” systems are another configuration that can be utilized in crossbows. A dual-cam two-groove “slave” systems configuration is described in commonly owned and co-pending U.S. patent application Ser. No. 12/290,750, the subject matter of which is incorporated by reference in its entirety. In that configuration, each cam includes a first let-out groove for letting out the bowstring and a hybrid groove that includes both a let-out portion for letting out a first power cable and a take-up portion for taking up a second power cable in the same groove. Because there are only two grooves and the power cables are both anchored at the hybrid groove, the load center of the cam is narrow and can be located near the center of the limb without introducing much torque during the draw cycle. The power cables, however, must still be deflected to move them out of the path of the bowstring and an arrow, which will still cause some twisting of the limbs.

BRIEF SUMMARY OF THE INVENTION

[0007] In a first embodiment, the invention is directed to a compound archery crossbow having a barrel supported by a stock. The crossbow further includes an upper pair and a lower pair of limbs, wherein the upper pair of limbs has a first member with a distal end and a proximal end, and a second member having a distal end and a proximal end. Similarly, the lower pair of limbs has a first member having a distal end and a proximal end, and a second member having a distal end and a proximal end. The upper pair and the lower pair of limbs are mounted to the stock by a riser, wherein an attachment means attaches the proximal end of the first member and the second member of the upper pair of limbs and the proximal end of the first member and the second member of the lower pair of limbs to the riser. The upper pair and the lower pair of limbs remain parallel at all times.

[0008] The invention further includes a first three-groove cam and a second three-groove cam, wherein the first cam has a first let-out groove, a second let-out groove, and a take-up groove. Similarly, the second cam also has a first let-out groove, a second let-out groove, and a take-up groove. The first let-out groove, the second let-out groove, and the take-up groove of the first cam are inverted in configuration from the first let-out groove, the second let-out groove, and the take-up groove of the second cam.

[0009] The invention further includes a first power cable extending from the first let-out groove of the first cam to the take-up groove of the second cam and a second power cable extending from the first let-out groove of the second cam to the take-up groove of the first cam. Additionally, a bowstring extends from the second let-out groove of the first cam to the second let-out groove of the second cam, wherein the first and second power cables are positioned between the riser and the bowstring.

[0010] A first axel assembly includes a first part that extends through the first cam, the distal end of the first member of the upper pair of limbs, and the distal end of the first member of the lower pair of limbs. A second axel assembly includes a first part that extends through the second cam, the distal end of the second member of the upper pair of limbs, and the second member of the lower pair of limbs. Drawing the bowstring away from the riser lets out the bowstring from the second let-out groove of the first and second cam, which causes the first cam and second cams to rotate around the first and second axel assemblies so as to let out the first and second power cables from the first let-out groove of the first and second cam, respectively.

[0011] The bowstring, the first power cable, and the second power cable are substantially parallel to each other, and the first part of the first and second axel assemblies have opposite rotational movement with respect to one another.

[0012] Each of the first let-out groove, the second let-out groove, and the take-up groove of the first and second cam includes a base having a periphery on which the bowstring, the first power cable, and the second cable are disposed. The base of the first let-out groove, the base of the second let-out groove, and the base of the take-up groove of the first and second cam are of substantially the same dimension.

[0013] At least one base of the first let-out groove, the second let-out groove, and the take-up groove of the first and second cam includes posts mounted thereto for anchoring the power cables and bowstring.

[0014] The crossbow further comprises a receiver attached to the barrel, wherein the receiver comprises a bowstring catch, safety, and trigger linkage. The stock includes a trigger attached to the trigger linkage for releasing the bowstring from the bowstring catch when the bowstring is in the loaded position in the receiver. A channel in the barrel can be positioned to hold an arrow so that the vanes, or fletches, on the arrow will not contact the first or second power cable as the arrow moves past the first and second power cable. The arrow may also be nocked to the bowstring to accomplish substantially same thing result without the use of the channel to support or guide the arrow.

[0015] In another embodiment, the cams are reversed in orientation with the bowstring positioned horizontally between cams and the riser so the power stroke can be increased, which results in better performance.

[0016] In yet another embodiment, a shoot-through design includes two-groove cams with the power cables anchored to the axle assemblies on the side opposite the take-up groove instead of the cam.

[0017] In still another embodiment, a hybrid two-groove cam is utilized that includes a let-out groove and a hybrid groove with let-out portion on take-up portions on the same grooved element. That embodiment provides a shoot-over design.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIG. 1 is a top view of an exemplary embodiment of a crossbow according to the present invention;

[0019] FIG. 2 is a front view of the crossbow illustrated in FIG. 1;

[0020] FIG. 3 is a side view of the crossbow illustrated in FIG. 1;

[0021] FIG. 4 is a top view of the crossbow illustrated in FIG. 1, modified to have a reverse draw;

[0022] FIG. 5 is a top view of the crossbow illustrated in FIG. 1, modified to include a tunnel for protecting the bowstring;

[0023] FIG. 6 is a rear view of the crossbow illustrated in FIG. 5;

[0024] FIG. 7 is a side view of the crossbow illustrated in FIG. 6;

[0025] FIG. 8 is a top view of an exemplary embodiment of a three-groove cam according to the present invention;

[0026] FIG. 9 is a top view of another exemplary embodiment of a crossbow according to the present invention;

[0027] FIG. 10 is a front view of the crossbow illustrated in FIG. 9;

[0028] FIG. 11 is a side view of the crossbow illustrated in FIG. 9;

[0029] FIG. 12 is a top view of the crossbow illustrated in FIG. 9, modified to have a reverse draw;

[0030] FIG. 13 is a bottom view of another exemplary embodiment of a crossbow according to the present invention;

[0031] FIG. 14 is a front view of the crossbow illustrated in FIG. 13;

[0032] FIG. 15 is a side view of the crossbow illustrated in FIG. 13;

[0033] FIG. 16 is a top view of the crossbow illustrated in FIG. 13, modified to have a reverse draw;

[0034] FIG. 17 is a top view of yet another exemplary embodiment of a crossbow according to the present invention with the limbs forward; and

[0035] FIG. 18 is a top view of the crossbow illustrated in FIG. 17, modified to have a reverse draw.

[0036] Reference will now be made in detail to non-limiting embodiments of the present invention by way of reference to the accompanying drawings, wherein like reference numerals refer to like parts, components, and structures.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] Certain terminology is used herein for convenience only and is not to be taken as a limitation on the present invention. The terminology includes the words specifically mentioned, derivatives thereof, and words of similar import. The embodiments discussed herein are not intended to be exhaustive or to limit the invention to the precise form disclosed. Those embodiments are chosen and described to best explain the principles of the invention and its application and practical use and to enable others skilled in the art to best utilize the invention.

[0038] Referring now to the drawings, FIGS. 1-3 illustrate a first embodiment of the present invention directed to a compound archery crossbow 10 that may have a barrel 12 supported by a stock 14. The crossbow 10 may include an upper pair 16A & B and a lower pair 18A & B of limbs, wherein the upper pair of limbs 16A & B has a first member 16A with a distal end 16A1 and a proximal end 16A2 and a second member 16B with a distal end 16B1 and a proximal end 16B2. Similarly, the lower pair of limbs 18A & B also has a first member 18A with a distal end 18A1 and a proximal end 18A2 and a second member 18B with a distal end 18B1 and a proximal end 18B2. The upper pair of limbs 16A & B and the lower pair of limbs 18A & B are mounted to the stock 14 by a riser 20, wherein attachment portion 22 attach the proximal end 16A2 of the first member 16A, the proximal end 16B2 of the second member 16B of the upper pair of limbs 16,

and the proximal end of the first member 18A2, and the second member 18B2 of the lower pair of limbs 18 to the riser 20. In the illustrated embodiment, the attachment portions 22 are limb caps. The upper pair of limbs 16A & B and the lower pair of limbs 18A & B are substantially parallel at all times.

[0039] It will be appreciated by those of skill in the art that the limb configuration can vary from the embodiment illustrated in FIGS. 1-3 without deviating significantly from the spirit of the present invention. The illustrated configurations are not intended to be limiting, but rather to provide an appreciation of the function of the limb(s) of the present invention, regardless of the configuration that one skilled in the art chooses. Accordingly, the limbs could be a single structure or they could include a single upper limb with a single parallel lower limb. Thus, the limb configuration could be one, two, or four pieces and still adhere to the basic concept of the present invention.

[0040] The crossbow 10 may include a three-groove first cam 24 and a three-groove second cam 26, wherein the first cam 24 has a first let-out groove 24A, a second let-out groove 24B, and a take-up groove 24C, and the second cam 26 has a first let-out groove 26A, a second let-out groove 26B, and a take-up groove 26C. The first let-out groove 24A, the second let-out groove 24B, and the take-up groove 24C of the first cam 24 are inverted with respect to the first let-out groove 26A, the second let-out groove 26B, and the take-up groove 26C of the second cam 26. Accordingly, the first let-out groove 24A of the first cam 24 is disposed at the top of the first cam 24, the second let-out groove 24B of the first cam 24 is disposed at the middle of the first cam 24, and the take-up groove 24C of the first cam 24 is disposed at the bottom of the first cam 24. Conversely, the first let-out groove 26A of the second cam 26 is disposed at the bottom of the second cam 26, the second let-out groove 26B of the second cam 26 is disposed in the middle of the second cam 26, and the take-up groove 26C of the second cam 26 is disposed at the top of the second cam 26.

[0041] The crossbow 10 may also include a first power cable 28 extending from the first let-out groove 24A of the first cam 24 to the take-up groove 26C of the second cam 26; a second power cable 30 extending from the first let-out groove 26A of the second cam 26 to the take-up groove 24C of the first cam 24; and a bowstring 32 extending from the second let-out groove 24B of the first cam 24 to the second let-out groove 26B of the second cam 26. The first power cable 28, the second power cable 30, and the bowstring 32 are each separate cables and are each anchored at their distal ends to the first cam 24 and second cam 26. Accordingly, the first power cable 28, the second power cable 30, and the bowstring 32 extend substantially parallel to each other between the first cam 24 and second cam 26, with the bowstring 32 being vertically disposed in between the first power cable 28 and the second power cable 30 (hereinafter, the "shoot-through" configuration).

[0042] Horizontally, the first power cable 28 and second power cable 30 may be disposed between the riser 20 and the bowstring 32 (see, e.g., FIG. 1), or the bowstring 32 may be disposed between the riser 20 and the first power cable 28 and second power cable 30 (see, e.g., FIG. 4). The crossbow 10' of the latter configuration (hereinafter, the "reverse draw" configuration) is substantially the same as the crossbow 10 illustrated in FIGS. 1-3, except the first cam 24 and second cam 26 are flipped so that the take-up groove 24C of the first cam 24 is at the top of the first cam 24 and the take-up groove 26C of

the second cam 26 is at the bottom of the second cam 26. That reverse draw configuration increases the distance that the bowstring 32 can be pulled away from the riser, thereby increasing the power stroke and improving the performance of the crossbow 10'. The shoot-through configuration enables the reverse draw configuration by allowing the bowstring 32 to be pulled away from the riser 20 and through the first power cable 28 and second power cable 30.

[0043] Because the first power cable 28 and second power cable 30 are substantially parallel to each other and are anchored at the top and bottom of the first cam 26 and second cam 28, they can be provided a sufficient vertical distance apart to allow the arrow pass between them. Accordingly, the first power cable 28 and second power cable 30 do not have to be deflected in the vertical direction to remove them from the path of the arrow. Moreover, the second power cable 30 can be run through a forked opening 54 in the barrel 12 to protect it from the arrow's sharp arrowhead when loading and shooting the arrow. And, although the first power cable 28 runs over the barrel 12, a tunnel 56 can be attached to the barrel 12 to surround the arrow and avoid a potential problem of the arrowhead cutting the first power cable 28 when loading the arrow. FIGS. 5-7 illustrate a crossbow 10" with a tunnel 56 attached to the barrel 12. Or, in the alternative, the first power cable 28 can be covered with a protective material, such as KEVLAR brand protective material, that is very difficult to cut. The bowstring 32 does not require such protection in either of those configurations because it is held out of the way when the an arrow is loaded.

[0044] In addition, because the distal ends of the first power cable 28 and second power cable 30 are anchored at the first cam 24 and second cam 26 instead of the limbs 16A & B and 18A & B or the axle assemblies 34A and 34B, the present invention also resolves timing issues between the first cam 24 and second cam 26. Anchoring the distal ends first power cable 28 and second power cable 30 at the first cam 24 and second cam 26 causes the first cam 24 and the second cam 26 become slaves to each other, thereby forcing the cams to rotate in unison, which helps maintain straightnock travel and prevents a user from attaching the bowstring off center of the bowstring catch 48. Both of those factors contribute to better arrow flight.

[0045] As FIGS. 1-3 also illustrate, a first axel assembly 34A extends through the distal end 16A1 of the first member 16A of the upper pair of limbs 16A & B, through the first cam 24, and through the distal end 18A1 of the first member 18A of the lower pair limbs 18A & B. And, a second axel assembly 34B extends through the distal end 16B1 of the second member 16B of the upper pair of limbs 16A & B, through the second cam 26, and through the distal end 18B1 of the second member 18B of the lower pair of limbs 18A & B. The first cam 24 rotates about the first axel assembly 34A, and the second cam 26 rotates about the second axel assembly. Accordingly, drawing the bowstring 32 away from the riser 20 pulls the bowstring 32 out of the second let-out grooves 24B and 26B of the first cam 24 and second cam 26, respectively, as the first cam 24 and second cam 26 rotate about the first axel assembly 34A and second axel assembly 34B, respectively. The rotation of the first cam 24 about the first axel assembly 34A is in the opposite direction of the rotation of the second cam 26 about the second axel assembly 34B. And, the rotation of the first cam 24 pulls the second power cable 30 out of the first let-out groove 26A of the second cam 26 and into the take-up groove 24C of the first cam 24 while the rotation of the second

cam 26 simultaneously pulls the first power cable 28 out of the first let-out groove 24A of the first cam 26 and into the take-up groove 26C of the second cam 26, thereby synchronizing the first cam 24 with the second cam 26 as the bowstring 32 is drawn away from the riser 20. As discussed above, by pulling one cable out of one groove on one cam and into a groove on another cam, each cam becomes a slave to the other, which provides the synchronization required to prevent the possibility of the nock point shifting from center when the bowstring 32 is drawn away from the riser 20. That configuration therefore improves the accuracy of the crossbow 10.

[0046] When the bowstring 32 is drawn back to cock the crossbow 10, the first power cable 28, the second power cable 30, and the bowstring 32 remain substantially parallel to each other, just as in the “relaxed” position. And, because the first power cable 28 is anchored at the top of the first cam 24 and second cam 26, the second power cable 30 is anchored at the bottom of the first cam 24 and second cam 26, and the bowstring 32 is anchored substantially in the middle of the first cam 24 and second cam 26, the torque on the first axle assembly 34A and the second axle assembly is effectively neutralized, which substantially eliminates twisting forces on the limbs 16A & B and 18A & B of the crossbow 10. Eliminating those twisting forces helps further improve the accuracy of the crossbow 10.

[0047] As FIG. 8 illustrates, the first let-out groove 24A, the second let-out groove 24B, and the take-up groove 24C of the first cam 24 are each disposed at different diameters R_1 , R_2 , and R_3 , respectively, from the first axle assembly 34A. Each of those diameters R_1 , R_2 , and R_3 may vary as required to produce the smoothest torque curve when drawing the bowstring 32 back and releasing it. Accordingly, the first let-out groove 24A, the second let-out groove 24B, and the take-up groove 24C of the first cam 24 may be formed in a circular shape, a kidney shape, or a combination thereof. It will be appreciated by those of skill in the art, however, that the shape of the first let-out groove 24A, the second let-out groove 24B, and the take-up groove 24C of the first cam 24 can be varied significantly without deviating significantly from the spirit of the present invention.

[0048] The first let-out groove 26A, the second let-out groove 26B, and the take-up groove 26C of the second cam 26 have substantially the same shape as the first let-out groove 24A, the second let-out groove 24B, and the take-up groove 24C of the first cam 24, respectively. That symmetry substantially equalizes the load on each side of the first axle assembly 34A and second axle assembly 34B, which thereby eliminates torque at the distal ends 16A1, 16B1, 18A1, and 18B1 of the limbs 16A & B and 18A & B of the crossbow 10. Accordingly, that symmetry causes the limbs 16A & B and 18A & B to deflect an equal amount as the bowstring 32 is drawn away from the riser 20. Equalizing the amount of deflection of the limbs 16A & B and 18A & B helps improve the accuracy of the crossbow 10.

[0049] In addition to being of substantially identical dimensions, the first cam 24 and second cam 26 also both include a first post 40, a second post 42, and a third post 44 extending therefrom for anchoring the distal ends of first power cable 28, the second power cable 30, and the bowstring 32, respectively. The first cam 24 and second cam 26 may also include a draw stop (not illustrated) extending therefrom to prevent the cams 24 and 26 from being over-rotated and to allow the bow to be locked at full draw with no tension on the bowstring 32.

[0050] As FIG. 3 illustrates, the barrel of the crossbow 10 may include a receiving portion 46 formed therein for receiving the bowstring 32 when it is drawn away from the riser 20. The receiver portion 46 includes a bowstring catch 48, a safety mechanism 50, and a trigger linkage (not shown) connecting the bowstring catch 48 to a trigger 52 disposed in the stock 14. Through interaction with the trigger linkage, moving the trigger 52 will pull the bowstring catch 48 downward toward the barrel 10 and release the bowstring 32 from the receiving portion 46. And, as FIG. 1 illustrates, the barrel 12 may also include a channel 58 running lengthwise down the barrel 12 for receiving the vane of an arrow so the arrow can remain flush with the barrel 12 when the arrow is loaded into and shot from the crossbow 10. The channel 58 also helps prevent the arrow from contacting the first power cable 28 and the second power cable 30 as it moves past them when it is shot from the crossbow 10. As an alternative to the channel 58, an arrow with a nock can be used so the arrow can be attached to the bowstring 32 after the bowstring 32 is held by the bowstring catch 48.

[0051] FIGS. 9-12 illustrate another embodiment of a crossbow 60 according to the present invention that utilizes the shoot-through configuration described above, but with a two-groove first cam 70 and two-groove second cam 72 in lieu of a three-groove first cam 24 and three-groove second cam 26. The two-groove first cam 70 includes a take-up groove 70A and a let-out groove 70B, and the second two-groove cam 72 includes a take-up groove 72A and a let-out groove 72B. But, instead of including a second let-out groove 24A or 26A like the first three-groove cam 24 and the second three-groove cam 26, a first anchor 74 is provided between the first two-groove cam 70 and the distal end 16A1 of the first member 16A of the upper pair of limbs 16A & B, and a second anchor 76 is provided between the second two-groove cam 72 and the distal end 18A1 of the first member 18A of the lower pair limbs 18A & B. The first anchor 74 is disposed on the first axle assembly 34A, and the second anchor 76 is disposed on the second axle assembly 34B.

[0052] The take-up groove 70A of the first cam 70, the let-out groove 70B of the first cam 70, and the first anchor 74 are inverted with respect to the take-up groove 72A of the second cam 72, the let-out groove 72B of the second cam 72, and the second anchor 76. Accordingly, the take-up groove 70A of the first cam 70 is disposed at the bottom of the first cam 70, the let-out groove 70B of the first cam 70 is disposed at the top of the first cam 70, and the first anchor 74 is disposed above the first cam 70. Conversely, the take-up groove 72A of the second cam 72 is disposed at the top of the second cam 72, the let-out groove 72B of the second cam 72 is disposed at the bottom of the second cam 72, and the second anchor 76 is disposed below the second cam 72.

[0053] In that configuration, the first power cable 28 extends from the take-up groove 72A of the second cam 72 to the first anchor 74; the second power cable 30 extends from the take-up groove 70A of the first cam 70 to the second anchor 76; and the bowstring 32 extends from the let-out groove 70B of the first cam 70 to the let-out groove 70B of the second cam 72. The first power cable 28, the second power cable 30, and the bowstring 32 are each separate cables. One end of the first power cable 28 is anchored at the second cam 72 and the other end is anchored at the first anchor 74; one end of the second power cable 30 is anchored at the first cam 70 and the other end is anchored at the second anchor 76; and the bowstring is anchored at its distal ends at the first cam 70 and

second cam 72. Accordingly, the first power cable 28, the second power cable 30, and the bowstring 32 extend substantially parallel to each other between the first cam 70 and second cam 72 in a shoot-through configuration.

[0054] Also in that configuration, the first power cable 28 and second power cable 30 may be horizontally disposed between the riser 20 and the bowstring 32 (see, e.g., FIG. 9), or the bowstring 32 may be horizontally disposed between the riser 20 and the first power cable 28 and second power cable 30 (see, e.g., FIG. 12). The crossbow 60' of the latter configuration (i.e., the reverse draw configuration) is substantially the same as the crossbow 60 illustrated in FIGS. 9-11, except the first cam 70 and second cam 72 are flipped so that the take-up groove 70A of the first cam 70 is at the top of the first cam 70 with the first anchor 74 disposed below the first cam 70, and the take-up groove 72A of the second cam 72 is at the bottom of the second cam 72 with the second anchor 76 disposed above the second cam 72. And, when provided in reverse draw configuration, the bowstring 32 does not interfere with the first power cable 28 or the second power cable 30 when the bowstring 32 is drawn back to cock the crossbow 60'.

[0055] The features of the crossbows 60 and 60' illustrated in FIGS. 9-12 provide substantially the same advantages as those described for the corresponding features of the crossbows 10 and 10' illustrated in FIGS. 1-4. The primary difference between those configurations is that, unlike the three-groove cam configuration illustrated in FIGS. 1-4, the ends of the first power cable 28 and the second power cable 30 that are attached to the first anchor 74 and second anchor 76, respectively, in the configuration illustrated in FIGS. 9-12 do not rotate at the point of attachment as the opposite ends of those cables rotate via the take-up groove 72A of the second cam 72 and the take-up groove 70A of the first cam 70, respectively. Thus, the two-groove cam configuration illustrated in FIGS. 9-12 does not provide the advantage of improved cam synchronization as is provided by the three-groove cam configuration illustrated in FIGS. 1-5.

[0056] FIGS. 13-15 illustrate yet another embodiment of a crossbow 100 according to the present invention that does not utilize the shoot-through configuration, but uses hybrid two-groove first cam 102 and hybrid two-groove second cam 104 to provide improved cam synchronization similar to that of the three-groove cam configuration illustrated in FIGS. 1-4. (NOTE: FIG. 13 shows a bottom view of the crossbow 100 so as to more clearly illustrate the hybrid two-groove first cam 102 and hybrid two-groove second cam 104. FIG. 14 shows a view taken along line 14-14 as if FIG. 13 were a top view.) The hybrid two-groove first cam 102 includes a let-out groove 102A and a hybrid groove 102B, wherein the hybrid groove 102B includes a let-out portion 102B1 and a take-up portion 102B2. And, the second hybrid two-groove cam 104 includes a let-out groove 104A and a hybrid groove 104B, wherein that hybrid groove 104B also includes a let-out portion 104B1 and a take-up portion 104B2. The hybrid groove 102B of the first cam 102 and the hybrid groove 104B of the second cam 104 allow the distal ends of the first power cable 28 and second power cable 30 to be attached to the first cam 102 and the second cam 104 so that each cam is a slave to the other, as described above. Accordingly, a first anchor 74 and second anchor 76 are not required as in the configurations illustrated in FIGS. 9-12.

[0057] In that configuration, the first power cable 28 extends from the let-out portion 102B1 of the first cam 102 to

the take-up portion 104B2 of the second cam 104; the second power cable 30 extends from the let-out portion 104B1 of the second cam 104 to the take-up portion 102B2 of the first cam 102; and the bowstring 32 extends from the let-out groove 102A of the first cam 102 to the let-out groove 104A of the second cam 104. Unlike the configurations illustrated in FIGS. 1-12, however, the let-out groove 102A and hybrid groove 102B of the first cam 102 are in the same orientation as the let-out groove 104A and the hybrid groove 104B of the second cam 104 in the configurations illustrated in FIGS. 13-16. Thus, the hybrid groove 102B of the first cam 102 and the hybrid groove 104B of the second cam 104 are each disposed at the bottom of the first cam 102 and second cam 104, respectively, and the first power cable 28 and the second power cable 30 therefore extend between the hybrid groove 102B of the first cam 102 and the hybrid groove 104B of the second cam 104 such that both the first power cable 28 and the second power cable 30 are vertically disposed below bowstring 32 (hereinafter, the "shoot-over" configuration).

[0058] In the shoot-over configuration, the barrel 12 may include a forked opening 54 through which the first power cable 28 and the second power cable 30 extend to provide clearance for the arrow and to protect the first power cable 28 and the second power cable 30 from an arrow's sharp arrowhead when loading and shooting the arrow. That configuration, however, requires that the first power cable 28 and the second power cable 30 be deflected slightly. A low friction guide 108 can be positioned within the forked opening 54 to guide the first power cable 28 and the second power cable 30 through the forked opening 54, to prevent them from fouling each other as they pass over one another, and to prevent them from abrading against the surfaces of the forked opening 54.

[0059] Also in the shoot-over configuration, the first power cable 28 and second power cable 30 may be horizontally disposed between the riser 20 and the bowstring 32 (see, e.g., FIG. 13), or the bowstring 32 may be horizontally disposed between the riser 20 and the first power cable 28 and second power cable 30 (see, e.g., FIG. 16). The crossbow 100' of the latter configuration (i.e., the reverse draw configuration) is substantially the same as the crossbow 100 illustrated in FIGS. 13-15, except that the first cam 102 and second cam 104 switch positions at the distal ends 16A1 & 18A1 and 16B1 & 18B1 of the limbs 16A & B and 18A & B without changing their orientation with respect to each other so that the let-out groove 102A of the first cam 102 and the let-out groove 104A of the second cam 104 both remain at the top of the first cam 102 and second cam 104, respectively.

[0060] The features of the crossbows 100 and 100' illustrated in FIGS. 13-16 provide substantially the same advantages as those described for the corresponding features of the crossbows 10, 10', 10'', 60, and 60' illustrated in FIGS. 1-12. The primary difference between those configurations is that, unlike those configurations, the first power cable 28 and the second power cable 30 are both located at the bottoms of the first cam 102 and second cam 104 and must therefore be deflected. That deflection may result in twisting forces being exerted on the limbs 16A & B and 18A & B. That twisting force, however, is significantly reduced because the let-out grooves 102A and 104A are disposed close to the hybrid grooves 102B and 104B on the first axle assembly 34A and second axle assembly 34B, respectively, thereby reducing the torque produced on the limbs 16A & B and 18A & B when the bowstring is drawn away from the riser 20. In addition, the hybrid two-groove cam configuration illustrated in FIGS.

13-16 also provides the benefit of improved cam synchronization, similar to that provided by the three-groove cam configuration illustrated in FIGS. 1-8.

[0061] Each of the configurations illustrated in FIGS. 1-16 and discussed above can also be provided with the limbs **16A** & **B** and **18A** & **B** and the riser **142** facing in the opposite direction (hereinafter, the “reverse limb” or “limb forward” configuration). FIGS. 17 and 18 illustrate a crossbow **140** and **140'** according to the hybrid two-groove cam shoot-over configuration of the present invention (see, e.g., FIGS. 13-16) with both a standard draw and a reverse draw, respectively. In addition, any of the configurations illustrated in FIGS. 1-18 can be modified and combined as required to provide any of the benefits discussed above. For example, the three-groove cam can be modified so that the first let out grooves **24A** and **26A** and the take-up grooves **24C** and **26C** are both below their associated second let-out grooves **24B** and **26C** on the first cam **24** and second cam **26**, respectively, so that the first power cable **28** and second power cable **30** are vertically disposed below the bowstring **32**, thereby providing a three-groove cam shoot-over configuration with either a standard or reverse draw.

[0062] The foregoing description and drawings should be considered as illustrative only of the principles of the invention. The invention may be configured in a variety of shapes and sizes and is not intended to be limited by the preferred embodiment. Numerous applications of the invention will readily occur to those skilled in the art. Therefore, it is not desired to limit the invention to the specific examples disclosed or the exact construction and operation shown and described. Rather, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.

What is claimed is:

1. A compound archery crossbow comprising:

- a) a stock with a barrel;
- b) at least one right limb and at least one left limb, wherein the at least one right limb and at least one left limb are mounted to the stock by a riser;
- c) a first cam and a second cam, wherein the first cam comprises a first let-out groove, a second let-out groove and a take-up groove, and the second cam comprises a first let-out groove, a second let-out groove and a take-up groove;
- d) a first power cable extending from the first let-out groove of the first cam to the take-up groove of the second cam;
- e) a second power cable extending from the first let-out groove of the second cam to the take-up groove of the first cam;
- f) a bowstring extending from the second let-out groove of the first cam to the second let-out groove of the second cam;
- g) a first axel assembly that extends through the first cam and the at least one right limb; and
- h) a second axel assembly that extends through the second cam and the at least one left limb,

wherein draw of the bowstring from the second let-out groove of the first and second cams rotates the first and second cams about the first and second axel assemblies and lets out portions of the first and second power cables from the first let-out groove on the first and second cams while taking up portions of the first and second power cables in the take up grooves of the first and second cams.

2. The crossbow of claim **1**, wherein the bowstring, the first power cable and the second power cable are substantially parallel, wherein the upper pair and the lower pair of limbs are parallel.

3. The crossbow of claim **2**, wherein the second let-out groove is positioned between the first let-out groove and the take-up groove in the first and second cam.

4. The crossbow of claim **3**, wherein the first let-out groove, the second let-out groove and the take-up groove of the second cam and the first let-out groove, the second let-out groove and the take-up groove of the first cam are inverted with respect to each other.

5. The crossbow of claim **4**, wherein the first part of the first axel assembly and first part of the second axel assembly have opposite rotation movement.

6. The crossbow of claim **5**, wherein each of the first let-out groove, the second let-out groove and the take-up groove of the first cam and the second cam comprises a base having a periphery on which the bowstring, first power cable and second cable are disposed, wherein the base of the first let-out groove of the first cam and the second cam are of substantially the same dimension, the base of the second let-out groove of the first cam and the second cam are of substantially the same dimension and the base of the take-up groove of the first cam and the second cam are of substantially the same dimension.

7. The crossbow of claim **6**, wherein the bowstring is positioned between the riser and the first and second power cables.

8. The crossbow of claim **7**, wherein the at least one right limb, the at least one left limb, the first cam, and the second cam extend forward of the riser.

9. The crossbow of claim **6**, wherein the first and second power cables are positioned between the riser and the bowstring.

10. The crossbow of claim **9**, wherein the at least one right limb, the at least one left limb, the first cam, and the second cam extend forward of the riser.

11. A compound archery crossbow comprising:

- a) a stock with a barrel;
- b) an right pair and a left pair of limbs, wherein the right pair of limbs has a first member comprising a distal end and a proximal end and a second member comprising a distal end and a proximal end and the left pair of limbs has a first member comprising a distal end and a proximal end and a second member comprising a distal end and a proximal end, wherein the right pair and the left pair of limbs are mounted to the stock by a riser, wherein an attachment means attaches the proximal end of the first member and the second member of the right pair of limbs and the proximal end of the first member and the second member of the left pair of limbs to the riser, and wherein the first member and the second member of the right pair of limbs are parallel and the first member and the second member of the left pair of limbs of limbs are parallel;

- c) a first cam and a second cam, wherein the first cam comprises a first let-out groove, a second let-out groove and a take-up groove, and the second cam comprises a first let-out groove, a second let-out groove and a take-up groove, wherein the second let-out groove is positioned between the first let-out groove and the take-up groove in the first and second cam, wherein the first let-out groove, the second let-out groove and the take-up groove of the second cam and the first let-out groove, the second let-

out groove and the take-up groove of the first cam are inverted with respect to each other;

- d) a first power cable extending from the first let-out groove of the first cam to the take-up groove of the second cam;
- e) a second power cable extending from the first let-out groove of the second cam to the take-up groove of the first cam;
- f) a bowstring extending from the second let-out groove of the first cam to the second let-out groove of the second cam, wherein the bowstring is positioned between the riser and the first and second power cables; and
- g) a first axel assembly extending through the first cam and the distal ends of the first member and second member of the right pair of limbs and a second axel assembly extending through the second cam and the distal ends of the first member and second member of the left pair of limbs,

wherein draw of the bowstring away from the riser lets out the bowstring from the second let-out groove of the first and second cam, rotates around the first and second axel assembly and lets out portions of the first and second power cables from the first let-out groove on the first and second cam.

12. The crossbow of claim **11**, wherein the bowstring, the first power cable and the second power cable are substantially parallel.

13. The crossbow of claim **12**, wherein the first part of the first axel assembly and first part of the second axel assembly have opposite rotation movement.

14. The crossbow of claim **13**, wherein each of the first let-out groove, the second let-out groove and the take-up groove of the first cam and the second cam comprises a base having a periphery on which the bowstring, first power cable and second cable are disposed, wherein the base of the first let-out groove of the first cam and the second cam are of substantially the same dimension, the base of the second let-out groove of the first cam and the second cam are of substantially the same dimension and the base of the take-up groove of the first cam and the second cam are of substantially the same dimension.

15. The crossbow of claim **14**, wherein at least one base of the first let-out groove, the second let-out groove and the take-up groove of the first cam and the second cam includes a post mounted thereto.

16. The crossbow of claim **14**, wherein the base of the take-up groove on the first and second cam includes a draw stop.

17. The crossbow of claim **14**, wherein the attachment is limb caps.

18. The crossbow of claim **14**, wherein the crossbow further comprises a receiver attached to the barrel, wherein the receiver comprises a bowstring catch, safety and trigger linkage.

19. The crossbow of claim **14**, wherein the stock includes a trigger attached to the trigger linkage, to release the bowstring from a string catch in the receiver in the loaded position.

20. The crossbow of claim **14**, wherein a groove on the barrel is positioned to hold an arrow, wherein vanes of an arrow would not contact the first or second power cable when traversed by an arrow.

21. The crossbow of claim **14**, wherein at least one base of the first let-out groove, the second let-out groove and the take-up groove of the first cam and the second cam is circular.

22. The crossbow of claim **14**, wherein at least one base of the first let-out groove, the second let-out groove and the take-up groove of the first cam and the second cam is non-circular.

23. A compound archery crossbow comprising:

- a) a stock with a barrel;
- b) limbs mounted to the stock by a riser;
- c) a first cam and a second cam, wherein the first cam comprises at least a first let-out groove and a take-up groove, and the second cam comprises at least a first let-out groove and a take-up groove;
- d) a first axel assembly extending through the first cam and the limbs;
- e) a second axel assembly extending through the second cam and the limbs;
- f) at least one independent groove traversed by the first axel assembly and at least one independent groove traversed by the second axel assembly;
- g) a first power cable extending from an anchor at the at least one independent groove traversed by the first axel assembly to the take-up groove of the second cam;
- h) a second power cable extending from an anchor at the at least one independent groove traversed by the second axel assembly to the take-up groove of the first cam;
- i) a bowstring extending from the first let-out groove of the first cam to the at least first let-out groove of the second cam;

wherein draw of the bowstring from the at least first let-out groove of the first cam and the at least first let-out groove of the second cam rotates the first cam around the first axel assembly and the second cam around the second axel assembly such that the a portion of the first power cable is pulled into the take-up groove on the first cam and a portion of the second power cable is pulled into the take-up groove on the second cam.

24. The crossbow of claim **23**, wherein the first axel assembly and the second axel assembly have opposite rotational movement.

25. The crossbow of claim **24**, wherein the bowstring is positioned between the riser and the first and second power cables.

26. The crossbow of claim **25**, wherein the limbs, the first cam, and the second cam extend forward of the riser.

27. The crossbow of claim **25**, wherein the bowstring, the first power cable, and the second power cable are substantially parallel.

28. The crossbow of claim **27**, wherein the at least first let-out groove of the first cam is positioned between the anchor at the at least one independent groove traversed by the first axel assembly and the take-up groove on the first cam and the at least first let-out groove of the second cam is positioned between the anchor at the at least one independent groove traversed by the second axel assembly and the take-up groove on the second cam.

29. The crossbow of claim **28**, wherein the at least one let-out groove and the take-up groove traversed by the first axel assembly are inverted in position with respect to the at least one let-out groove and the take-up groove traversed by the second axel assembly.

30. The crossbow of claim **29**, wherein the at least one independent groove traversed by the first axel assembly is disposed below the at least first let-out groove of the first cam and the at least one independent let-out groove traversed by

the second axel assemble is disposed above the at least first let-out groove of the second cam.

31. The crossbow of claim **30**, wherein the first and second power cables are positioned between the riser and the bow-string.

32. The crossbow of claim **31**, wherein the limbs, the first cam, and the second cam extend forward of the riser.

33. The crossbow of claim **25**, wherein a second let-out groove is provided with the take-up groove as a hybrid groove on the first cam and replaces the independent groove traversed by the first axle assembly, and a second let-out groove is

provided with the take-up groove as a hybrid groove on the second cam and replaces the independent groove traversed by the second axel assembly.

34. The crossbow of claim **33**, wherein the stock has a forked portion that is traversed by the first and second power cable, wherein means is positioned within the forked portion to guide the first and second power cables.

35. The crossbow of claim **33**, wherein the limbs and first came and second cam extend forward of the riser.

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