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(54) **VARIABLE RADIUS FAIRLEAD**

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B63B 21/10 (2006.01)

(52) **U.S. Cl.**
CPC ***B66D 1/36*** (2013.01); ***B63B 21/10*** (2013.01)

(58) **Field of Classification Search**
CPC B66D 1/36; B63B 21/10
See application file for complete search history.

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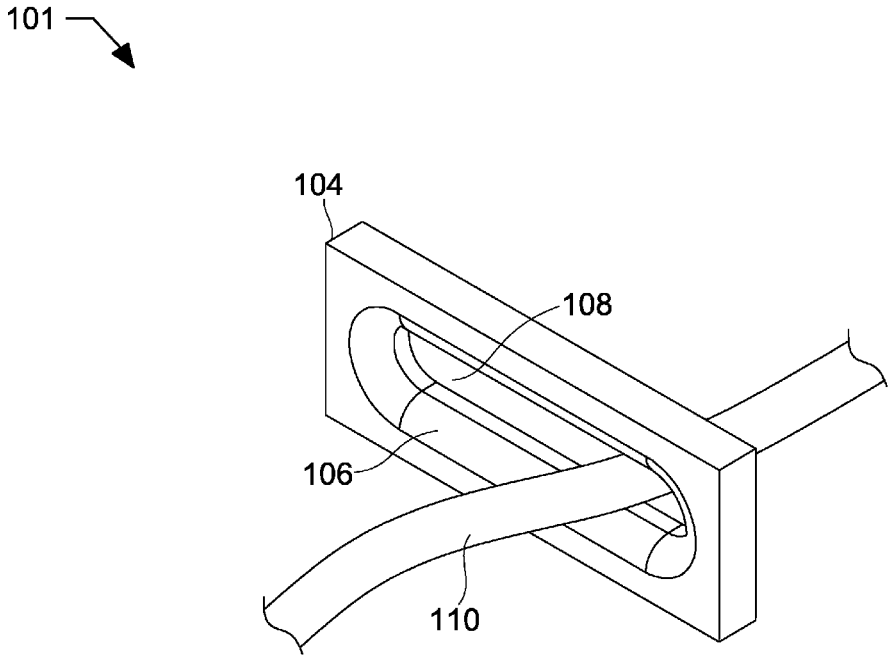
Primary Examiner — Emmanuel M Marcelo

(57) **ABSTRACT**

Devices, methods, and systems for a fairlead changing direction of a line under tensions are disclosed. The fairlead may include an opening with a front lip. The line under tension may be roved through the opening. The front lip may have a variable radius round. The front lip guides a change in direction of the line.

20 Claims, 10 Drawing Sheets



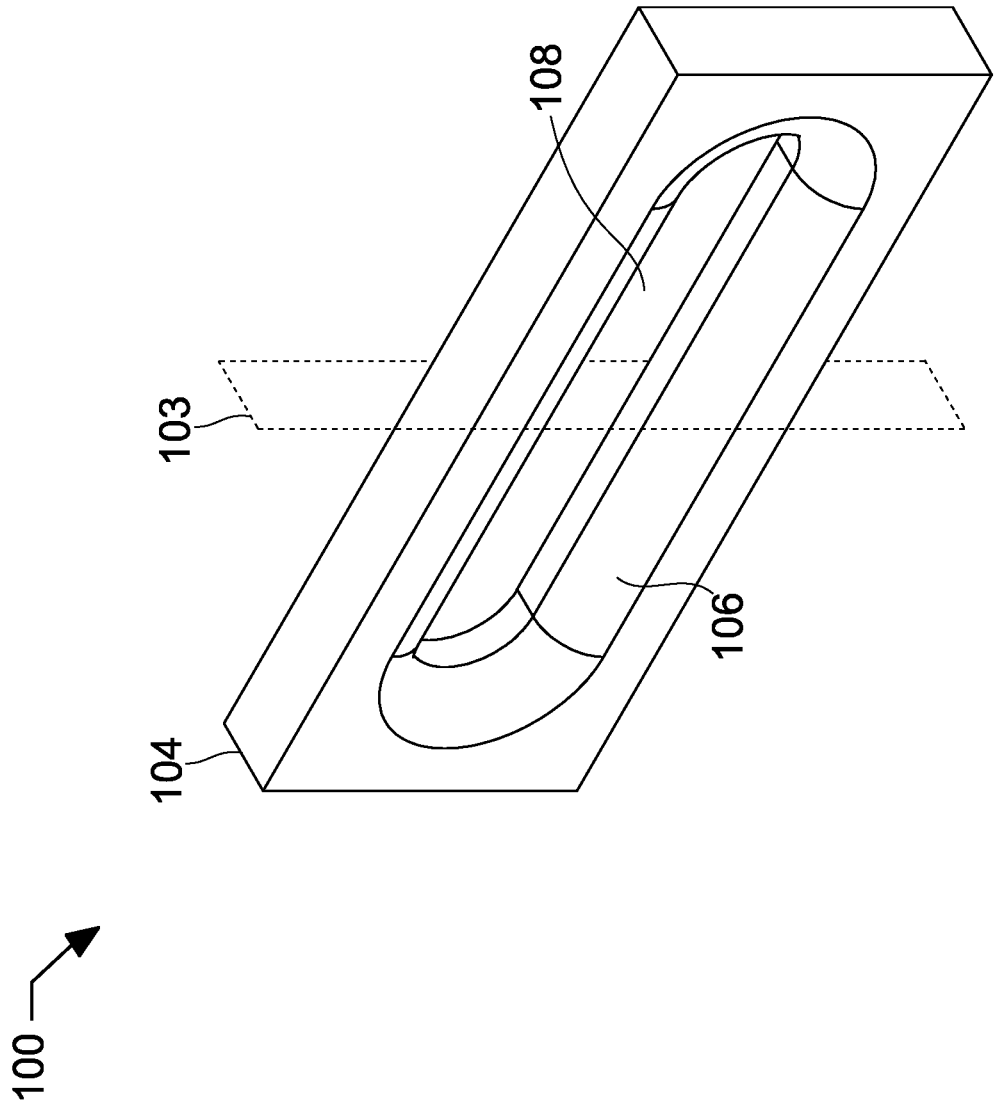


FIG. 1A

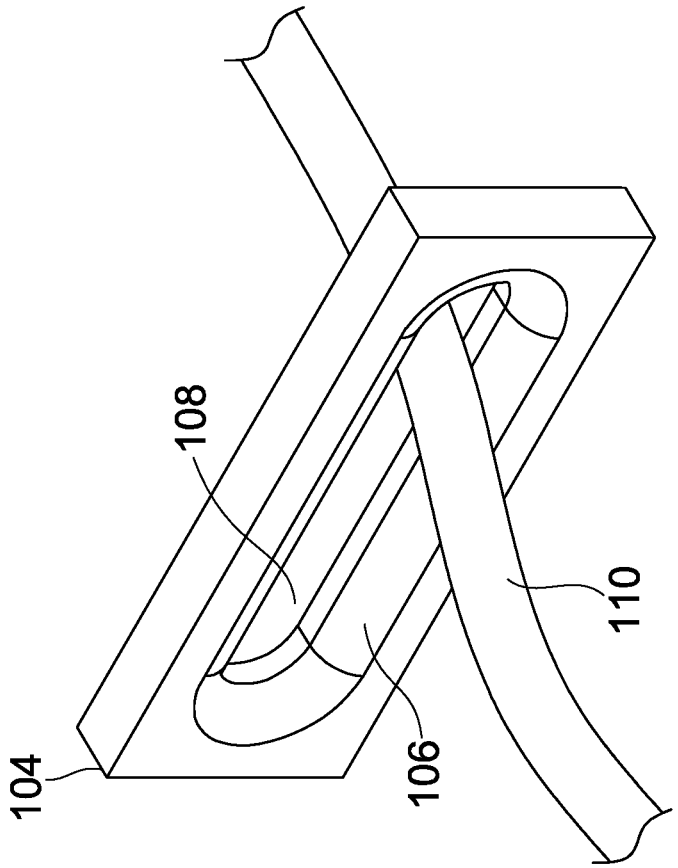
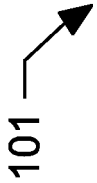


FIG. 1B



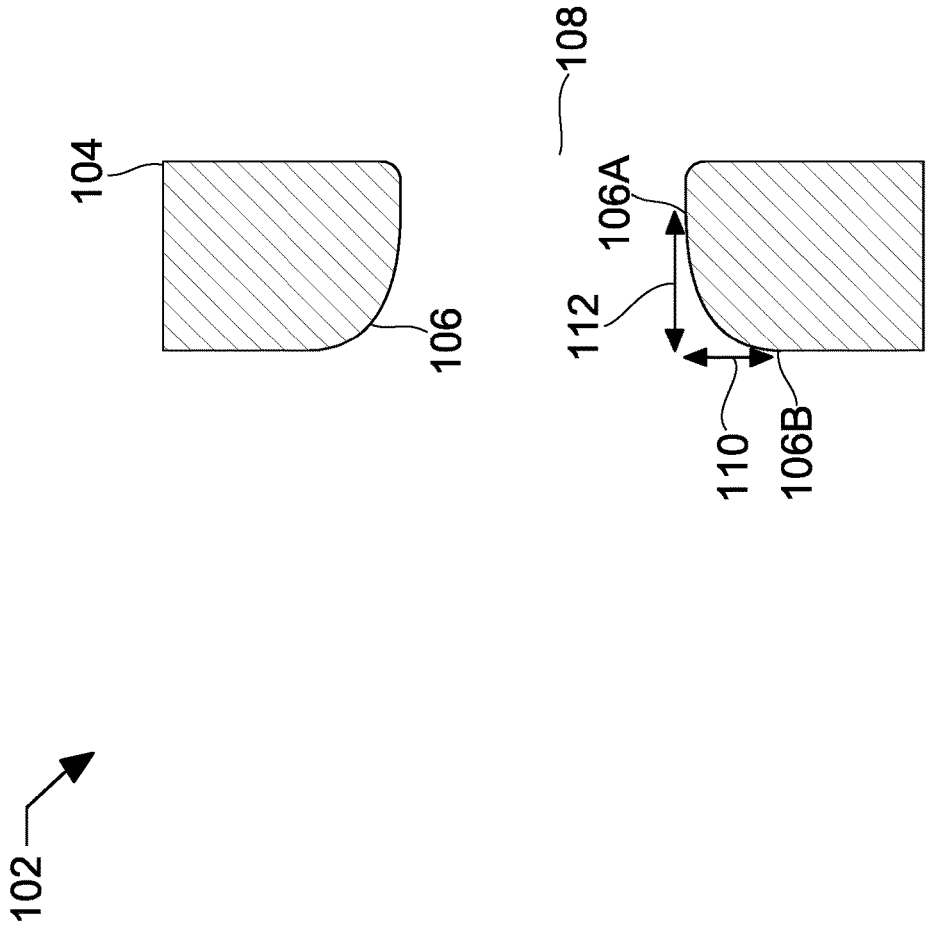


FIG. 1C

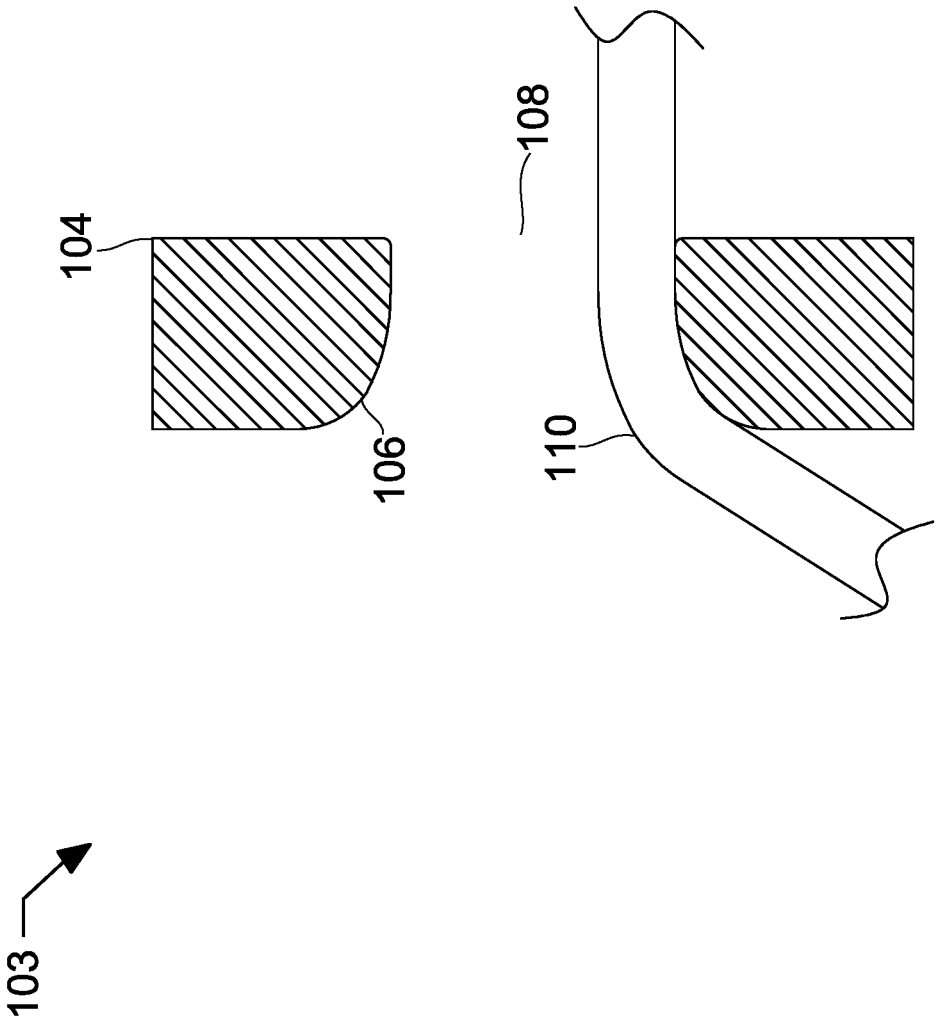


FIG. 1D

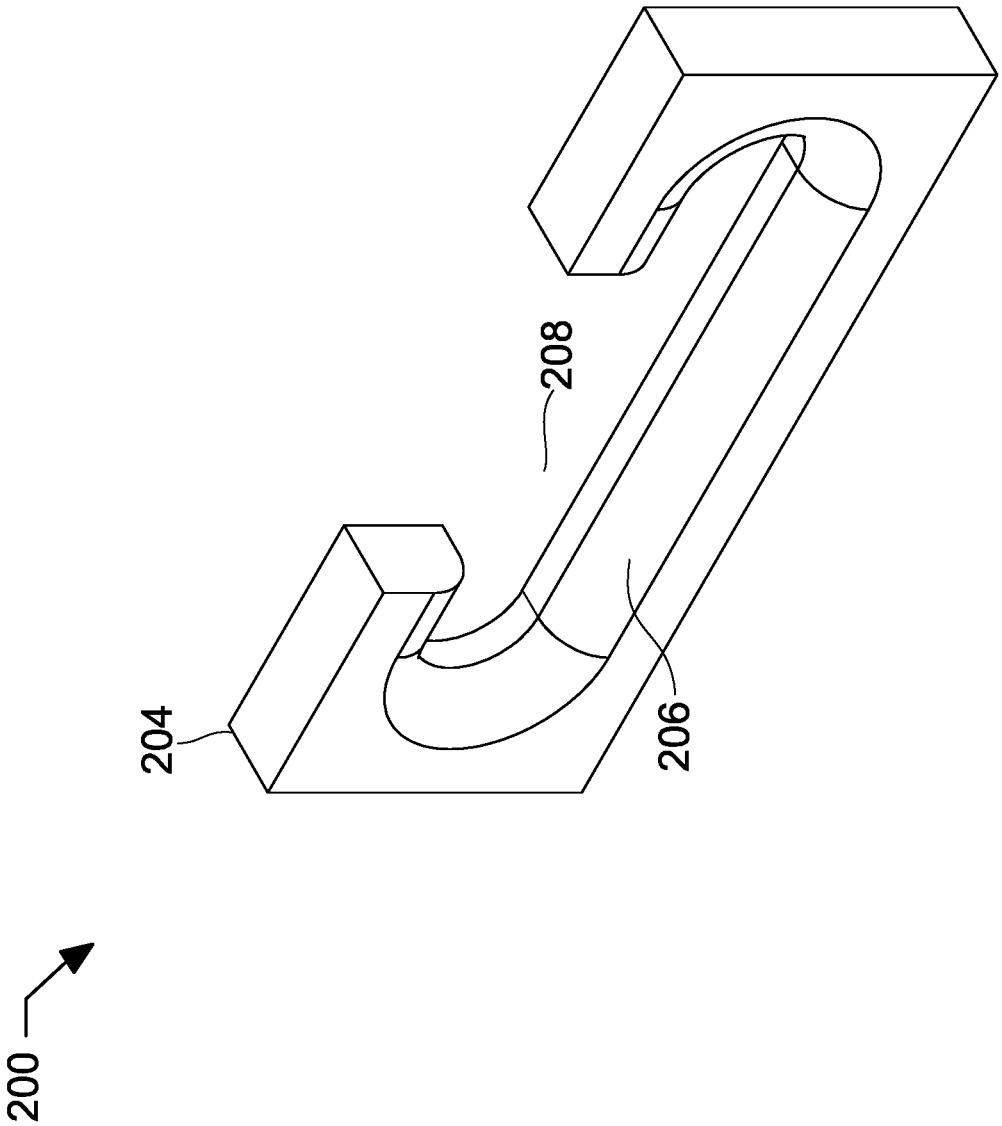


FIG. 2A

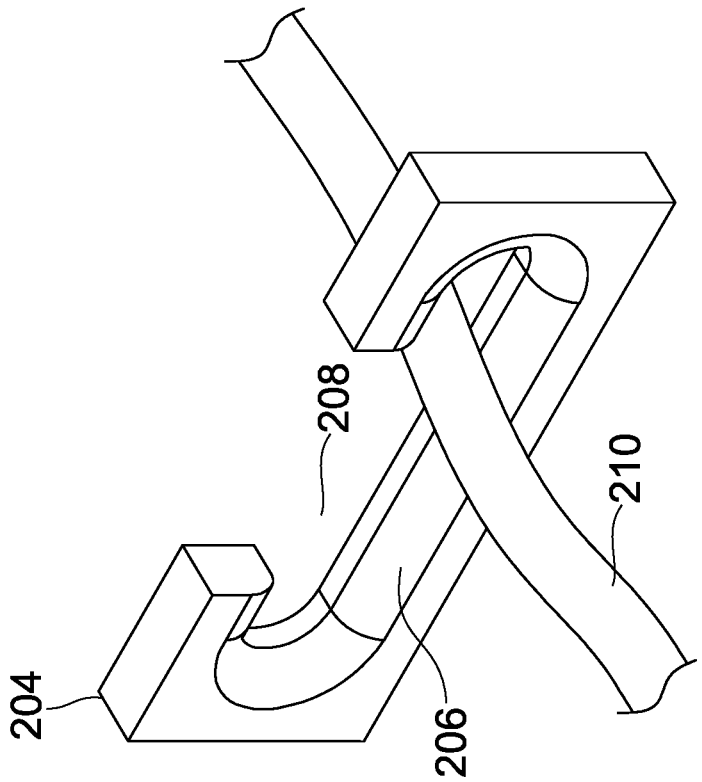
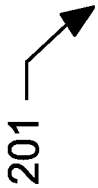


FIG. 2B



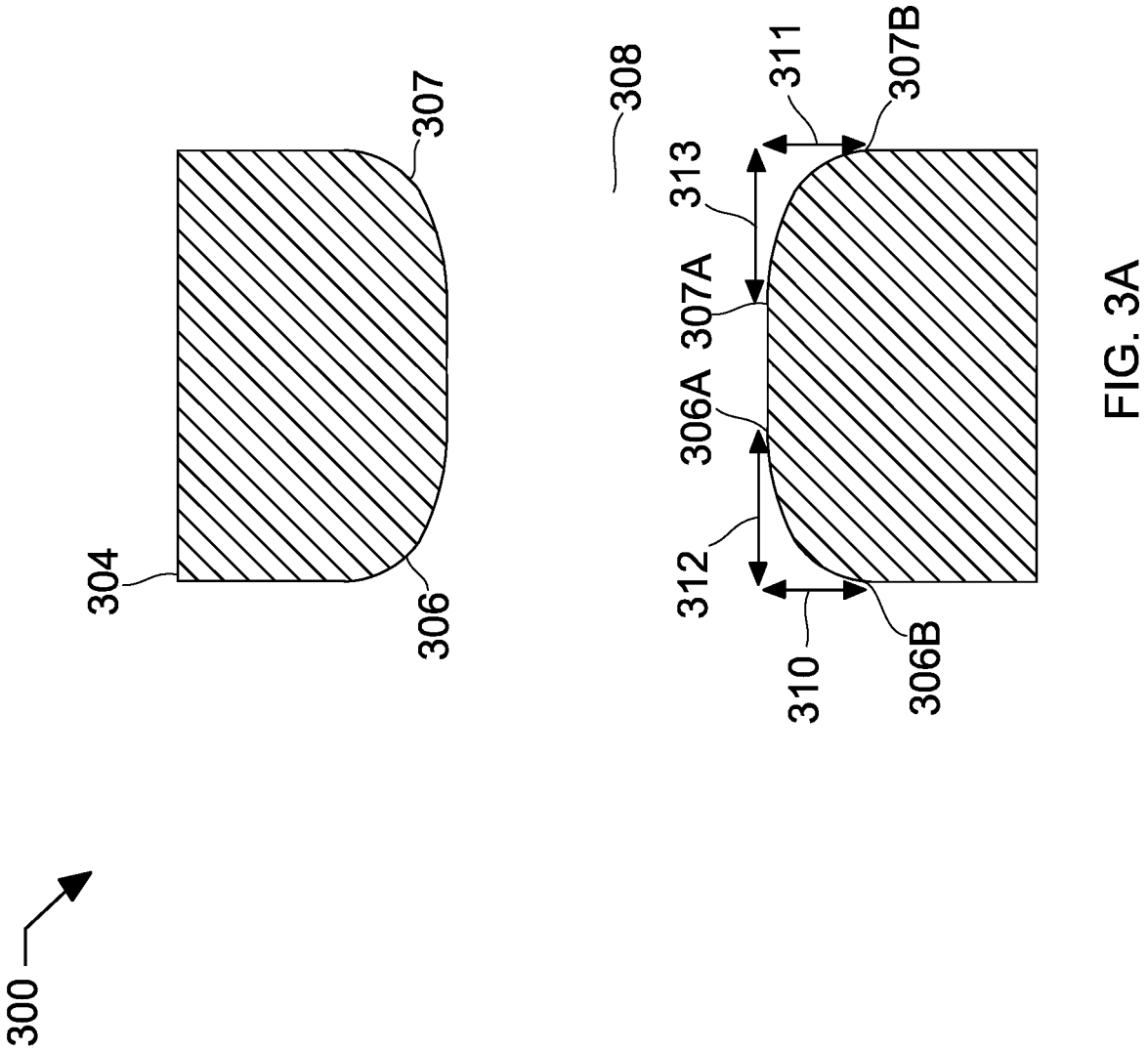


FIG. 3A

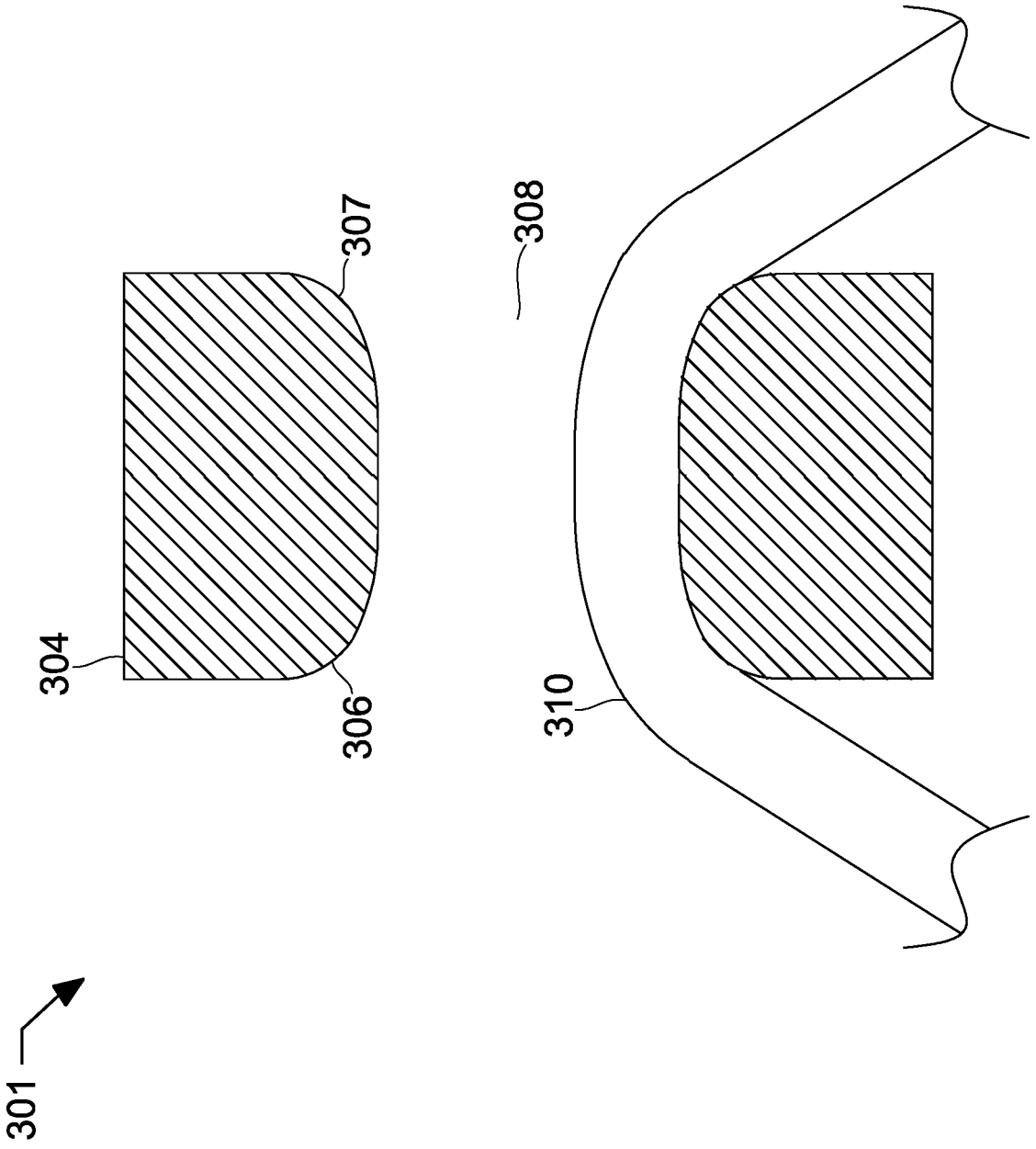
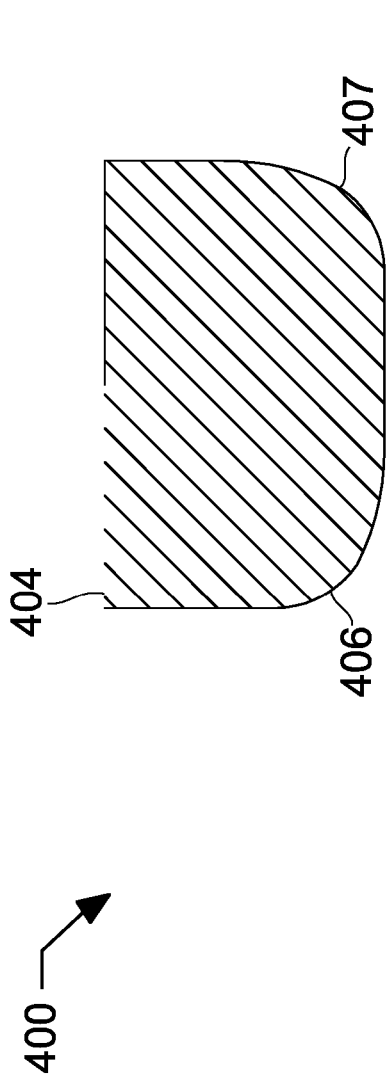


FIG. 3B



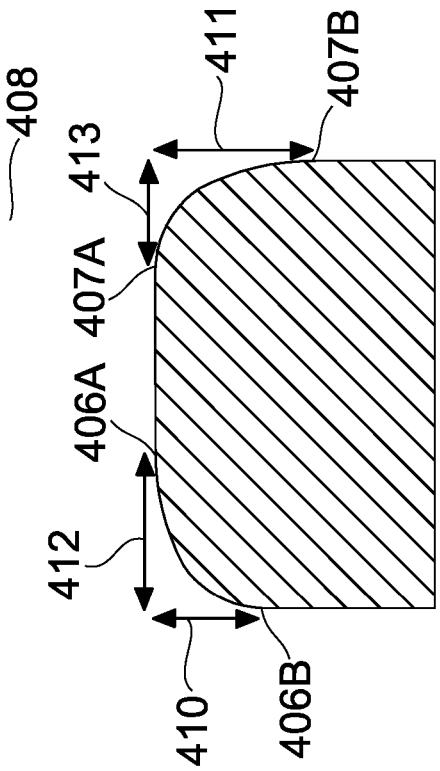


FIG. 4A

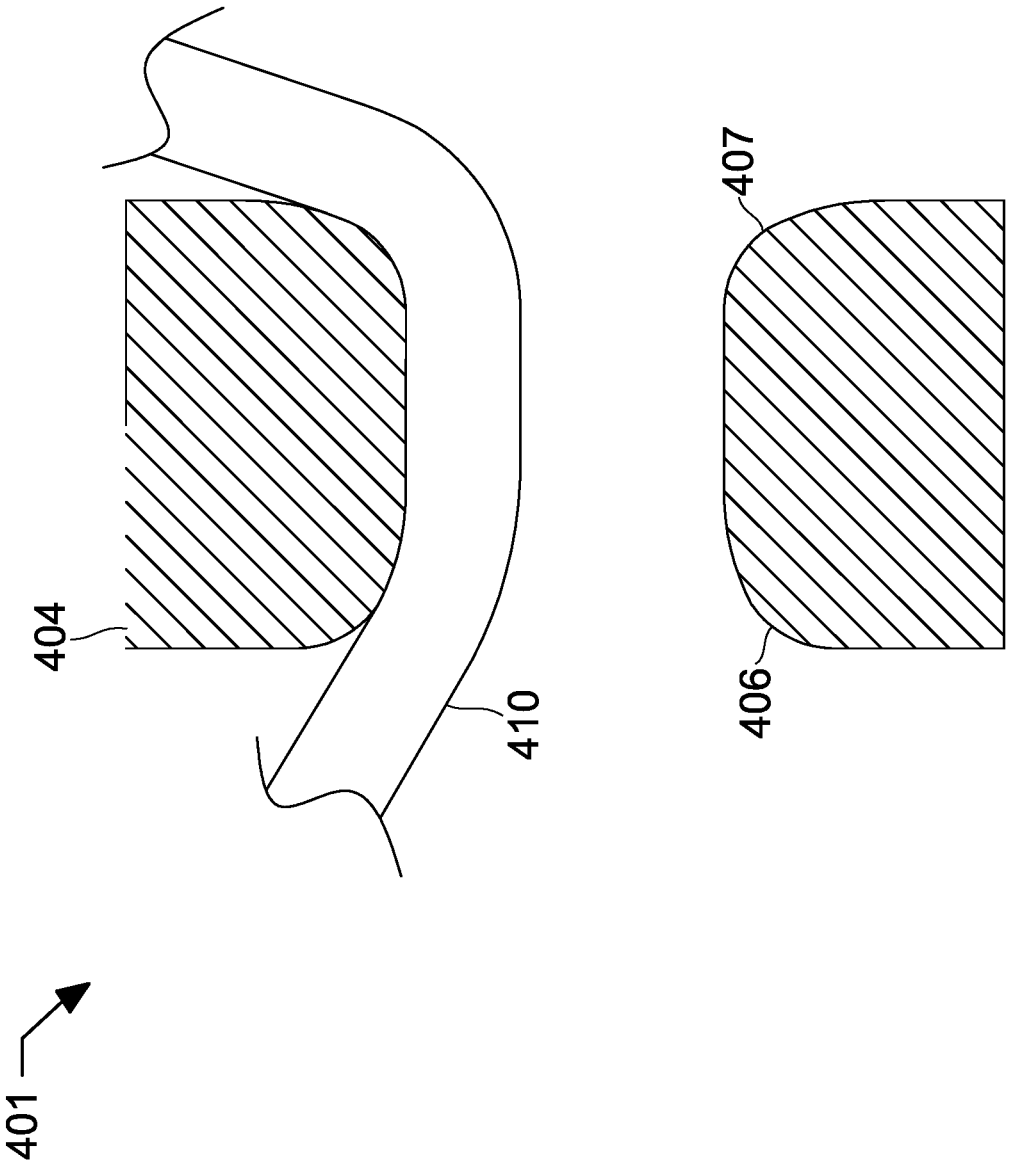


FIG. 4B

VARIABLE RADIUS FAIRLEAD

FIELD OF THE INVENTION

The devices, systems, and methods described herein relate generally to line redirection. More particularly, the devices, systems, and methods described herein relate to fairleads.

BACKGROUND

A typical fairlead is a device to guide a line, rope or cable around an object, out of the way or to stop it from moving too far laterally. Typically, a fairlead will be a ring or hook through which the line passes under tension. The line is moved laterally and the line contacts the fairlead, the fairlead thereby changing the direction of the line and preventing the line from rubbing against other objects that it would otherwise contact. This lowers the stress concentration of the line. Typical fairleads include roller-type fairleads, most commonly used with metal lines, and curved-edge fairleads, such as nautical leads, used with most other materials.

SUMMARY

Devices, methods, and systems for a fairlead changing direction of a line under tensions are disclosed. The fairlead may include an opening with a front lip. The line under tension may be roved through the opening. The front lip may have a variable radius round. The front lip guides a change in direction of the line.

The fairlead may be mounted on a winch, a crane, or a pulley system. The variable radius round may have a shorter radius on an inside portion of the variable-radius round and a longer radius on an outside portion of the variable radius round, or the inverse. The shape of the variable radius round may be parabolic.

A back lip of the opening may be a mirror image of the variable radius round, or a mirror image rotated 180 degrees in a plane of the opening.

The general shape of the opening may be round, elliptical, U-shaped, omega shaped, C-shaped, or rectangular with rounded corners. A portion of the fairlead may be discontinuous, resulting in a gap in the front lip.

The front lip may be made of plastics, ceramics, aluminum, steel, bronze, metal alloys, or a combination thereof. The front lip may have a low-friction surface comprising polytetrafluoroethylene, polychlorotrifluoroethylene, natural diamond, man-made diamond, chemical-vapor deposition diamond, polycrystalline diamond, or a combination thereof.

The line may be a cable, wire, line, cord, twine, strand, thread, or rope. The line may be made of nylon, polyester, polypropylene, high modulus polyethylene, aramid, carbon fiber, vegetable fibers, wood fibers, animal fibers, asbestos fibers, or a combination thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the advantages of the described devices, systems, and methods will be readily understood, a more particular description of the described devices, systems, and methods briefly described above will be rendered by reference to specific embodiments illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the described devices, systems, and methods and are not therefore to be considered limiting of its scope, the devices, systems, and methods will be described and explained with additional specificity and detail through use of the accompanying drawings, in which:

FIG. **1**A is a top-right isometric elevation view of a fairlead.

FIG. **1**B is a top-right isometric elevation view of the fairlead of FIG. **1**A with a line rove through the opening.

FIG. **1**C is a cross-sectional side view of the fairlead of FIG. **1**A.

FIG. **1**D is the same cross-sectional side view of the fairlead of FIG. **1**A, with the line **110** included.

FIG. **2**A is a top-right isometric elevation view of a nautical fairlead.

FIG. **2**B is a top-right isometric elevation view of the fairlead of FIG. **2**A with a line rove through the opening.

FIG. **3**A is a cross-sectional side view of a fairlead.

FIG. **3**B is a cross-sectional side view of FIG. **3**A, with a line added.

FIG. **4**A is a cross-sectional side view of a fairlead.

FIG. **4**B is a cross-sectional side view of FIG. **4**A, with a line added.

DETAILED DESCRIPTION

It will be readily understood that the components of the described devices, systems, and methods, as generally described and illustrated in the Figures herein, could be arranged and designed in a wide variety of different configurations. Thus, the following more detailed description of the embodiments of the described devices, systems, and methods, as represented in the Figures, is not intended to limit the scope of the described devices, systems, and methods, as claimed, but is merely representative of certain examples of presently contemplated embodiments in accordance with the described devices, systems, and methods.

Cables, wires, lines, cords, twine, strands, thread, and ropes will all be referred to herein as 'lines.' A fillet is a rounding of an interior or exterior corner of a part design, though it generally refers to interior corners. The rounding of an exterior corner is commonly referred to as a "round." In the present application, the term "round" will be used to refer to a rounded exterior corner, or lip, of a part. The word "to rove" means to put fibers through an eye or opening.

Vegetable fibers include but are not limited to cotton, hemp, jute, flax, ramie, sisal, bagasse, and banana. Wood fibers include but are not limited to groundwood, lacebark, thermomechanical pulp, and bleached or unbleached kraft or sulfite pulps. Animal fibers include silkworm silk, spider silk, sinew, catgut, wool, sea silk; hair such as cashmere wool, mohair, and angora; and fur such as sheepskin, rabbit, mink, fox, and beaver.

A fairlead is used to change the direction of a line while preventing the stress concentration of the point in the line that changes direction from exceeding the line's stress tolerances. The curved-edge fairleads of which the Applicant is aware all have constant radius rounds as edges or lips. The devices, systems, and methods of the present application improve upon the curved-edge fairlead by use of a variable radius round as a lip, rather than the constant radius round. The variable radius round edge allows for a more gradual change of direction by the line, resulting in less stress on the line upon direction changes. In one embodiment, the ratio of the longest radius of the round to the shortest radius of the round is greater than 1. In a preferred embodiment, the ratio is at least 1.5. In a more preferred embodiment, the ratio is at least 2. In a most preferred embodiment, the ratio is at least 2.5.

The fairlead may be an integral part of a larger structure or a separate piece of hardware.

Referring now to the Figures, FIG. **1**A is a top-right isometric elevation view **100** of a fairlead **104** that may be used in the devices, methods, and systems disclosed herein. FIG. **1**B is a top-right isometric elevation view **101** of the fairlead **104** of FIG. **1**A with a line **110** rove through opening **108**. FIG. **1**C is a cross-sectional side view **103** of the fairlead **104**. FIG. **1**D is the same cross-sectional side view **103** of the fairlead **104**, with the line **110** included. Fairlead **104** has a generally rectangular-shaped opening **108** with rounded corners. The front lip **106** of the opening **108** is a variable radius round. In other words, the curve of front lip **106** has a first radius **110** that is less than a second radius **112**. The radius decreases gradually from the beginning **106**A of front lip **106** to the end **106**B of front lip **106**. In this embodiment, the shape is generally parabolic, with the change in radius generally following the quadratic. Logarithmic, exponential, cubic, or other curves could also be used in other embodiments. Line **110** is rove through opening **108**. Line **110** is under tension and is moved laterally against front lip **106**, changing the direction of line **110**. Due to the shape of front lip **106**, line **110** changes direction as needed, but with reduced stress in line **110** at the point of contact with front lip **106** when compared to a constant radius round lip.

Referring now to FIG. **2**, FIG. **2**A is a top-right isometric elevation view **200** of a nautical fairlead **204** that may be used in the devices, methods, and systems disclosed herein. FIG. **2**B is a top-right isometric elevation view **201** of the fairlead **204** of FIG. **2**A with a line **210** rove through opening **208**. Fairlead **204** has a generally rectangular-shaped opening **208** with rounded corners, as in FIG. **1**A, except the top portion of the fairlead **204** is removed, resulting in an elongated "C" shape. This style of fairlead is known as a "nautical" fairlead, as the shape makes quick attachment and detachment of lines on ocean going vessels possible without threading the line through an opening. The front lip **206** of the opening **208** is a variable radius round, as in FIG. **1**A. In other words, the curve of front lip **206** is like that of FIG. **1**A. Line **210** is under tension and is moved laterally against front lip **206**, changing the direction of line **210**. Due to the shape of front lip **206**, line **210** changes direction as needed, but with reduced stress in line **210** at the point of contact with front lip **206** when compared to a constant radius round lip.

Referring now to FIG. **3**, FIG. **3**A is a cross-sectional side view **300** of a fairlead **304** (e.g., **104**, **204**) that may be used in the devices, methods, and systems disclosed herein. FIG. **3**B is a cross-sectional side view **301** of FIG. **3**A, with line **310** added. Fairlead **304** has a front lip **306** that is a variable radius round. In other words, the curve of front lip **306** has a first radius **310** that is less than a second radius **312**. The radius decreases gradually from the beginning **306**A of front lip **306** to the end **306**B of front lip **306**. Back lip **307** is a mirror image of this variable radius round. In other words, the curve of back lip **307** has a first radius **311** that is less than a second radius **313**. The radius increases gradually from the beginning **307**B of back lip **307** to the end **307**A of back lip **307**. Line **310** is under tension and is moved laterally against front lip **306** and back lip **307**, changing the direction of line **310**. Due to the shape of front lip **306** and back lip **307**, line **310** changes direction as needed, but with reduced stress in line **310** at the points of contact with front lip **306** and back lip **307** when compared to a constant radius round lip.

Referring now to FIG. **4**, FIG. **4**A is a cross-sectional side view **400** of a fairlead **404** (e.g., **104**, **204**, **304**) that may be used in the devices, methods, and systems disclosed herein. FIG. **4**B is a cross-sectional side view **401** of FIG. **4**A, with line **410** added. Fairlead **404** has a front lip **406** that is a variable radius round. In other words, the curve of front lip **406** has a first radius **410** that is less than a second radius **412**. The radius decreases gradually from the beginning **406**A of front lip **406** to the end **406**B of front lip **406**. Back lip **407** is a 90-degree rotation of this variable radius round. In other words, the curve of back lip **407** has a first radius **411** that is greater than a second radius **413**. The radius decreases gradually from the beginning **407**B of back lip **407** to the end **407**A of back lip **407**. Line **410** is under tension and is moved laterally against front lip **406** and back lip **407**, changing the direction of line **410**. Due to the shape of front lip **406** and back lip **407**, line **410** changes direction as needed, but with reduced stress in line **410** at the points of contact with front lip **406** and back lip **407** when compared to a constant radius round lip.

In both FIGS. **3** and **4**, the orientations of the variable radius round can be alternated depending upon the angle at which the line is coming into the opening, and the angle at which it leaves the opening. In some instances, using the bottom half of FIG. **3** and the top half of FIG. **4** would be optimal for the line to pass with minimal stress. In others, the opposite may be best.

In some embodiments, the fairlead may be mounted on a winch, a crane, or a pulley system.

In some embodiments, the variable radius round has a shorter radius on an inside portion of the variable-radius round and a longer radius on an outside portion of the variable radius round. In other embodiments, the variable radius round has a shorter radius on an outside portion of the variable-radius round and a longer radius on an inside portion of the variable radius round.

In some embodiments, the general shape of the opening may be round, elliptical, U-shaped, omega shaped (as in ship warping fairleads), C-shaped, or rectangular with rounded corners.

In some embodiments, a portion of the fairlead is discontinuous, resulting in a gap in the front lip, as in ship warping fairleads.

In some embodiments, the front lip is plastic, ceramic, aluminum, steel, bronze, a metal alloy, or a combination thereof. In some embodiments, the front lip is a low-friction surface comprising polytetrafluoroethylene, polychlorotrifluoroethylene, natural diamond, man-made diamond, chemical-vapor deposition diamond, polycrystalline diamond, or a combination thereof.

In various embodiments, the line may be a cable, wire, line, cord, twine, strand, thread, or rope.

In some embodiments, the line is made of nylon, polyester, polypropylene, high modulus polyethylene, aramid, carbon fiber, vegetable fibers, wood fibers, animal fibers, asbestos fibers, or a combination thereof.

The invention claimed is:

1. A fairlead comprising:

an opening through which a line under tension is rove;

a front lip of the opening comprising a variable radius round;

the front lip guides a change in direction of the line, and

a back lip of the opening comprising a mirror image of the variable radius round.

2. The fairlead of claim **1**, wherein the fairlead is mounted on a winch, a crane, or a pulley system.

3. The fairlead of claim 1, wherein the variable radius round has a shorter radius on an inside portion of the variable-radius round and a longer radius on an outside portion of the variable radius round.

4. The fairlead of claim 1, wherein the variable radius round has a shorter radius on an outside portion of the variable-radius round and a longer radius on an inside portion of the variable radius round.

5. The fairlead of claim 1, wherein a shape of the variable radius round is parabolic.

6. The fairlead of claim 1, wherein a general shape of the opening is round, elliptical, U-shaped, omega shaped, C-shaped, or rectangular with rounded corners.

7. The fairlead of claim 6, wherein a portion of the fairlead is discontinuous, resulting in a gap in the front lip.

8. The fairlead of claim 1, wherein the front lip comprises plastics, ceramics, aluminum, steel, bronze, metal alloys, or a combination thereof.

9. The fairlead of claim 8, wherein the front lip comprises a low-friction surface comprising polytetrafluoroethylene, polychlorotrifluoroethylene, natural diamond, man-made diamond, chemical-vapor deposition diamond, polycrystalline diamond, or a combination thereof.

10. The fairlead of claim 1, wherein the line comprises cables, wires, lines, cords, twine, strands, threads, or ropes.

11. The fairlead of claim 10, wherein the line comprises nylon, polyester, polypropylene, high modulus polyethylene, aramid, carbon fiber, vegetable fibers, wood fibers, animal fibers, asbestos fibers, or a combination thereof.

12. The fairlead of claim 1, wherein the variable radius round has a shortest radius and a longest radius, and wherein the ratio of the longest radius and the shortest radius is greater than 1.

13. The fairlead of claim 1, wherein the variable radius round has a shortest radius and a longest radius, and wherein the ratio of the longest radius and the shortest radius is greater than 1.5.

14. The fairlead of claim 1, wherein the variable radius round has a shortest radius and a longest radius, and wherein the ratio of the longest radius and the shortest radius is greater than 2.

15. The fairlead of claim 1, wherein the variable radius round has a shortest radius and a longest radius, and wherein the ratio of the longest radius and the shortest radius is greater than 2.5.

16. A fairlead comprising:

an opening through which a line under tension is rove;

a front lip of the opening comprising a variable radius round;

the front lip guides a change in direction of the line; and

a back lip of the opening comprising a 90 degree rotation of the variable radius round.

17. The fairlead of claim 16, wherein the fairlead is mounted on a winch, a crane, or a pulley system.

18. The fairlead of claim 16, wherein the variable radius round has a shorter radius on an inside portion of the variable-radius round and a longer radius on an outside portion of the variable radius round.

19. The fairlead of claim 16, wherein the variable radius round has a shorter radius on an outside portion of the variable-radius round and a longer radius on an inside portion of the variable radius round.

20. The fairlead of claim 16, wherein a shape of the variable radius round is parabolic.

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