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(54) **REEL WITH HOUSING HAVING TRIANGULAR APERTURE FOR ENTRY OF LINEAR MATERIAL**

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Publication Classification

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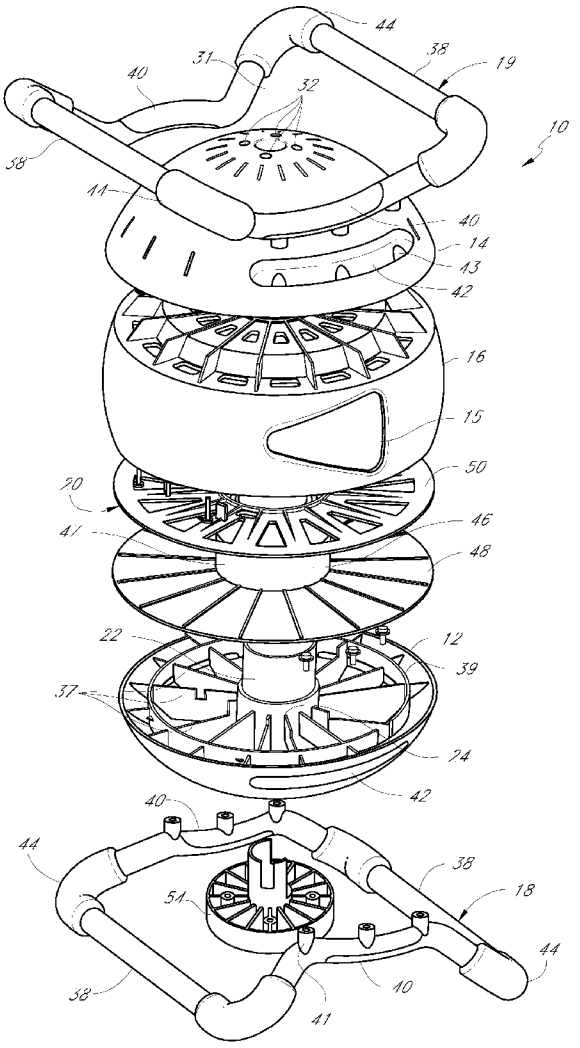
(52) **U.S. Cl.** **242/398**

(57) **ABSTRACT**

A reel is provided with a housing having a triangular aperture for entry and removal of linear material wound upon the reel drum. The drum has a spool surface onto which a linear material may be wound, the spool surface having two ends. The housing substantially encloses the drum, and the drum is rotatable about a drum axis relative to at least a portion of the housing. The at least a portion of the housing has a generally triangular aperture sized to receive a linear material wound onto the drum. The aperture has a first side oriented generally parallel to the drum axis, and second and third sides meeting at a vertex generally midway between opposing ends of the spool surface of the drum.



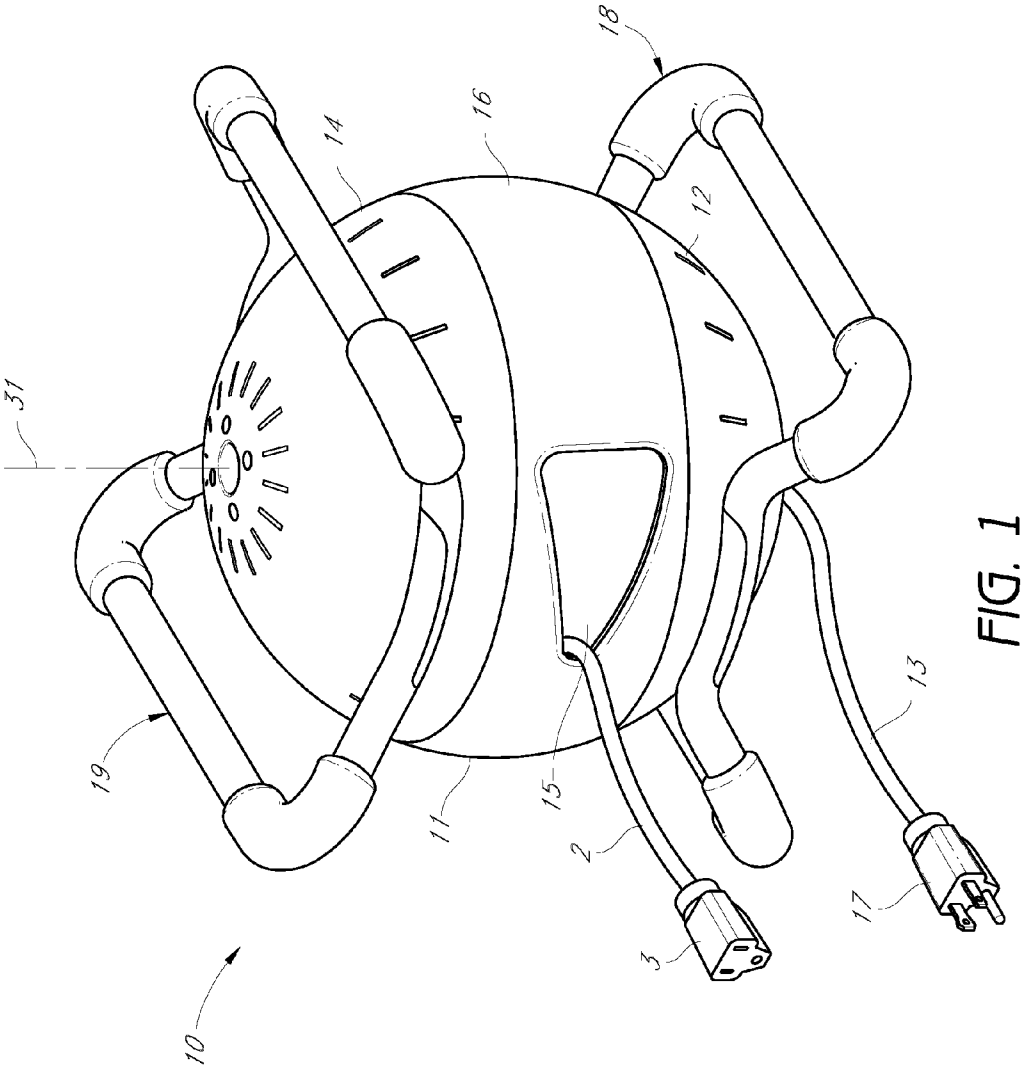


FIG. 1

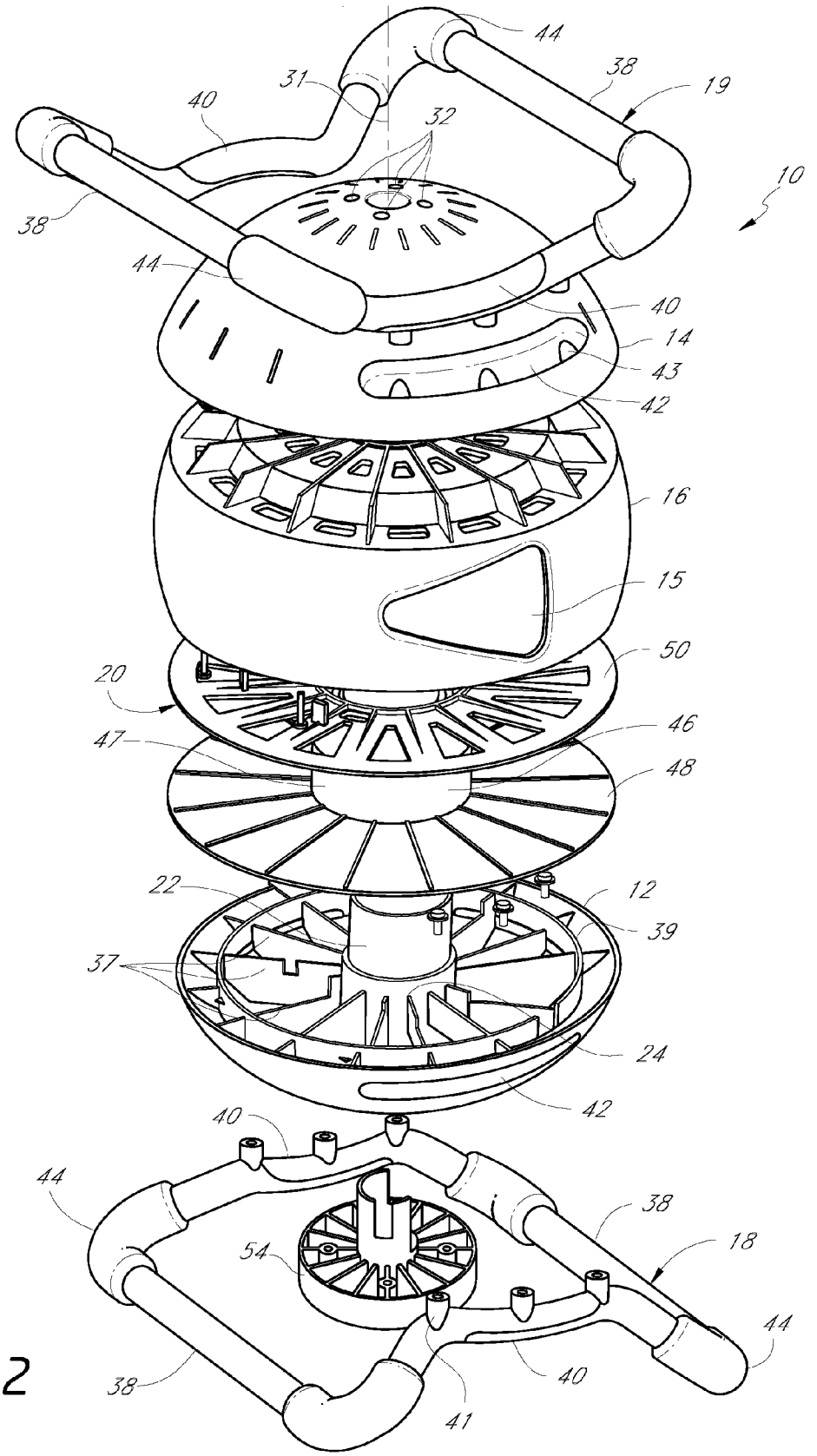

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FIG. 2

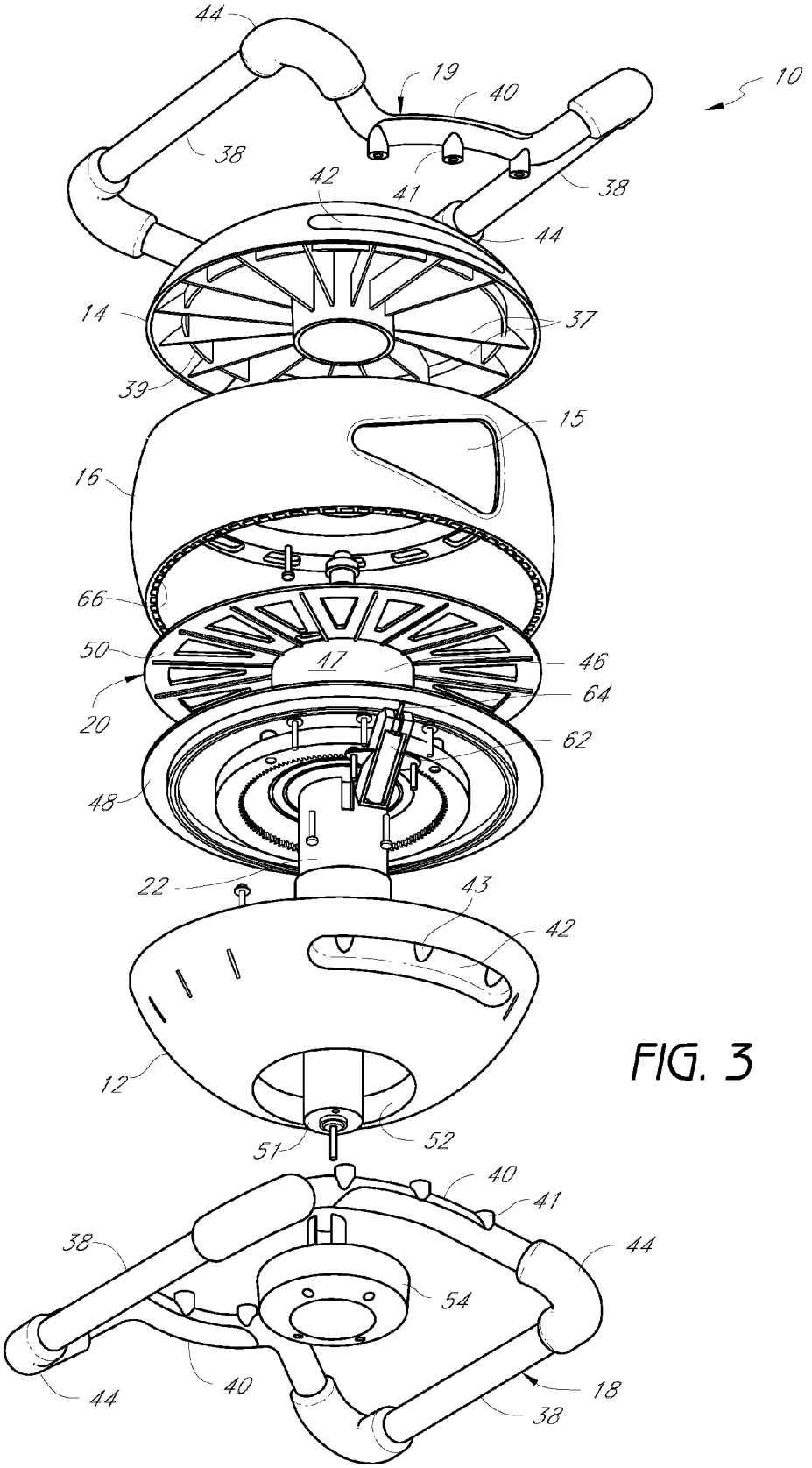
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FIG. 3

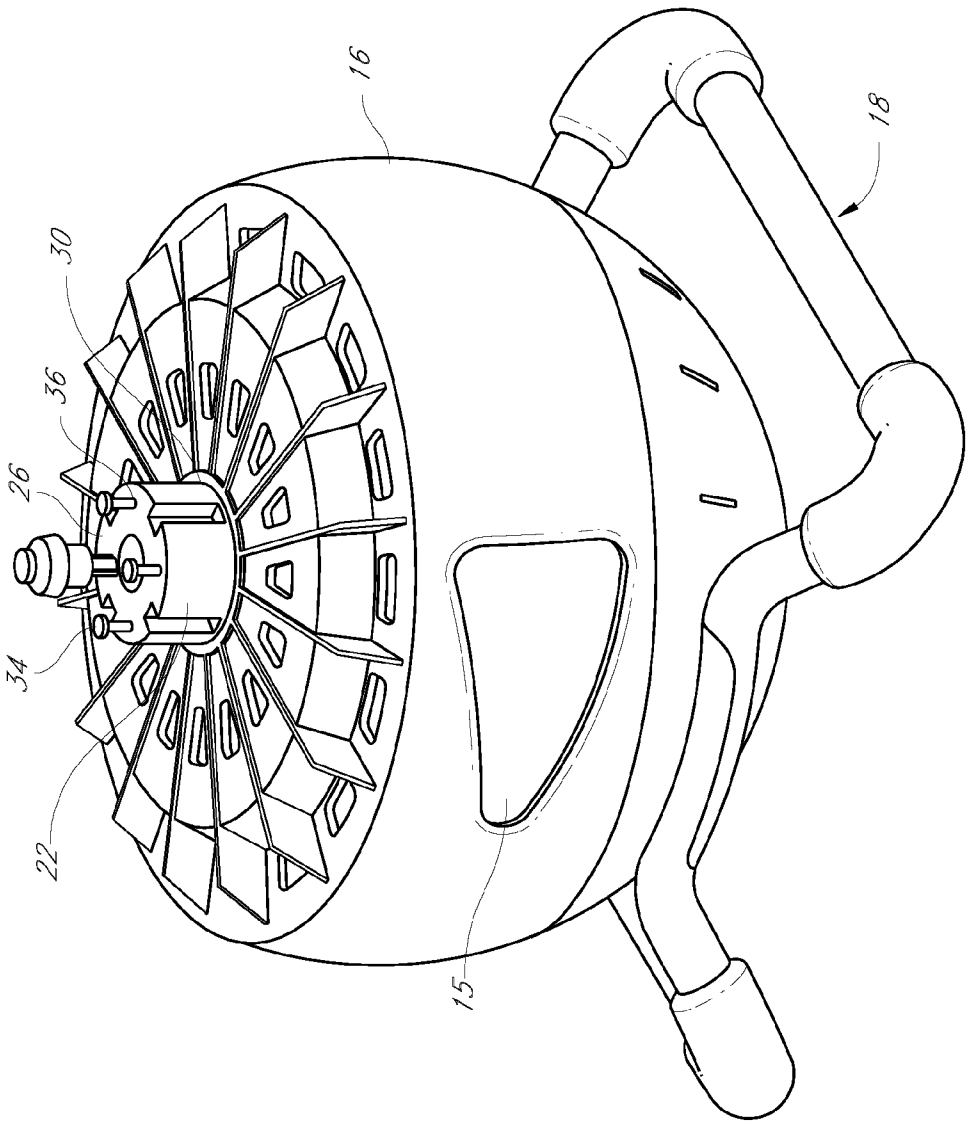

FIG. 4

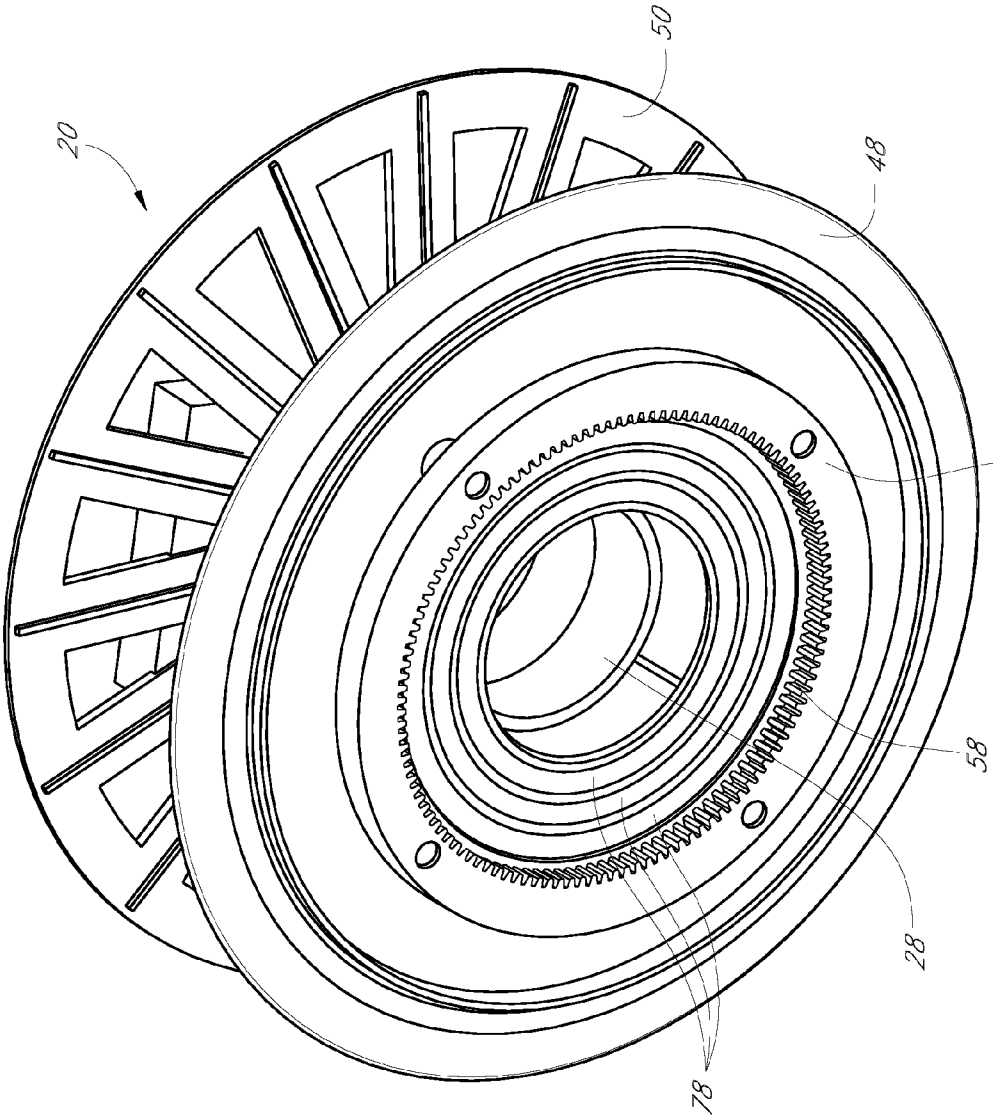

FIG. 5

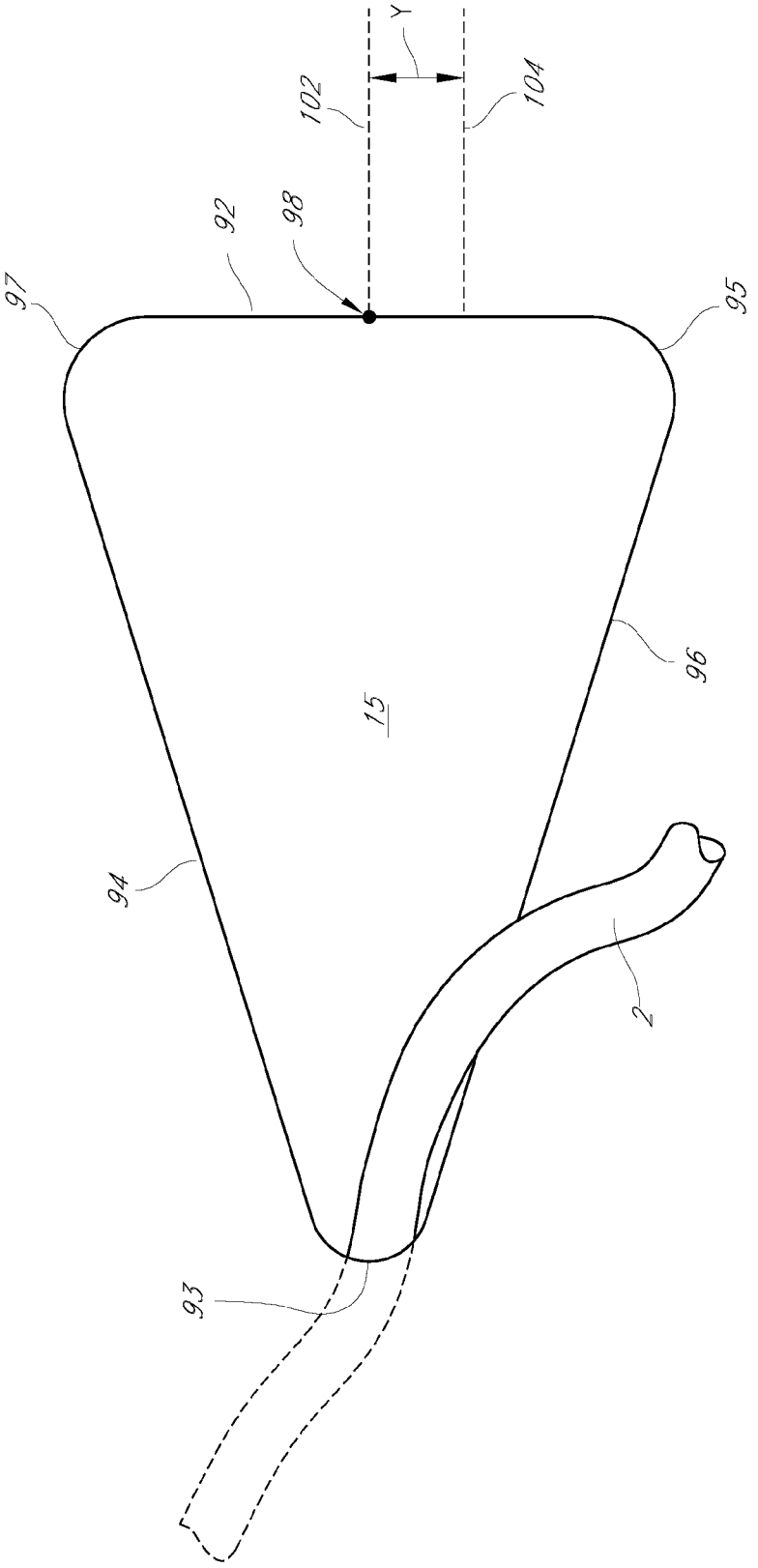

FIG. 6

REEL WITH HOUSING HAVING TRIANGULAR APERTURE FOR ENTRY OF LINEAR MATERIAL

CLAIM FOR PRIORITY

[0001] This application claims priority under 35 U.S.C. §119(e) to Provisional Patent Application No. 60/775,629, filed Feb. 21, 2006.

INCORPORATION BY REFERENCE

[0002] The present application incorporates by reference the entire disclosure of U.S. Patent Application Publication No. US 2006-0266605 A1.

BACKGROUND OF THE INVENTION

[0003] 1. Field of the Invention

[0004] The present invention relates generally to reels for winding and unwinding linear material, and specifically to apparatuses and methods for improving the uniformity of wound material and ease of unwinding.

[0005] 2. Description of the Related Art

[0006] A reel typically comprises a cylindrical reel drum onto which a flexible linear material (such as cord, hose, etc.) is wound. The drum ordinarily rotates about a central axis to wind or unwind (also referred to herein as "spooling" and "unspooling") the linear material with respect to the cylindrical drum surface. Some reels include housings that protect the drum and spooled linear material from the environment. The housing may include an opening or aperture through which the linear material extends, so that it may be pulled from the housing and subsequently retracted back into the housing. Rotation of the drum can be motorized or manual, such as by a hand crank or other like device.

[0007] Some reel housings have a portion that includes the linear material aperture and is movable with respect to the remainder of the housing, thereby permitting a user to change the position from which the linear material is pulled from the reel. For example, U.S. Pat. No. 6,279,848 to Mead discloses a cylindrical reel drum that rotates about a horizontal axis and is enclosed within a spherical housing comprising upper and lower semispherical shell portions. The upper shell portion includes a guide aperture for the spooled linear material and is linked to the drum. The upper shell portion and drum together rotate about a vertical central axis with respect to the lower shell portion. This permits a user to pull the linear material out of the housing through the guide aperture, and move around the reel with the guide aperture following the radial position of the user. The upper shell portion and drum form a unit that is freely rotatable (about the vertical axis) with respect to the lower shell portion, through **3600** and more.

[0008] Another example of a reel housing having a portion that includes a linear material aperture and is movable with respect to the remainder of the housing is shown and described in U.S. Patent Application Publication No. US 2006-0266605 A1. That reference discloses a spherical reel housing comprising lower, intermediate, and upper housing portions, an internal vertical spindle member fixed with respect to the lower and upper housing portions, and a drum rotatable on the spindle member and surrounded by the intermediate housing portion. In that reference, the intermediate housing portion includes a linear material aperture and is also rotatable, independently of the drum, about the spindle member.

[0009] A variety of reels, particularly non-motorized reels, include spring return mechanisms for automatically spooling the linear material. Typically, a coil of flat spring steel stock is provided with one end secured to the reel drum and the other end secured to a spindle on which the drum rotates. For example, U.S. Pat. No. 6,273,354 to Kovacik et al. discloses such a reel. Such reels are often provided with a ratchet and pawl mechanism (or similar apparatus) for permitting the user to initiate rewinding of the reel by a slight tug on the linear material.

SUMMARY OF THE INVENTION

[0010] In one aspect, the present invention provides a reel comprising a drum and a housing substantially enclosing the drum. The drum has a spool surface onto which a linear material may be wound, the spool surface having two ends. The drum is rotatable about a drum axis relative to at least a portion of the housing. The at least a portion of the housing has a generally triangular aperture sized to receive a linear material wound onto the drum. The aperture has a first side oriented generally parallel to the drum axis, and second and third sides meeting at a vertex generally midway between opposing ends of the spool surface of the drum.

[0011] In another aspect, the present invention provides a method comprising rotating a drum about a drum axis to wind a linear material onto a spool surface of the drum or unwind the linear material from the spool surface of the drum. During the step of rotating the drum, the linear material is drawn through a generally triangular aperture in a housing substantially enclosing the drum, the drum being rotatable about the drum axis with respect to a portion of the housing that includes the aperture. The aperture has a first side oriented generally parallel to the drum axis, and second and third sides meeting at a vertex generally midway between opposing ends of the spool surface of the drum.

[0012] In another aspect, the present invention provides a reel comprising a drum and a housing substantially enclosing the drum. The drum has a spool surface onto which a linear material may be wound, and is rotatable about a drum axis relative to at least a portion of the housing. The at least a portion of the housing has a generally triangular aperture sized to receive a linear material wound onto the drum.

[0013] In other aspect, the present invention provides a method comprising rotating a drum about a drum axis to wind a linear material onto a spool surface of the drum or unwind the linear material from the spool surface of the drum. During the step of rotating the drum, the linear material is drawn through a generally triangular aperture in a housing substantially enclosing the drum, the drum being rotatable about the drum axis with respect to a portion of the housing that includes the aperture.

[0014] For purposes of summarizing the invention and the advantages achieved over the prior art, certain objects and advantages of the invention have been described above and as further described below. Of course, it is to be understood that not necessarily all such objects or advantages may be achieved in accordance with any particular embodiment of the invention. Thus, for example, those skilled in the art will recognize that the invention may be embodied or carried out in a manner that achieves or optimizes one advantage or

group of advantages as taught herein without necessarily achieving other objects or advantages as may be taught or suggested herein.

[0015] All of these embodiments are intended to be within the scope of the invention herein disclosed. These and other embodiments of the present invention will become readily apparent to those skilled in the art from the following detailed description of the preferred embodiments having reference to the attached figures, the invention not being limited to any particular preferred embodiment(s) disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. **1** is a perspective view of a reel according to one embodiment of the present invention.

[0017] FIG. **2** is an exploded top perspective view of the reel of FIG. **1**.

[0018] FIG. **3** is an exploded bottom perspective view of the reel of FIG. **1**.

[0019] FIG. **4** is a top perspective view of the reel of FIG. **1**, with the upper housing portion removed.

[0020] FIG. **5** is a bottom perspective view of the drum of the reel of FIG. **1**.

[0021] FIG. **6** is a front view of a triangular aperture according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Overview

[0022] Embodiments of the present invention provide a reel comprising a reel drum substantially enclosed within a housing having a portion with a triangular aperture for receiving and guiding linear material onto a spool surface of the drum as the drum rotates relative to the housing about a drum axis. In some embodiments, the housing portion having the triangular guide aperture is also rotatable about the drum axis, relative to the drum. In some embodiments, the rotatable housing portion having the triangular guide aperture is also rotatable, about the drum axis, with respect to one or more other portions of the housing. In other words, the drum and housing portion with the triangular guide aperture are preferably independently rotatable with respect to the remainder of the housing. In preferred embodiments, the housing portion with the triangular guide aperture is freely rotatable through at least 360°, and preferably any fraction or multiple thereof, with respect to a remainder of the housing. In preferred embodiments, the reel is adapted to spool electrical cord. However, skilled artisans will appreciate that reels of the present invention can spool other types of linear materials, such as hoses, ropes, and the like.

[0023] Reels that employ a drum that rotates about a vertical axis are susceptible to the problem of non-uniform winding. In other words, the linear material wound upon the drum tends to form a non-uniform spool. This is because the linear material tends to wind upon the lower portion of the drum, due to the effects of gravity. The present inventors have discovered that this tendency is reduced significantly by a linear material guide or housing aperture that is located generally midway between opposing ends of the spool surface of the drum. During winding, a guide or aperture so positioned causes the linear material to wind more evenly on the spool surface. However, when the direction of drum rotation is reversed, the centrally located guide or aperture can substantially impede or slow down the process of unwinding the linear material, due to the restrictive position and size of the aperture relative to the length of the spool. In many cases, the linear material tends to become stuck or immovable during unwinding.

[0024] As used herein, the terms "winding" and "spooling" refer to the process of rotating the drum in a direction to accumulate the linear material onto the spool surface of the drum, and "unwinding" and "unspooling" refer to the process of retracting the linear material from the drum, which involves rotating the drum in the opposite direction.

[0025] The present invention addresses this problem by providing a reel having a housing with a generally triangular guide aperture for the linear material. A first vertex of the triangular aperture is preferably located generally midway between the ends of the spool surface of the drum. The first vertex points in the direction in which the linear material is wound so that, during winding, the linear material tends to slide against the first vertex. Thus, during winding, the linear material is guided onto the drum from a position generally midway between the opposing ends of the spool surface, advantageously producing more even and uniform winding as explained above. The side of the triangular aperture that is opposite the first vertex is preferably oriented substantially parallel to the drum's axis of rotation and has a length preferably large enough to significantly improve the ease of unwinding. During unwinding, the linear material is free to slide against the fall length of this side of the triangle, advantageously reducing the likelihood of the linear material getting stuck.

Exemplary Reel

[0026] In order to provide a fuller understanding of the invention, the following paragraphs describe an exemplary reel and reel housing that are particularly suited to having a triangular aperture as taught herein. While the illustrated reel **10** is an electrical cord reel, triangular apertures of the invention can be provided for reels adapted to wind different types of linear materials. Further details of the illustrated reel **10** are shown and described in U.S. Patent Application Publication No. US 2006-0266605 A1.

[0027] FIG. **1** shows a reel **10** comprising a housing **11** enclosing a rotatable reel drum **20** (FIGS. **2**, **3**, and **5**) onto which a flexible linear material **2** can be spooled. In the illustrated embodiment, the linear material **2** comprises an electrical cord with a female plug connector **3**, as known in the art. The housing **11** comprises a first or lower housing portion **12**, a second or upper housing portion **14**, and a middle housing portion **16** interposed therebetween. In the illustrated embodiment, the housing portions **12**, **14**, and **16** collectively form a substantially spherical shape. However, the housing **11** can have other shapes, giving due consideration to the goal of collectively substantially surrounding and preferably enclosing the drum **20**. The reel **10** also includes a first or lower support structure **18** mounted to the lower housing portion **12**, as well as a second or upper support structure **19** mounted to the upper housing portion **14**. The lower support structure **18** is configured to support the reel **10** on a lower support surface. In a preferred embodiment, the reel is capable of operating upside down, and the upper support structure **19** is also configured to support the reel **10** on a lower support surface. As explained in further detail below, the middle housing portion **16** includes a triangular aperture **15** through which the linear material **2** can extend.

[0028] As mentioned above, in a preferred embodiment the reel **10** is adapted to spool electrical cord **2**. Preferably, the reel **10** provides electrical power to the cord **2** from an external electrical power outlet. In the embodiment of FIG. **1**, the reel **10** includes an electrical cable **13** that extends out of a lower opening (not shown) of the lower housing portion **12**. The cable **13** preferably includes a standard electrical plug **17** that is adapted to plug into a standard electrical power outlet. The cable **13** preferably provides power to the electrical cord **2** spooled on the reel **10**. While the illustrated connectors **3** and **17** are respectively female and male, these "genders" can be reversed.

[0029] FIGS. **2** and **3** are exploded top and bottom views, respectively, of the reel **10**. The reel **10** includes a spindle member **22** having a first end **24** and a second end **26** (FIG. **4**). The first end **24** is connected to, and preferably integrally formed with, the lower housing portion **12**. In this embodiment, the spindle member **22** is configured to extend through an opening **28** (FIG. **5**) in the drum **20** so that the drum is rotatable about a spindle axis **31** (also referred to herein as a "drum axis") defined by the spindle member **22**. Preferably, the opening **28** is sized to closely receive the spindle member **22**. The spindle member **22** is also configured to extend through an opening **30** (FIG. **4**) of the middle housing portion **16**. Preferably, the opening **30** is sized to closely receive the spindle member **22**. In one embodiment, the spindle member **22** has a lower larger diameter portion for a close fit with the opening **28** of the drum **20**, and an upper smaller diameter portion for a close fit with the opening **30** of the middle housing portion **16**, it being understood that the opening **28** is larger than the opening **30**. In another embodiment, the openings **28** and **30** are approximately the same size, and the spindle member **22** has a substantially uniform diameter. Skilled artisans will appreciate that other configurations of the spindle member **22** and openings **28** and **30** are possible, keeping in mind the goal of permitting both the middle housing portion **16** and drum **20** to rotate with respect to the spindle member **22** and independently with respect to each other.

[0030] With reference to FIGS. **2-4**, the upper housing portion **14** is preferably adapted to connect to the second end **26** of the spindle member **22** when the member **22** extends through the drum **20**. Preferably, the upper housing portion **14** and the spindle member **22** are detachably secured to one another so that they cannot rotate with respect to each other. In the illustrated embodiment, the upper housing portion **14** includes four through-holes **32** sized and configured to receive screws **34** (FIG. **4**) that are in turn adapted to screw into threaded holes **36** in the second end **26** of the spindle member **22**. Skilled artisans will appreciate that any of a wide variety of means can be employed for detachably securing the upper housing portion **14** to the spindle member **22**.

[0031] The reel **10** thus permits the middle housing portion **16** and drum **20** to rotate freely about the spindle member **22** and independently with respect to each other. In order to assist or facilitate the rotation of the drum **20** and/or middle housing portion **16**, rotation-assistance elements such as ball bearings, rollers, and the like may (but need not) be provided at interfaces between the housing portions **12** and **16**, between the housing portions **14** and **16**, between the middle housing portion **16** and the drum **20**, between the lower housing portion **12** and the drum **20**, between the spindle member **22** and the drum **20**, and/or between the spindle member **22** and the middle housing portion **16**. Also, tracks or other guide means can be provided to control the relative movement of these members. Lubricants can also be used to reduce friction at these interfaces.

[0032] With continued reference to FIGS. **2** and **3**, each of the upper and lower housing portions **12** and **14** preferably includes an annular wall **39** and a plurality of radial ribs **37** for added strength. Alternative configurations for internal walls and ribs are also possible, keeping in mind the goal of improving the strength and rigidity of the housing portions **12**, **14**. In other embodiments, the housing portions **12** and **14** do not have any internal members for added strength.

[0033] In the disclosed embodiments, the upper and lower support structures **18** and **19** are (but need not be) substantially similar. Accordingly, only the lower support structure **18** is described in detail herein. With reference to FIGS. **2** and **3**, the lower support structure **18** preferably comprises two mounting portions **40** and two handle portions **38**. The illustrated mounting portions **40** comprise elongated tubular members that are configured to be mounted on opposing sides of the lower housing portion **12**. Skilled artisans will appreciate that the mounting portions **40** can alternatively have non-tubular shapes. In a preferred embodiment, the lower housing portion **12** includes recesses **42** that are sized and shaped to receive the mounting portions **40**. The mounting portions **40** can be secured (preferably detachably) to the lower housing portion **12** by any of a wide variety of means, such as by screws, nut and bolt combinations, and the like. For example, the illustrated mounting portions **40** include vertical internally threaded stubs **41** that fit snugly into corresponding recesses **43** inside the recesses **42**. The recesses **43** are configured to receive screws for creating a detachable connection between the mounting portions **40** and the lower housing portion **12**. The mounting portions **40** can be curved to conform more closely to the semispherical shape of the lower housing portion **12**, providing a more stable and secure connection.

[0034] The illustrated handle portions **38** are positioned generally on opposing sides of the lower housing portion **12** and are substantially parallel to one another. In the illustrated embodiment, the handle portions **38** comprise elongated tubular members oriented generally perpendicular to the spindle member **22** and positioned so as to maintain a lower extreme of the lower housing portion **12** at least slightly above the lower support surface. The handle portions **38** are preferably sized and shaped to allow a person to grip them directly with his or her hands. Each mounting portion **40** preferably has one end coupled to an end of one of the handle portions **38** and another end coupled to an end of the other of the handle portions **38**. Each end of the handle portions **38** is preferably coupled to only one of the mounting portions **40**. The end portions of the illustrated mounting portions **40** extend downward and outward from a central portion that mounts to the recess **42** of the lower housing portion **12**.

[0035] In a preferred embodiment, the lower support structure **18** further comprises four coupling members **44**, each of which couples one of the ends of one of the handle portions **38** to one of the ends of one of the mounting portions **40**. In the illustrated embodiment, the coupling members **44** contact the lower support surface, while the handle portions **38** and mounting portions **40** do not. The illustrated coupling members **44** comprise elbow-shaped tubular members.

[0036] As mentioned above, the upper support structure **19** is preferably substantially similar to the lower support structure **18**. Accordingly, the illustrated support structure **19** preferably includes handle portions **38**, mounting portions **40** adapted to mount within recesses **42** of the upper housing portion **14**, and coupling members **44**, substantially as described above. The handle portions **38** of either support structure **18**, **19** can advantageously be used to conveniently grip onto and move the reel **10**. Preferably, the support structures **18**, **19** are configured to prevent the housing **11** (e.g., housing portions **12**, **14**, and **16**) from contacting a generally flat support surface regardless of the orientation of the reel **10**. For example, the illustrated support structures **18**, **19** prevent the housing **11** from contacting the ground even if the reel **10** is turned onto its side. In this configuration, the support structures more effectively protect the housing **11** from damage. In other embodiments, the upper support structure **19** is configured differently or can even be omitted from the reel **10**. It will be appreciated that a wide variety of different types of support structures **18**, **19** can be used without departing from the scope of the invention.

[0037] FIGS. **2**, **3**, and **5** show a preferred embodiment of the reel drum **20**. The illustrated drum **20** comprises a substantially cylindrical member **46** having a spool surface **47** onto which linear material can be spooled, a first end plate **48** at one end of the member **46**, and a second end plate **50** at the other end of the member **46**. The cylindrical member **46** and end plates **48** and **50** preferably rotate in unison together about the spindle member **22**. The cylindrical member **46** and end plates **48** and **50** can be formed integrally as a single unitary piece or can be formed separately and secured together. The middle housing portion **16** encircles the drum **20** and preferably rotates about the spindle member **22** independently of the drum **20**. The triangular aperture **15** is preferably positioned near the surface of a cylindrical member **46**, so as to direct the linear material onto the drum **20** during spooling.

[0038] With reference to FIGS. **3** and **5**, the lower housing portion **12** is preferably adapted to house a motor **51** that drives the reel drum **20** through a gear reduction assembly. In the illustrated embodiment, the motor **51** is housed within the spindle member **22**. The motor **51** is inserted into an opening **52** in the underside of the lower housing portion **12**. A motor cover **54** can be provided to support the motor **51** and/or close and possibly seal the opening **52** to protect the motor and gears from dust and debris. For ease of illustration, the gear reduction is not shown in the drawings. However, skilled artisans will understand that the gear reduction may comprise any suitable number of gears assembled to convert the motor rotational output into rotation of the drum **20** about the drum axis **31**. For example, as shown in FIGS. **3** and **5**, the gear reduction can effect rotation of the drum **20** by rotating a ring gear **58** comprising an annular wall on the bottom side of the end plate **48**, with teeth facing radially inward from the annular wall. In the illustrated embodiment, the annular wall is part of a ring-shaped piece **70** that is secured to the bottom side of the end plate **48**. In other embodiments, the piece **70** can be formed integrally with the end plate **48**. Further details of a preferred configuration of the gear reduction are set forth in U.S. Patent Application Publication No. US 2006-0266605 A1.

[0039] Thus, the motor **51** produces rotation of the drum **20** about the spindle member **22**. As seen in FIG. **3**, in the preferred embodiment the motor **51** is upside down (i.e., its output faces downward). However, it will be appreciated that the motor **51** can be oriented other than as shown. Skilled artisans will also understand that a variety of different types of motors and gear reduction assemblies can be employed without departing from the scope of the invention.

[0040] In use, a user can unwind the linear material **2** from the drum **20** by pulling the material out through the triangular aperture **15** of the middle housing portion **16**. In doing so, the drum **20** begins to rotate with respect to the upper and lower housing portions **12**, **14** and the spindle member **22**. The middle housing portion **16** is also freely rotatable, and its rotational position may vary because the aperture **15** will tend to follow the radial direction in which the user pulls the linear material **2**. As the user moves around the reel **10** holding a portion of the linear material that is withdrawn from the housing **11**, the middle housing portion **16** freely rotates to allow the aperture **15** to follow the radial direction of the withdrawn linear material. In this manner, the freely rotatable middle housing portion **16** facilitates using the linear material within a larger area. For example, the reel **10** can be placed centrally within a room or outdoor area (e.g., on the ground or mounted to a ceiling) and the linear material can be relatively easily withdrawn toward any direction or portion of the room or area. When the user wishes to spool the linear material onto the drum **20**, the user can switch on the motor **51** accordingly. The resultant rotation of the drum **20** causes the linear material to be pulled back into the housing **11** through the aperture **15** of the middle housing portion **16**.

[0041] During spooling, the middle housing portion **16** may tend to rotate along with the drum **20**, due to friction therebetween. This can cause the linear material to swing around the reel **10**, which can result in harm to surrounding persons or objects. Preferably, the reel **10** includes a mechanical and/or electrical mechanism to rotationally lock the middle housing portion **16** with respect to the upper and lower housing portions **12**, **14** during spooling. With reference to FIG. **3**, the illustrated embodiment includes a solenoid device **62** secured to the lower housing portion **12**. The solenoid device **62** is electrically operable, as well known in the art, to cause a piston stem **64** to extend in and out of an outer opening of its housing. The stem **64** is sized and shaped to slide into any one of a ring of indentations **66** provided on the inner surface of the middle housing portion **16**. The indentations **66** can have any of wide variety of shapes and sizes, keeping in mind the goal of permitting the solenoid stem **64** to stop the middle housing portion **16** from rotating by entering one of the indentations **66**. When the stem **64** enters one of the indentations **66**, it "locks" the middle housing portion **16**. In other words, the extended stem **64** prevents the middle housing portion **16** from rotating with respect to the upper and lower housing portions **12**, **14**. An electronic control system can be provided to actuate the solenoid device **62** (i.e., cause the stem **64** to extend) when the motor **51** is switched to a spooling operation, and to retract the solenoid device **62** (i.e., cause the stem **64** to retract into its housing) when the motor **51** is switched off or to a powered unspooling operation.

[0042] In a preferred embodiment, the illustrated electrical cord reel **10** is adapted to provide electrical power to an electrical cord **2** wound on the drum **20**, the cord **2** being operable to deliver power to an external device. Accordingly, the reel **10** can include suitable means for enabling a power connection between the cord **13** (FIG. **1**) and the

wound cord **2**, as known in the art. For example, the bottom of the end plate **48** of the drum **20** can include electrically conductive rings **78** (FIG. **5**), also referred to as "slip rings," adapted to contact electrical brushes (not shown) that are in turn in electrical communication with the cord **13**. Further, the drum **20** can be configured to provide an electrical connection between the slip rings **78** and a power connector (not shown) on the drum **20**, to which the wound cord **2** is connected. Further details of a preferred configuration for providing electrical power to the wound cord **2** are provided in U.S. Patent Application Publication No. US 2006-0266605 A1.

Triangular Aperture

[0043] FIG. **6** shows the triangular aperture **15**, in accordance with a preferred embodiment of the invention. As mentioned above, the middle housing portion **16** includes a generally triangular aperture **15** sized to receive a linear material (in the illustrated embodiment, the electrical cord **2**) wound onto the drum **20**. The aperture **15** has a first side **92**, a second side **94**, and a third side **96**. The first side **92** is preferably oriented generally parallel to the drum axis **31** (FIG. **2**). The first side **92** and second side **94** meet at a vertex **97**. The first side **92** and third side **96** meet at a vertex **95**. The second side **94** and the third side **96** meet at a vertex **93**.

[0044] The vertex **93** is preferably positioned generally midway between opposing ends of the spool surface **47** of the drum **20**. For example, in the illustrated embodiment, the vertex **93** is preferably positioned generally midway between inner surfaces of the end plates **48** and **50**. The aperture **15** is advantageously sized and oriented so that, during winding, the linear material **2** tends to translate against the vertex **93**. Preferably, a locking apparatus or mechanism (such as the solenoid device **62** described above) is provided to positionally lock the middle housing portion **16** while the linear material **2** is being wound onto the drum **20**, so that the vertex **93** remains fixed with respect to the rotating drum.

[0045] During unwinding of the linear material **2**, the middle housing portion **16** is preferably unlocked with respect to the housing portions **12**, **14**, allowing the housing portion **16** to rotate in a direction that would ease the retraction of the linear material. As a result, the linear material **2** is free to retract through a portion of the triangular aperture **15** other than just the vertex **93** (in FIG. **6**, any portion of the aperture **15** to the right of the vertex **93**). Advantageously, a larger vertical dimension of the aperture **15** is available for retracting the linear material **2**, resulting in significant improvements in the ease of retraction of the linear material. Also, the novel triangular shape of the aperture **15** allows for a greater amount of linear material **2** to be spooled into the housing **11**, such as an increase of about 25%.

[0046] In a preferred embodiment, the vertices **93**, **95**, and **97** are rounded, with a radius preferably equal to or greater than that of the linear material **2**. Such rounded vertices are preferred over sharp vertices because the latter would involve heightened stress concentrations in the middle housing portion **16**. Also, the thickness of the middle housing portion **16** is preferably increased along the edges or sides **92**, **94**, **96** of the aperture **15**, to provide increased strength for withstanding loads imposed against such edges by the taught linear material **2** during winding or unwinding.

[0047] Skilled artisans will appreciate that the ease with which the linear material **2** can be unwound from the reel **10** depends upon the length of the first side **92** of the triangular aperture **15** relative to the length of the drum **20**. The first side **92** extends across preferably at least 35%, more preferably at least 50%, more preferably at least 60%, more preferably at least 80%, and even more preferably at least 95% of a length of the spool surface **47** of the drum **20**. It will also be appreciated that the ease with which the linear material can be unwound depends upon the extent to which the first side **92** of the triangular aperture **15** is centered with respect to the length of the drum **20**. In this regard, a distance y between (1) a plane **102** that is parallel to the drum axis **31** (FIG. **1**) and that extends through a center **98** of the first side **92**, and (2) a plane **104** that is perpendicular to the drum axis **31** and that extends through a center of a length of the spool surface **47** of the drum **20**, is preferably less than 20%, more preferably less than 10%, and even more preferably less than 5% of the length of the spool surface. In the illustrated embodiment of FIG. **6**, the plane **104** is below the center **98** of the length of the first side **92** of the aperture **15**; however, it will be appreciated that the plane **104** could be above or directly level with the center **98**.

[0048] Skilled artisans will understand that the advantages of providing the triangular aperture **15** are achieved when the aperture "points" in the correct direction. In particular, the linear material **2** is preferably wound in a direction in which the vertex **93** points. For example, in the orientation of FIG. **6**, the linear material **2** is preferably wound in a clockwise direction (viewing the reel and aperture **15** of FIG. **6** from above) about the drum. In other words, the linear material **2** is preferably wound in a direction so that, during winding of the linear material onto the drum, the linear material tends to slide against the vertex **93**.

[0049] Skilled artisans will also appreciate that the ease of retraction of the linear material depends also upon the shape of the triangular aperture **15**. In a preferred embodiment, the aperture **15** is shaped substantially like an isosceles triangle and the second side **94** and third side **96** are oriented with respect to one another at an angle preferably within 20-50°, more preferably within 25-45°, and even more preferably within 30-40°. Other possible ranges include 25-55°, 30-50°, and 35-45°.

[0050] Skilled artisans will also appreciate that the ease of retraction of the linear material also depends upon the size of the aperture **15** relative to that of the drum **20**. The spool surface **47** of the drum **20** is preferably cylindrical and the distance between the vertex **93** and the first side **92** is preferably within 40-300%, more preferably within 60-200%, more preferably within 75-150%, and even more preferably within 85-125% of a diameter of the spool surface **47**. In one embodiment, the distance between the vertex **93** and the first side **92** is about the same as the diameter of the spool surface. Other suitable ranges for said angle are 70-130%, 85-115%, and 95-105% of the diameter of the spool surface **47**.

[0051] Although the invention has been disclosed in the context of certain embodiments and examples, it will be understood by those skilled in the art that the invention extends beyond the specifically disclosed embodiments to other alternative embodiments and/or uses and obvious modifications and equivalents thereof. Accordingly, the invention is not intended to be limited by the specific disclosures of preferred embodiments herein.

What is claimed is:

1. A reel comprising:

a drum having a spool surface onto which a linear material may be wound, the spool surface having two ends; and

a housing substantially enclosing the drum, the drum being rotatable about a drum axis relative to at least a portion of the housing, the at least a portion of the housing having a generally triangular aperture sized to receive a linear material wound onto the drum, the aperture having a first side oriented generally parallel to the drum axis, and second and third sides meeting at a vertex generally midway between opposing ends of the spool surface of the drum.

2. The reel of claim **1**, wherein the aperture has rounded vertices.

3. The reel of claim **1**, wherein the first side of the aperture extends across at least 50% of a length of the spool surface of the drum.

4. The reel of claim **1**, wherein a distance between a center of the first side of the aperture and a plane perpendicular to the drum axis and extending through a center of a length of the spool surface of the drum is less than 20% of the length of the spool surface.

5. The reel of claim **1**, wherein a thickness of the housing is increased along edges of the aperture.

6. The reel of claim **1**, further comprising a linear material at least partially wound upon the spool surface of the drum and extending through the aperture, the linear material being wound in a direction in which the vertex points.

7. The reel of claim **1**, farther comprising a linear material at least partially wound upon the spool surface of the drum, the linear material being wound in a direction so that, during winding of the linear material onto the drum, the linear material tends to slide against the vertex.

8. The reel of claim **1**, wherein the triangular aperture is shaped substantially like an isosceles triangle and the second and third sides are oriented at an angle of 20-50° with respect to one another.

9. The reel of claim **1**, wherein the spool surface of the drum is cylindrical and the distance between the vertex and the first side is within 40-300% of a diameter of the spool surface.

10. The reel of claim **1**, wherein the housing comprises a first portion and a second portion rotatable with respect to the first portion about the drum axis, the second portion including the aperture and being rotatable with respect to the drum about the drum axis.

11. The reel of claim **10**, further comprising a mechanism for rotatably locking the first and second portions of the housing while the rotating the drum in a direction to wind linear material thereon.

12. A method comprising:

rotating a drum about a drum axis to wind a linear material onto a spool surface of the drum or unwind the linear material from the spool surface of the drum;

and

during said step of rotating the drum, drawing the linear material through a generally triangular aperture in a housing substantially enclosing the drum, the drum being rotatable about the drum axis with respect to a portion of the housing that includes the aperture, the aperture having a first side oriented generally parallel to the drum axis, and second and third sides meeting at a vertex generally midway between opposing ends of the spool surface of the drum.

13. The method of claim **12**, further comprising rounding one or more vertices of the aperture.

14. The method of claim **12**, further comprising configuring the aperture so that the first side of the aperture extends across at least 50% of a length of the spool surface of the drum.

15. The method of claim **12**, further comprising positioning the first side of the aperture so that a distance between a center of the first side of the aperture and a plane perpendicular to the drum axis and extending through a center of a length of the spool surface of the drum is less than 20% of the length of the spool surface.

16. The method of claim **12**, further comprising increasing a thickness of the housing along edges of the aperture.

17. The method of claim **12**, wherein rotating the drum about the drum axis comprises winding the linear material onto the drum in a direction in which the vertex points.

18. The method of claim **12**, wherein rotating the drum about the drum axis comprises causing the linear material to slide against the vertex.

19. The method of claim **12**, further comprising:

shaping the aperture substantially like an isosceles triangle; and

orienting the second and third sides of the aperture at an angle of 20-50° with respect to one another.

20. The method of claim **12**, wherein the spool surface of the drum is cylindrical and the distance between the vertex and the first side is within 40-300% of a diameter of the spool surface.

21. The method of claim **12**, wherein the housing comprises a first portion and a second portion rotatable with respect to the first portion about the drum axis, the second portion including the aperture and being rotatable with respect to the drum about the drum axis.

22. The method of claim **21**, wherein rotating the drum about the drum axis comprises rotating the drum in a direction to wind the linear material onto the drum, the method further comprising rotatably locking the first and second portions of the housing during the step of rotating the drum.

23. A reel comprising:

a drum having a spool surface onto which a linear material may be wound; and

a housing substantially enclosing the drum, the drum being rotatable about a drum axis relative to at least a portion of the housing, the at least a portion of the housing having a generally triangular aperture sized to receive a linear material wound onto the drum.

24. A method comprising:

rotating a drum about a drum axis to wind a linear material onto a spool surface of the drum or unwind the linear material from the spool surface of the drum; and

during said step of rotating the drum, drawing the linear material through a generally triangular aperture in a housing substantially enclosing the drum, the drum being rotatable about the drum axis with respect to a portion of the housing that includes the aperture.

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