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(54) **REEL ASSEMBLY FOR WINDING WEB MATERIALS**

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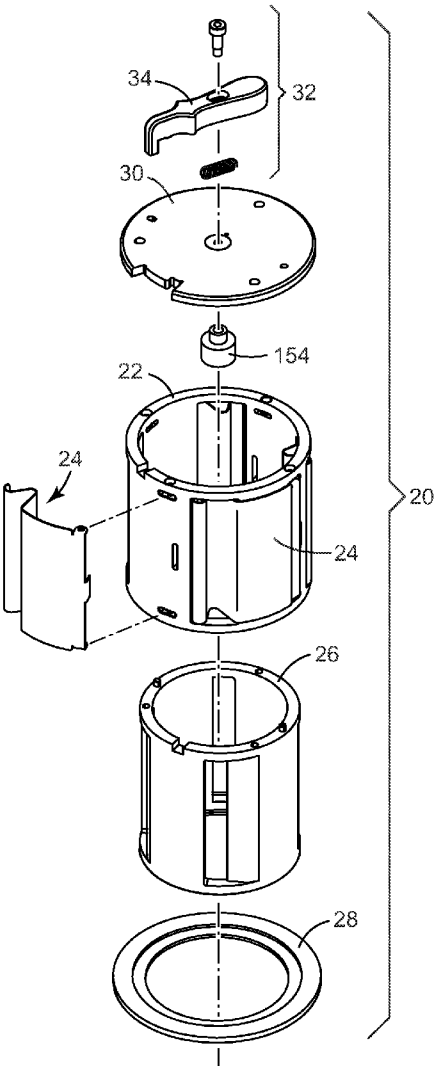
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(52) **U.S. Cl.** **242/571**

(57) **ABSTRACT**

A reel assembly includes a first hub defining an outer surface, a second hub co-axially disposed relative to the first hub, and a first movable member including a spooling surface that is movable to a position exterior to the outer surface to define at least a portion of an effective outer reel diameter of the assembly. The first and second hubs are manually rotatable relative to one another between a first rotational position and a second rotational position, the assembly being characterized by an expanded state in the first rotational position and a contracted state in the second rotational position where the effective outer reel diameter is greater in the expanded state than in the contracted state.



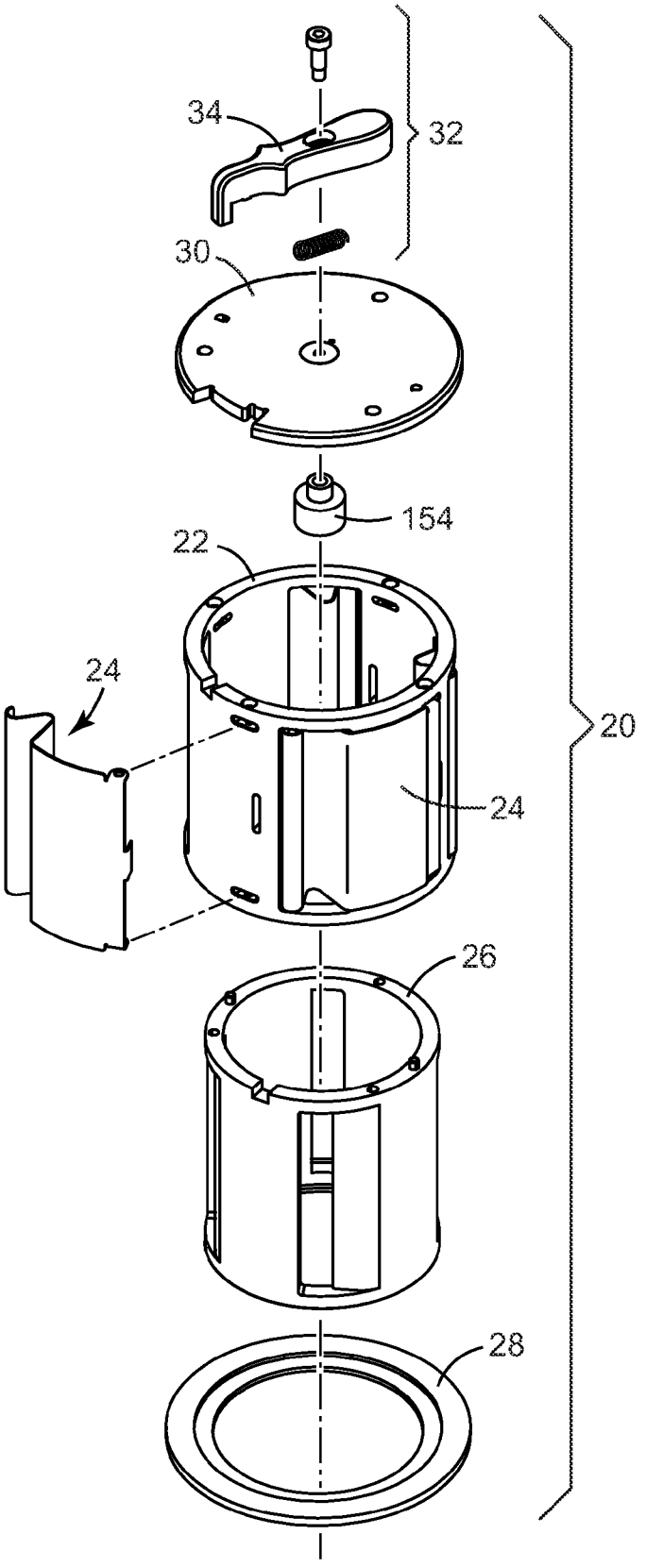


FIG. 1

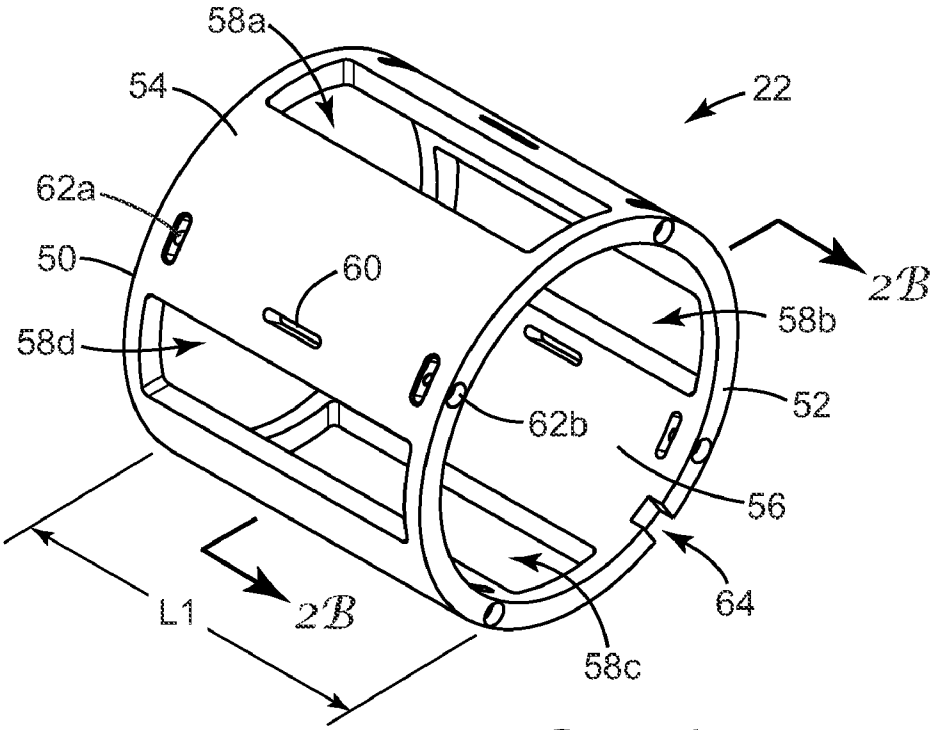

58a
54
22
62a
50
60
58d
2B
58b
52
62b
56
64
L1
2B
58c

FIG. 2A

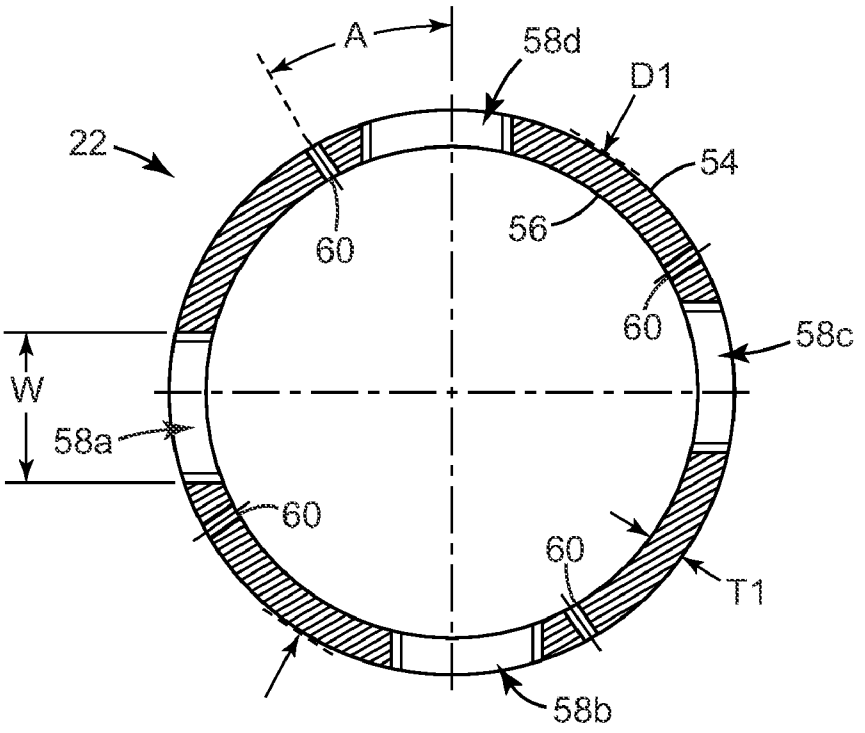

A
58d
D1
22
54
60
56
60
58c
W
58a
60
60
T1
58b

FIG. 2B

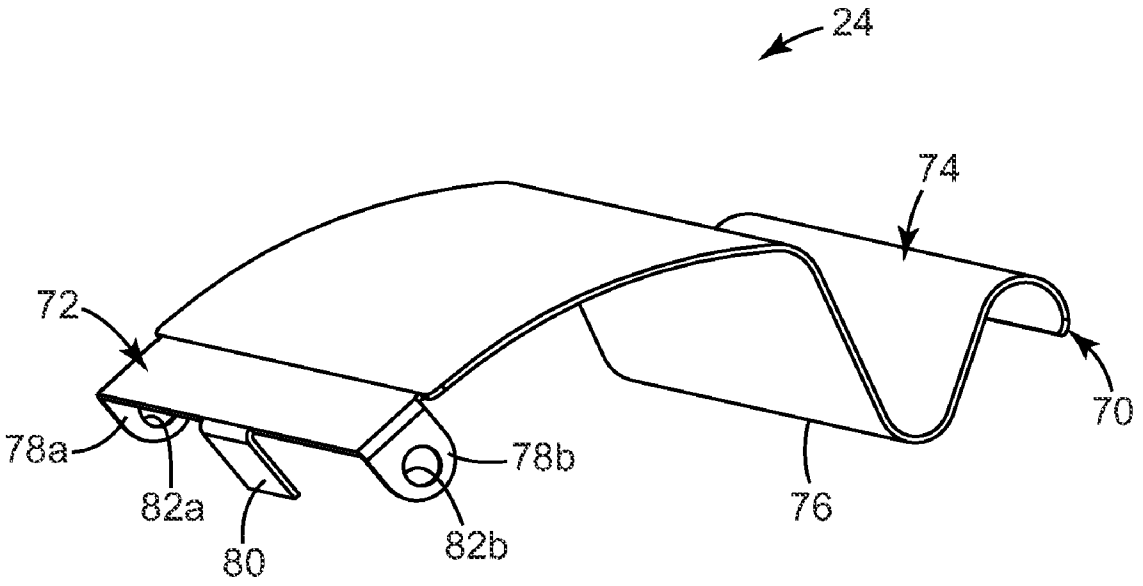


FIG. 3

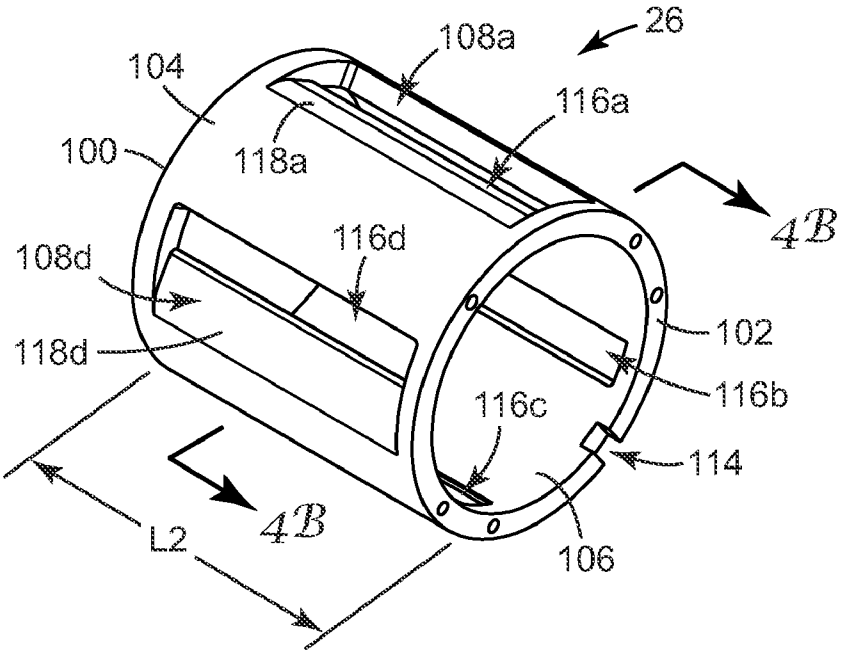

26
108a
104
116a
100
118a
4B
116d
108d
102
118d
116b
116c
114
4B
L2
106

FIG. 4A

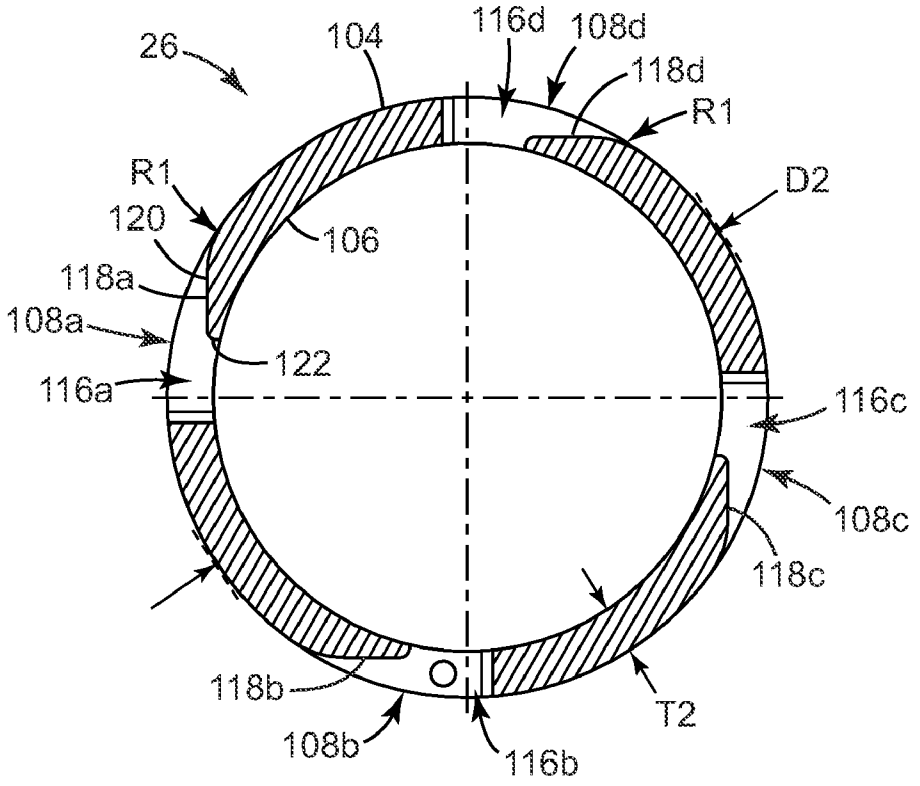

26
104
116d
108d
118d
R1
R1
D2
120
106
118a
108a
122
116a
116c
108c
118c
118b
T2
108b
116b

FIG. 4B

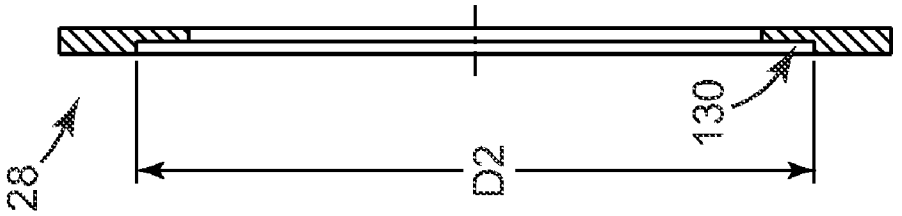


FIG. 5B

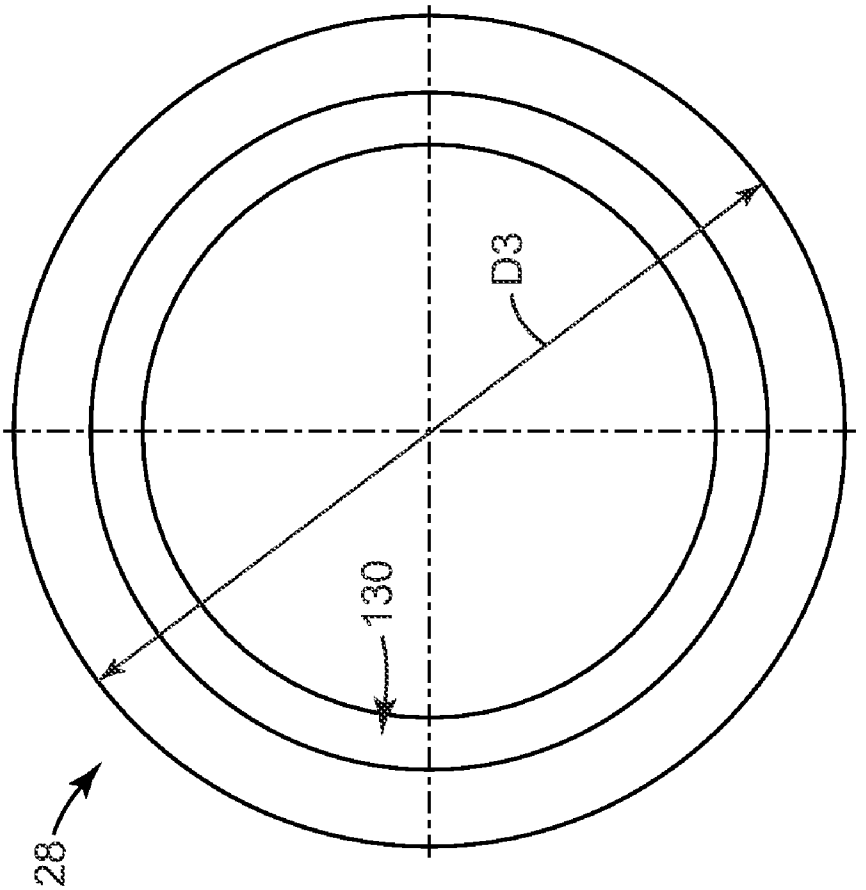


FIG. 5A

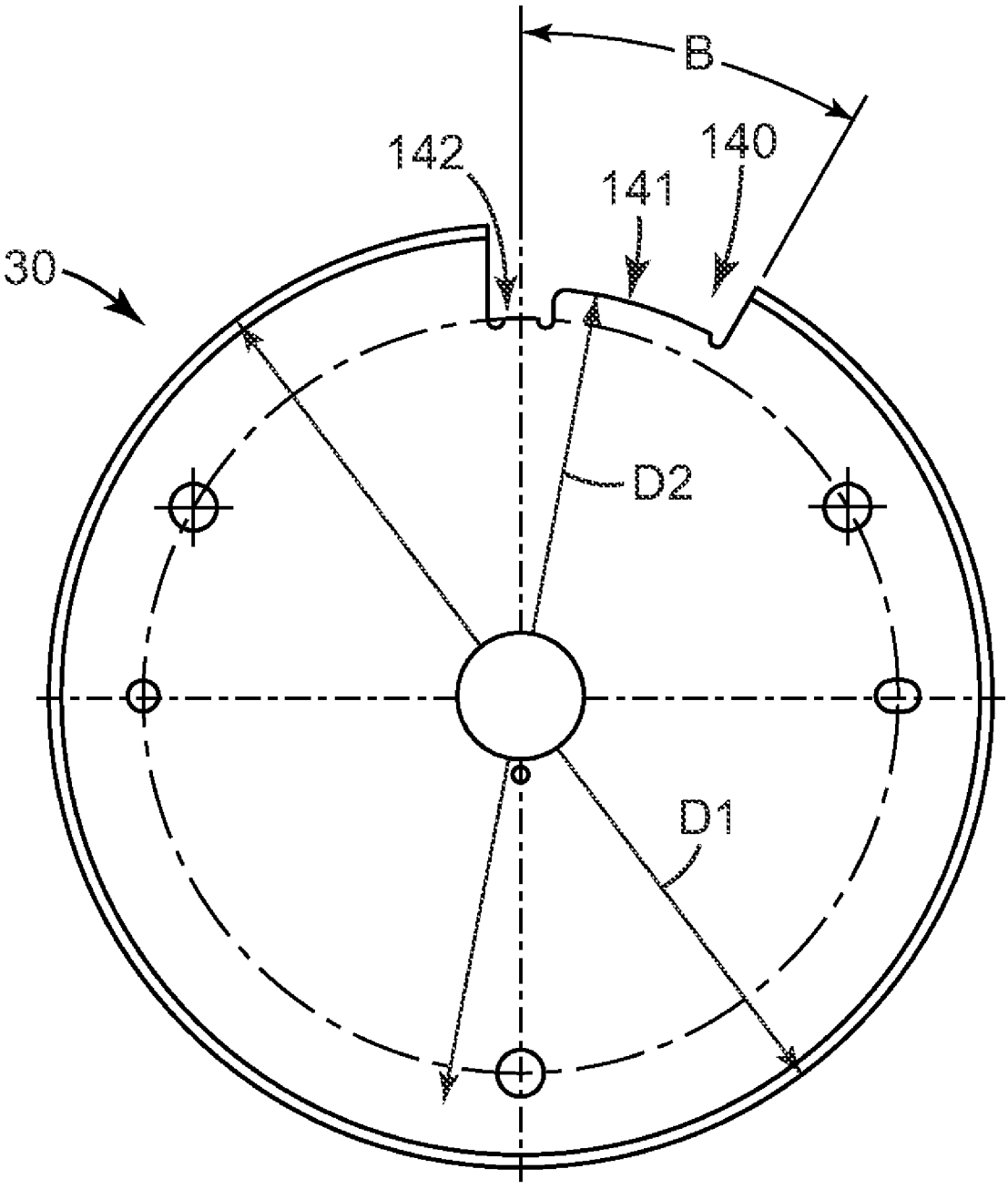


FIG. 6

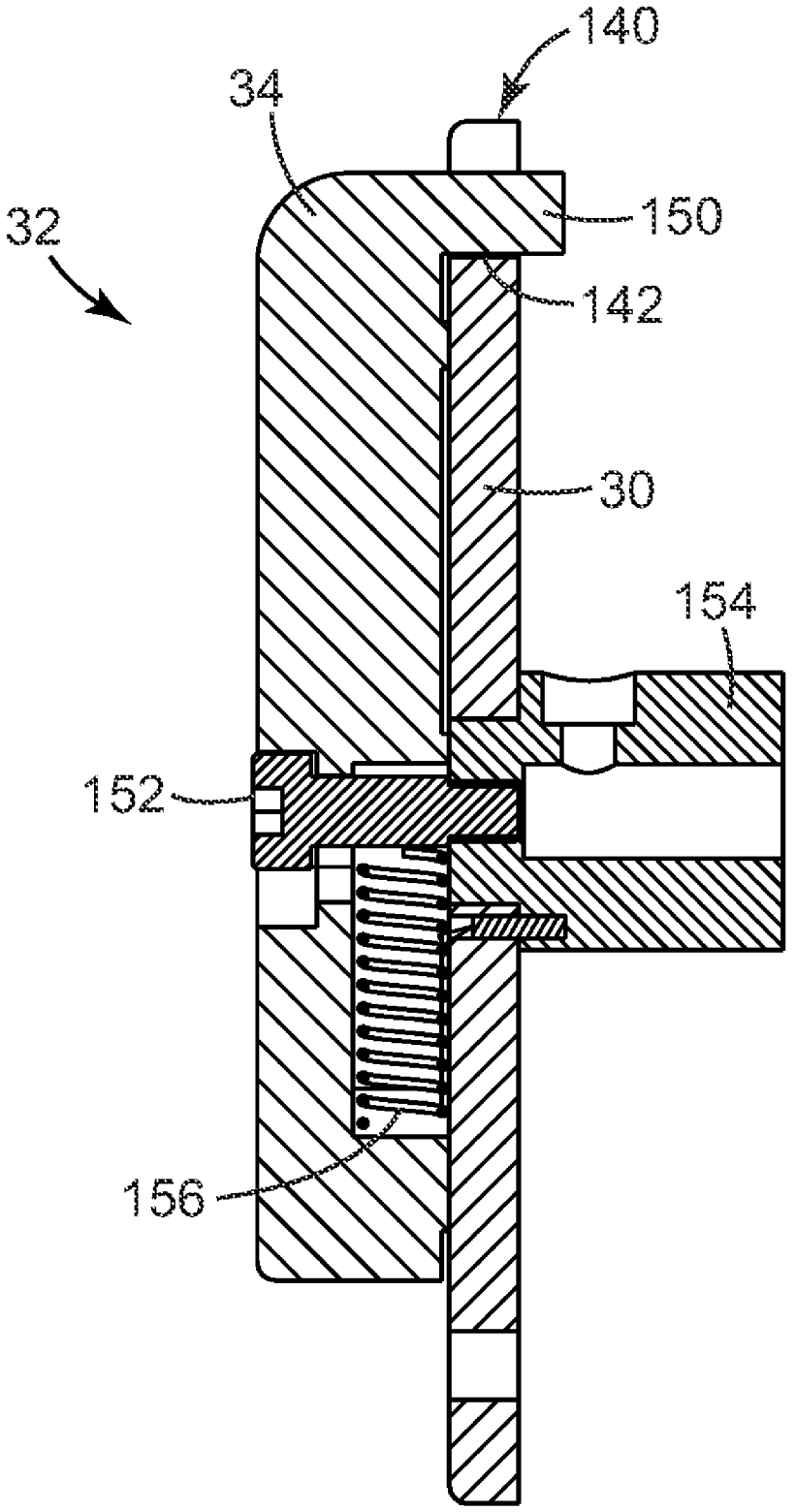


FIG. 7

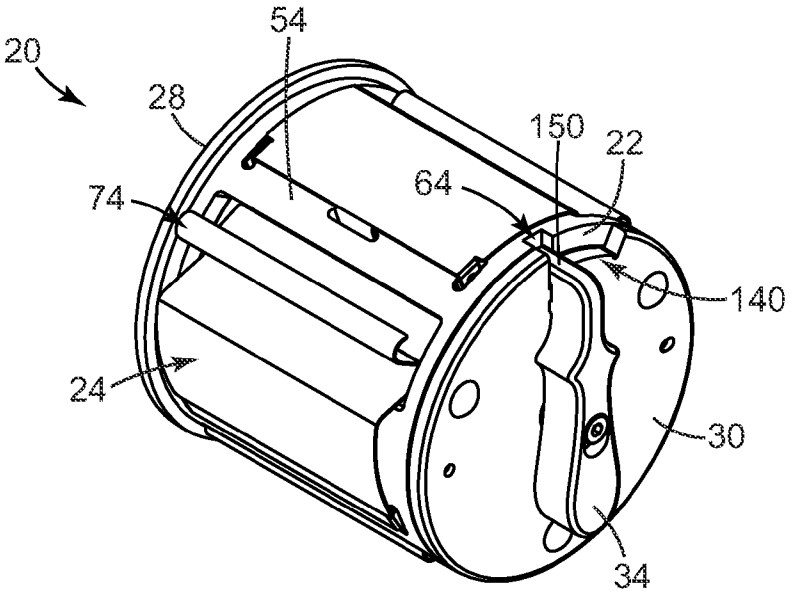

54
20
28
150
22
64
74
140
24
30
34

FIG. 8

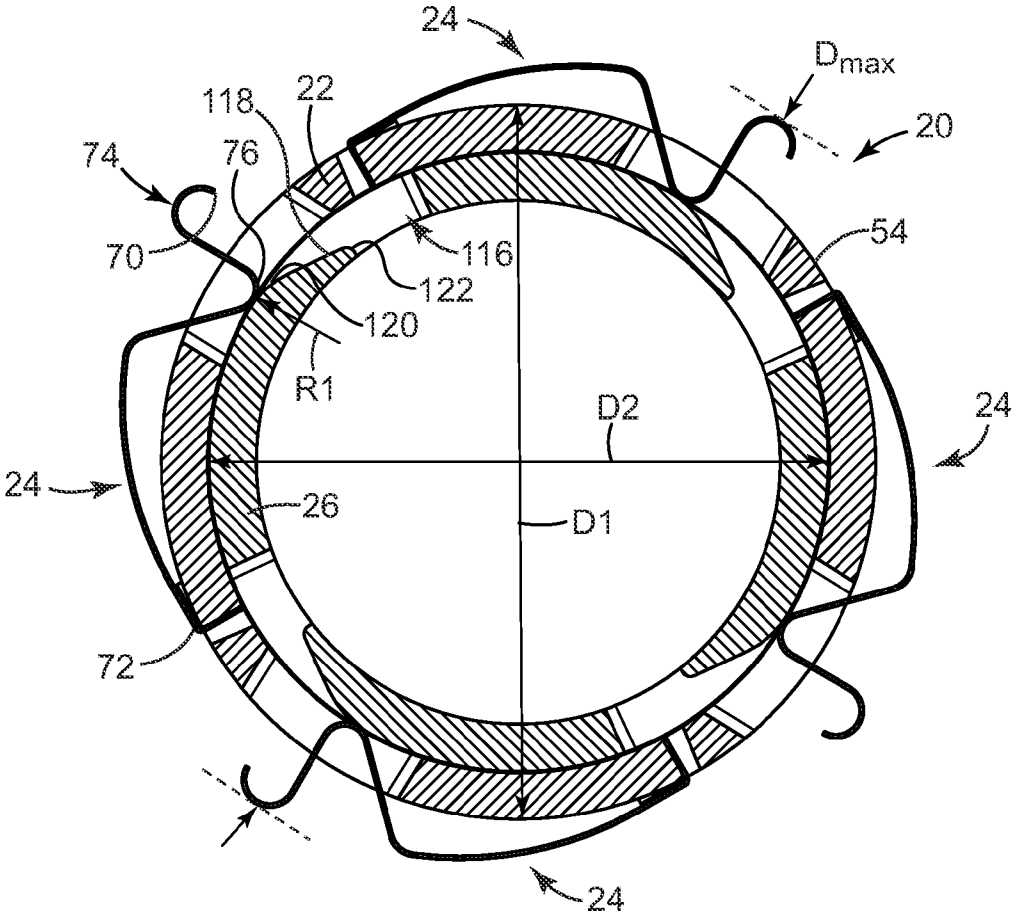

24
Dmax
20
118
22
74
76
54
70
116
122
120
R1
D2
24
24
26
D1
72
24

FIG. 9A

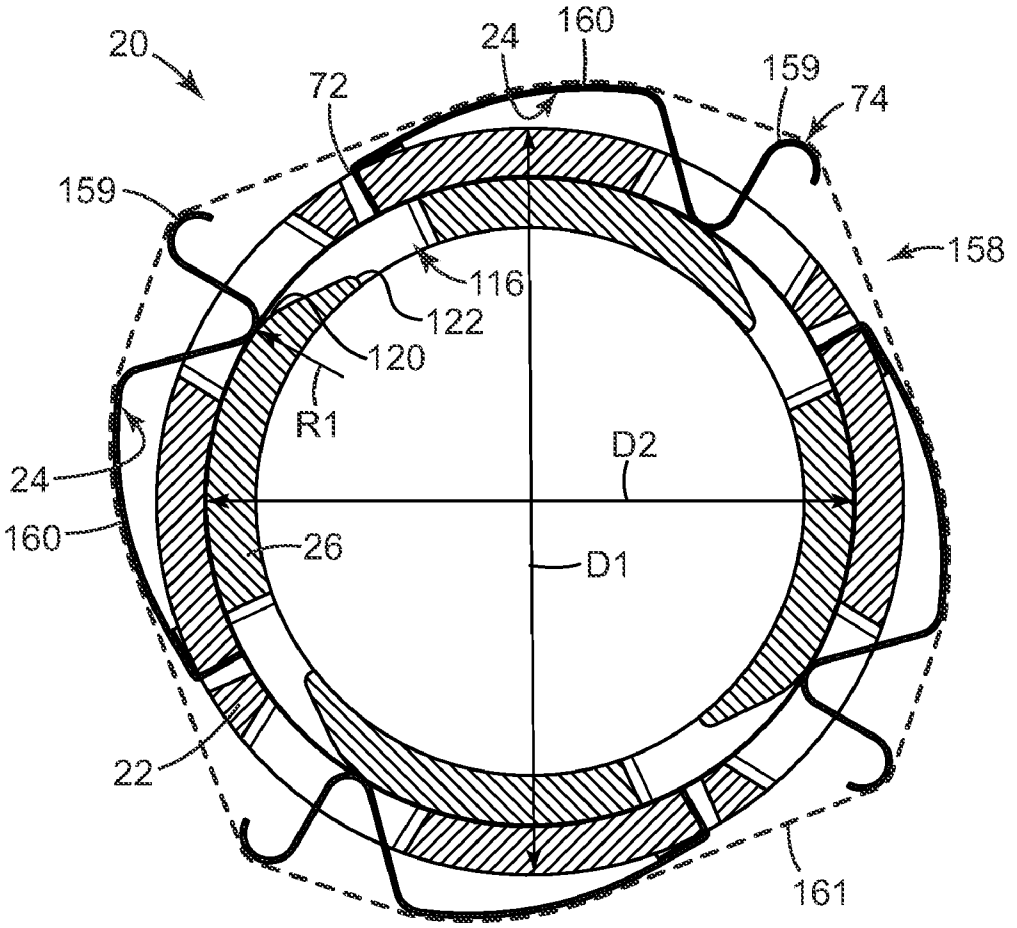

20
24
160
72
159
74
159
158
116
122
120
R1
D2
24
160
26
D1
22
161

FIG. 9B

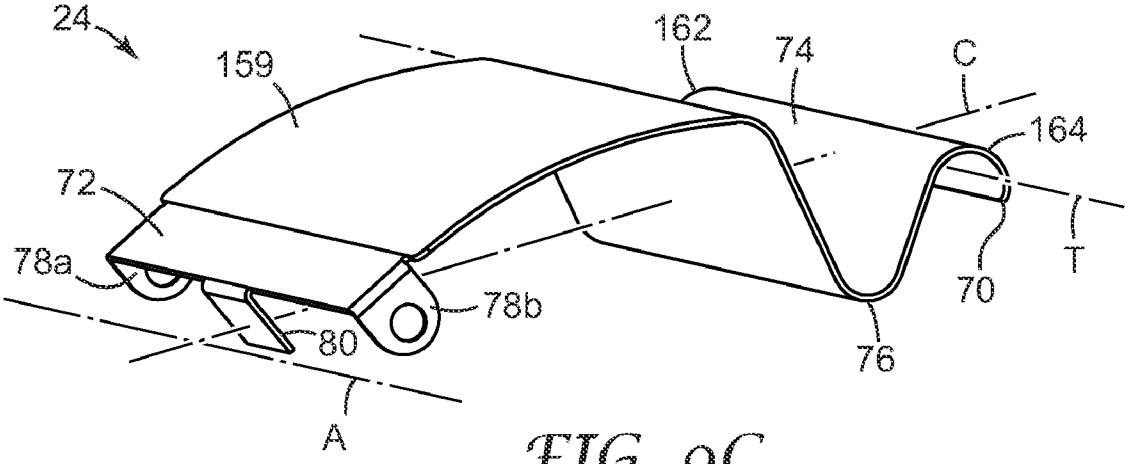

24
159
162
74
C
164
72
78a
78b
80
70
T
76
A

FIG. 9C

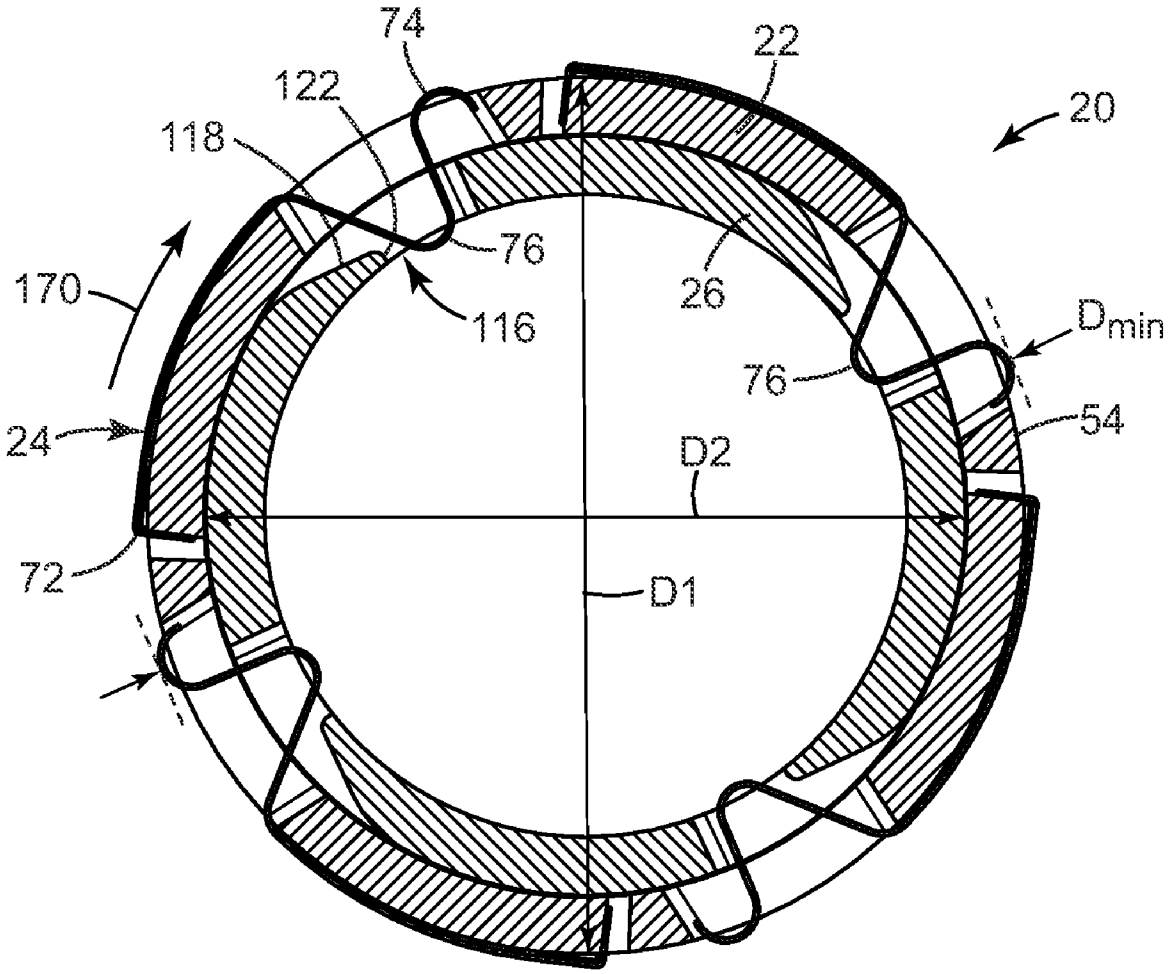


FIG. 10

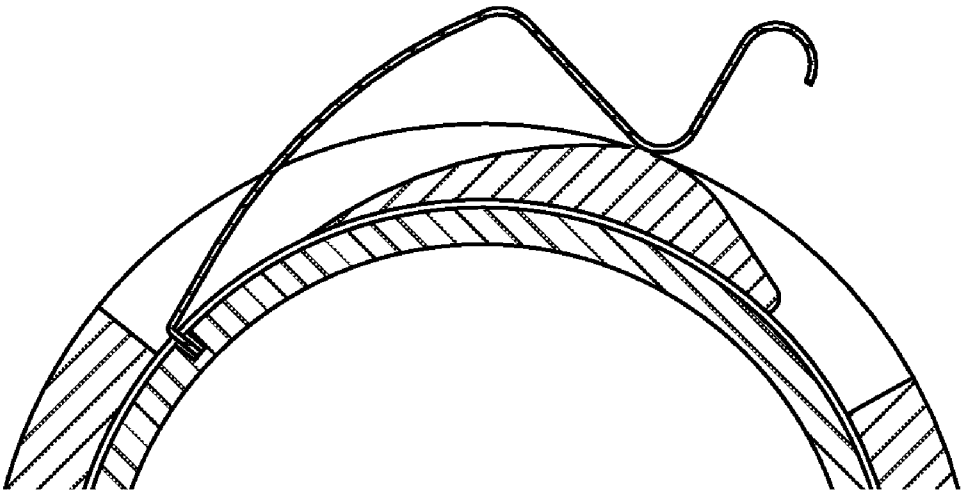


FIG. 11A

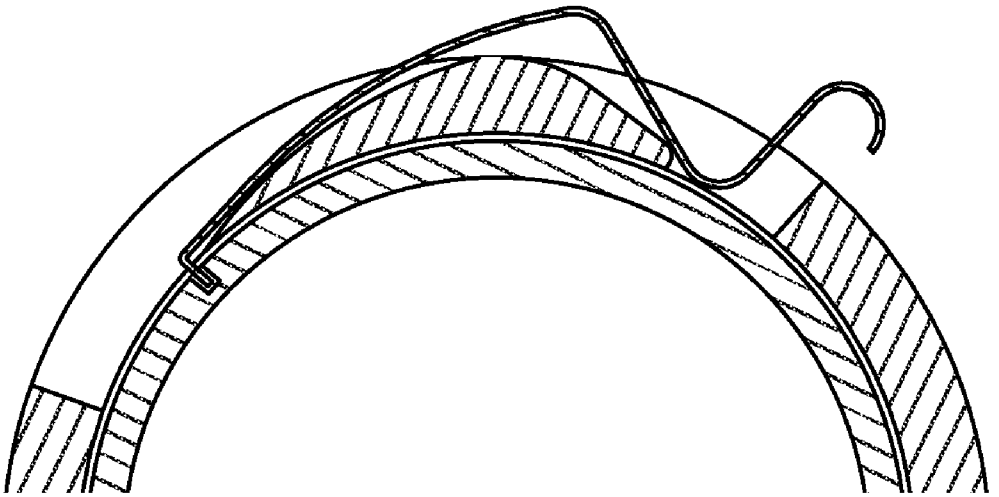


FIG. 11B

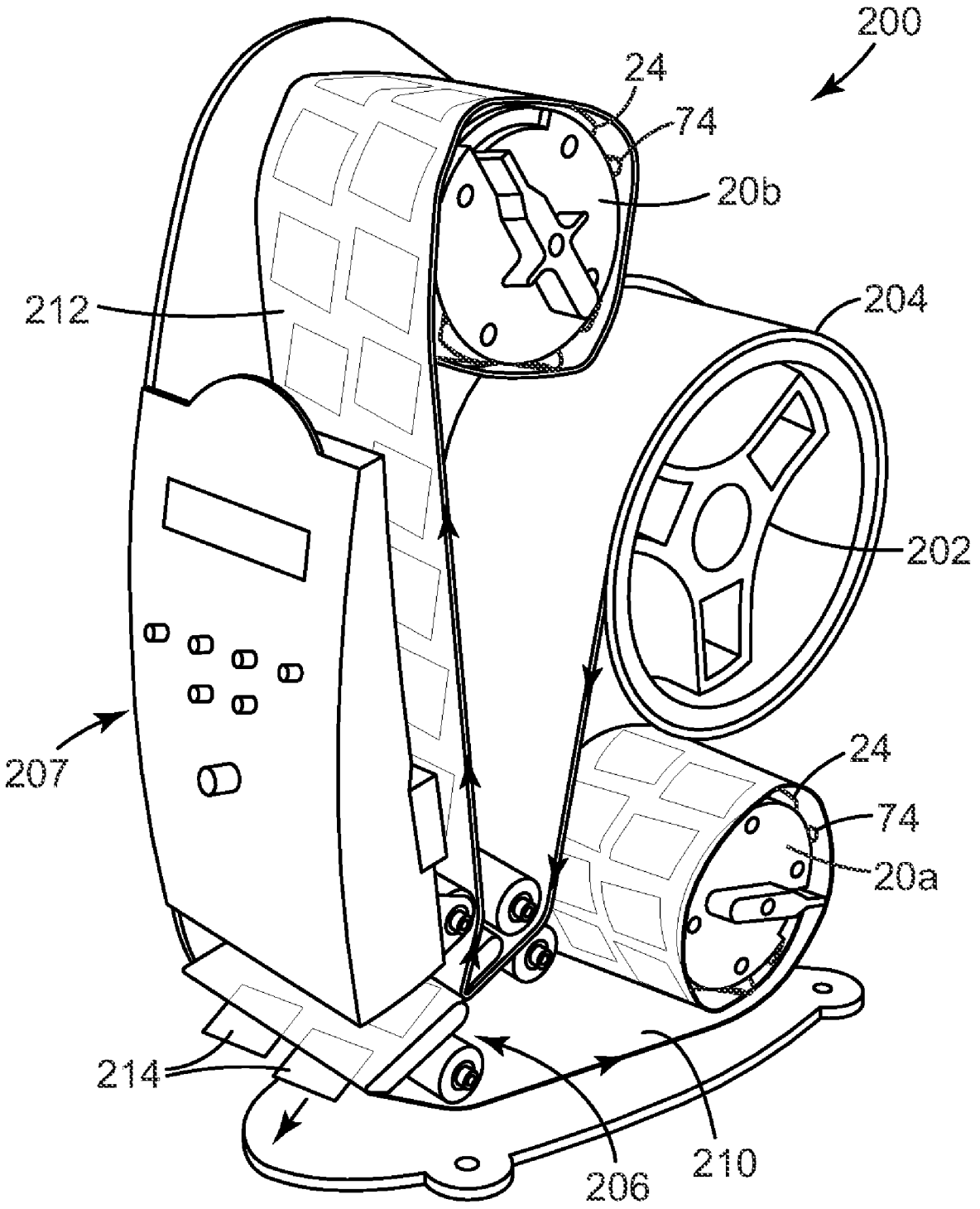


FIG. 12

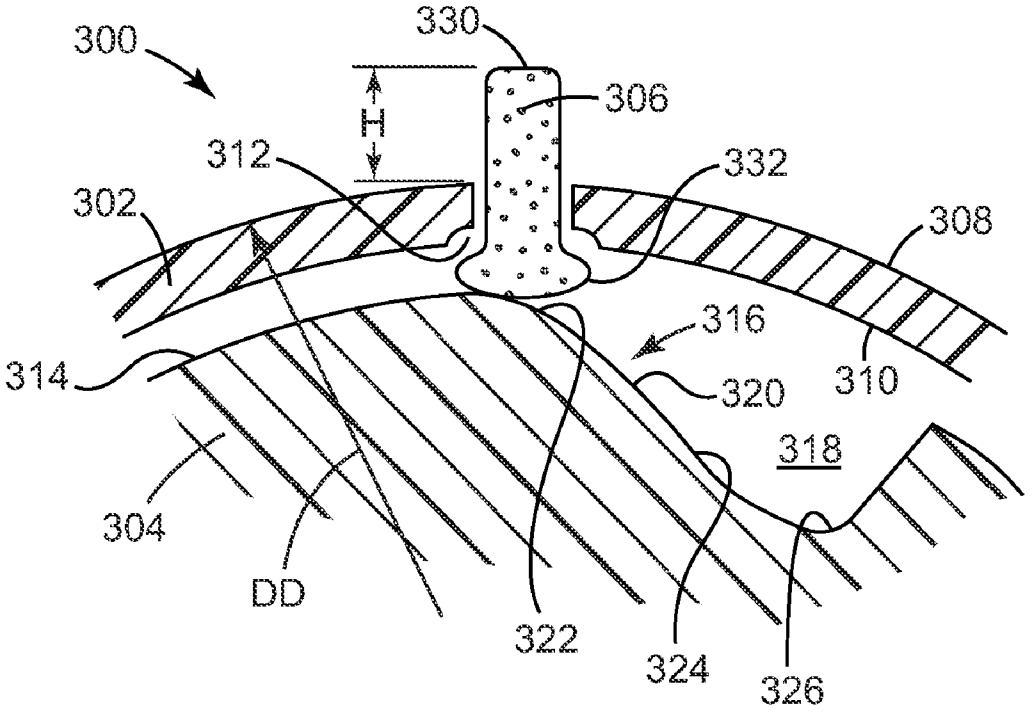


FIG. 13A

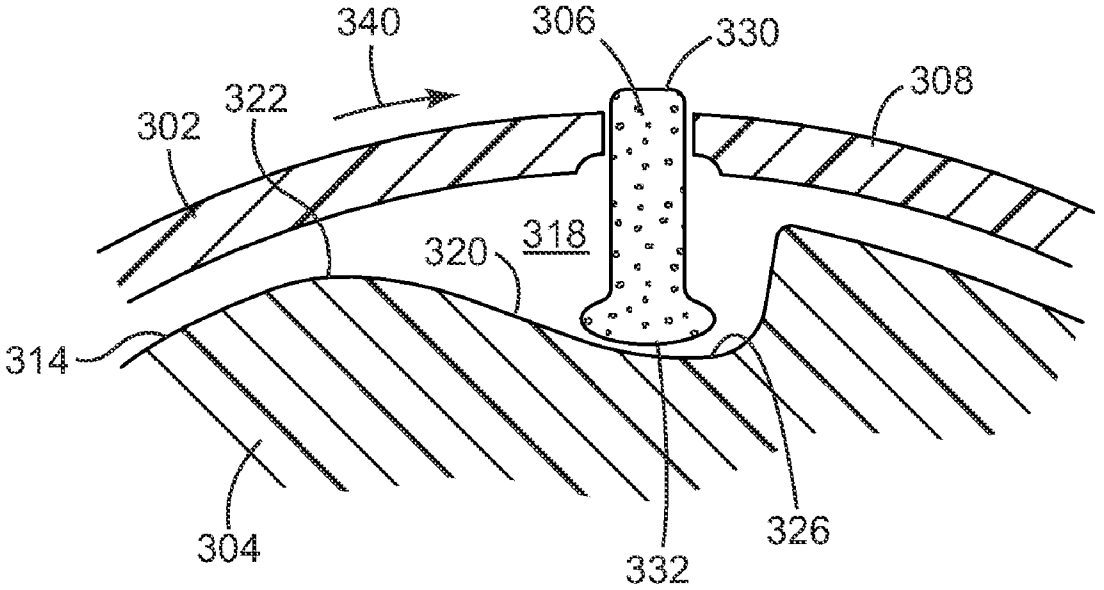


FIG. 13B

REEL ASSEMBLY FOR WINDING WEB MATERIALS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/803559, filed May 31, 2006, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] The production and use of web materials have been beneficially employed in a wide range of industrial and technical applications. Web materials include paper webs, fibrous webs, thin films and film laminates, and metal foils and sheets. Such web materials are commonly produced in widths up to several meters wide to take advantage of production economies of scale, but the production web materials are often slit down to a desired usable size of, for example, as small as a few centimeters in width. In this regard, the wider production web materials are typically slit down to size and rolled onto cores, resulting in a desired width of web material on a core that is suited for subsequent transportation and end use.

[0003] Cores useful in winding web materials include plastic cores, cardboard cores, and laminate cores, in general. The cores are typically slid over a winding mandrel, and optionally, an exterior surface of the core is prepared for gripping and winding web material. For example, some cardboard cores are provided with an adhesive coated onto a portion of the exterior surface. In this manner, the web material adheres to the exterior surface of the core and is prevented from sliding over the exterior surface of the core during winding. In any regard, the use of a core in winding web material adds an expense to the downstream processing of the web material.

[0004] Other winding processes employ a coreless mandrel that enables winding of web material directly onto the mandrel without the added expense of a core. Such mandrels typically are expandable to a winding configuration. The known expandable mandrels typically employ either fluid expandable bladders, or a collection of moving parts that are actuated to expand an outer surface of the mandrel to the winding configuration. In this regard, the greater the extent of the expansion of the outer surface of the mandrel, the greater the extent that the moving parts are displaced.

[0005] Web materials have become ubiquitous due to their wide range of beneficial applications across many industries. The manner in which the webs are wound and unwound can play an important role in the ultimate end use of the webs. To this end, improvements in the winding and unwinding of web materials will be beneficial to a wide variety of industries and welcomed by a wide variety of end users of web materials.

SUMMARY

[0006] The present application discloses, inter alia, a reel assembly for winding a material web. The reel assembly includes a first hub defining an outer surface, a second hub co-axially disposed relative to the first hub, and a first movable member movable to a position exterior to the outer surface to define at least a portion of an effective outer reel diameter of the assembly. In particular, the first hub defines the outer surface and an inner surface. The first movable member forms a spooling surface for receiving a material web and a bearing surface, and the spooling surface is movable to a position exterior to the outer surface to define at least a portion of an effective outer reel diameter of the assembly. The second hub includes an outer circumferential surface and a first transition zone defining a recess and a ramp, the ramp extending in a radially inward fashion from a first side that is contiguous with the circumferential surface to a second side that is opposite the first side. The first and second hubs are rotatable relative to one another between a first rotational position in which the bearing surface is proximate the first side of the ramp, and a second rotational position in which the bearing surface is proximate the second side of the ramp, and the assembly is characterized by an expanded state in the first rotational position and a contracted state in the second rotational position where the effective outer reel diameter is greater in the expanded state than in the contracted state.

[0007] The present application also describes a reel assembly for winding a material web. The reel assembly includes an outer hub, an inner hub, and a first moveable member having a spooling surface and a bearing surface. The outer hub includes an outer surface, an inner surface, and a first slot extending from the outer surface to the inner surface. The inner hub is rotatably mounted within the outer hub between at least a first and second rotational position, and is provided with a first recess. The first moveable member is mounted such that at least a portion thereof extends through the first slot, and such that in the first rotational position the inner hub contacts the bearing surface to maintain the spooling surface at an extended position, and in the second rotational position the first recess receives the bearing surface to move the spooling surface to a retracted position.

[0008] The present application also describes a method of processing a material web. The method includes providing a reel assembly manually operable to transition a spooling surface thereof between an expanded state and a contracted state, and transitioning the spooling surface to the expanded state. The reel assembly includes an inner hub co-axially disposed within an outer hub, where the inner hub defines a ramp and the outer hub defines an outer surface and a through-slot corresponding with the ramp. The method additionally includes winding the material web directly onto the spooling surface in the expanded state to form a wound web. The method further includes manually transitioning the spooling surface to the contracted state, and removing the wound web from the spooling surface.

[0009] The present application also describes a system for processing web material. The system includes a supply of web material, and the reel assembly described above, about which a length of web material from the supply is wound.

[0010] These and other aspects of the present application will be apparent from the detailed description below. In no event, however, should the above summaries be construed as limitations on the claimed subject matter, which subject matter is defined solely by the attached claims, as may be amended during prosecution.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The accompanying drawings are included to help describe the present invention. The elements of the drawings are not necessarily to scale relative to each other. Like reference numerals designate like parts.

[0012] FIG. **1** illustrates an exploded perspective view of a reel assembly;

[0013] FIG. **2**A illustrates a perspective view of a first hub of the reel assembly;

[0014] FIG. **2**B illustrates a cross-sectional view of the hub of FIG. **2**A;

[0015] FIG. **3** illustrates a perspective view of a movable member of the reel assembly;

[0016] FIG. **4**A illustrates a perspective view of a second hub of the reel assembly;

[0017] FIG. **4**B illustrates a cross-sectional view of the hub of FIG. **4**A;

[0018] FIG. **5**A illustrates a top view of a flange of the reel assembly;

[0019] FIG. **5**B illustrates a cross-sectional view of the flange of FIG. **5**A;

[0020] FIG. **6** illustrates a top view of an end plate of the reel assembly;

[0021] FIG. **7** illustrates a cross-sectional view of a locking mechanism assembled to the end plate of FIG. **6**;

[0022] FIG. **8** illustrates a perspective view of an assembled reel assembly;

[0023] FIG. **9**A illustrates a cross-sectional view of the assembled reel assembly illustrated in FIG. **8** in a first rotational position where the reel assembly is in an expanded state;

[0024] FIG. **9**B illustrates a cross-sectional view of the reel assembly of FIG. **8** including a web wrapped around expanded spooling surfaces of the assembly;

[0025] FIG. **9**C illustrates a perspective view of a free body diagram of a movable member separate from other components the reel assembly illustrated in FIG. **9**B;

[0026] FIG. **10** illustrates a cross-sectional view of the assembled reel assembly illustrated in FIG. **8** in a second rotational position where the reel assembly is in a contracted state;

[0027] FIGS. **11**A-B illustrate a cross-sectional view of a portion of an alternative reel assembly in which moveable members are pivotably attached to an inner hub and have bearing surfaces that slide along a ramp in a recess formed in the outer hub, where FIG. **11**A illustrates the alternative reel assembly in an expanded state and FIG. **11**B illustrates the alternative reel assembly in a contracted state;

[0028] FIG. **12** illustrates a perspective view of a reel assembly employed in a system for processing web material;

[0029] FIG. **13**A illustrates a cross-sectional view of another reel assembly in a first expanded rotational position; and

[0030] FIG. **13**B illustrates a cross-sectional view of another reel assembly in a second contracted rotational position.

DETAILED DESCRIPTION

[0031] FIG. **1** illustrates an exploded perspective view of a reel assembly **20**. The reel assembly **20** includes a first hub **22**, a plurality of movable members **24** coupled to the first hub **22**, a second hub **26** co-axially disposed relative to the first hub **22**, a flange **28** and an end plate **30** coupled to opposing ends of the second hub **26**, and a locking mechanism **32** coupled to the end plate **30** and the first hub **22**.

[0032] The flange **28** and the end plate **30** can be coupled to the second hub **26** to define a substantially stationary "barrel" around which the first hub **22** rotates. The locking mechanism **32** includes a handle **34** that is coupled to the rotatable first hub **22**, such that the handle **34** and the first hub **22** rotate relative to the substantially stationary barrel formed by the second hub **26** and the opposing flange **28** and end plate **30** (or vice-versa). In this manner, the locking mechanism **32** is movable between a locked position that maintains a fixed relative position between the first and second hubs **22**, **26**, and an unlocked position that permits the first hub **22** to rotate relative to the second hub **26** (or vice-versa).

[0033] In one embodiment, the first hub **22** is an outer hub, and the second hub **26** is an inner hub. The hubs **22**, **26** are co-axially mounted relative to one another such that the outer hub **22** rotates around the inner hub **26** (and vice-versa) between a first rotational position in which the assembly **20** is in an expanded state, and a second rotational position in which the assembly **20** is in a contracted state. In particular, rotation of the outer hub **22** relative to the inner hub **26** actuates movement of the movable members **24**. Rotation of the outer hub **22** from the first position relative to the inner hub **22** (i.e., the assembly **20** in the expanded state) to the second rotational position (i.e., the assembly **20** in the contracted state) is characterized by a radial inward movement of the movable members **24**. In this manner, an effective outer reel diameter of the assembly **20** is greater in the expanded state as compared to the contracted state.

[0034] As employed herein, the term "diameter" is used broadly to refer to a maximum width of a body, whether or not the body is circular in shape. Thus, the term diameter is applicable to non-circular shapes. Non-circular bodies may also be characterized by an effective diameter, where the effective diameter is the circumference of the body (or the circumference of a path circumscribing the body, such as the path of a web wrapped tautly around the body as shown for example in FIG. **9**B) divided by pi. The effective diameter is thus the diameter of a circle whose circumference is the same as the circumference of the body or of a path circumscribing the body. Of course, this definition also includes the case where the body or path is circular.

[0035] In an exemplary embodiment described in detail below, the locking mechanism **32** selectively locks the hubs **22**, **26** in the first rotational position characterized by a relative maximum effective outer reel diameter that is suited for winding web material onto the reel assembly **20**. Actuation of the locking mechanism **32** to the unlocked position permits the hubs **22**, **26** to rotate relative to one another to the second rotational position characterized by a relative minimum effective outer reel diameter that is suited for removing the wound web material from the reel assembly **20**.

[0036] FIG. **2**A illustrates a perspective view of an exemplary embodiment of the first hub **22**. The first hub **22** includes a first end **50**, an opposing second end **52**, an outer surface **54**, an inner surface **56**, and slots **58***a*, **58***b*, **58***c*, **58***d* extending from the outer surface **54** to the inner surface **56**. In alternative embodiments, at least some of the slots **58***a-d* can be omitted, or more slots can be added.

[0037] However, the hub **22** preferably includes at least one slot, for example, one of the slots **58***a*-**58***d*. A movable member **24** (FIG. **1**) is associated with each slot that is provided. In one embodiment, the movable members **24** are coupled to the outer surface **54** of the hub **22**, and the hub **22** includes a hinge trough **60** and bores **62***a*, **62***b* that are configured to pivotally receive one of the movable members **24**. As noted above, the number of slots **58***a*-**58***d* corre-

sponds to the number of movable members **24**, such that the number of hinge troughs **60** equals the number of slots **58***a*-**58***d*. Although FIG. **2**A illustrates four slots **58***a*-**58***d*, it is to be understood that the hub **22** can include from one to more than four slots, depending upon the application to which the assembly **20** is directed.

[0038] The second end **52** of the hub **22** can include a channel **64** sized and configured to receive a portion of the handle **34** (FIG. **1**) of the locking mechanism **32**. The channel **64** is preferably sized to slideably receive the handle **34** portion. In some cases, a width of the channel **64** along the circumference of the second end **52** is in a range from 0.2 to 0.4 inch (0.5 to 1.0 cm), preferably from 0.25 to 0.3 inch (0.6 to 0.8 cm), depending upon a selection of material for the handle **34**, the size of the hub **22**, and the application to which the assembly **20** is directed.

[0039] The hub **22** has a length L**1** of any desired dimension. In some cases, L**1** can be in a range from 3 to 4 inches (7.6 to 10.2 cm), e.g. about 3.4 inches (8.6 cm). In miniaturized applications, L**1** can be 1 inch (2.54 cm) or less. In large industrial applications, L**1** can be 4 inches (10.2 cm) or more.

[0040] FIG. **2**B illustrates a cross-sectional view of the hub **22**. As a point of reference in light of FIG. **2**A, the slot **58***d* is oriented in an up position relative to the illustration in FIG. **2**B, and the view in FIG. **2**B is directed from the first end **50** toward the second end **52**. Preferably, the slots **58***a*-**58***d* are through-slots, extending from the outer surface **54** to the inner surface **56**. In some embodiments, each of the slots **58***a*-**58***d* can have a width W in a range from 0.5 to 1.5 inches (1.3 to 3.8 cm), preferably about 1.0 inch (2.54 cm), although other suitable dimensions are also acceptable depending upon the design of the moveable members **24** and the application to which the assembly **20** is directed.

[0041] The hub **22** has an outside diameter D**1** defined by the outer surfaces **54** and a wall thickness of T**1** extending between the outer surface **54** and the inner surface **56** of the hub **22**. Again, the term "diameter" is used broadly to refer to the width or cross-wise dimension of a body, whether or not the body is circular in shape. In one embodiment, the outside diameter D**1** is in a range from 3 to 4 inches (7.6 to 10.2 cm), preferably about 3.75 inches (9.5 cm), although other sizes can of course be selected depending on the intended application for assembly **20**. In one embodiment, the wall thickness T**1** is in a range from 0.25 to 0.75 inches (0.63 to 1.9 cm), preferably about 0.5 inches (1.3 cm), but again other sizes are also acceptable based upon the materials selected for the hub **22** and the application to which the assembly **20** is directed. As illustrated in FIG. **2**B, four slots **58***a*-**58***d* are provided. Alternative embodiments may use other numbers of slots, whether one, two, three, or four or more. Where more than one slot is provided, the slots are preferably arranged to be substantially equally spaced along the periphery of the hub **22** as shown in FIGS. **2**A-**2**B.

[0042] The hinge troughs **60** can extend from the outer surface **54** to the inner surface **56** and can be offset relative to a corresponding one of the slots **58***a*-**58***d*. For example, the hinge trough **60** proximate slot **58***d* can be offset from the slot **58***d* by an angle A that ranges from 25 to 40 degrees, preferably about 30 degrees. In the embodiment shown, the four slots **58***a*-**58***d* are separated from each other by approximately 90 degrees, and four corresponding hinge troughs **60** are provided, each hinge trough being offset from and associated with a respective one of the slots **58***a*-**58***d*. Although the hinge troughs **60** are each shown as being oriented radially (i.e., parallel or roughly parallel to a radius of hub **22**), they can also have other orientations. For example, each hinge trough **60** can be in-line with its associated (neighboring) slot **58***a*-*d*.

[0043] The outer hub **22** is formed from suitable materials including, for example, metals such as aluminum or stainless steel, and plastics such as polyvinyl chloride (PVC), styrene including acrylonitrile butadiene styrene (ABS), thermoplastics such as polyethylene, nylon, or polyester, thermosets such as certain polyesters, rubbers, or epoxies, blends or compounds of such plastics, or other suitable reel assembly materials.

[0044] FIG. **3** illustrates a perspective view of an exemplary movable member **24**. This member **24**, which is capable of pivotal motion like a hinge, has a leading end **70** opposite a trailing end **72**, as well as a spooling surface **74** (referenced generally) and a bearing surface **76**.

[0045] In the illustrated embodiment, the leading end **70** is a curved portion of thin material, for example a shaped stainless steel plate, which undulates to define a curved segment, a prominent portion of which includes the spooling surface **74**. The trailing end **72** defines a first ear **78***a* opposite a second ear **78***b*, and a hinge tab **80**. The trailing end **72** is configured to pivotally couple to the first hub **22** (FIG. **2**A). In this regard, one embodiment provides a bore **82***a* in the first ear **78***a* that is configured to align with the bore **62***a* (FIG. **2**A) of the first hub **22**, and a bore **82***b* in the second ear **78***b* that is configured to align with the bore **62***b* (FIG. **2**A) of the first hub **22**, and hinge tab **80** configured to be received by the hinge trough **60** (FIG. **2**A). In this manner, the movable member **24** is coupleable to the first hub **22** at the trailing end **72**, with the leading end **70** being free to move relative to the outer surface **54** (FIGS. **2**A, **2**B).

[0046] Other mechanisms can be used to pivotally couple the trailing end **72** to the outer surface **54** of the hub **22**. For example, a continuously hinged edge can be used at the trailing end **72**, or a living hinge can be used particularly where the movable member **24** (or at least the trailing end thereof) is formed of a flexible plastic.

[0047] In the illustrated embodiment, the spooling surface **74** is opposite the bearing surface **76**, the spooling surface **74** being disposed at an uppermost extension of the member **24** and the bearing surface **76** being disposed at a lowermost extension thereof. Changing the geometry of the curvature adjacent the leading end **70** can change the distance between the spooling surface **74** and the bearing surface **76**, which in turn can change an effective outer reel diameter of the assembly **20** (FIG. **1**), as more fully described below.

[0048] Generally, the movable member **24** is formed from suitable materials including, for example, metals such as aluminum or stainless steel, and plastics such as PVC, styrene including ABS, thermoplastics such as polyethylene, nylon, or polyester, thermosets such as certain polyesters, rubbers, or epoxies, blends or compounds of such plastics, or other suitable reel assembly materials.

[0049] FIG. **4**A illustrates a perspective view of the second hub **26** introduced in FIG. **1**. The second hub **26** has a first end **100** opposite a second end **102**, an outer circumferential surface **104** opposite an inner surface **106**, and a plurality of transition zones **108***a*, **108***b*, **108***c*, **108***d* (transition zones **108***b* and **108***c* are obstructed from view). Each of the transition zones **108***a*-**108***d* has a respective recess **116***a*-

116*d* and a respective ramp **118***a*-**118***d* (ramps **118***b* and **118***c* are obstructed from view).

[0050] In some cases, the hub **26** is an inner hub about which the first hub **22** (FIG. **2**A) rotates (and vice-versa) between the first and second rotational positions as previously described. The second end **102** of the second hub **26** can include a detent **114** that is configured to align with the channel **64** (FIG. **2**A) and receive a portion of the locking mechanism **32** (FIG. **1**) when the hubs **22**, **26** are selectively locked in the first rotational position.

[0051] Hub **26** has a length L**2** which is preferably slightly greater than the length L**1** of outer hub **22**. In exemplary embodiments L**2** can be in a range from 3 to 4 inches (7.6 to 10.2 cm), preferably about 3.56 inches (9.04 cm), but the reader will understand that other dimensions for the length L**2** can also be selected. For example, in miniaturized applications, L**2** may be less than 1 inch (2.54 cm), while in large industrial applications, L**2** may be greater than 4 inches (10.2 cm).

[0052] FIG. **4**B illustrates a cross-sectional view of the second hub **26**. Relative to FIG. **4**A, the cross-sectional view of FIG. **4**B is directed from the first end **100** toward the second end **102**. Each transition zone **108***a*-**108***d* includes a respective recess **116***a*-**116***d* and a respective ramp **118***a*-**118***d*. In the illustrated embodiment, each of the recesses **116***a*-**116***d* defines a passage through the second hub **26**, and each of the ramps **118***a*-**118***d*, for example the ramp **118***a*, includes a ramp surface **120** that is contiguous with circumferential surface **104** and that extends radially inwardly, and a ramp tip **122**. The ramp surface **120** can be straight or curved (whether uniformly curved or cammed) as desired.

[0053] Preferably, the ramp surface **120** joins the circumferential surface **104** smoothly rather than abruptly, the smooth junction being characterized by a radius R**1**. The transition zone **108***a* thus transitions radially inward from circumferential surface **104** to the smooth junction coincident therewith of radius R**1**, to the ramp surface **120** and finally to the ramp tip **122**. Ramp tip **122** can also be rounded.

[0054] The radius R**1** of the ramp **118***a* is continuous with the outer circumferential surface **104** and defines a location of maximum potential energy for objects moving along the transition zone **108***a*, such as, for example, the bearing surface **76** of the movable member **24** (FIG. **3**). In this regard, the ramp **118***a* can be viewed as a potential energy surface where the potential energy of an object on the ramp **118***a* is greater when proximate to the radius R**1**, and the potential energy is lower when the object moves toward the ramp tip **122**. That is to say, absent other constraints (such as provided by the locking mechanism **32** of FIG. **1**), objects positioned on the radius R**1** are predisposed to move towards the ramp tip **122** to a lower energy state.

[0055] The second hub **26** has a diameter D**2** less than diameter D**1** of the first hub **22** (FIG. **2**B), and preferably the second hub **26** is configured and sized to fit inside of first hub **22** in a co-axial arrangement such that the two hubs **22**, **26** can rotate independently of each other. In an exemplary embodiment, D**2** is in a range from 3 to 3.5 inches (7.6 to 8.9 cm), preferably about 3.25 inches (8.26 cm). The second hub **26** also has a wall thickness T**2** extending between the circumferential surface **104** and the inner surface **106**, which in exemplary embodiments is in a range from 0.25 to 0.75 inches (0.64 to 1.91 cm), preferably about 0.5 inches (1.27 cm).

[0056] The inner hub **26** is formed from suitable materials including, for example, metals such as aluminum or stainless steel, and plastics such as PVC, styrene including ABS, thermoplastics such as polyethylene, nylon, or polyester, thermosets such as certain polyesters, rubbers, or epoxies, blends or compounds of such plastics, or other suitable reel assembly materials.

[0057] FIG. **5**A illustrates a top view of the flange **28** of the reel assembly **20**. In an exemplary embodiment, the flange **28** is annular in shape, and includes an annular step **130** sized to receive the second, inner hub **26** (FIG. **1**). With reference to FIG. **1**, the flange **28** can be coupled to the inner hub **26** so as to form an end stop that keeps the inner hub **26** centered inside of the outer hub **22** while permitting relative rotation therebetween. To this end, the flange **28** can form one end of a "barrel" about which the hub **22** rotates. In an exemplary embodiment, flange **28** has a diameter D**3** in a range from 3.75 inches to 4.2 inches (9.53 to 10.67 cm), and preferably about 4.0 inches (10.2 cm).

[0058] FIG. **5**B illustrates a cross-sectional view of the flange **28**. In an exemplary embodiment, the annular step **130** has a diameter that is approximately equal to diameter D**2** of the second hub **26**, such that the annular step **130** can receive the first end **100** of the second hub **26**. The flange **28** is fastened or otherwise coupled to the second hub **26** by any known fastening mechanism, such as bolts, screws, weld joints, adhesives, or the like.

[0059] The flange **28** is formed from suitable materials including, for example, metals such as aluminum or stainless steel, and plastics such as PVC, styrene including ABS, thermoplastics such as polyethylene, nylon, or polyester, thermosets such as certain polyesters, rubbers, or epoxies, blends or compounds of such plastics, or other suitable reel assembly materials.

[0060] FIG. **6** illustrates a top view of the end plate **30** of the reel assembly **20**. The end plate **30** has a notch **140** and a cover detent **142** formed within the notch **140**, where the notch **140** is sized to slideably receive the locking mechanism **32** (FIG. **1**).

[0061] The notch **140** can extend along an outer perimeter of the end plate **30** to define a port for receiving the locking mechanism **32** (FIG. **1**) between the first rotational position and the second rotational position. In this regard, the notch **140** subtends an angle B along a perimeter arc length of the end plate **30**, the angle B preferably falling in a range from 20 to 40 degrees, preferably about 30 degrees, although other are lengths are also acceptable.

[0062] In an exemplary embodiment, the end plate **30** is attached to the second hub **26** and defines a cover diameter that is selected to be approximately the same as diameter D**1** of the first hub **22**, or at least no greater than diameter D**1**. In this manner, when the assembly **20** (FIG. **1**) is in the contracted state (e.g., the hubs **22**, **26** in the second rotational position), wound web material can be removed from the assembly **20** by being slid off of the assembly **20** over the end plate **30**. The end plate **30** can be attached to the second hub **26** by any known fastening mechanism, such as bolts, screws, weld joints, adhesives, or the like.

[0063] The notch **140** can be formed in the end plate **30** by any known means, whether by machining or otherwise removing material from an initially intact (fully circular) disk, or forming the end plate in the shape shown in FIG. **6** without any material removal steps. Preferably, a first portion **141** of the notch **140** has a radius that is sized to

geometrically correspond to the radius (half of D2) of the second, inner hub **26**. That is to say, when assembled, the first portion **141** of the notch **140** is aligned with the circumferential surface **104** of the second hub **26**.

[0064] The end plate **30** includes the cover detent **142** that is relieved within the notch **140**. When the end plate **30** is coupled to the second hub **26** (FIG. **4**A), the cover detent **142** aligns with the detent **114** (FIG. **4**A) formed in the second hub **26**. The channel **64** formed in the first hub **22** (FIG. **2**A) moves as the first hub **22** rotates relative to the second hub **26**, such that the channel **64** is aligned with the detent **114** and the cover detent **142** when the locking mechanism **32** (FIG. **1**) is maneuvered to rotate the hub(s) **22** and/or **26** to the first rotational position.

[0065] The end plate **30** is formed from suitable materials including, for example, metals such as aluminum or stainless steel, and plastics such as PVC, styrene including ABS, thermoplastics such as polyethylene, nylon, or polyester, thermosets such as certain polyesters, rubbers, or epoxies, blends or compounds of such plastics, or other suitable reel assembly materials.

[0066] FIG. **7** illustrates a cross-sectional view of the locking mechanism **32** assembled to the end plate **30**. The locking mechanism **32** includes: the handle **34** having a tab **150**; an offset shoulder screw **152**; a boss **154** sized to receive the screw **152**; and a spring **156** configured to bias the handle **34** relative to the screw **152**. Although boss **154** and end plate **30** are shown in FIG. **7** as being separate pieces joined during the assembly of locking mechanism **32**, it is to be understood that boss **154** and end plate **30** can instead be formed as a single piece. Referring to FIG. **6**, when the locking mechanism **32** is assembled to the end plate **30**, the tab **150** can move along the notch **140** between a locked position where the tab **150** is secured within the cover detent **142**, to an unlocked position where the tab **150** is not secured within the cover detent **142** and is free to move along the first portion **141** of notch **140**, for example, to a position opposite the cover detent **142**.

[0067] When assembled, the shoulder screw **152** is threaded into the boss **154** to connect the handle **34** to the end plate **30** such that the handle **34** is able to rotate relative to the end plate **30**. A clearance is provided between the handle **34** and the end plate **30** to permit such rotation. The spring **156** biases the handle **34** relative to the end plate **30** (and the notch **140**) to force the tab **150** into secure engagement with the cover detent **142** when the handle **34** is in the locked position and the first and second hubs are in the first rotational position.

[0068] From this position, the operator can grasp the handle **34**, manually pushing it first in a radially outward direction to compress the spring **156** and disengage the tab **150** from the cover detent **142**, then manually rotating the handle clockwise so that the tab **150** travels along the first portion **141** of the notch **140** until the tab **150** reaches the end of the notch **140**. During this rotation, the (outer) first hub **22** rotates in unison with the handle since the tab **150** of the handle slidably engages the channel **64** of hub **22** (see FIG. **8**). When further clockwise rotation is no longer possible, i.e., the tab **150** reaches the end of the notch **140** and contacts the side wall of the notch, the first and second hubs are oriented in the second rotational position discussed above. To return the hubs to the first rotational position, the operator simply grasps the handle **34**, manually turning it counterclockwise until the tab **150** contacts the opposite side wall of the notch **140** (the side wall proximate the cover detent **142**), whereupon the spring **156** forces the handle radially inward so that tab **150** again engages the cover detent **142**. The reader will understand that the reel assembly can be easily modified to reverse the direction for turning the handle **34**, such that transitioning the reel assembly from the first (expanded) rotational position to the second (contracted) rotational position requires a counterclockwise rotation of the handle, and transitioning the assembly from the second (contracted) position to the first (expanded) position requires a clockwise rotation of the handle.

[0069] In general, the handle **34** and the boss **154** are formed from suitable materials including, for example, metals such as aluminum or stainless steel, and plastics such as PVC, styrene including ABS, thermoplastics such as polyethylene, nylon, or polyester, thermosets such as certain polyesters, rubbers, or epoxies, blends or compounds of such plastics, or other suitable reel assembly materials.

[0070] FIG. **8** illustrates a perspective view of the reel assembly **20** upon final assembly. The flange **28** and the end plate **30** are coupled to the second (inner) hub **26** (FIGS. **1** and **4**A) to form the barrel of the assembly **20** about which the first (outer) hub **22** rotates (it being understood that in other embodiments, the assembly **20** can be configured such that operation thereof entails rotation of the second hub **26** relative to the first hub **22**). In this manner, the first hub **22** is co-axially disposed over the second hub **26** and is rotatably retained between the flange **28** and the end plate **30**.

[0071] The handle **34** is coupled to the boss **154** (FIG. **7**) such that both the handle **34** and the first hub **22** rotate relative to the end plate **30** and the second hub **26**. In this regard, the tab **150** of the handle **34** is received within the channel **64** of the first hub **22**, such that the handle **34** and the first hub **22** move in unison. As illustrated in FIG. **8**, the tab **150** of the handle **34** is secured in the locked position such that the hubs **22**, **26** are maintained in the first rotational position. In this position, the spooling surface **74** is offset away from (above) the outer surface **54** of the first hub **22** to define the expanded state of the assembly **20** in which the effective outer reel diameter thereof is increased or expanded (compared to the contracted state described below).

[0072] FIG. **9**A illustrates a cross-sectional view of the assembled reel assembly **20** in the expanded state (e.g., the hubs **22**, **26** in the first rotational position). The second hub **26** is co-axially disposed within the first hub **22**, and the movable member **24** is pivotally coupled along the trailing end **72** to the first hub **22**. The bearing surface **76** of the movable member **24** is positioned proximate the radius R**1** and the first side **120** of the ramp **118** such that the spooling surface **74** is elevated away from the outer surface **54** of the first hub **22** to define an expanded outer reel diameter D_{max} of the assembly **20**. (As a point of reference, the assembly **20** defines a contracted outer reel diameter D_{min} in the contracted state, with D_{min} being less than D_{max}. Both the expanded state and the contracted state also have corresponding effective diameters, the effective diameter of the expanded state being no greater than D_{max} but being greater than the effective diameter of the contracted state, the latter effective diameter being no greater than D_{mim}.) In operation, as web material is wound onto the spooling surface **74**, the movable member **24** is supported along the bearing surface **76** by the outer circumferential surface **104** (FIG. **4**B) of the

second hub **26** such that the spooling surface **74** supports large loads associated with high winding tension of web materials.

[0073] As shown in FIG. **9**A, the hubs **22**, **26** are selectively locked in the first rotational position such that the bearing surface **76** is retained proximate the radius R**1** but poised to slide radially inward along the ramp **118** from the first side **120** of the ramp **118** to the ramp tip **122**. Thus, when in the first rotational position, the movable members **24** are positioned such that the outer reel diameter D_{max} defined by the spooling surface **74** (in the expanded state) is exterior to the outer surface **54** of the first hub **22**.

[0074] In this manner, the spooling surfaces **74** of the plurality of moveable members **24** can combine to prevent winding of the material web onto the outer surface **54** of the first hub **22**. With a sufficient number and suitable placement of moveable members, and where the reel assembly **20** is in the expanded state, the wound material web may extend from spooling surface **74** to spooling surface without contacting the outer surface **54** of the first hub **72**.

[0075] The undulating shape of the movable member **24** adjacent the leading end **70** can be selectively sized such that the outer reel diameter D_{max} in the expanded state is significantly greater than the outer reel diameter D_{min} of the assembly **20** in the contracted state (e.g., D_{min} may nominally equal the diameter D**1** of the first hub **22**). For example, D_{max} can be in a range from 1% to 100% larger than D_{min}. Preferably, D_{max} ranges from 20% to 60% larger than D_{min}. For example, when D**1** and D_{min} both equal about 3.75 inches (9.53 cm), D_{max} may be about 4.5 inches (11.43 cm), such that D_{max} is about 25% larger than D_{min}. Note that the same ranges of 1 to 100% and 20 to 60% also apply to the effective reel diameters in the expanded and contracted states of the reel assembly.

[0076] The outer reel diameter D_{max} can be selectively sized to accommodate the elasticity of a web that is wound about the assembly **20**. For example, for applications in which a web having low elasticity (for example a metal film/foil) is wound about the assembly **20**, the outer reel diameter D_{max} can be selected to range from about 1% to 5% larger than D_{min}. That is to say, substantially inelastic webs wound onto an expanded assembly **20** can be removed from the assembly **20** after it is transitioned to the contracted state (i.e., the hubs are rotated to the second rotation position e.g. as shown in FIG. **10**) even when the expanded state reel diameter D_{max} is only slightly larger, e.g., 1 to 5% larger, than the contracted state reel diameter D_{min}.

[0077] Conversely, for elastic, stretchy webs, the expanded state reel diameter D_{max} is more significantly larger, e.g., 5 to 100% larger, than the contracted state reel diameter D_{min}. Elastic webs ordinarily stretch when wound onto a reel assembly, creating a static load directed radially inward. The static load is borne by the assembly during winding, but should be substantially released after winding to permit removal of the wound roll. This is done by transitioning the reel assembly from the expanded state to the contracted state, where the contracted state is sufficiently smaller than the expanded state (the diameter or effective diameter in the expanded state is sufficiently larger than that of the contracted state) so that the static load is substantially released.

[0078] FIG. **9**B illustrates a cross-sectional view of the reel assembly **20** in the expanded state as in FIG. **9**A, but also illustrates a web **158** wrapped tautly around the reel assembly. The plurality of movable members **24** prevent the material web **158** from contacting the outer surface **54** of the first hub **22**. Furthermore, each of the spooling surfaces **74** includes a primary spooling surface **159** and a secondary spooling surface **160**, with the primary spooling surface **159** extending a maximum radial distance from a center of the assembly **20** (and thus defining the expanded state outer reel diameter D_{max}). In this regard, "spooling surface" refers to a surface contacted by the web as it is wound (or "spooled") around the reel, normally when the reel is in its expanded state. Note that one can modify the shape of the moveable members **24** so that only one spooling surface (e.g. primary spooling surface **159**) is formed on each moveable member, or two or more discrete spooling surfaces are formed on each moveable member. Furthermore, if the shape of the moveable members does not prevent the web from contacting the outer surface **54** of the first hub **22**, portions of such outer surface **54** may also become spooling surfaces. With the configuration of FIG. **9**B, however, when the web **158** is wrapped onto the assembly **20**, the spooling surfaces **159**, **160** support the web **158** and define its winding path **161**. In this manner, the web **158** contacts distinct spooling surfaces **159**, **160** on each of the moveable members **24**. Thus, the surface originally identified as spooling surface **74** can comprise two or more discrete, non-contiguous spooling surfaces, depending on the design or shape of the moveable members.

[0079] Preferably, each moveable member **24** is shaped and oriented on the hub such that, in the expanded state of the reel assembly, the section of the moveable member that bears the greatest static load of the web extends in a direction approximately parallel to the direction of such load for maximum stability and strength. Referring to FIGS. **9**B and **9**C, the direction of the static load of a tautly wound web **158** is approximately radially inward towards the center of rotation of the hubs **22**, **26**, and the section of each moveable member **24** that bears the greatest static load of the web (i.e., the section between the primary spooling surface **159** and the bearing surface **76**) also extends approximately radially inward in the expanded state of the reel assembly.

[0080] The winding path **161** is not necessarily circular; in fact, it is usually not precisely circular. For example, as illustrated, the winding path **161** is non-circular and spans across the movable members **24** from the primary spooling surfaces **159** of one movable member **24** to the secondary spooling surface **160** of the circumferentially adjacent movable member **24**. The circumference of the winding path **161** can be used to calculate an effective (expanded state) outer reel diameter by dividing the winding path circumference by pi. Thus, a circle whose diameter is the effective diameter has a circumference equal to the length of one circuit of the winding path **161**.

[0081] Although four movable members **24** are illustrated, it is to be understood that even one movable member **24** can be provided, with the resultant assembly configured to provide an expanded state effective outer reel diameter that is from 1 to 100% or more, or 20 to 60%, larger than the contracted state effective outer reel diameter.

[0082] FIG. **9**C illustrates a perspective view of a free body diagram of movable member **24** separate from other components of reel assembly **20**. The movable member **24** is fixed to the first hub **22** by the ears **78***a*, **78***b* and the hinge tab **80**. Although the member **24** is preferably composed of a metal or other suitable material having sufficient rigidity to

support the static load of the wound web material without substantially deforming, the construction of the member **24** (e.g. a stamped metal plate or sheet that is curved or bent in one plane but flat or straight in an orthogonal plane) also preferably allows leading end **70** of the movable member **24** to flex and rotate a small amount in response to forces imparted by the web **158** (FIG. **9**B). In this manner, the leading end **70** is responsive to winding forces and preferentially and automatically shifts relative to an axis of the reel assembly **20** to achieve automatic tracking of the web **158**, as more fully described below. Movable member **24** includes a central longitudinal axis C, and a transverse axis T that is transversely aligned with the leading end **70**. The reel assembly has an axis of rotation A (that is illustrated in FIG. **9**C in free space, although it is to be understood that axis A coincides with the intersection of D**1** and D**2** as shown in FIG. **9**B). When assembled as part of the reel assembly **20**, movable member **24** is fixed to first hub **22** by the ears **78***a*, **78***b* such that the leading end **70** is cantilevered relative to the trailing end **72**. To the extent the moveable member is capable of flexing, a first side **162** and an opposing second side **164** of the spooling surface **74** can translate and rotate relative to the fixed trailing end **72**. Specifically, the sides **162**, **164** can rotate about the central longitudinal axis C and translate relative to the first hub **22** to independently, automatically, and correctively adjust the orientation of transverse axis T of the leading end **70** relative to the reel assembly axis A in response to differential tension across the width of the web so that as the web is wound it remains centered on the reel assembly rather than telescoping away from the reel assembly.

[0083] Winding forces delivered from the web **158** (FIG. **9**B) to the movable member **24** can be unbalanced and can potentially lead to a cumulative imbalance in the winding of the web **158**. However, the movable member **24** is responsive to such imbalances in web **158** windings and provides an automatic tracking feature whereby each side **162**, **164** is free to move independently relative to the outer hub **22** and automatically adjust the orientation of the leading end **70** such that the transverse axis T responsively adjusts (e.g. aligns) relative to reel assembly axis A.

[0084] During winding of the web **158**, variations in the thickness of the web **158** and variations in other forces external to the web **158**, can result in an imbalance in the lateral tracking of the web **158** along spooling surface **74**. Without wishing to be bound by theory, it is believed that the cantilevered leading end **70** of the movable member **24** rotates and translates during winding to accommodate the unbalanced forces and correct possible variations in lateral tracking of the web **158** relative to the spooling surface **74**.

[0085] For example, referring to FIGS. **9**A-C, if a winding force of the web **158** material is imbalanced such that the winding force is greater on side **162** and less on side **164**, side **162** flexes downward (i.e., that side of the bearing surface **76** moves slightly down the ramp **118**). Thus, side **164** becomes elevated relative to **162**, and the transverse axis T becomes misaligned with the reel assembly axis A. Such a canted position, which would normally be considered unstable, accommodates the imbalanced forces in the web and keeps the web centered on the reel assembly as it is wound. Thereafter, if the winding forces become balanced across the web or if they become imbalanced in an opposite sense (greater winding force on side **164** and less on side **162**), the leading end **70** can translate and rotate in response to the changing forces to reorient the transverse axis T with respect to the reel assembly axis A. Thus, the design of the moveable member **24**, allowing it to flex slightly in response to imbalanced or changing cross-web forces or tension, acts as a kind of "independent suspension" to allow the transverse axis of the spooling surface to reorient relative to the reel axis A in response to the imbalanced or changing forces in order to keep the web centered on the reel assembly during winding.

[0086] Note that the configuration of the moveable members to provide the automatic tracking feature can be adapted for use on a wide variety of reel assemblies, including reel assemblies that may have only one hub, and reel assemblies of otherwise conventional design.

[0087] FIG. **10** illustrates a cross-sectional view of the hubs **22**, **26** in the second rotational position, such that the reel assembly **20** is in the contracted or retracted state. In the contracted state, the movable member(s) **24** have pivoted such that the spooling surface(s) **74** are retracted (relative to a spatial position in the expanded state), and the assembly **20** is characterized by an outer reel diameter D_{min} that is approximately equal to D**1**, the diameter of the first hub **22**. In transitioning from the expanded state to the contracted state, the first and second hubs **22**, **26** have been manually rotated relative to one another by movement of the handle **34** (FIG. **8**). That is, the hubs **22**, **26** have rotated from the first rotational position (FIGS. **9**A, **9**B) in which the bearing surface **76** is proximate the first side **120** of the ramp **118**, to the second rotational position in which the bearing surface **76** is received by the recess **116**.

[0088] In translating from the first rotational position to the second rotational position, the first hub **22** has rotated in the direction of arrow **170** relative to the second hub **26** such that the bearing surface **76** of the movable member **24** has moved down the ramp **118** radially inwardly from the first side **120** of the ramp **118** past the ramp tip **122** and received by the passage **116** such that the spooling surface **74** has retracted inwardly, and the assembly **20** occupies the contracted state.

[0089] The bearing surface **76** in the expanded state is preferably positioned at a relative maximum potential energy location proximate the first side **120** of the ramp **118**. Consequently, the movable member **24** is naturally predisposed to move to a position associated with a lower potential energy position, such as is achieved when the bearing surface **76** moves to a location proximate the ramp tip **122**. This state of quasi-equilibrium in the expanded state is accentuated by the inward compressive force that is exerted by wound web material wrapped around the spooling surfaces **74**.

[0090] Thereafter, when the operator wants to removed the wound web material, he or she can manually rotate the hubs **22**, **26** via the handle **34** such that the assembly **20** transitions to the contracted state of FIG. **10**. As described above, when web material is wrapped onto the spooling surfaces **74**, the assembly **20** is pre-disposed to transition to the contracted state of FIG. **10**. In this contracted state, the spooling surface **74** is preferably retracted inwardly such that the outer reel diameter D_{min} or effective outer reel diameter is reduced to be approximately equal to D**1**, the diameter of the outer hub **22**, so that the wound web material can be conveniently removed from the contracted assembly **20**.

[0091] In alternative reel assemblies, the role of the first and second hubs can be at least partially reversed compared

to those described above. For example, if suitably sized slots are provided in the outer hub, the moveable members can extend through such slots so that the trailing edge pivotably attaches to the inner hub. Further, a recess and ramp can be provided in the outer hub for each moveable member, and the bearing surface of the moveable member (proximate the leading edge thereof) can engage the recess, sliding along the ramp as the hubs are rotated relative to each other, forcing the spooling surface of each moveable member radially outward or inward to produce the expanded or contracted states (respectively) of the alternative reel assembly. FIG. **11**A illustrates an alternative reel assembly in an expanded state, and FIG. **11**B illustrates the alternative reel assembly in a contracted state.

[0092] FIG. **12** illustrates a perspective view of a system for processing web material. The system **200** includes an unwind spindle **202** rotatably maintaining a supply **204** of web material, a separation station **206**, and reel assemblies **20***a* and **20***b* rotatably maintained downstream from the supply **204** of web material. In alternative embodiments, only one of the assemblies **20***a*, **20***b* can be employed, for example assembly **20***a*, or more than two assemblies can be employed.

[0093] The unwind spindle **202** receives a wound roll of laminate web supply **204**, the separation station **206** separates the laminate of web supply **204** into a desired output product and one or more remaining carrier (or waste) webs, and the reel assembly **20** winds the carrier/waste web(s) for subsequent disposal or reuse. In some cases, two carrier/waste webs are provided with the laminate of web supply **204**, and two reel assemblies **20***a* and **20***b* are employed to wind the two waste webs exiting the separation station **206**, as described below. In other embodiments, only one of the reel assemblies **20***a* and **20***b* is provided to wind one waste web, although it is to be understood that more than two reel assemblies can be beneficially employed when more than two waste webs are to be wound up.

[0094] The unwind spindle **202** is generally located upstream from the separation station **206**, and upstream from the reel assembly/assemblies **20**. In one embodiment, the unwind spindle **202** is driven by a motor (not shown) that is controlled by a control panel **207**. Alternatively, the unwind spindle **202** and the reel assembly/assemblies **20** are each driven by a motor controlled by the control panel **207**. Any differential rotation of the unwind spindle **202** relative to the reel assembly/assemblies **20** may create a wind-up tension in the waste webs wound onto the reel assembly/assemblies **20**.

[0095] Since waste webs are often subsequently disposed of or recycled, it may be desirable to wind the waste webs into tightly compressed rolls to minimize their size. The wind-up tension delivered onto the reel assembly/assemblies **20** can be significant, and in the case of the waste webs being polymeric film material, the wind-up tension can be in a range from 1 pound per lineal inch (pli) (0.18 kg per lineal cm), in applications where the waste web is allowed to "float" on assembly **20** with minimal tensioning, to 50 pli or more. Consequently, the compressive force directed radially inward to the wound roll ranges from several pounds force to several hundred pounds force. For example, the illustrated reel assembly **20** that is provided with four stainless steel movable members **24** bears about 400 pounds of compressive force when winding some film-based waste webs, and this compressive force is spread across the four movable members **24**.

[0096] The supply **204** of web material includes a backing layer **210**, a cover layer **212**, and output product in the form of a plurality of film strips **214**. However, in some applications the cover layer **212** is optional. During use, the unwind spindle **202** unwinds the supply **204** of web material and the separation station **206** separates the plurality of film strips **214** from the backing layer **210** and the cover layer **212**. The reel assembles **20***a* and **20***b* operate to wind the waste/excess backing layer **210** and the cover layer **212** into coreless waste rolls.

[0097] In an exemplary process of winding web material, the control panel **207** receives input data and drives the unwind spindle **202** to direct the supply **204** of web material into the separation station **206**. The separation station **206** separates the plurality of useable film strips **214** from the backing layer **210** and the cover layer **212**. Relative to FIG. **12**, the reel assembly **20***a* winds the waste backing layer **210** about the expanded spooling surface **74** and the reel assembly **20***b* winds the waste cover layer **212** about a corresponding expanded spooling surface **74**. As noted above, the waste layers **210**, **212** can be wound onto the reel assemblies **20***a*, **20***b* with a significant level of wind-up tension. Such tightly wound waste rolls of layers **210**, **212** can potentially collapse plastic and/or fiber board cores.

[0098] In contrast, each of the reel assemblies **20***a*, **20***b* is constructed to withstand the high wind-up tensions, even when the web is exclusively supported (in the expanded state of the reel assemblies) by the spooling surface(s) of the moveable member(s) and spaced apart from the outer surface of the respective outer hubs. Upon completion of separating the desired number of strips **214** off of the web supply **204**, the reel assemblies are manually transitionable to a contracted state where the outer reel diameter D_{min} is substantially smaller than the diameter D_{max} in the expanded state, and D_{min} may if desired approximately equal the diameter of the outer hub, D1 The wound waste layer **210**, **212** material can then be conveniently removed and disposed of.

[0099] FIG. **13**A illustrates a cross-sectional view of another reel assembly **300** in a first expanded rotational position. The reel assembly **300** includes a first hub **302**, a second hub **304** co-axially disposed relative to the first hub **302**, and a first movable member **306** disposed between the first hub **302** and the second hub **304**.

[0100] The first hub **302** is an outer hub having an outer surface **308**, an inner surface **310**, and a first slot **312** extending from the outer surface **308** to the inner surface **310**.

[0101] The second hub **304** is an inner hub co-axially disposed within the first hub **302** and having an outer circumferential surface **314** and a transition zone **316**. The transition zone **316** includes a recess **318** and a ramp **320**, where the ramp **320** extends in a radially inward fashion from a first side **322** that is contiguous with the circumferential surface **314** to a second side **324**. Preferably, the ramp **320** joins circumferential surface **314** smoothly rather than abruptly. The transition zone **316** thus transitions radially inward from circumferential surface **314** smoothly over the ramp **320** to the second side **324** adjacent to a minima **326** of the recess **318**.

[0102] A plurality of movable members **306** can be disposed in a plurality of corresponding slots **312** such that the movable members **306** associate with a plurality of transition zones **316** formed in the second hub **304**. Alternative embodiments may use one, two, three, or four or more movable member(s) **306** and corresponding slot(s) **312**. When more than one slot **312** is provided, the slots are preferably arranged to be substantially equally spaced along a periphery of the hub **302**.

[0103] The movable member **306** has a spooling surface **330** opposite a bearing surface **332**. FIG. **13**A illustrates the reel assembly **300** in an expanded state in which the spooling surface **330** defines an outer reel diameter or effective diameter that is greater than a diameter DD of the reel assembly **300** extending between opposing outer surfaces **308** of the outer hub **302**.

[0104] For example, diameter DD transects a center of the first hub **302** and extends to opposing outer surfaces **308** of the first hub **302**. The spooling surface **330** extends beyond the diameter DD and the outer surface **308** of the first hub **302** by a distance H. In the expanded state, the bearing surface **332** of the movable member **306** contacts the first side **322** of the ramp **320** such that the spooling surface **330** projects out of the slot **312** by the distance H to a position exterior to (i.e., beyond) the outer surface **308**. In this manner, the extended movable member **306** defines an outer reel diameter of the assembly **300** that is greater than the diameter DD of the first hub **302** by the distance H. If an identical moveable member **306** is disposed on an opposite side of the reel assembly **300**, the two moveable members define an expanded state outer reel diameter that is greater than the diameter DD by 2H. Depending on the number of moveable members **306** distributed around the reel assembly **300**, the effective diameter of the reel assembly **300** in its expanded state is greater than the diameter DD by an amount that will not exceed 2H. For example, a sufficient number of moveable members **306** can be provided and distributed around the periphery of the reel assembly **300** so that the spooling surfaces **330** of the movable members **306** combine to prevent the material web from contacting the outer surface **308** of the first hub **302**.

[0105] FIG. **13**B illustrates a cross-sectional view of the reel assembly **300** in a second, contracted state. The outer hub **302** has been rotated in the direction of arrow **340** relative to the inner hub. The bearing surface **332** of the movable member **306** has translated down the ramp **320** from the first side **322** down to the minima **326** of the recess **318**. Preferably, in transitioning from the expanded state to the contracted state, the movable member **306** retracts into the recess **318** by a distance of about H such that the spooling surface **330** is flush with or even retracted relative to the outer surface **308** of the outer hub **302**.

[0106] In the contracted state illustrated in FIG. **13**B, the bearing surface **332** is proximate the minima **326** of the recess **318** such that the movable member **306** is almost flush with the outer surface **308**. In this manner, the outer reel diameter and effective outer reel diameter of the assembly **300** in the contracted state is approximately equal to the outer diameter DD of the outer hub **302**. Thus, the outer reel diameter of the assembly **300** is greater in the expanded state illustrated in FIG. **13**A than in the contracted state illustrated in FIG. **13**B.

[0107] Various reel assemblies have been described herein that provide a coreless reel assembly including a first hub and a second hub co-axially disposed relative to the first hub, where the first and second hubs are manually rotatable relative to one another between a first rotational position and a second rotational position. The reel assemblies also include one or more movable members that define an outer reel diameter (including an effective outer reel diameter) and that shift between an expanded state in the first rotational position and a contracted state in the second rotational position, the outer reel diameter being greater in the expanded state than in the contracted state.

[0108] The reel assemblies can be constructed to withstand the high-compression winding of waste rolls of web material directly onto a spooling surface of the reel assemblies. In the manner described above, the spooling surface(s) are collapsible to the contracted state in the second rotational position to enable easy removal of the rolls of material web by sliding the rolls off of the coreless reel assemblies.

[0109] In addition, the reel assemblies can include movable members designed to flex and otherwise move to accommodate even tracking of web material wound onto spooling surfaces of the movable members. Consequently, web materials wound onto the spooling surfaces wind-up uniformly without skewing or telescoping.

[0110] The spooling surfaces of the movable members can, if desired, be retractable without the need for spring-loaded moving spooling surfaces that may be susceptible to tangling with web materials.

[0111] Unless otherwise indicated, all numbers expressing feature sizes, amounts, and physical properties used in the specification and claims are to be understood as being modified by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings disclosed herein.

[0112] Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations may be substituted for the specific embodiments shown and described without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this invention be limited only by the claims and the equivalents thereof.

What is claimed is:

1. A reel assembly for winding a material web, comprising:

an outer hub having an outer surface, an inner surface, and a first slot extending from the outer surface to the inner surface;

an inner hub rotatably mounted within the outer hub between at least a first and second rotational position, the inner hub having a first recess therein; and

a first moveable member having a spooling surface and a bearing surface;

wherein the first moveable member is mounted such that at least a portion thereof extends through the first slot, and such that in the first rotational position the inner hub contacts the bearing surface to maintain the spooling surface at an extended position, and in the second

rotational position the first recess receives the bearing surface to move the spooling surface to a retracted position.

2. The assembly of claim **1**, wherein the first recess includes a ramp surface.

3. The assembly of claim **2**, wherein the bearing surface slides along the ramp surface as the inner and outer hubs are rotated from the first rotational position to the second rotational position.

4. The assembly of claim **1**, wherein the first recess includes a through-slot in the inner hub.

5. The assembly of claim **4**, wherein the bearing surface extends through the through-slot in the second rotational position.

6. The assembly of claim **1**, wherein the inner hub has a wall thickness, and wherein the extended and retracted positions of the spooling surface define a distance greater than the wall thickness.

7. The assembly of claim **1**, wherein the first moveable member has a leading end proximate the spooling surface and a trailing end pivotally coupled to the outer hub.

8. The assembly of claim **1**, wherein the first slot is one of a plurality of slots extending from the outer surface to the inner surface, and wherein the first recess is one of a plurality of recesses in the inner hub, and wherein the first moveable member is one of a plurality of moveable members each having a spooling surface and a bearing surface.

9. The assembly of claim **8**, wherein the plurality of slots are substantially equally spaced around a circumference of the outer hub, and wherein the plurality of recesses are substantially equally spaced around a circumference of the inner hub.

10. The assembly of claim **8**, wherein the spooling surfaces are each maintained at extended positions in the first rotational position and each move to retracted positions in the second rotational position, and wherein the spooling surfaces in the extended positions produce a maximum effective diameter of the reel assembly, and the spooling surfaces in the retracted positions produce a minimum effective diameter of the reel assembly.

11. A reel assembly for winding a material web, the reel assembly comprising:

a first hub having an outer surface and an inner surface;

a first movable member forming a spooling surface for receiving a material web and a bearing surface, the spooling surface movable to a position exterior to the outer surface to define an outer reel diameter of the assembly; and

a second hub co-axially disposed relative to the first hub, the second hub including an outer circumferential surface and a first transition zone defining a recess and a ramp, the ramp extending radially inward from a first side to a second side opposite the first side;

wherein the first and second hubs are manually rotatable relative to one another between a first rotational position in which the bearing surface is proximate the first side of the ramp, and a second rotational position in which the bearing surface is proximate the second side, the assembly characterized by an expanded state in the first rotational position and a contracted state in the second rotational position, the outer reel diameter being greater in the expanded state than in the contracted state.

12. The reel assembly of claim **11**, further comprising:

a plurality of hinged members respective ones of which are pivotally coupled to the first hub adjacent a respective one of a plurality of slots; and

a plurality of transition zones defined by the second hub that correspond with the plurality of hinged members.

13. The reel assembly of claim **12**, wherein the reel assembly is configured such that in the expanded state, the spooling surfaces of the plurality of hinged members combine to prevent winding of the material web onto the outer surface of the first hub.

14. The reel assembly of claim **12**, wherein each of the plurality of hinged members defines a spooling surface exterior the outer surface of the first hub.

15. The reel assembly of claim **12**, wherein the reel assembly is configured such that in the expanded state, a web wound tautly around the reel assembly contacts the spooling surfaces without contacting the outer surface of the first hub.

16. The reel assembly of claim **11**, wherein the first side of the ramp defines a radius coincident with the circumferential surface, and further wherein the bearing surface abuts the radius in the first rotational position.

17. The reel assembly of claim **11**, further comprising:

a locking mechanism coupled to the first and second hubs for releasably locking the reel assembly in the first rotational position;

wherein the locking mechanism includes a handle defining a tab, the tab movably received within a channel formed in an end of the first hub and the handle movably coupled to an end plate that is coupled to the second hub.

18. The reel assembly of claim **17**, wherein the second hub defines a detent sized to receive the tab, the handle biased relative to the end plate tab such that the tab is secured within the detent in the first rotational position.

19. A system for processing web material, the system comprising:

a supply of web material; and

the reel assembly of claim **1**.

20. The system of claim **19**, wherein the supply of web material includes a backing layer maintaining a plurality of film strips, the system further comprising:

an unwind spindle rotatably maintaining the supply of web material upstream of the reel assembly; and

a separation station located between the unwind spindle and the reel assembly, the separation station adapted to separate the film strips from the backing layer;

wherein the reel assembly is operable to wind the backing layer into a coreless roll of waste web following processing of the web material at the separation station.

21. A method of processing a material web, the method comprising:

providing a reel assembly manually operable to transition a spooling surface thereof between an expanded state and a contracted state, the reel assembly including an inner hub co-axially disposed within an outer hub, the inner hub defining a ramp and the outer hub defining an outer surface and a through-slot corresponding with the ramp;

transitioning the spooling surface to the expanded state;

winding the material web directly onto the spooling surface in the expanded state to form a wound web;

manually transitioning the spooling surface to the contracted state; and

removing the wound web from the spooling surface.

22. The method of claim **21**, wherein the wound web is characterized by the absence of a separate core.

23. The method of claim **21**, wherein transitioning the spooling surface to the expanded state includes rotating the outer hub relative to the inner hub and moving a portion of a movable member up the ramp of the inner hub and through the through-slot such that the spooling surface extends beyond the outer surface of the outer hub.

24. The method of claim **21**, wherein manually transitioning the spooling surface to the contracted state includes rotating the outer hub relative to the inner hub and moving a portion of a movable member down the ramp of the inner hub and through the through-slot such that the spooling surface retracts relative to the outer surface of the outer hub.

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