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United States Patent Application Publication	20250257973
Kind Code	A1
Publication Date	August 14, 2025
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BOW STRING CAM ARRANGEMENT FOR A COMPOUND BOW

Abstract

A dual-cam archery bow with simultaneous power cable take-up and let-out journals. Each cam has power cable journals located on opposite sides of the draw string journal, where at least one of power cable journals is a helical journal.

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Family ID:	**95067771**
Appl. No.:	**19/031767**
Filed:	**January 18, 2025**

Related U.S. Application Data

parent US continuation 17201847 20210315 PENDING child US 19031767
parent US continuation 15821372 20171122 parent-grant-document US 10962322 child US 17201847
parent US continuation-in-part 15294993 20161017 parent-grant-document US 9879936 child US 15821372
parent US continuation-in-part 15098537 20160414 parent-grant-document US 9494379 child US 15294993
parent US continuation-in-part 14107058 20131216 parent-grant-document US 9354015 child US 15098537
us-provisional-application US 62244932 20151022

Publication Classification

Int. Cl.: **F41B5/12** (20060101); **F41B5/06** (20060101); **F41B5/10** (20060101); **F41B5/14** (20060101)

U.S. Cl.:

CPC **F41B5/123** (20130101); **F41B5/066** (20130101); **F41B5/10** (20130101); **F41B5/105** (20130101); **F41B5/143** (20130101); F41B5/1469 (20130101)

Background/Summary

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS [0001] The present application is a continuation of U.S. patent application Ser. No. 17/201,847, entitled “Bow String Cam Arrangement for a Compound Bow,” filed Mar. 15, 2021, which is continuation of U.S. patent application Ser. No. 15/821,372, entitled “Bow String Cam Arrangement for a Compound Bow,” filed Nov. 22, 2017, which is a continuation-in-part of U.S. patent application Ser. No. 15/294,993, entitled “String Guide for a Bow,” filed Oct. 17, 2016, which is a continuation-in-part of U.S. patent application Ser. No. 15/098,537, entitled “Crossbow,” filed Apr. 14, 2016 (issued as U.S. Pat. No. 9,494,379), which claims the benefit of U.S. Prov. Application Ser. No. 62/244,932, filed Oct. 22, 2015 and is also a continuation-in-part of U.S. Pat. No. 14/107,058 entitled String Guide System for a Bow, filed Dec. 16, 2013 (issued as U.S. Pat. No. 9,354,015), the entire disclosures of which are hereby incorporated by reference.

FIELD OF THE INVENTION
[0002] The present disclosure is directed to a bow and a string guide for a bow that permits greater rotation of the cams and pulleys and a longer power stroke.
BACKGROUND OF THE INVENTION
[0003] Bows have been used for many years as a weapon for hunting and target shooting. More advanced bows include earns that increase the mechanical advantage associated with the draw of the bowstring. The cams are configured to yield a decrease in draw force near full draw. Such cams preferably use power cables that load the bow limbs. Power cables can also be used to synchronize rotation of the cams, such as disclosed in U.S. Pat. No. 7,305,979 (Yehle).
[0004] With conventional bows and crossbows the draw string is typically pulled away from the generally concave area between the limbs and away from the riser and limbs. This design limits the power stroke for bows and crossbows.
[0005] In order to increase the power stroke, the draw string can be positioned on the down-range side of the string guides so that the draw string unrolls between the string guides toward the user as the bow is drawn, such as illustrated in U.S. Pat. No. 7,836,871 (Kempf) and U.S. Pat. No. 7,328,693 (Kempf). One drawback of this configuration is that the power cables can limit the rotation of the cams to about 270 degrees. In order to increase the length of the power stoke, the diameter of the pulleys needs to be increased. Increasing the size of the pulleys results in a larger and less usable bow.
[0006] FIGS. **1**-**3** illustrate a string guide system for a bow that includes power cables **20**A, **20**B (“**20**”) attached to respective string guides **22**A, **22**B (“**22**”) at first attachment points **24**A, **24**B (“**24**”). The second ends **26**A, **26**B (“**26**”) of the power cables **20** are attached to the axles **28**A, **28**B (“**28**”) of the opposite string guides **22**. Draw string **30** engages down-range edges **46**A, **46**B of string guides **22** and is attached at draw string attachment points **44**A, **44**B (“**44**”)
[0007] As the draw string **30** is moved from released configuration **32** of FIG. **1** to drawn configuration **34** of FIGS. **2** and **3**, the string guides **22** counter-rotate toward each other about 270 degrees. The draw string **30** unwinds between the sting guides **22** from opposing cam journals **48**A, **48**B (“**48**”) in what is referred to as a reverse draw configuration. As the first attachment points **24** rotate in direction **36**; the power cables **20** are wrapped around respective power cable take-up journal of the string guides **22**, which in turn bends the limbs toward each other to store the energy

needed for the bow to fire the arrow.

[0008] Further rotation of the string guides **22** in the direction **36** causes the power cables **20** to contact the power cable take-up journal, stopping rotation of the cam. The first attachment points **24** may also contact the power cables **20** at the locations **38**A, **38**B ("**38**"), preventing further rotation in the direction **36**. As a result, rotation of the string guides **22** is limited to about 270 degrees, reducing the length **40** of the power stroke.

BRIEF SUMMARY OF THE INVENTION

[0009] The present disclosure is directed to a bow and a string guide system for a bow that permits greater rotation of the string guides and a longer power stroke.

[0010] One embodiment is directed to a bow with at least one first bow limb and at least one second bow limb attached to a riser. A first cam is mounted to the at least one first bow limb and rotatable around a first axis. The first cam comprising a first draw string journal having a first plane of rotation perpendicular to the first axis. A first helical power cable journal is located on one side of the first draw string journal and extends in a direction perpendicular to the first plane of rotation of the first draw string journal. A second helical power cable journal is located on an opposite side of the first draw string journal and extends in an opposite direction perpendicular to the first plane of rotation. A second cam is mounted to the at least one second bow limb and rotatable around a second axis. The second cam includes a second draw string journal having a second plane of rotation perpendicular to the second axis. A third helical power cable journal is located on one side of the second draw string journal and extends in a direction perpendicular to the second plane of rotation of the second draw string journal. A fourth helical power cable journal is located on an opposite side of the second draw string journal and extends in an opposite direction perpendicular to the second plane of rotation. A draw string is received in the string guide journals and secured to the first and second cams, wherein the draw string unwinds from the string guide journals as it translates from a released configuration to a drawn configuration. At least two power cables are received in each of the first, second, third and fourth helical power cable journals.

[0011] In one embodiment, the at least two power cables include first and second power cable, each of which is attached at opposite ends to the first and second cams. Rotating the first and second cams causes the helical power cable journals to displace the at least two power cables along the first and second axes relative to the first and second planes of rotation, respectively. In another embodiment, as the bow is moved between the released configuration to the drawn configuration a portion of the power cables wrap on or off each power cable journal and are displaced along the first and second axes relative to the first and second planes of rotation of the first and second draw string journals. In one embodiment, as the bow is moved from the released configuration to the drawn configuration the power cables unwind from at least two of the helical power cable journals. In another embodiment, the power cables wrap more than about 270 degrees around at least two of the helical power cable journals when the bow is in the released configuration.

[0012] In another embodiment, the at least two power cables include a first set of power cables attached to the first cam and received in the first and second helical power cable journals on the first cam, and a second set of power cables attached to the second cam and received in the third and fourth helical power cable journals on the second cam. The first set of power cables optionally is attached at an opposite end to the second cam and the second set of power cables is optionally attached at an opposite end to the first cam. In one embodiment, the power cables wrap more than about 270 degrees around at least two of the helical power cable journals when the bow is in the drawn configuration.

[0013] The present disclosure is also directed to a bow with a first cam mounted to the at least one first bow limb and rotatable around a first axis. The first cam includes a first draw string journal having a first plane of rotation perpendicular to the first axis. A first power cable journal is located on a first side of the first draw string journal and extends in a direction perpendicular to the first plane of rotation of the first draw string journal. A second power cable journal is located on an opposite side of the first draw string journal and extends in an opposite direction perpendicular to the first plane of rotation, wherein at least one of the first and second power cable journals is a helical power cable journal. A second cam is mounted to the at least one second bow limb and rotatable around a second axis. The second cam includes a second draw string journal having a second plane of rotation perpendicular to the second axis. A third power cable journal is located on a first side of the second draw string journal and extends in a direction perpendicular to the second plane of rotation of the second draw string journal. A fourth power cable journal is located on an opposite side of the second draw string journal and extends in an opposite direction perpendicular to the second plane of rotation, wherein at least one of the third and fourth power cable journals is a helical power cable journal. A draw string is received in the string guide journals and secured to the first and second cams, wherein the draw string unwinds from the string guide journals as it translates from a released configuration to a drawn configuration. A first set of power tables are attached to the first cam and received in the first and second power cable journals and a second set of power cables are attached to the second cam and received in the third and fourth power cable journals.

[0014] In one embodiment, as the bow is moved from the released configuration to the drawn configuration the power cables unwind from at least two of the power cable journals. In another embodiment, all of the power cable journals are helical power cable journals. In another embodiment, rotating the first and second cams causes the helical power cable journals to displace the upper and lower power cables along the first and second axes relative to the first and second planes of rotation, respectively. As the bow is moved between the released configuration to the drawn configuration the power cables wrap on or off the power cable journals and are displaced along the first and second axes relative to the first and second planes of rotation by the helical power cable journals. In another embodiment, as the bow is moved from the drawn configuration to the release configuration the power cables wind on at least two of the power cable journals. The power cables preferably wrap more than about 270 degrees around at least two of the power cable journals when the bow is in the released configuration.

[0015] The present disclosure is also directed to a method of configuring a dual-cam archery bow. The method includes the steps of attaching a first bow limb and a second bow limb to a riser. A first cam is mounted to the first bow limb to rotate around a first axis. The first cam includes a first drawstring journal having a first plane of rotation perpendicular to the first axis. A first helical power cable journal is located on one side of the first draw string journal and extends in a direction perpendicular to the first plane of rotation of the first draw string journal. A second helical power cable journal is located on an opposite side of the first draw string journal and extends in an opposite direction perpendicular to the first plane of rotation. A second cam is mounted to the second bow limb to rotate around a second axis. The second cam includes a second draw string journal having a second plane of rotation perpendicular to the second axis. A third helical power cable journal is located on one side of the second draw string journal and extends in a direction perpendicular to the second plane of rotation of the second draw string journal. A fourth helical power cable journal is located on an opposite side of the second draw string journal and extends in an opposite direction perpendicular to the second plane of rotation. A draw string is received in the string guide journals such that the draw string unwinds from the string guide journals as it translates from a released configuration to a drawn configuration. Power cables extend between the first and second cams and are located in helical power cable journals on at least one of the first and second cams. The first and second cams are rotated as the bow is moved between the released configuration to the drawn, configuration, displacing the power cables in the helical power cable journals along the first and second axe relative to the first and second planes of rotation, respectively, as the first and second cams rotate.

[0016] In one embodiment, opposite ends of the power cables are attached to the first and second cams, respectively. Moving the bow from the released configuration to the drawn configuration so as to cause the power cables to unwind from at least two of the helical power cable journals. In one embodiment, the power cables wrap more than about 270 degrees around at least two of the helical power cable journals when the bow is in the released configuration.

[0017] In another embodiment, the method includes attaching a first set of upper and lower power cables to the first cam and locating the first set of upper and lower power cables in the first and second helical power cable journals on the first cam and attaching a second set of upper and lower power cables to the second cam and locating the second set of upper and lower power cables in the third and fourth helical power cable journals on the second cam.

Description

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0018] FIG. **1** is a bottom view of a prior art string guide system for a bow in a released configuration.

[0019] FIG. **2** is bottom view of the string guide system of FIG. **1** in a drawn configuration.

[0020] FIG. **3** is a perspective view of the string guide system of FIG. **1** in a drawn configuration.

[0021] FIG. **4** is a bottom view of a string guide system for a bow with a helical take-up journal in accordance with an embodiment of the present disclosure,

[0022] FIG. **5** is a bottom view of the string guide system of FIG. **4** in a drawn configuration.

[0023] FIG. **6** is a perspective view of the string guide system of FIG. **4** in a drawn configuration.

[0024] FIG. **7** is an enlarged view of the left string guide of the string guide system of FIG. **4**.

[0025] FIG. **8** is an enlarged view of the right string guide of the string guide system of FIG. **4**.

[0026] FIG. **9**A is an enlarged view of a power cable take-up journal sized to two full wraps of the power cable in accordance with an embodiment of the present disclosure.

[0027] FIG. **9**B is an enlarged view of a power cable take-up journal and draw string journal sized to receive two full wraps of the power cable and draw string in accordance with an embodiment of the present disclosure.

[0028] FIG. **9**C is an enlarged view of an elongated power cable take-up journal in accordance with an embodiment of the present disclosure.

[0029] FIGS. **10** and **10**A are schematic illustrations of a bow with a string guide system in accordance with an embodiment of the present disclosure.

[0030] FIG. **11** is a schematic illustration of an alternate bow with a string guide system in accordance with an embodiment of the present disclosure.

[0031] FIG. **12** is a schematic illustration of an alternate dual-cam bow with a string guide system in accordance with an embodiment of the present disclosure.

[0032] FIGS. **13**A and **13**B are top and side views of a crossbow with helical power cable journals in accordance with an embodiment of the present disclosure.

[0033] FIG. **14**A is an enlarged top view of the crossbow of FIG. **13**A.

[0034] FIG. **14**B is an enlarged bottom view of the crossbow of FIG. **13**A.

[0035] FIG. **14**C illustrates an arrow rest in accordance with an embodiment of the present disclosure.

[0036] FIGS. **14**D and **14**E illustrate the cocking handle for the crossbow of FIG. **13**A.

[0037] FIGS. **14**F and **14**G illustrate the quiver for the crossbow of FIG. **13**A.

[0038] FIG. **15** is a front view of the crossbow of FIG. **13**A.

[0039] FIGS. **16**A and **16**B are top and bottom views of cams with helical power cable journals in accordance with an embodiment of the present disclosure.

[0040] FIGS. **17**A and **17**B are opposite side view of a trigger assembly in accordance with an embodiment of the present disclosure.

[0041] FIG. **17**C is a side view of the trigger of FIG. **17**A with a bolt engaged with the draw string

in accordance with an embodiment of the present disclosure.
[0042] FIG. **17**D is a perspective view of a low friction interface at a rear edge of a string catch in accordance with an embodiment of the present disclosure.
[0043] FIGS. **18**A and **18**B illustrate operation of the trigger mechanism in accordance with an embodiment of the present disclosure.
[0044] FIGS. **19** and **20** illustrate a cocking mechanism for a crossbow in accordance with an embodiment of the present disclosure.
[0045] FIGS. **21**A and **21**B illustrate a crossbow in a release configuration in accordance with an embodiment of the present disclosure.
[0046] FIGS. **22**A and **22**B illustrate the cams of the crossbow of FIGS. **21**A and **21**B in the release configuration.
[0047] FIGS. **23**A and **23**B illustrate the crossbow of FIGS. **21**A and **21**B in a drawn configuration in accordance with an embodiment of the present disclosure.
[0048] FIGS. **24**A, **24**B, and **24**C illustrate the cams of the crossbow of FIGS. **23**A and **23**B in the drawn configuration.
[0049] FIGS. **25**A and **25**B illustrate an alternate trigger assembly in accordance with an embodiment of the present disclosure.
[0050] FIG. **25**C is a front view of an alternate string carrier for the crossbow in accordance with an embodiment of the present disclosure.
[0051] FIGS. **26**A and **26**B illustrate an alternate cocking handle in accordance with an embodiment of the present disclosure.
[0052] FIGS. **27**A-**27**D illustrate an alternate tunable arrow rest for a crossbow in accordance with an embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE INVENTION

[0053] FIG. **4** illustrates a string guide system **90** for a bow with a reverse draw configuration **92** in accordance with an embodiment of the present disclosure. Power cables **102**A, **102**B ("**102**") are attached to respective string guides **104**A, **104**B ("**104**") at first attachment points **106**A, **106**B ("**106**"). Second ends **108**A, **108**B ("**108**") of the power cables **102** are attached to axles **110**A, **110**B ("**110**") of the opposite string guides **104**. In the illustrated embodiment, the power cables **102** wrap around power cable take-ups **112**A, **112**B ("**112**") located on the respective cam assembles **104** when in the released configuration **116** of FIG. **4**.
[0054] In the reverse drain configuration **92** the draw string **114** is located adjacent down-range side **94** of the string guide system **70** when in the released configuration **116**. In the released configuration **116** of FIG. **4**, the distance between the axles **110** may be in the range of less than about 16 inches to less than about 10 inches. In the drawn configuration **118**, the distance between the axles **110** may be in the range of about 6 inches to about 8 inches.
[0055] As illustrated in FIGS. **5** and **6**, the draw string **114** translates from the down-range side **94** toward the up-range side **96** and unwinds between the first and second string guides **104** in a drawn configuration **118**. In the illustrated embodiment, the string guides **104** counter-rotate toward each other in directions **120** more than 360 degrees as the draw string **114** unwinds between the string guides **104** from opposing cam journals **130**A, **130**B ("**130**").
[0056] The string guides **104** each include one or more grooves, channels or journals located between two flanges around at least a portion of its circumference that guides a flexible member, such as a rope, string, belt, chain, and the like. The string guides can be cams or pulleys with a variety of round and non-round shapes. The axis of rotation can be located concentrically or eccentrically relative to the string guides. The power cables and draw strings can be any elongated flexible member, such as woven and non-woven filaments of synthetic or natural materials, cables, belts, chains, and the like.
[0057] As the first attachment points **106** rotate in direction **120**, the power cables **102** are wrapped onto cams **126**A, **126**B ("**126**") with helical journals **122**A, **122**B ("**122**"), preferably located at the

respective axles **110**. The helical journals **122** take up excess slack in the power cables **102** resulting from the string guides **104** moving toward each other in direction **124** as the axles **104** move toward each other.

[0058] The helical journals **122** serve to displace the power cables **102** away from the string guides **104**, so the first attachment points **106** do not contact the power cables **102** while the bow is being drawn (see FIGS. **7** and **8**). As a result, rotation of the string guides **104** is limited only by the length of the draw string journals **130**A, **103**B ("**130**"). For example; the draw string journals **130** can also be helically in nature, wrapping around the axles **110** more than 360 degrees.

[0059] As a result, the power stroke **132** is extended. In the illustrated embodiment, the power stroke **132** can be increased by at least 25%, and preferably by 40% or more, without changing the diameter of the string guides **104**.

[0060] In some embodiments, the geometric profiles of the draw string journals **130** and the helical journals **122** contribute to let-off at full draw. A more detailed discussion of cams suitable for use in bows is provided in U.S. Pat. No. 6,990,970 (Darlington) entitled Compound Archery Bow; U.S. Pat. No. 7,305,979 (Yehle) entitled Dual-Cam Archery Bow with Simultaneous Power Cable Take-Up and Let-Out; U.S. Pat. No. 7,441,555 (Larson) entitled Synchronized Compound Archery Bow; U.S. Pat. No. 8,181,638 (Yehle) entitled Eccentric Power Cable Let-out Mechanism for Compound Archer Bow; and U.S. Pat. No. 9,423,202 (Obteshka) entitled Cable Arrangement for Compound Archery Bow, which are hereby incorporated by reference.

[0061] FIGS. **7** and **8** are enlarged views of the string guides **104**A, **104**B, respectively, with the draw string **114** in the drawn configuration **118**. The helical journals **122** have a length corresponding generally to one fall wrap of the power cables **102**. The axes of rotation **146**A, **146**B ("**146**"), of the first and second helical journals **122** preferably extend generally perpendicular to a plane of rotation of the first and second string guides **104**. The helical journals **122** displace the power cables **102** away from the draw string **114** as the bow is drawn from the released configuration **116** to the drawn configuration **118**. Height **140** of the helical journals **122** raises the power cables **102** above top surface **142** of the string guides **104**. The resulting gap **144** permits the first attachment points **106** and the power cable take-ups **112** to pass freely under the power cables **102**. The length of the helical journals **122** can be increased or decreased to optimize draw force versus draw distance for the bow and let-off. The axes of rotation **146** of the helical journals **122** are preferably co-linear with axes **110** of rotation for the string guides **104**.

[0062] FIG. **9**A illustrates an alternate string guide **200** in accordance with an embodiment of the present disclosure. Power cable take-ups **202** have helical journals **204** that permit the power cables **102** to wrap around about two full turns or about 720 degrees. The extended power cable take-up **202** increases the gap **206** between the power cables **102** and top surface **208** of the string guide **200** and provides excess capacity to accommodate more than **360** degrees of rotation of the string guides **200**.

[0063] FIG. **9**B illustrates an alternate string guide **250** in accordance with an embodiment of the present disclosure. The draw string journals **252** and the power cable journals **254** are both helical structures designed so that the draw string **114** and the power cables **102** can wrap two full turns around the string guide **250**.

[0064] FIG. **9**C illustrates an alternate string guide **270** with a smooth power cable take-up **272** in accordance with an embodiment of the present disclosure. The power cable take-up has a surface **274** with a height **276** at least twice a diameter **278** of the power cable **102**. In another embodiment, the surface **274** has a height **276** at least three times the diameter **278** of the power cable **102**. Biasing force **280**, such as from a cable guard located on the how shifts the power cables **102** along the surface **274** away from top surface **282** of the string guide **270** when in the drawn configuration **284**.

[0065] FIG. **10** is a schematic illustration of bow **150** with a string guide system **152** in accordance with an embodiment of the present disclosure. Bow limbs **154**A, **154**B ("**154**") extend oppositely from riser **156**. String guides **158**A, **158**B ("**158**") are rotatably mounted, typically eccentrically, on respective limbs **154**A, **154**B on respective axles **160**A, **160**B ("**160**") in a reverse draw configuration **174**.

[0066] Draw string **162** is received in respective draw string journals (see e.g., FIGS. **7** and **8**) and secured at each end to the string guides **158** at locations **164**A, **164**B. When the bow is in the released configuration **176** illustrated in FIG. **10**, the draw string **162** is located adjacent the down-range side **178** of the bow **150**. When the bow **150** is drawn, the draw string **162** unwinds from the draw string journals toward the up-range side **180** of the bow **150**, thereby rotating the string guides **158** in direction **166**.

[0067] First power cable **168**A is secured to the first string guide **158**A at first attachment point **170**A and engages with a power cable take-up with a helical journal **172**A (see FIGS. **7** and **8**) as the bow **150** is drawn. As the string guide **158**A rotates in the direction **166**, the power cable **168**A is taken up by the cam **172**A. The other end of the first: power cable **168**A is secured to the axle **160**B,

[0068] Second power cable **168**B is secured to the second string guide **158**B at first attachment point **170**B and engages with a power cable take-up with a helical journal **172**B (see FIGS. **7** and **8**) as the bow **150** is drawn. As the string guide **158**B rotates, the power cable **168**B is taken up by the cam **172**B. The other end of the second power cable **168**B is secured to the axle **160**A. Alternatively, the other ends of the first and second power cables **168** can be attached to the riser **156** or an extension thereof, such as the pylons **32** illustrated in commonly assigned U.S. Pat. No. 8,899,217 (Islas) and U.S. Pat. No. 8,651,095 (Islas), which are hereby incorporated by reference. Any of the power cable, and helical and/or non-helical take-up and let-out journal configurations illustrated herein can be used with the bows **150**, **150**A illustrated in FIGS. **10** and **10**A (See e.g., FIGS. **22**A and **22**B). The power cable take-ups **172** are arranged so that as the bow **150** is drawn, the bow limbs **154** are drawn toward one another.

[0069] FIG. **10**A is a schematic illustrations of a dual-cam archery bow **150**A with simultaneous Power cable take-up and let-out in accordance with an embodiment of the present disclosure. Draw cable **240** is secured at each end to the cam assemblies **230***a* and **230***b* and received in respective draw cable journals **232***a* and **232***b* thereof. When the bow is drawn, the draw cable unwinds from the draw cable journals, thereby rotating the earn assemblies. A first power cable **245***a* is secured to the first cam assembly **230***a* and engaged with a power cable take-up mechanism thereof so that as the bow is drawn and the cam assembly **230***a* rotates, the power cable **245***a* is taken up by cam assembly **230***a*. The other end of power cable **245***a* is secured to cam assembly **230***b* and engaged with a power cable let-out mechanism thereof, so that as the bow is drawn and cam assembly **230***b* rotates, power cable **245***a* is let out by cam assembly **230***b*. The power cable take-up mechanism of cam assembly **230***a* and the power cable let-out mechanism of cam assembly **230***b* are arranged so that as the bow is drawn, the bow limbs are drawn toward one another. In an analogous fashion, power cable **245***b* is secured at one end to cam assembly **230***b*, engaged with a power cable take-up mechanism thereof, and is taken up when the bow is drawn, while its other end is secured to cam assembly **230***a*, engaged with a power cable let-out mechanism thereof, and is let out when the bow is drawn.

[0070] The draw force versus draw distance for the bow is determined at least in part by: the relative rates of take-up and let-out of the first power cable by the first and second cam assemblies, respectively; and the relative rates of take-up and let-out of the second power cable by the second and first cam assemblies, respectively. The power cables are typically held out of the arrow path by a cable guard (not shown). Both take-up of the first ends of the power cables and let-out at the other ends can be manipulated, along with let-out of the draw cable, to yield a desired draw force curve. With this, additional degree of design flexibility, for example, it may be possible to generate greater let-off of draw force while maintaining a desired amount of energy stored by the bow at full draw. It may also be possible, for example, to generate a given amount of energy Stored at full draw with a smaller range of rotation of the cam assemblies, or with a smaller degree of bow limb deflection. Other advantageous adaptations that may be enabled by securing the power cables to cam assemblies at both ends thereof shall fall within the scope of the present disclosure or appended claims.

[0071] FIG. **11** is a schematic illustration of a crossbow **300** with a reverse draw configuration **302** in accordance with an embodiment atilt present disclosure. The crossbow **300** includes a center portion **304** with down-range side **306** and up-range side **308**. In the illustrated embodiment, the center portion **304** includes riser **310**. First and second flexible limbs **312**A, **312**B ("**312**") are attached to the riser **310** and extend from opposite sides of the center portion **304**.

[0072] Draw string **314** extends between first and second string guides **316**A, **316**B ("**316**"). In the illustrated embodiment, the string guide **316**A is substantially as shown in FIGS. **4-8**, while the string guide **316**B is a conventional pulley.

[0073] The first string guide **316**A is, mounted to the first bow limb **312**A and is rotatable around a first axis **318**A. The first string guide **316**A includes a first draw string journal **320**A and a first power cable take-up journal **322** A, both of which are oriented generally perpendicular to the first axis **318**A. (See e.g., FIG. **8**). The first power cable take-up journal **322**A includes a width measured along the first axis **318**A that is at least twice a width of power cable **324**.

[0074] The second string guide **316**B is mounted to the second bow limb **312**A and rotatable around a second axis **318**B. The second string guide **316**B includes a second draw string journal **320**B oriented generally perpendicular to the second axis **318**B.

[0075] The draw string **314** is received in the first and second draw string journals **320**A, **320**B and is secured to the first string guide **316**A at first attachment point **324**. The draw string extends adjacent to the down-range side **306** to the second string guide **316**B, wraps around the second string guide **316**B, and is attached at the first axis **318**A.

[0076] Power cable **324** is attached to the string guide **316**A at attachment point **326**. See FIG. **4**. Opposite end of the power cable **324** is attached to the axis **318**B. In the illustrated embodiment, power cable wraps **324** onto the first power cable take-up journal **322**A and translates along the first power cable take-up journal **322**A away from the first draw string journal **320**A as the bow **300** is drawn from the released configuration **328** to the drawn configuration (see FIGS. **5-8**).

[0077] FIG. **12** is, a schematic illustration of a dual-cam crossbow **350** with a reverse draw configuration **352** in accordance with an embodiment of the present disclosure. The crossbow **350** includes a center portion **354** with down-range slide **356** and up-range side **358**. First and second flexible limbs **362**A, **362**B ("**362**") are attached to riser **360** and extend from opposite sides of the center portion **354**. Draw string **364** extends between first and second string guides **366**A, **366**B ("**366**"). In the illustrated embodiment, the string guides **366** are substantially as shown in FIGS. **4-8**.

[0078] The string guides **366** are mounted to the bow limb **362**-and are rotatable around first and second axis **368**A, **368**B ("**368**"), respectively. The string guides **366** include first and second draw string journals **370**A, **370**B ("**370**") and first and second power cable take-up journals **372**A, **372**B ("**372**"), both of which are oriented generally perpendicular to the axes **368**, respectively. (See e.g., FIG. **8**). The power cable take-up journals **372** include widths measured along the axes **368** that is at least twice a width of power cables **374**A, **374**B ("**374**").

[0079] The draw string **364** is received in the draw string journals **370** and is secured to the string guides **316** at first and second attachment points **375**A, **375**B ("**325**").

[0080] Power cables **374** are attached to the string guides **316** at attachment points **376**A, **376**B ("**376**"). See FIG. **4**. Opposite ends **380**A, **380**B ("**380**") of the power cables **374** are attached to anchors **378**A, **378**B ("**378**") on the center portion **354**. The power cables **374** preferably do not cross over the center support **354**.

[0081] In the illustrated embodiment, power cables wrap **374** onto the power cable take-up journal **372** and translates along the power cable take-up journals **372** away from the draw string journals

370 as the bow **350** is drawn from the released configuration **378** to the drawn configuration (see FIGS. **5-8**).

[0082] The string guides disclosed herein can be used with a variety of bows and crossbows, including those disclosed in commonly assigned U.S. patent application Ser. No. 13/799,518, entitled Energy Storage Device for a Bow, filed Mar. 13, 2013 and Ser. No. 14/071,723, entitled DeCocking Mechanism for a Bow, filed Nov. 5, 2013, both of which are hereby incorporated by reference.

[0083] FIGS. **13**A and **13**B illustrate an alternate crossbow **400** in accordance with an embodiment of the present disclosure. The crossbow **400** includes a center rail **402** with a riser **404** mounted at the distal end **406** and a stock **408** located at the proximal end **410**. The arrow **416** is suspended above the rail **402** before firing. In one embodiment, the central rail **402** and the riser **404** may be a unitary structure, such as, for example, a molded carbon fiber component. In the illustrated embodiment, the stock **408** includes a scope mount **412** with a tactical, picatinny, or weaver mounting rail. Scope **414** preferably includes a reticle with gradations corresponding to the ballistic drop of bolts **416** of particular weight. The riser **404** includes a pair of limbs **420**A, **420**B (“**420**”) extending rearward toward the proximal end **410**. In the illustrate embodiment, the limbs **420** have a generally concave shape directed toward the center rail **402**. The terms “bolt” and “arrow” are both used for the projectiles launch by crossbows and are used interchangeable herein.

[0084] FIGS. **14**A and **14**B are top and bottom views of the riser **404**. Limbs **420** are attached to the riser **404** near the distal end **406** by mounting brackets **422**A, **422**B (“**422**”). In the illustrated embodiment, distal ends **424**A, **424**B (“**424**”) of the limbs **420** extend past the mounting brackets **422** to create pocket **426** that contains arrowhead **428**. Bumpers **430** are preferably attached to the distal ends **424** of the limbs **420**. The tip of the arrowhead **428** is preferably completely contained within the pocket **426**.

[0085] Pivots **432**A, **432**B (“**432**”) attached to the riser **404** engage with the limbs **420** proximally from the mounting brackets **422**. The pivots **432** provide a flexure point for the limbs **420** when the crossbow **400** is in the drawn configuration.

[0086] Cams **440**A, **440**B (“**440**”) are attached to the limbs **420** by axle mounts **442**A, **442**B (“**442**”). In the illustrated embodiment, the axle mounts **442** are attached to the limbs **420** offset a distance **446** from the proximal ends **444**A, **444**B (“**444**”) of the limbs **420**. Due to their concave shape, greatest width **448** of the limbs **420** (in both the drawn configuration and the release configuration) preferably occurs at a location between the axle mounts **442** and the pivots **432**, not at the proximal ends **444**.

[0087] The offset **446** of the axle mounts **442** maximizes the speed of the limbs **420**, minimizes limb vibration, and maximizes energy transfer to the bolts **416**. In particular, the offset **446** is similar to hitting a baseball with a baseball bat at a location offset from the tip of the bat, commonly referred to as the “sweet spot”. The size of the offset **446** is determined empirically for each type of limb. In the illustrated embodiment, the offset **446** is about 1.5 to about 4 inches, and more preferably about 2 to about 3 inches.

[0088] Tunable arrow rest **490** is positioned just behind the pocket **426**. A pair of supports **492** are secured near opposite sides of the bolt **416** by fasteners **494**. The supports **492** preferably slide in the plane of the limbs **420**. As best illustrated in FIG. **14**C, the separation **496** between the supports **492** can be adjusted to raise or lower front end of the bolt **416** relative to the draw string **501**. In particular, by increasing the separation **496** between the supports **492** the curved profile of the front end of the bolt **416** is lowered relative to the string carrier **480** (see FIG. **17**A). Alternatively, by decreasing the separation **496** the curved profile of the bolt **416** is raised.

[0089] FIG. **14**B illustrates the bottom of the riser **404**. Rail **450** on the riser **404** is used as the attachment point for accessories, such as quiver **452** for holding, bolts **416** and cocking handle **454** that engages with pins **570** to rotate the driver shaft **564** (see FIG. **18**A).

[0090] FIG. **14**D illustrates the cocking handle **454** in greater detail. Distal end **700** is configured to engage with drive shaft **564** and pins **570** illustrated in FIG. **18**A. Center recess **702** receives the drive shaft **564** and the undercuts **704** engage with the pins **570** when the system is under tension. Consequently, when cocking or uncocking the crossbow **400** the tension in the system locks the pins **570** into the undercuts **704**. When tension in the system is removed, the cocking handle **454** can be rotated a few degrees and disengaged from the drive shaft **564**.

[0091] The distal end **700** includes stem **706** that extends into hollow handle **708**. Pins **710** permit the stem **706** to rotate a few degrees around pin **712** in either direction within the hollow handle **708**. As best illustrated in FIG. **14**E, torque assembly **714** is located in hollow handle **708** that resists rotation of the stem **706** until a pre-set torque is reached. Once that torque threshold is exceeded, the stem **706** breaks free of block **716** and rotates within the hollow handle **708**, generating an audible noise and snapping sensation that signal to the user that the crossbow **400** is fully cocked.

[0092] FIGS. **14**F and **14**G illustrate a mounting system **730** for the quiver **452** and the cocking handle **454**. Quiver spine **732** includes a pair of mounting posts **734** spaced to engage with openings **736** in the mounting bracket **738**. Magazine catch **740** (see FIG. **14**G) slides within mounting bracket **738**. Spring **742** biases the magazine catch **740** in direction **744**. Openings **746** in the magazine catch **740** engage with undercuts **748** on the mounting posts **734** under pressure from the spring **742**. To remove the quiver **452** the user presses the handle **750** in direction **752** until the openings **746** in the magazine catch **740** are aligned with the openings **736** in the mounting bracket **738**. Once aligned, the mounting posts **734** can be removed from the mounting bracket **738**.

[0093] FIG. **15** is a front view of the crossbow **400** with the draw string or the power cables removed to better illustrate the cams **440** having upper and lower helical journals **460**A, **460**B above and below draw string journal **464**. As illustrated in FIG. **21**A, separate power cables **610**A, **610**B are operatively engaged with each of the helical journals **460**A, **460**B, and minimizing torque on the cams **440**. The draw string journal **464** defines plane **466** that passes through the bolt **416**. The helical journals **460**A, **460**B move the power cables **610**A, **610**B in directions **468**A, **468**B, respectively, away from the plane **466** as the bow **400** is drawn.

[0094] FIGS. **16**A and **16**B are upper and lower perspective views of the cams **440** with the power cables and draw string removed. Recess **470** contains draw string mount **472** located generally in the plane **466** of the draw string journal **464**. Power cable attachment **462**A and pivot post **463**A correspond to helical journal **460**A. As best illustrated in FIG. **16**B, power cable attachment **462**B and pivot post **463**B corresponds to the helical journal **460**B. The-pivot pots **463** serve to take-up a portion of the power cables **610** and redirect the power cables **610** onto the helical journals **460**.

[0095] FIGS. **17**A through **17**D illustrate string carrier **480** for the crossbow **400** in accordance with an embodiment of the present disclosure. As best illustrated in FIG. **21**A, the string carrier **480** slides along axis **482** of the center rail **402** to the location **483** (see FIG. **21**A) to capture the draw string **501**. After the string carrier **480** captures the draw string **501**, the cocking mechanism **484** (see FIGS. **18**A and **18**B) is used to return the string carrier **480** back to the position illustrated in FIGS. **17**A and **17**B at the proximal end **410** of the crossbow **400** and into engagement with trigger **558**.

[0096] The string carrier **480** includes fingers **500** on catch **502** that engage the draw string **501**. The catch **502** is illustrated in a closed position **504**. After firing the crossbow the catch **502** is retained in open position (see FIG. **18**B), such as for example, by spring **510** in the illustrated embodiment, the catch biasing force is applied to the catch **502** by spring **510** to rotate in direction **506** around pin **508** and retains the catch **502** in the open position **505**. Absent an external force, the catch **502** automatically move to open position **505** (see FIG. **18**B) and releases the draw string **501**.

[0097] In the closed position **504** illustrated in FIGS. **17**A, **17**B, **18**A, recess **512** on sear **514** engages low friction device **513** at rear edge of the catch **502** at interface **533** to retain the catch **502** in the closed position **504**. The sear **514** is biased in, direction **516** by a sear biasing force applied by spring **511** to engage with and retain the catch **502** in the closed position **504**.

[0098] FIG. **17**D illustrates the string carrier **480** with the sear **514** removed for clarity. In the illustrated embodiment, the low friction device **513** is a roller pin **523** mounted in rear portion of the catch **520**. In one embodiment, the roller pin **523** has a diameter corresponding generally to the diameter of the recess **512**. The roller pin **523** is preferably supported by ball bearings **525** to reduce friction between the catch **502** and the recess **512** when firing the crossbow **400**. A force necessary to overcome the friction at the interface **533** to release the catch **502** is preferably less than about 1 pound, substantially reducing the trigger pull weight. In an alternate embodiment, the positions of the roller pin **523** and the ball bearings **525** can be reversed so that the sear **514** engages directly on the ball bearings **525**.

[0099] In one embodiment, a force necessary to overcome the friction at the interface **533** to release the catch **502** is preferably less than the biasing force applied to the sear **514** by the spring **511**. This feature causes the sear **514** to return fully to the cocked position **524** in the event the trigger **558** is partially depressed, but then released before the catch **502** releases the draw string **501**.

[0100] In another embodiment, a force necessary to overcome the friction at the interface **533** to release the catch **502** is preferably less than about 3.2% and more preferably less than about 1.6% of the draw force to retain the draw string **501** to the drawn configuration. The draw force can optionally be measured as the force on the flexible tension member **585** when the string carrier **480** is in the drawn position (See-Figure **18**A).

[0101] Turning back to FIGS. **17**A and **17**B, when in safe position **509** shoulder **520** on safety **522** retains the sear **514** in a cocked position **524** and the catch **502** in the closed position **504**. Safety button **530** is used to move the safety **522** in direction **532** from the safe position **509** illustrated in FIGS. **17**A and **17**B to free position **553** (see FIG. **18**B) with the shoulder **520** disengaged from the sear **514**.

[0102] A dry fire lockout biasing force is applied by spring **540** to bias dry fire lockout **542** toward the catch **502**. Distal end **544** of the dry fire lockout **542** engages the sear **514** in a lockout position **541** to prevent the sear **514** from releasing the catch **502**. Even if the safety **522** is disengaged from the sear **514**, the distal end **544** of the dry fire lock out **542** retains the sear **514** in the cocked position **524** to prevent the catch **502** from releasing the draw string **501**.

[0103] FIG. **17**C illustrates the string carrier **480** with the catch **502** removed for clarity. Nock **417** of the bolt **416** is engaged with the dry fire lockout **542** and rotated it in the direction **546**. Distal end **544** of the dry fire lockout **542** is now in disengaged position **547** relative to the sear **514**. Once the safety **522** is removed from the safe position **509** using the safety button **530**, the crossbow **400** can be fired. In the illustrated embodiment, the nock **417** is a clip-on version that flexes to form a snap-fit engagement with the draw string **501**. Only when a bolt **416** is fully engaged with the draw string **501** will the dry fire lockout **542** be in the disengaged position **547** that permits the sear **514** to release the catch **502**.

[0104] FIGS. **18**A and **18**B illustrate the relationship between the string carrier **480**, the cocking mechanism **484**, and the trigger assembly **550** that form string control assembly **551**. The trigger assembly **550** is mounted in the stock **408**, separate from the string carrier **480**. Only when the string carrier **480** is fully retracted into the stock **408** is the trigger pawl **552** positioned adjacent to the sear **514**. When the user is ready to fire the crossbow **400**, the safety button **530** is moved in direction **532** to a free position **553** where the extension **515** is disengaged from the shoulder **520**. When the trigger **558** is depressed the sear **514** rotating in direction **517** to a de-cocked position **557** and the catch **502** moves to the open position **505** to release the draw string **501**.

[0105] As best illustrate in FIG. **18**B, after firing the crossbow the sear **514** is in a de-cocked position **557** and the safety **522** is in the free position **553**. The catch **502** retains the sear **514** in the de-cocked position **557** even though the spring **511** biases it toward the cocked position **524**. In the de-cocked position **557** the sear **514** retains the dry fire lockout **542** in the disengaged position **547** even though the spring **540** biases it toward lockout position **541**. The extension **515** on the sear **514** is located in recess **521** on the safety **522**.

[0106] To cock the crossbow **400** again the string carrier **480** is moved forward to location **483** (see FIG. **21**A) into engagement with the draw string **501**. Lower edge **503** of the catch **502** engages the draw string **501** and overcomes the force of spring **510** to automatically push the catch **502** to the closed position **504** (See FIG. **18**A). Spring **511** automatically rotates the sear **514** back into the cocked position **524** so recess **512** formed interface **533** with the catch **502**. Rotation of the sear **514** causes the extension **515** to slide along the surface of the recess **521** until it engages with the shoulder **520** on the safety **522** in the safe position **509**. With the sear **514** back in the cocked position **524** (See FIG. **18**A), the spring **540** biases dry fire lockout **542** to the lockout position **541** so the distal end **544** engages the sear **514** to prevent the catch **502** from releasing the draw string **501** (See FIG. **18**A) until an arrow is inserted into the sting carrier **480**. Consequently, when the string carrier **480** is pushed into engagement with the draw string **501**, the draw string **501** pushes the catch **502** from the open position **505** to the closed position **504** to automatically (i) couple the sear **514** with the catch **502** at the interface **533** to retain the catch **502** in the closed position **504**, (ii) move the safety **522** to the safe position **509** coupled with the seat **514** to retain the sear **514** in the cocked position **524**, and (iii) move the dry fire lockout **542** to the lockout position **541** to block the sear **514** from moving to the de-cocked position **557**.

[0107] The cocking mechanism **484** includes a spool **560** with a flexible tension member, such as for example, a belt, a tape of webbing material **585**, attached to pin **587** on the string carrier **480**. As best illustrated in FIGS. **19** and **20**, the cocking mechanism **484** includes drive shaft **564** with a pair of drive gears **566** meshed with gear teeth **568** on opposite sides of the spool **560**. Consequently, the spool **560** is subject to equalize torque applied to the spool **560** during the cocking operation. Cocking handle **454** releasably attaches to either of exposed ends of pin **570** of the driver shaft **564**.

[0108] A pair of pawls **572**A, **572**B ("**572**") include teeth **574** (see FIG. **20**) that are biased into engage with the gear teeth **568**. The pawls **572** are preferably offset ½ the gear tooth **568** spacing so that when the teeth **574** of one pawl **572** are disengaged from the gear teeth **568**, the teeth **574** on the pawl **572** are positioned to engage the gear teeth **568**. Consequently, during winding of the spool **560**, the teeth **574** on one of the pawls **572** are always positioned to engage with the gear teeth **568** on the spool. If the user inadvertently released the cocking handle **454** when the crossbow **400** is under tension, one of the pawls **572** is always in position to arrest rotation of the spool **560**.

[0109] In operation, the user presses the release **576** to disengage the pawls **572** from the spool **560** and proceeds to rotate the cocking handle **454** to move the string carrier **480** in either direction **482** along the rail **402** to cock or de-cocking the crossbow **400**. Alternatively, the crossbow **400** can be cocked without depressing the release **576**, but the pawls **572** will make a clicking sound as they advance over the gear teeth **568**.

[0110] FIGS. **21**A and **21**B illustrate the crossbow **400** in the released configuration **600**. Draw string **501** is located adjacent down-range side **602** of the cams **440** in a reverse draw configuration **604**. In the illustrated embodiment of the released configuration **600** the draw string **501** is adjacent stops **606** attached to power cable bracket **608**.

[0111] Upper power cables **610**A are attached to the power cable bracket **608** at upper attachment points **612**A and to power cable attachments **462**A on the cams **440** (see also FIG. **22**A). Lower power cables **610**B are attached to the power cable bracket **608** at lower attachment points **612**B and to the power cable attachments **462**B on the cams **440** (see also FIG. **22**B).

[0112] In the illustrated embodiment, the attachment points **612**A, **612**B for the respective power cables **610** are located on opposite sides of the center rail **402**. Consequently, the power cables **610** do not cross over the center rail **402**. As used herein, "without crossover" refers to a cabling system in which power cables do not pass through a vertical plane bisecting the center rail **402**.

[0113] As best illustrated in FIG. **21**B, the upper and lower attachment points **612**A, **612**B on the power cable bracket **608** maintains gap **614** between the upper and lower power cables **610**A, **610**B greater than the gap at the axes of the cams **440**, Consequently, the power cables **610**A, **610**B angle toward each other near the cams **440**.

[0114] FIGS. **22**A and **22**B are tipper and lower perspective views of the cams **440** with the cables **510**, **610**A, and **610**B in the released configuration **600**. The cams **440** are preferably symmetrical so only one of the cams **440** is illustrated. Upper power cables **610**A are attached to power cable attachments **462**A, wrap around the upper pivots **463**A and then return toward the, bow **400** to attach to the power cable bracket **608** (See FIG. **21**A). The draw cable **501** is, attached to the draw string mount **472** and then wraps almost completely around the cam **440** in the draw string journal **464** to the down range side **602**.

[0115] FIGS. **23**A and **23**B illustrate the crossbow **400** in the drawn configuration **620**. Draw string **501** extends from the down-range side **602** of the cams **440** in a reverse draw configuration **604**. As best illustrated in FIG. **23**B, the power cables **610**A, **610**B move away from the cams **440** as they wrap onto the upper and lower helical journals **460**A, **460**B. In the drawn configuration **620** the power cables **610**A, **610**B are generally parallel (compare the angled relationship in the released configuration **600** illustrated in FIG. **21**B). The resulting gap **622** permits the power cable attachments **462** and pivot **463** to pass under the power cables **610** without contacting them (see also, FIGS. **24**A and **24**B) as the crossbow **400** moves between the released configuration **600** and the drawn configuration **620**. As best illustrated in FIG. **24**C, gaps **623** between surfaces **625** of the cams **440** and the power cables **610** is greater than height **627** of the power cable attachments **462** and the pivots **463**.

[0116] FIGS. **24**A and **24**B are upper and lower perspective views of the cams **440** with the cables **510**, **610**A, and **610**B in the drawn configuration **620**. The upper power cables **610**A wraps around the upper pivots **463**A and then onto the upper helical journal **460**A, before returning to the power cable bracket **608** (see FIG. **23**A). Similarly, the lower power cables **610**B wraps around the lower pivots **463**B and then onto the lower journal **460**B, before returning to the power table bracket **608** (see FIG. **23**A). The draw cable **501** attached to the draw string mount **472** unwraps almost completely from the draw string journal **464** of the cam **440** to the down range side **602**.

[0117] In the illustrated embodiment, the draw string journal **464** rotates between about 270 degrees APO about 33.0 degrees, and more preferably from about 300 degrees to about 360 degrees, when the crossbow **400** is drawn from the released configuration **600** to the drawn configuration **620**. In another embodiment, the draw string journal **464** rotates more than 360 degrees (see FIG. **9**A).

[0118] FIGS. **25**A and **25**B illustrate an alternate string carrier **480**A for the crossbow **400** in accordance with an embodiment of the present disclosure. The string carrier **480**A is similar to the assembly illustrated in FIGS. **17**A-**17**C, so the same reference numbers are used where applicable.

[0119] FIG. **25**A illustrates the catch **502** is illustrated in a closed position **504**. The catch **502** is biased by spring **510** to rotate in direction **506** and retained in open position **505** (see FIG. **18**B). Absent an external force, the catch **502** automatically releases the draw string **501** (See FIG. **17**A). In the closed position **504** illustrated in FIG. **25**A, recess **512** on sear **514** engages with low friction device **513** on the catch **502** to retain the catch **502** in the closed position **504**. The sear **514** is biased by spring **519** to retain the catch **502** in the closed position **504**. The safety **522** operates as discussed in connection with FIGS. **17**A-**17**C.

[0120] Spring **540**A biases dry fire lockout **542**A toward the catch **502**. Distal end **544**A of the dry fire lockout **542**A engages the sear **514** in a lockout position **541** to prevent the sear **514** from releasing the catch **502**. Even if the safety **522** is disengaged from the sear **514**, the distal end **544**A of the dry fire lockout **542**A locks the sear **514** in the closed position **504** to prevent the catch **502** from releasing the draw sting **501**.

[0121] As illustrated in FIG. **25**B, when the bolt **416** is positioned on the string carrier **480**A the rear portions or arms on the clip-on nock **417** extends past the draw string **501** (so a portion of the nock **417** is behind the draw sting **501**) and engages with the portion **543**A on the dry fire lockout **542**A, causing the dry fire lockout **542**A to rotate in direction **546**A so that the distal end **544**A is disengaged front the sear **514**. In the illustrated embodiment, the portion **543**A is a protrusion or finger on the dry fire lockout **542**A. Only when a bolt **416** is fully engaged with the draw string **501** will the dry fire lockout **542**A permit the sear **514** to release the catch **502**.

[0122] In the illustrated embodiment, the portion **543**A on the dry fire lockout **542**A is positioned behind the draw string location **501**A. As used herein, the phrase “behind the draw string” refers to region between a draw string and a proximal end of a crossbow. Conventional flat or half-moon nocks do not extend far enough rearward to reach the portion **543**A of the dry fire lockout **542**A, reducing the chance that non-approved arrows can be launched by the crossbow **400**.

[0123] FIGS. **25**A and **25**B illustrate elongated arrow capture recess **650** that retains rear portion **419** of the arrow **416** and the clip-on nock **417** engaged with the string earlier **480**A in accordance with an embodiment of the present disclosure. The elongated arrow capture recess. **650** extends along a direction of travel of an arrow launched from the crossbow **400**. The arrow capture recess **650** is offset above the rail **402** as is the rest **490** (see FIG. **14**C) so the arrow **416** is suspended above the rail **402** (see FIG. **13**B).

[0124] Upper roller **652** is, located near the entrance of the arrow capture recess **650**. The upper roller **652** is configured to rotate in the direction of travel of the arrow **416** as it is launched. That is, the axis of rotation of the upper roller **652** is perpendicular to a longitudinal axis of the arrow **416**. The upper roller **652** is displaced within the slot in a direction generally perpendicular to the arrow **416**, while spring **654** biases the upper roller **652** in direction **656** against the arrow **416**. As best illustrated in FIG. **25**C, the arrow capture recess **650** extends rearward past the fingers **500** on catch **502**. The string carrier **480**A includes lower angled surfaces **658**A, **658**B (“**658**”) and upper angled surfaces **660**A, **660**B (“**660**”) configured to engage the arrow **416** around the perimeter of the rear portion.

[0125] In the illustrated embodiment, the clip-on nock **417** must be fully engaged with the draw string **510**A near the rear of the arrow capture recess **650** to disengage the dry fire lock out **542**A. In this configuration (see FIG. **25**B), the rear portion **419** of the arrow **416** is fully engaged with the arrow capture recess **650**, surrounded by the rigid structure of the string carrier **480**A.

[0126] In one embodiment, the lower angled surfaces **658** do not support the arrow **416** in the arrow capture recess **650** unless the clip-on nock **417** is used. In particular, the upper angled surfaces **660** prevent the nock **417** from rising upward when the crossbow **400** is fired, but the arrow **417** tends to slide downward off the lower angled surfaces **658** unless the clip-on nock **417** is fully engaged with the draw string **519**A.

[0127] By contrast, prior art crossbows typically include a leaf spring or other biasing structure to retain the arrow against the rail. These devices tend to break and are subject to tampering, which can compromise accuracy.

[0128] FIG. **26**A illustrates an alternate the cocking handle **720** with an integral clutch to prevent excessive torque on the cocking mechanism **484** and tension on the flexible tension member **585** in accordance with an embodiment of the present disclosure. As discussed in connection with FIG. **14**D, distal end **700** is configured to engage with drive shaft **564** and pins **570**. Center recess **702** receives the drive shaft **564** and the undercuts **704** engage with the pins **570** when the system is under tension. Consequently, when cocking or uncocking the crossbow **400** the tension in the system locks the pins **570** into the undercuts **704**. When tension in the system is removed, the cocking handle **454** can be rotated a few degrees and disengaged front the drive shaft **564**.

[0129] FIG. **26**B is an exploded view of the cocking handle **720** of FIG. **26**A. Distal end **700** contains a torque control mechanism **722**. Head **724** that engages with the drive shaft **564** is contained between a pair of opposing friction washers **726** and a pair of opposing notched washers **728**. Pins **730** couple the notched washers **728**. One or more spring washers **732**, such as for example Belleville washers, conical spring washers, and the like, maintain a compressive load on

the head **724** to control the torque applied to the drive shaft **564**. In an alternate embodiment, the torque control mechanism **722** is located in the stock **408** between the drive shaft **564** and the spool **560**.
[0130] FIGS. **27**A-**27**C illustrates an alternate tunable arrow rest **750** in accordance with an embodiment of the present disclosure. The tunable arrow rest **750** includes housing **760** that is positioned just behind the pocket **426**. A pair of spring loaded support rollers **752** are rotatably secured in slots **754** by pins **756**. The support rollers **752** rotate freely around the pins **756**. When compressed, the support rollers **752** can be independently displaced in directions **758**. Springs **764** (see FIG. **27**B) bias the pins **756** and the support rollers **752** to the tops of the slots.
[0131] As best seen in FIG. **27**B with the housing **760** removed, arrow rest **750** is mounted to distal end **776** of the center rail **402** by fasteners **762**. Each of the support rollers **752** is biased to the tops of the slots **754** by the springs **764**. Rotating member **766** is provided at the interface between the support rollers **752** and the springs **764** to reduce friction and permit the support rollers **752** to turn freely.
[0132] As best seen in FIGS. **27**C and **27**D the housing **760** includes enlarged openings **768** with diameters larger than the diameters of the fasteners **762**. Consequently, the position of the arrow rest **750** can be adjusted (i.e., tuned) in at three degrees of freedom—the Y-direction **770**, the Z-direction **772**, and roll **774** relative to the center rail **402**. FIG. **27**D illustrates an arrow **412** with arrowhead **428** positioned on the support rollers **752** and the various degrees of freedom **770**, **772**, **774** available for tuning the arrow rest **750**.
[0133] Where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit unless the context clearly dictates otherwise, between the upper and lower limit of that range and any other stated or intervening value in that stated range is encompassed within this disclosure. The upper and lower limits of these smaller ranges which may independently be included in the smaller ranges is also encompassed within the disclosure, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either both of those included limits are also included in the disclosure.
[0134] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the various methods, and materials are now described. All patents and publications mentioned herein, including those cited in the Background of the application, are hereby incorporated by reference to disclose and described the methods and/or materials in connection with which the publications are cited.
[0135] The publications discussed herein are provided solely for their disclosure prior to the filing date of the present application. Nothing herein is to be construed as an admission that the present disclosure is not entitled to antedate such publication by virtue of prior invention. Further, the dates of publication provided may be different from the actual publication dates which may need to be independently confirmed.
[0136] Other embodiments are possible. Although the description above contains much specificity, these should not be construed as limiting the scope of the disclosure, but as merely providing illustrations of some of the presently preferred embodiments. It is also contemplated that various combinations or sub-combinations of the specific features and aspects of the embodiments may be made and still fall within the scope of this, disclosure. It should be understood that various features and aspects of the disclosed embodiments can be combined with or substituted for one another in order to form varying modes disclosed. Thus, it is intended that the scope of at least some of the present disclosure should not be limited by the particular disclosed embodiments described above.
[0137] Thus the scope of this disclosure should be determined by the appended claims and their legal equivalents. Therefore, it will be appreciated that the scope of the present disclosure fully

encompasses other embodiments which may become obvious to those skilled in the art, and that the scope of the present disclosure is accordingly to be limited by nothing other than the appended claims, in which reference to an element in the singular is not intended to mean “one and only one” unless explicitly so stated, but rather “one or more.” All structural, chemical, and functional equivalents to the elements of the above-described preferred embodiment that are known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the present claims. Moreover, it is not necessary for a device or method to address each and every problem sought to be solved by the present disclosure for it to be encompassed by the present claims. Furthermore, no element, component, or method step in the present disclosure is intended to be dedicated to the public regardless of whether the element, component, or method step is explicitly recited in the claims.

Claims

1-24. (canceled)
25. A bow comprising: a center rail defining a projectile axis, an up-range side proximate a user, and a down-range side; a riser coupled to the center rail; a first limb coupled to the riser and positioned to a first side of the center rail; a second limb coupled to the riser and positioned to a second side of the center rail; a first cam rotatably coupled to the first limb, the first cam rotatable about a first axis; a second cam rotatably coupled to the second limb, the second cam rotatable about a second axis; a drawstring coupled to the first cam and the second cam, the drawstring configured to move along the projectile axis between a released configuration and a drawn configuration, wherein in the released configuration, the drawstring extends between the first cam and the second cam, at least a portion of the drawstring positioned to a down-range side of the first cam and a down-range side of the second cam; a string carrier slidably coupled to the center rail and movable between a first position with the drawstring in the released configuration and a second position with the drawstring in the drawn configuration, the string carrier configured to engage the drawstring and move between the first position and the second position to move the drawstring between the released configuration and the drawn configuration; and a first power cable and a second power cable, the first power cable coupled to the first cam and the second cam, the second power cable coupled to the first cam and the second cam; wherein, during operation of the bow with the drawstring in the drawn configuration, a distance between the first axis and the second axis is less than 10 inches.
26. The bow of claim 25, wherein during operation of the bow with the drawstring in the drawn configuration, the distance is between 6 inches and 8 inches.
27. The bow of claim 25, wherein the first cam includes a first power cable journal and a second power cable journal, wherein during operation of the bow as the drawstring moves from the released configuration to the drawn configuration, the first power cable winds onto the first power cable journal and the second power cable unwinds from the second power cable journal.
28. The bow of claim 25, wherein the second cam includes a first power cable journal and a second power cable journal, wherein during operation of the bow as the drawstring moves from the released configuration to the drawn configuration, the second power cable winds onto the first power cable journal and the first power cable unwinds from the second power cable journal.
29. The bow of claim 25, further comprising an arrow rest coupled to the center rail and positioned proximate the down-range side of the center rail, the arrow rest comprising a pair of rollers rotatably coupled to the arrow rest, the pair of rollers structured to support a shaft of a projectile.
30. The bow of claim 25, further comprising a cocking mechanism to move the string carrier from the first position to the second position when the string carrier engages the drawstring, the cocking mechanism comprising: a spool with a flexible tension member, the flexible tension member configured to engage the string carrier; and a cocking handle selectively coupled to the spool and

configured to receive a user input to rotate the spool to wind the flexible tension member onto the spool.

31. The bow of claim 30, wherein the string carrier further comprises a string catch, the string catch including a pair of fingers to engage the drawstring, wherein a portion of the drawstring positioned between the pair of fingers is exposed to engage a nock of a projectile.

32. The bow of claim 25, wherein: the first cam includes a first let-out journal and a first take-up journal, the first let-out journal configured to unwind second power cable and the first take-up journal configured to wind the first power cable as the first cam rotates in a first direction about the first axis; and the second cam includes a second let-out journal and a second take-up journal, the second let-out journal configured to unwind the first power cable and the second take-up journal configured to wind the second power cable as the second cam rotates in a second direction about the second axis.

33. The bow of claim 32, wherein the first take-up journal is a helical power cable journal structured to wrap the first power cable along a helical path.

34. A bow comprising: a center rail defining a projectile axis, an up-range side proximate a user, and a down-range side; a riser coupled to the center rail; a first limb coupled to the riser and positioned to a first side of the center rail; a second limb coupled to the riser and positioned to a second side of the center rail; a first cam rotatably coupled to the first limb, the first cam rotatable about a first axis; a second cam rotatably coupled to the second limb, the second cam rotatable about a second axis; a drawstring coupled to the first cam and the second cam, the drawstring configured to move along the projectile axis between a released configuration and a drawn configuration, wherein in the released configuration, the drawstring extends between the first cam and the second cam, at least a portion of the drawstring positioned to a down-range side of the first cam and a down-range side of the second cam; a string carrier slidably coupled to the center rail, the string carrier moveable between a first position with the drawstring in the released configuration and a second position with the drawstring in the drawn configuration, the string carrier configured to engage the drawstring and move from the first position and the second position to move the drawstring from the released configuration and the drawn configuration; and a cocking mechanism including a spool and a flexible tension member, the flexible tension member coupled with the string carrier, the spool configured wind the flexible tension member to move the string carrier from the first position to the second position; wherein, during operation of the bow with the drawstring in the drawn configuration, a distance between the first axis and the second axis is less than 10 inches.

35. The bow of claim 34, wherein the cocking mechanism further comprises: a drive shaft including a pin and a pair of drive gears, the pair of drive gears configured to engage with the spool to rotate the spool in a first direction; a cocking handle releasably engageable with the pin of the drive shaft, the cocking handle configured to receive a user input to rotate the spool to wind the flexible tension member onto the spool; a pawl configured to engage the spool to arrest rotation of the spool in a second direction; and a release operatively coupled to the pawl and configured to disengage the pawl from the spool to allow rotation of the spool in the second direction.

36. The bow of claim 34, wherein during operation of the bow with the drawstring in the released configuration, a first distance between the first axis of the first cam and the second axis of the second cam is about 10 inches to about 16 inches.

37. The bow of claim 34, wherein as the drawstring moves along the projectile axis from the released configuration to the drawn configuration: the second cam unwinds a first power cable, and the first cam winds the first power cable; and the first cam unwinds a second power cable, and the second cam winds the second power cable.

38. The bow of claim 37, wherein the first cam and the second cam include a plurality of helical power cable journals structured to wrap the first power cable and the second power cable along a helical path.

39. The bow of claim 34, further comprising an arrow rest coupled to the center rail and positioned proximate the down-range side of the center rail, the arrow rest comprising a pair of rollers rotatably coupled to the arrow rest, the pair of rollers structured to support a shaft of a projectile.
40. The bow of claim 34, wherein the string carrier further comprises a string catch, the string catch including a pair of fingers to engage the drawstring, wherein a portion of the drawstring positioned between the pair of fingers is exposed to engage a nock of a projectile.
41. A bow comprising: a center rail defining a projectile axis, an up-range side proximate a user, and a down-range side proximate a target; a riser coupled to a center rail; a first limb coupled to the riser and positioned to a first side of the center rail; a second limb coupled to the riser and positioned to a second side of the center rail; a first cam rotatably coupled to the first limb, the first cam rotatable about a first axis; a second cam rotatably coupled to the second limb, the second cam rotatable about a second axis; a drawstring coupled to the first cam and the second cam, the drawstring configured to move along the projectile axis between a released configuration and a drawn configuration, wherein in the released configuration, the drawstring extends between the first cam and the second cam, at least a portion of the drawstring positioned to a down-range side of the first cam and a down-range side of the second cam; and a string carrier slidably coupled to the center rail and movable between a first position with the drawstring in the released configuration and a second position with the drawstring in the drawn configuration, the string carrier comprising a string catch with a pair of fingers to engage the drawstring, wherein a portion of the drawstring positioned between the pair of fingers is exposed to engage a nock of a projectile; wherein, during operation of the bow with the drawstring in the drawn configuration, a distance between the first axis and the second axis is less than 10 inches.
42. The bow of claim 41, further comprising an arrow rest coupled to the center rail and positioned proximate the down-range side of the center rail, the arrow rest comprising a pair of rollers rotatably coupled to the arrow rest, the pair of rollers structured to support a shaft of a projectile.
43. The bow of claim 41, further comprising a first power cable and a second power cable, the first power cable coupled to the first cam and the second cam, the second power cable coupled to the first cam and the second cam.
44. The bow of claim 43, further comprising a cocking mechanism to move the string carrier from the first position to the second position when the string carrier engages the drawstring, the cocking mechanism comprising: a spool with a flexible tension member, the flexible tension member configured to engage the string carrier; and a cocking handle selectively coupled to the spool and configured to receive a user input to rotate the spool to wind the flexible tension member onto the spool.
