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(54) **STARWHEEL FEED APPARATUS AND METHOD**

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(52) **U.S. Cl.** **271/187; 271/315**

(58) **Field of Classification Search** 271/182,
271/187, 315, 70

See application file for complete search history.

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Exhibit A—9-page disclosure relating to a transfer system manufactured by the assignee.

(Continued)

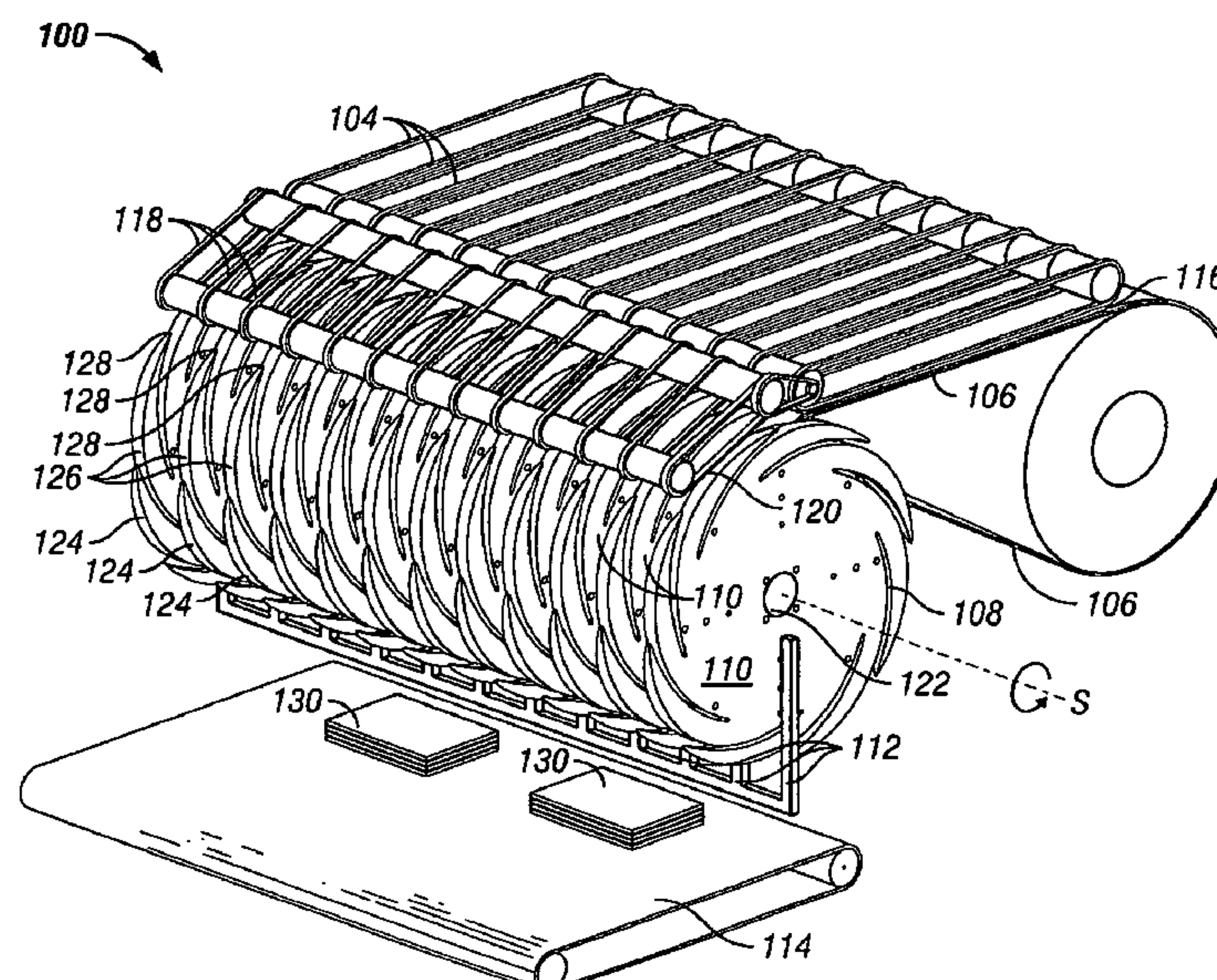
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(57) **ABSTRACT**

A starwheel feed apparatus and method for feeding and guiding sheets of a web material into a starwheel assembly. In some embodiments, a feeding conveyor is movable to convey sheets at a first velocity toward the starwheel, and a guiding conveyor is located adjacent the starwheel and has a conveying surface movable at a velocity less than the first velocity. In other embodiments, other relative speeds of the guiding and feeding conveyors are employed. In some embodiments, a feeding conveyor feeds sheets into slots of a starwheel, and a guiding conveyor located adjacent the starwheel has a conveying surface to guide trailing edges of the sheets along a length of the conveying surface as the sheets enter the slots.

70 Claims, 8 Drawing Sheets



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Exhibit B—13-page disclosure relating to transfer system manufactured by the assignee.

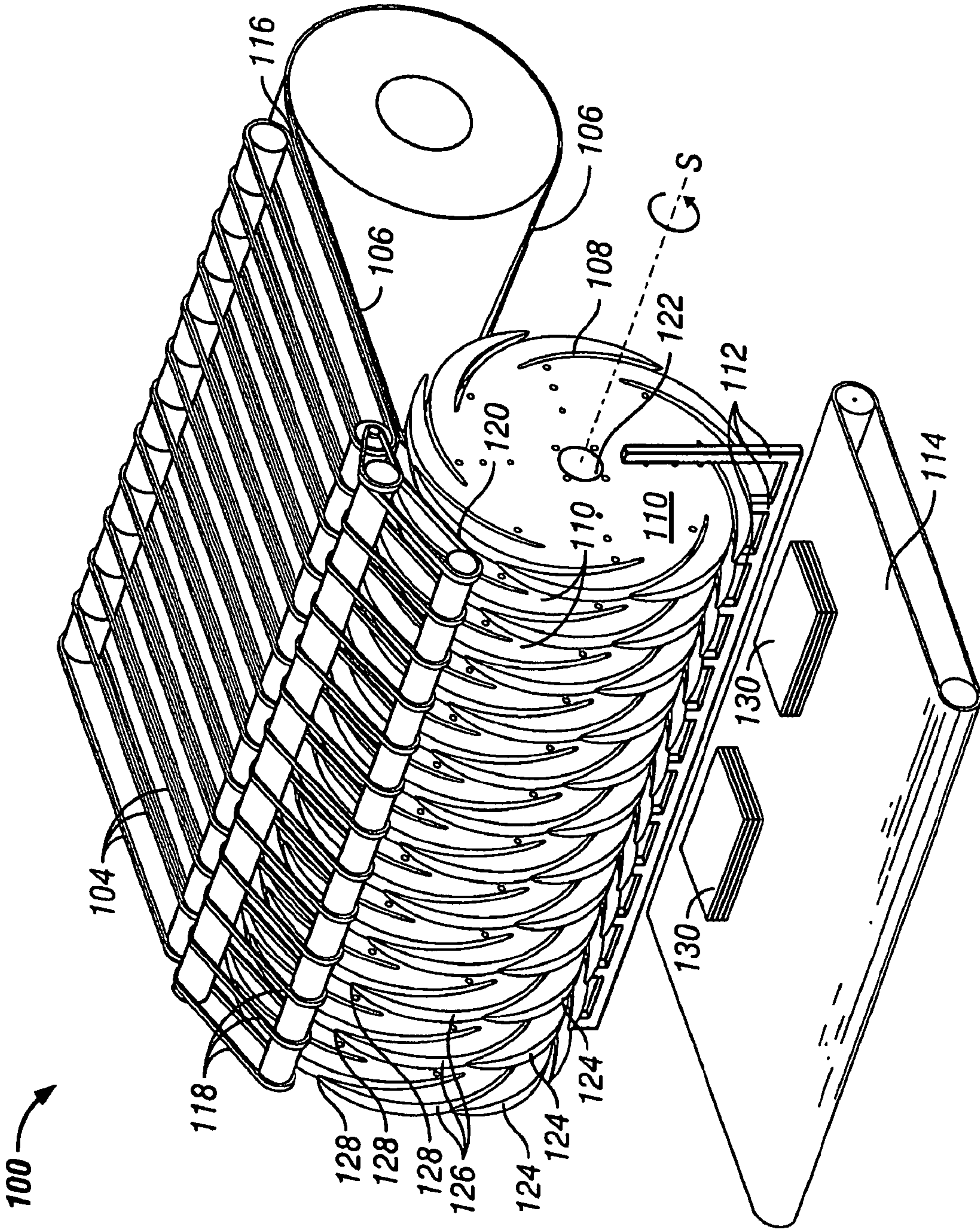


FIG. 1

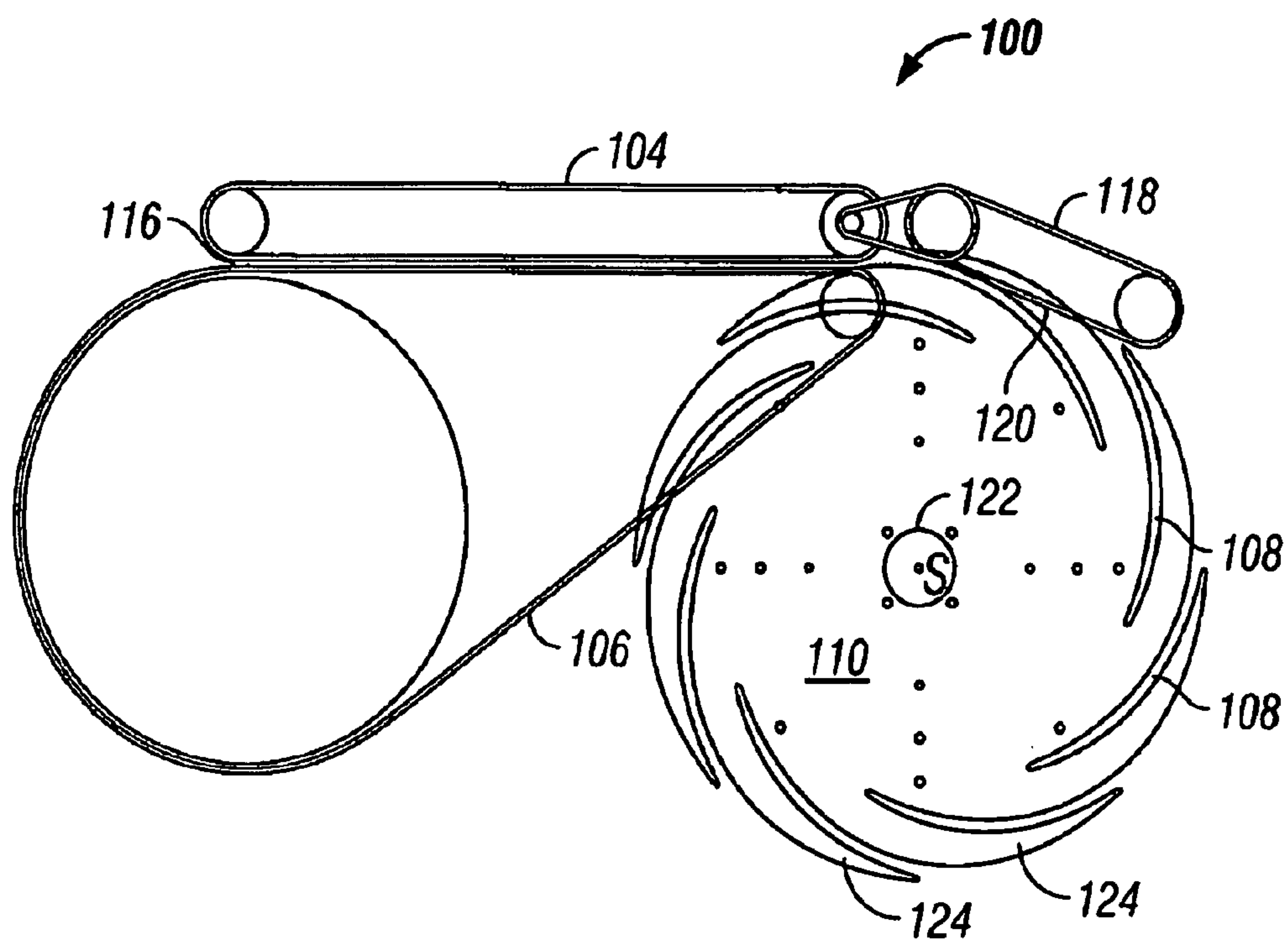


FIG. 2

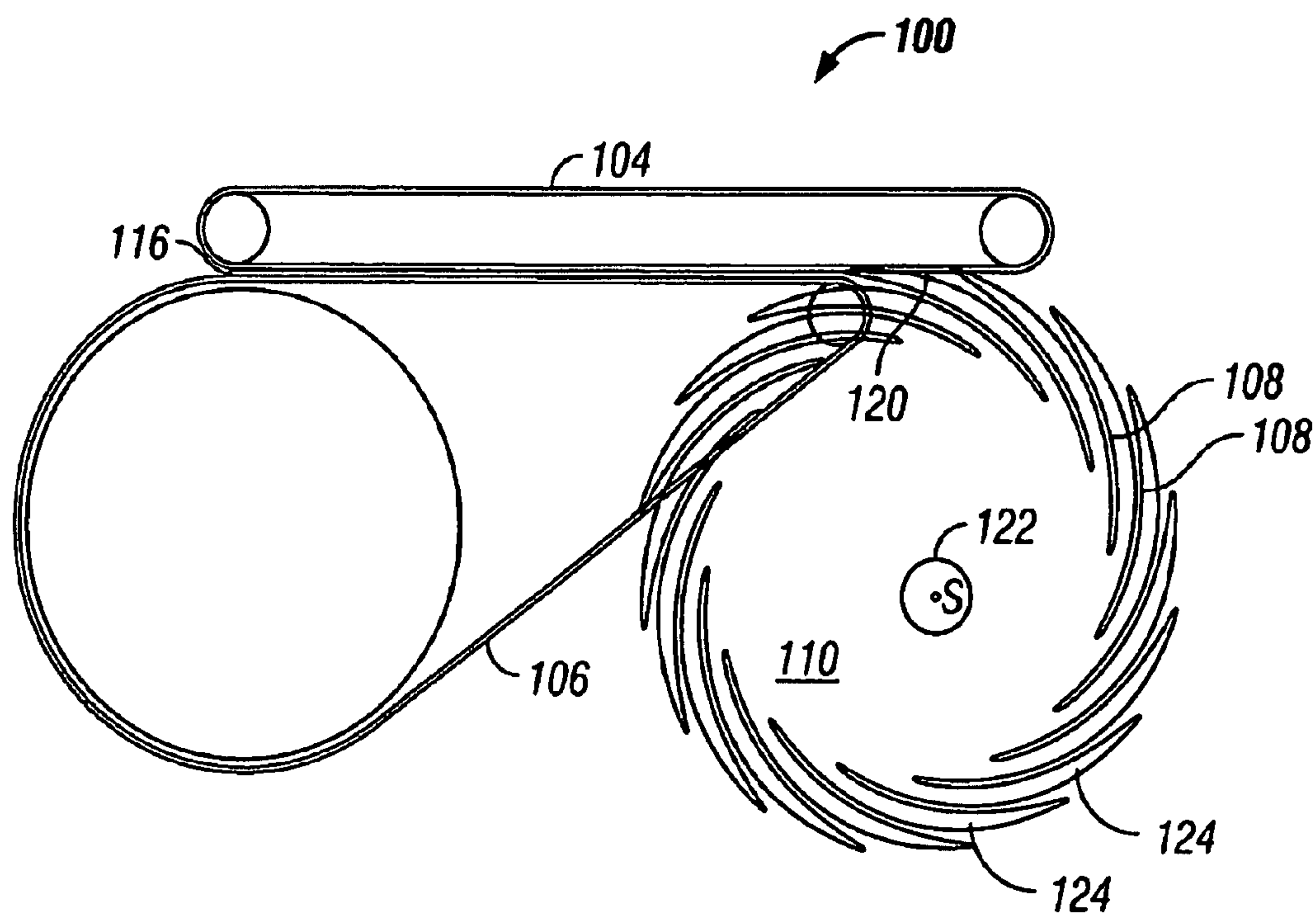


FIG. 3

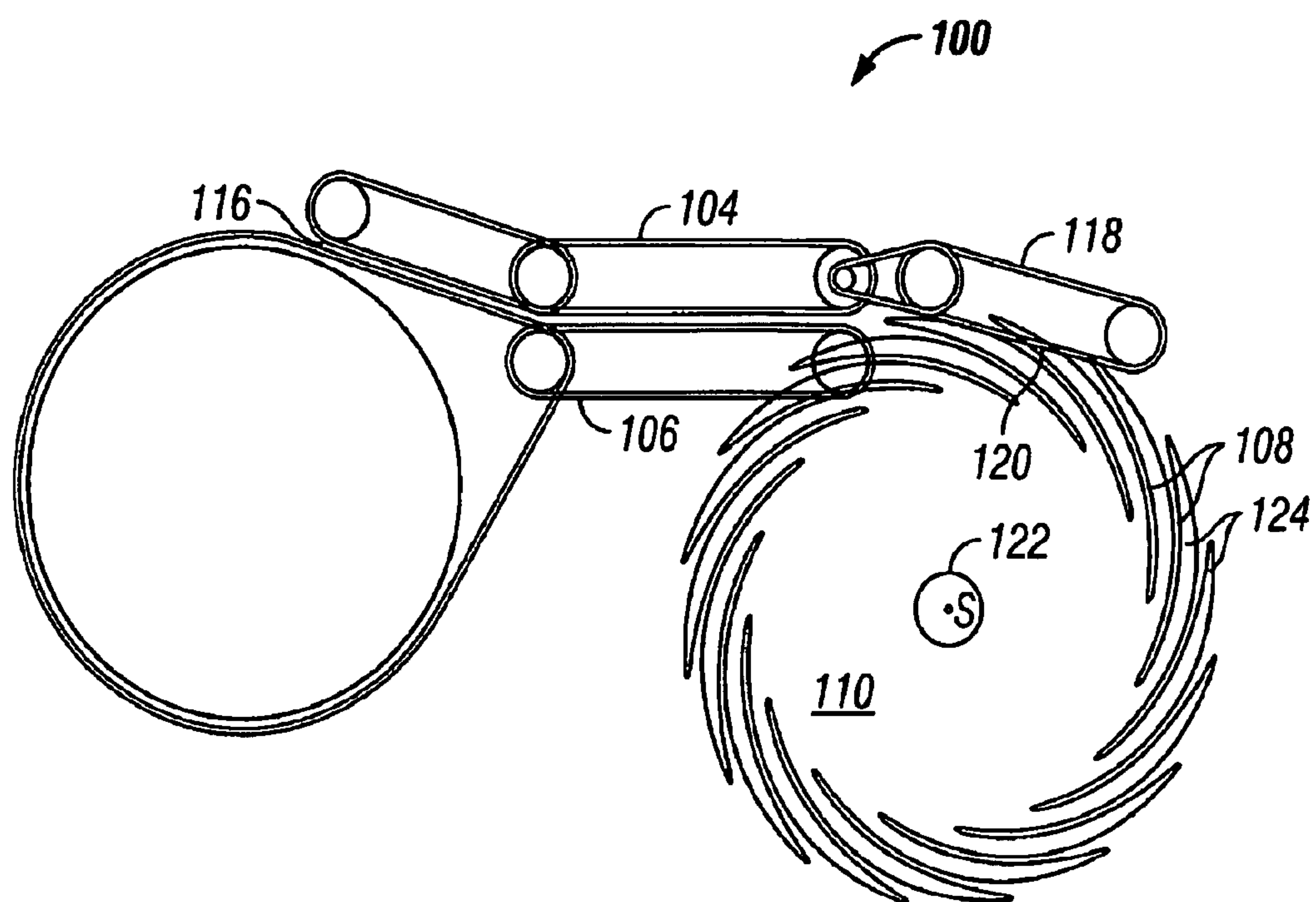


FIG. 4

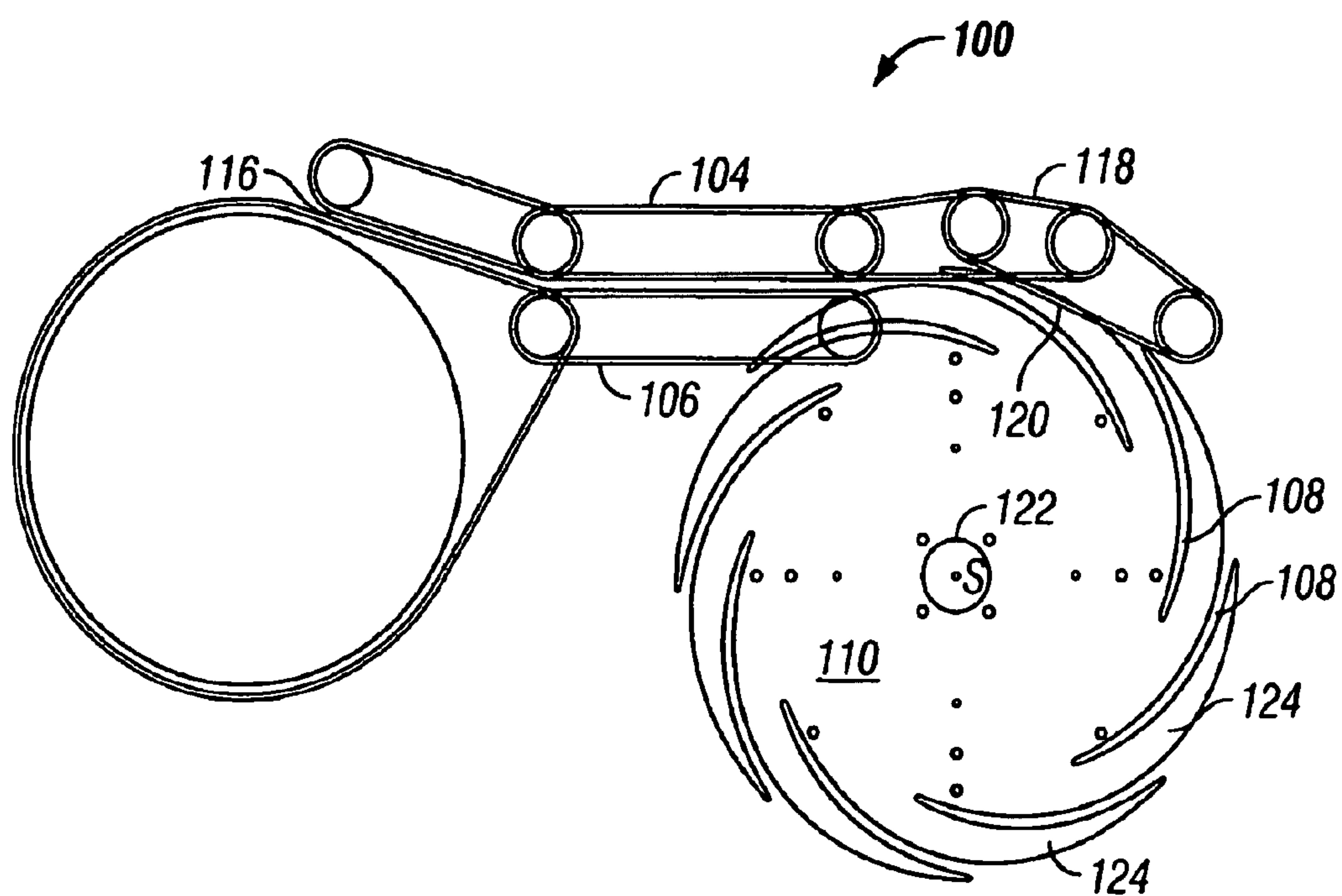


FIG. 5

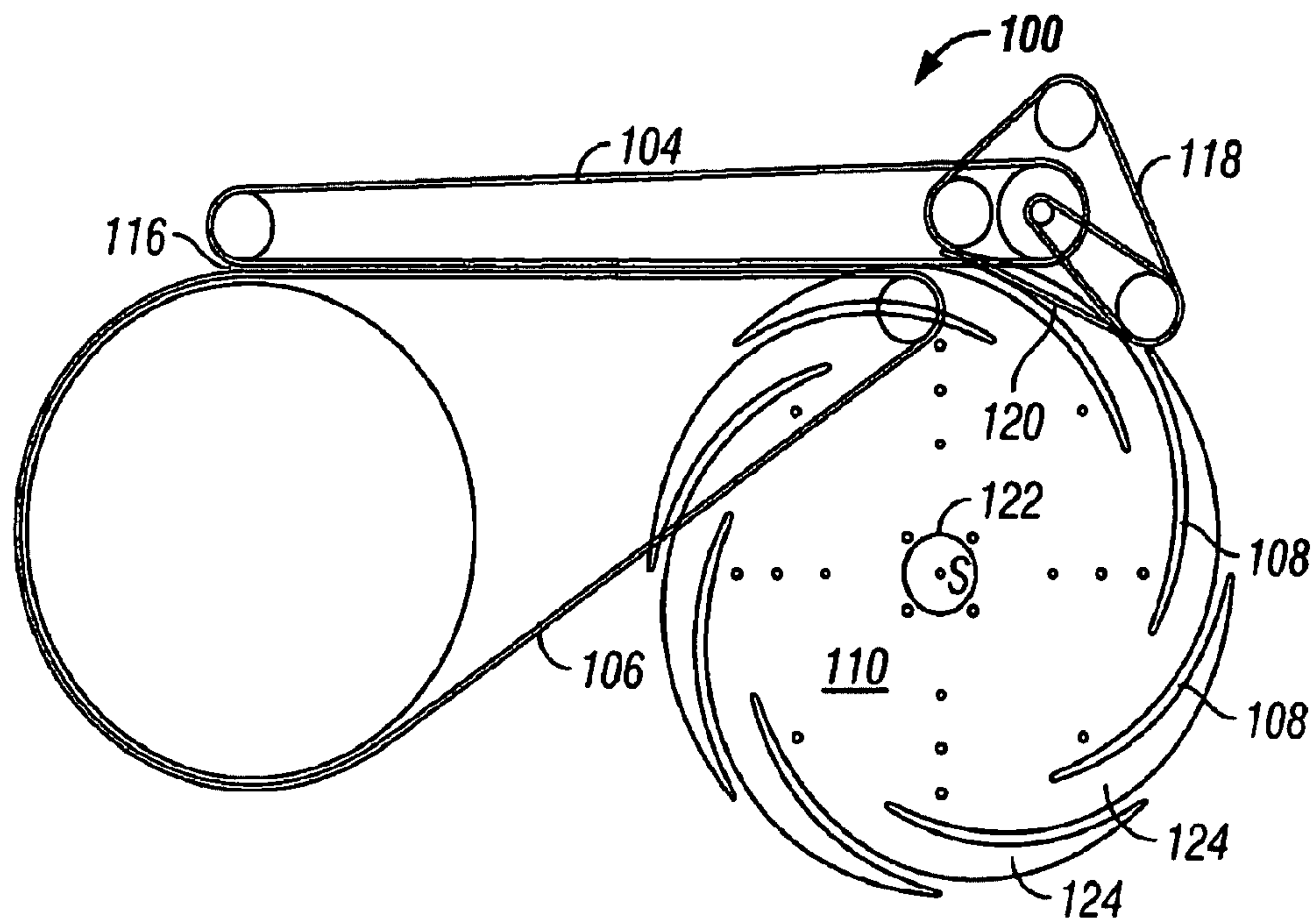


FIG. 6

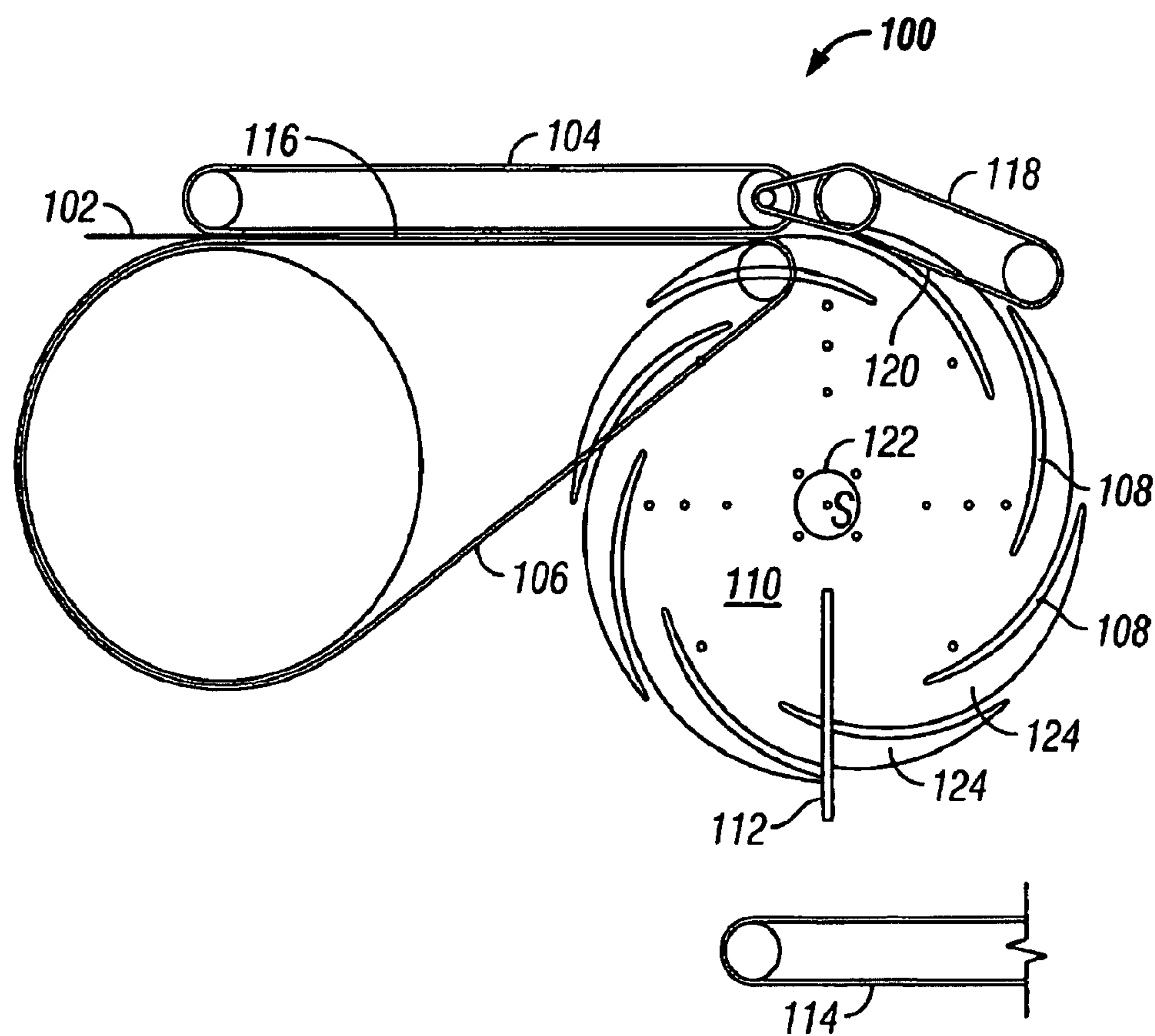


FIG. 7

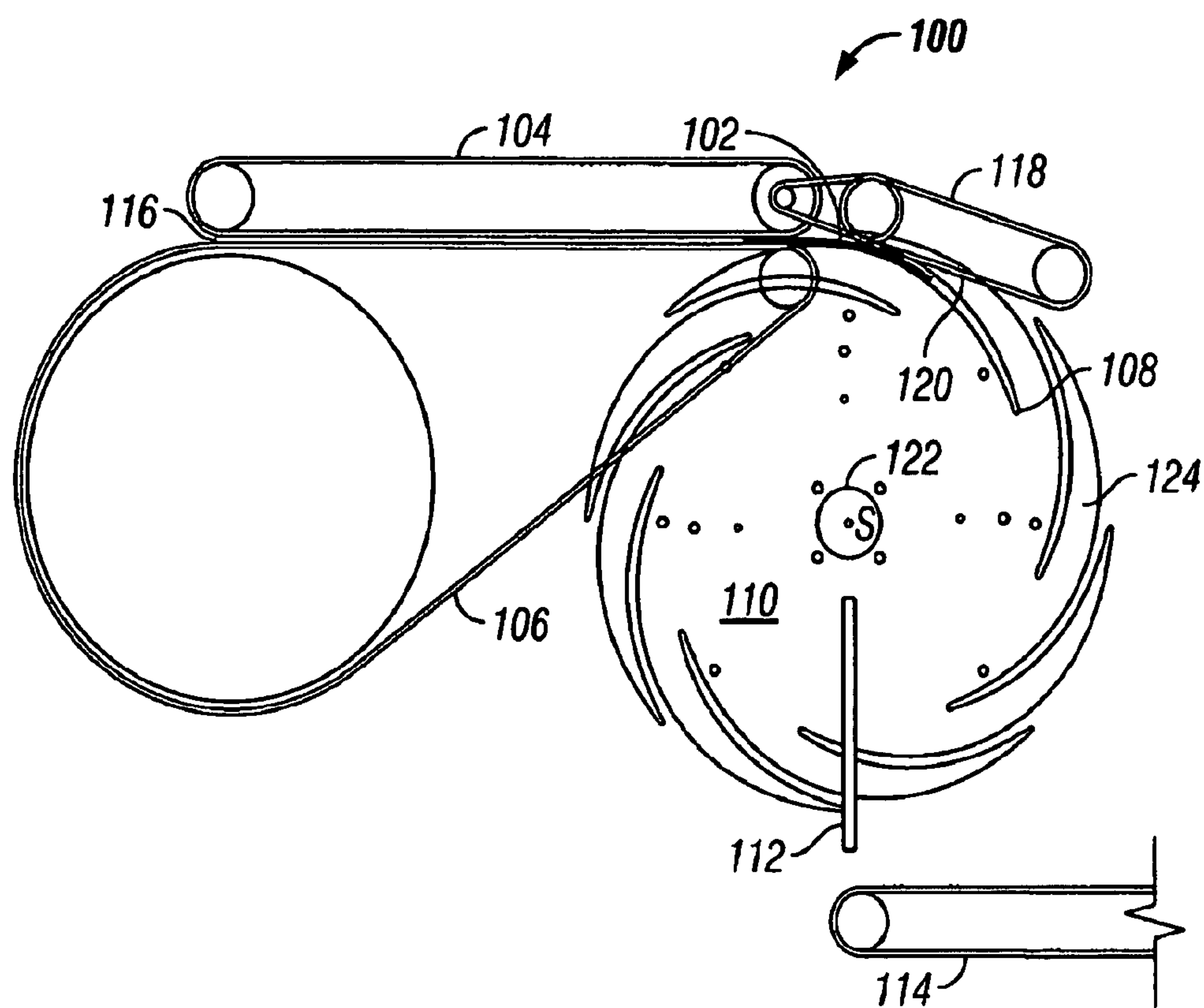


FIG. 8

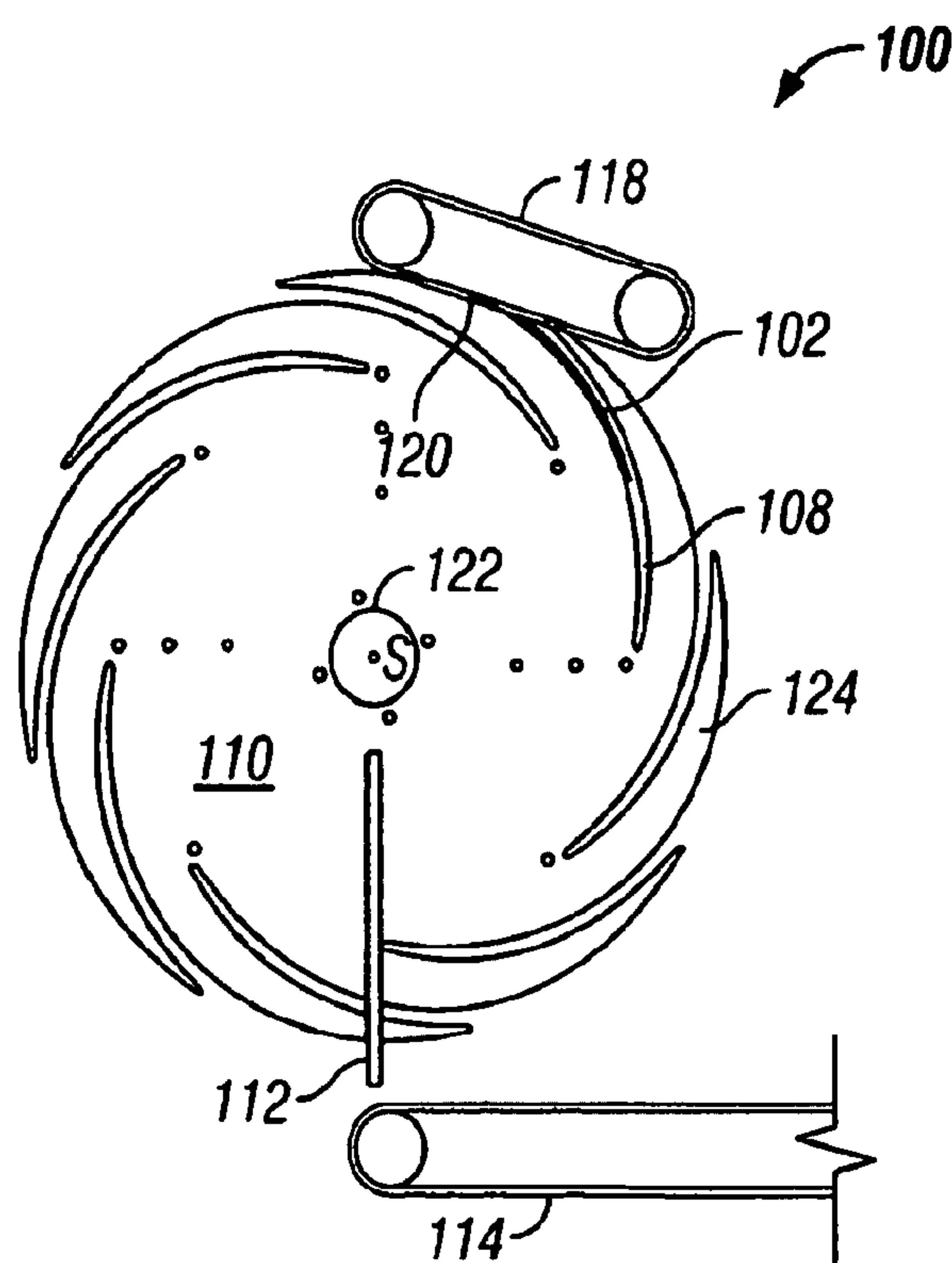


FIG. 9

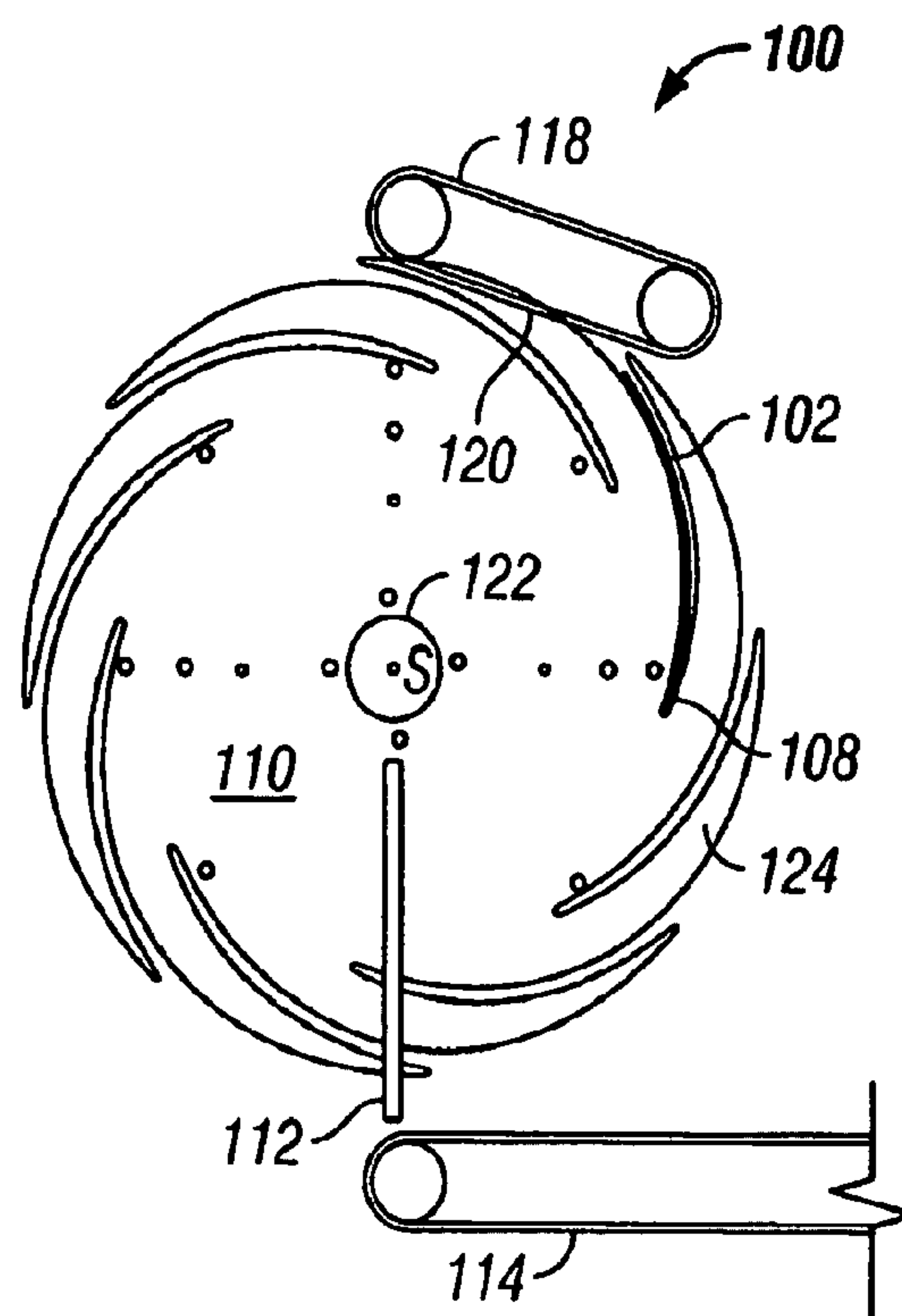


FIG. 10

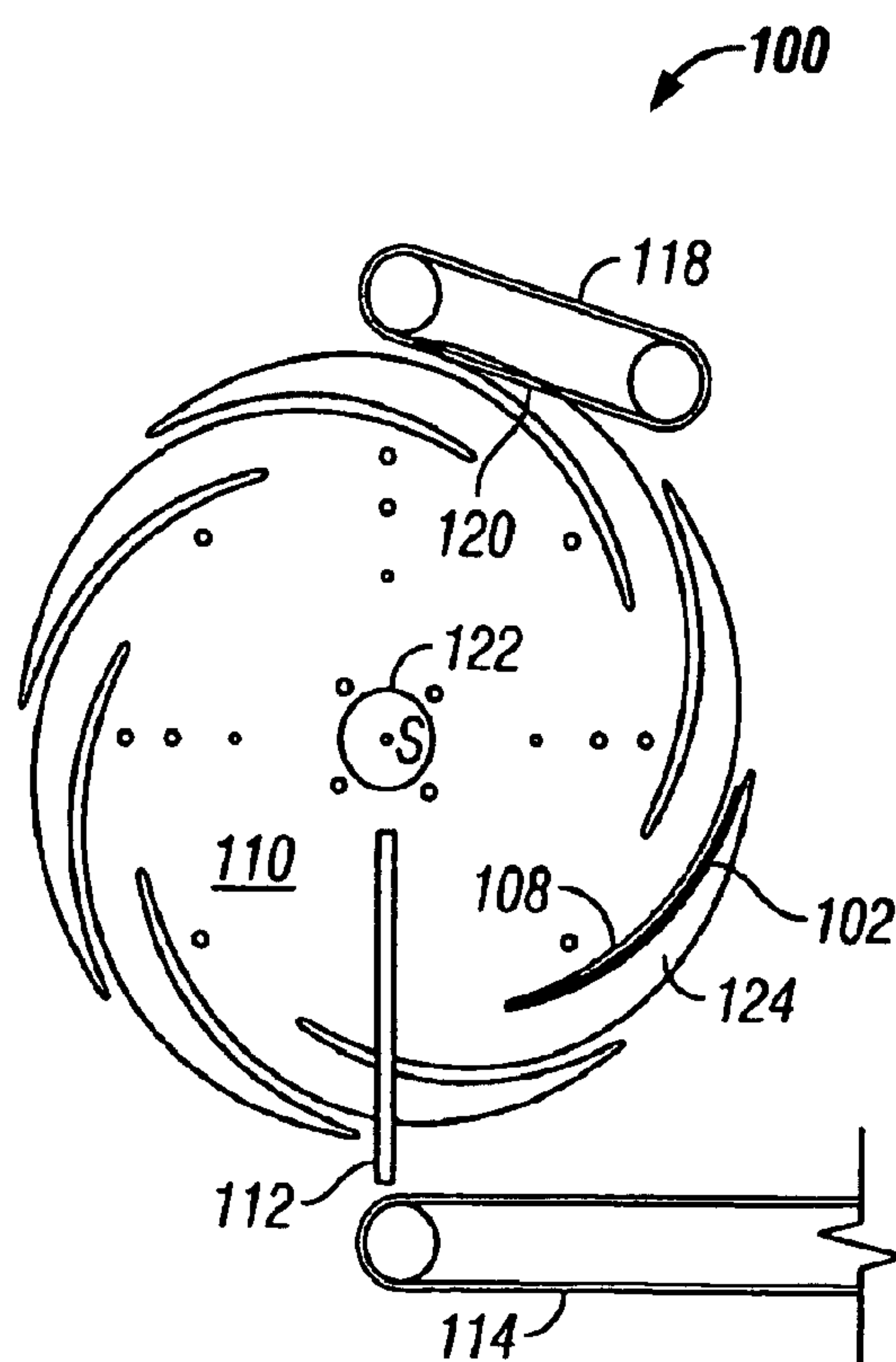


FIG. 11

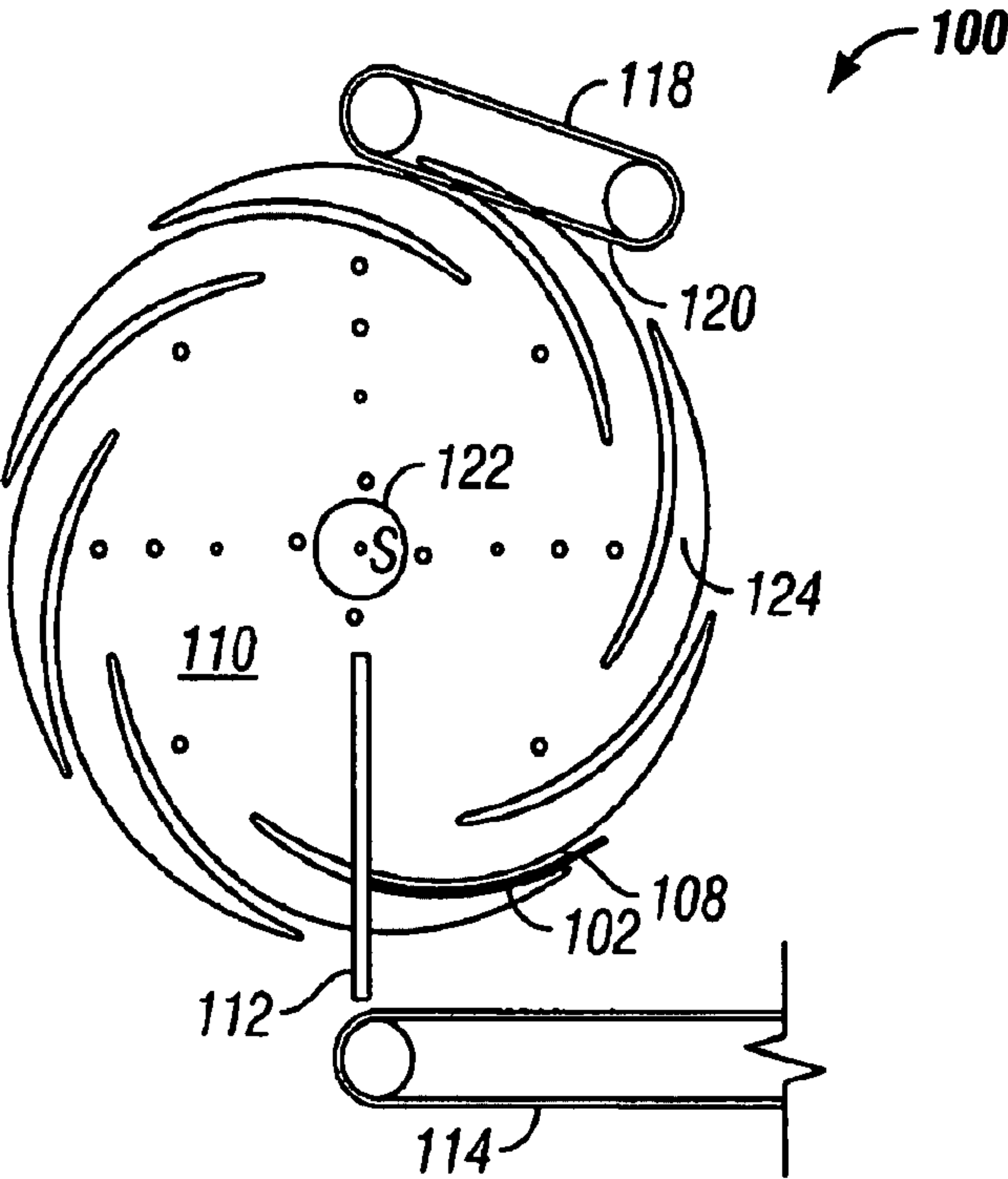


FIG. 12

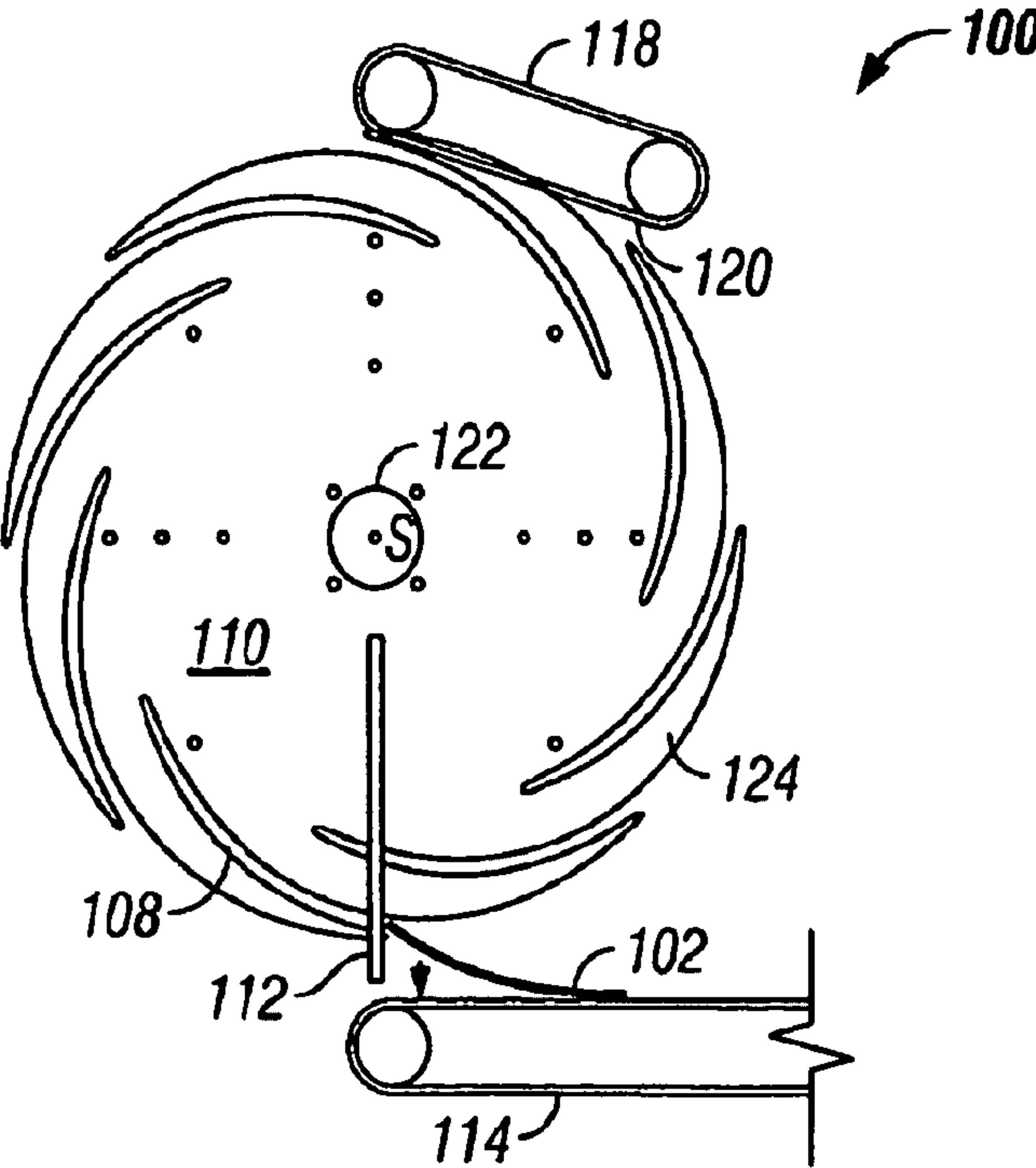


FIG. 13

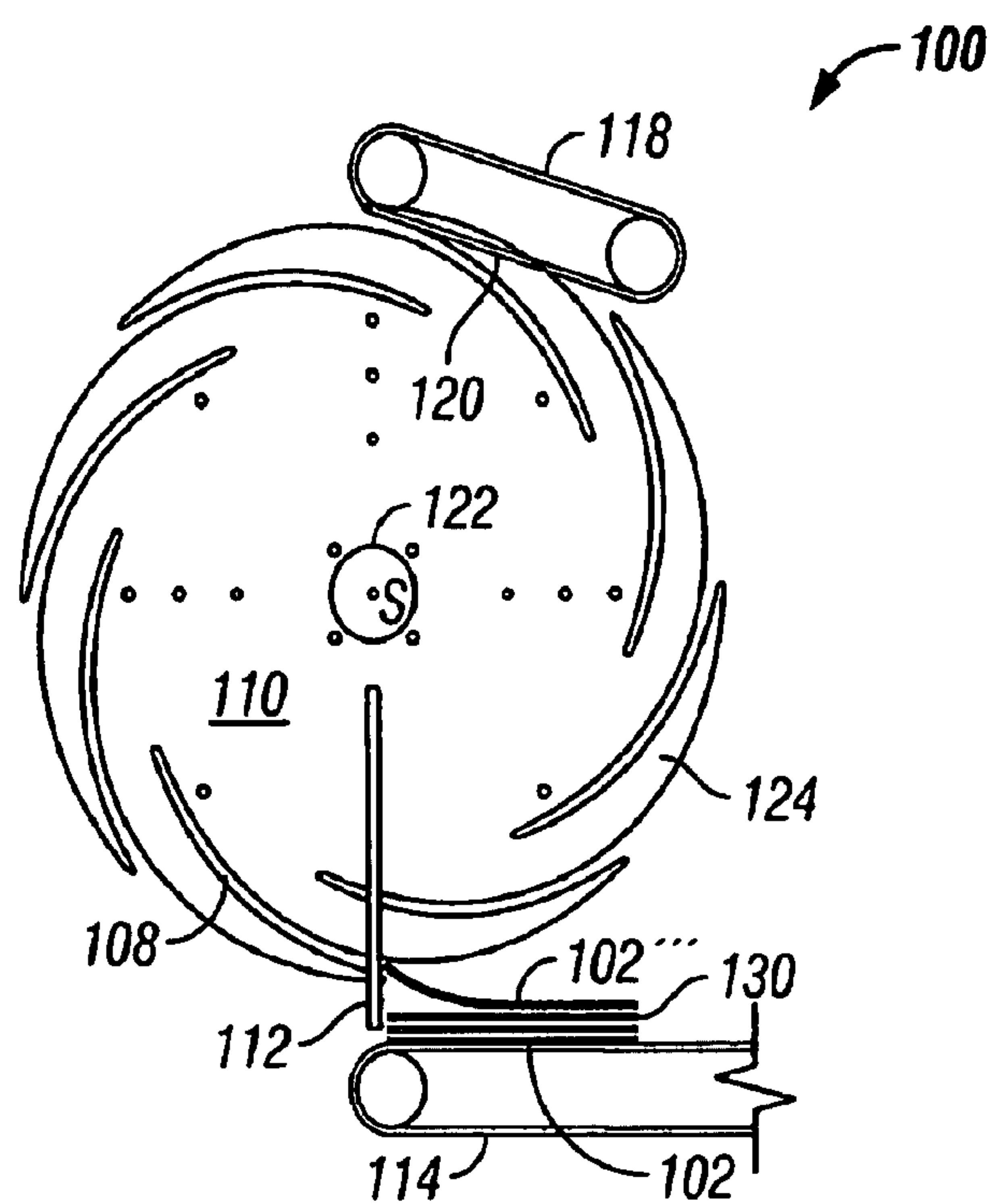


FIG. 14

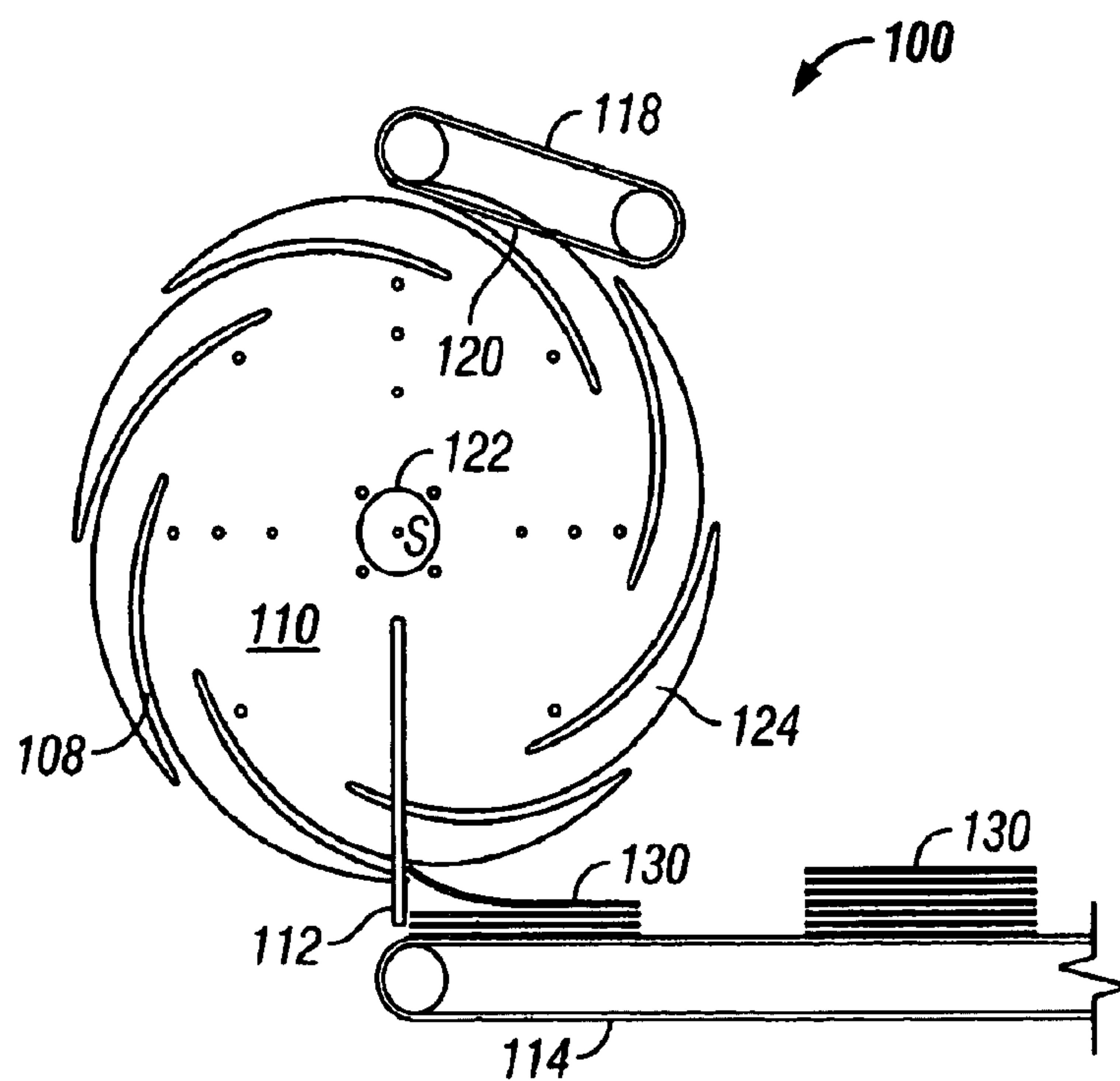


FIG. 15

STARWHEEL FEED APPARATUS AND METHOD

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a reissue of U.S. patent application Ser. No. 11/104,399, filed Apr. 12, 2005, now U.S. Pat. No. 7,219,887, which is a continuation of U.S. patent application Ser. No. 10/630,352, filed Jul. 30, 2003, now U.S. Pat. No. 6,877,740.

BACKGROUND OF THE INVENTION

Many stacking devices are used to continuously create stacks of sheet products. In some common stacking devices, the sheets are fed from a feeding system to a first position of a starwheel that is rotated about a starwheel axis. The starwheel includes a plurality of blades or fins between which sheets are received to be rotated with the starwheel. Each sheet is fed into a slot having a width and formed between two adjacent fins, and each sheet is rotated within the starwheel to a second position where the sheet is stopped and thereby removed from the starwheel, such as by a barrier. The removed sheets can then be stacked upon a stacking platform or other structure to be carried away by a downstream conveyor of any type.

Existing feeding systems do not adequately feed sheets of web material into starwheels (particularly at high speeds) leading to sheet wrinkling or damage, increased scrap material and machine downtime and in some cases, poor stack quality. Existing feeding systems attempt to decelerate sheets as the sheets are fed into a starwheel by adjusting the width of the starwheel slots, thereby requiring the design and use of a different starwheel for each type of sheet. In light of the limitations of existing starwheel feeding systems, an improved starwheel feed apparatus would be welcome in the art.

SUMMARY OF THE INVENTION

The present invention relates to a starwheel feed apparatus and method for feeding and guiding sheets into a starwheel assembly. A feeding conveyor can be located upstream of the starwheel for conveying sheets toward the starwheel, and a guiding conveyor having a conveying surface can be located adjacent the starwheel for guiding the sheets into slots of the starwheel. In some embodiments, the feeding conveyor is located upstream of the starwheel and is movable to convey sheets at a first velocity toward the starwheel, and the guiding conveyor is located adjacent the starwheel and has a conveying surface movable at a velocity less than or equal to the first velocity to guide the sheets into slots of the starwheel. In some embodiments, the conveying surface velocity can be adjusted to feed different sheets into the same starwheel assembly. Also, in some embodiments, the feeding conveyor is movable to feed sheets into slots of a starwheel, and the guiding conveyor is located adjacent the starwheel and has a conveying surface to guide trailing edges of the sheets along a length of the conveying surface as the sheets enter the slots.

Further aspects of the present invention, together with the organization and manner of operation thereof, will become apparent from the following detailed description of the invention when taken in conjunction with the accompanying drawings, wherein like elements have like numerals throughout the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is further described with reference to the accompanying drawings, which show exemplary embodiments of the present invention. However, it should be noted that the invention as disclosed in the accompanying drawings is illustrated by way of example only. The various elements and combinations of elements described below and illustrated in the drawings can be arranged and organized differently to result in embodiments which are still within the spirit and scope of the present invention.

In the drawings, wherein like reference numerals indicate like parts:

FIG. 1 is a perspective view of a starwheel feed apparatus according to an exemplary embodiment of the present invention;

FIG. 2 is a side view of the starwheel feed apparatus illustrated in FIG. 1;

FIG. 3 is a side view of a starwheel feed apparatus according to a second embodiment of the present invention;

FIG. 4 is a side view of a starwheel feed apparatus according to a third embodiment of the present invention;

FIG. 5 is a side view of a starwheel feed apparatus according to a fourth embodiment of the present invention;

FIG. 6 is a side view of a starwheel feed apparatus according to a fifth embodiment of the present invention; and

FIGS. 7-15 are side views of the starwheel feed apparatus illustrated in FIGS. 1 and 2, shown in different stages of operation as a sheet of web is advanced through the starwheel feed apparatus and an adjacent starwheel.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Referring to the figures, and more particularly to FIG. 1, a starwheel feed apparatus constructed in accordance with an exemplary embodiment of the present invention is shown generally at 100. The starwheel feed apparatus 100 comprises several components and devices performing various functions. The starwheel feed apparatus 100 includes feeding conveyor(s) 104, 106 that feed a sheet 102 of web material toward a starwheel 110, and a guiding apparatus. The guiding apparatus can take the form of or include guiding conveyor(s) 118 that guide and/or decelerate the sheet 102 as it enters the starwheel 110. As will be described in greater detail below, in some embodiments of the present invention, a sheet 102 of web material is advanced along and between one or more sets of first and second feeding conveyors 104, 106; decelerated and/or guided by a guiding conveyor 118 into a slot 108 located in a starwheel 110; moved along with the slot 108 as the starwheel 110 is rotated about an axis; abutted against a barrier 112; ejected from the slot 108; and stacked upon a platform 114 or in another location. Any number, combination, and series of conveyors 104, 106 and 118, slots 108, starwheels 110, barriers 112, and platforms 114 can be used without departing from the present invention.

The starwheel feed apparatus 100 according to the present invention can be employed to feed material into one or more starwheels or starwheel assemblies 110 following any type of upstream process or processes, including without limitation

folding, embossing, cutting, and other processes. In this regard, any upstream equipment or elements (not shown) for manufacturing, treating, modifying or preparing sheet material before it reaches the starwheel feed apparatus **100** can be employed in conjunction with the present invention. As used herein and in the appended claims, the term “upstream” is used to describe any location, element or process that occurs prior to the point or area being referred to, whereas the term “downstream” is used to describe any location, element or process that occurs subsequent to the point or area of reference.

In some embodiments of the present invention, such as those illustrated in FIGS. 1-15, the starwheel **110** includes a shaft **122** and a plurality of starwheels **110**. The shaft **122** is rotatably coupled to a frame (not shown) about an axis S and is rotated by a motor (not shown) either directly or indirectly (e.g., via one or more gears, belts, chains, and the like driven by the motor, feeding and/or guiding conveyor(s) **104**, **106**, **118**, or other associated equipment). The shaft **122** can be driven independently from the starwheel feed apparatus **100**.

With continued reference to the exemplary embodiments illustrated in FIGS. 1-15, each starwheel **110** is coupled to the shaft **122** such that the rotational axis S of the shaft **122** is located at the center of each starwheel **110**. Each starwheel **110** can be disk shaped and can be generally defined by a diameter and a thickness. In other embodiments, one or more starwheels **110** can comprise rods or other elongated elements of a generally star-shaped structure. Still other starwheel shapes are possible, each having a number of slots, grooves, recesses, or other types of apertures capable of receiving sheets **102** therein for transport as the starwheels **110** rotate. Good performance has been demonstrated by embodiments in which each starwheel **110** is the same size and thickness.

In some embodiments of the present invention, each starwheel **110** includes a plurality of fins **124** (best illustrated in FIG. 1) that project from the center of each starwheel **110**. With continued reference to the illustrated exemplary embodiment, each fin **124** includes a base **126** and a tip **128**. The tip **128** is positioned at a farther radial distance from the center of the starwheel **110** than the base **126**. The fins **124** can be the same thickness as the body of the starwheel **110**, or can have a varying or other different thickness along their lengths. In addition, in some embodiments, the fins **124** curve in a uniform direction opposite to the direction of rotation, and overlap with adjacent fins **124** such that a slot **108** is formed between adjacent fins **124** (see FIGS. 1-15). Each slot **108** thus curves in the same direction as the direction of the fins **124**, and can be narrowest adjacent to the base **126** of the adjacent fins **124** and widest at the tips **128** of the adjacent fins **124**. The slots **108** receive sheets **102** from the feeding conveyors **104**, **106** and support the sheets **102** within the starwheel **110** until a force causes the sheets **102** to be removed from the slots **108**.

The size, shape, and number of fins **124** (and thus slots **108**) included on each starwheel **110** can be varied. For example, each starwheel **110** can include as few as two fins **124** and as many as structurally possible. In some embodiments, the starwheels **110** have between 4 and 30 fins. In other embodiments, the starwheels have between 8 and 24 fins. Good performance has been achieved by embodiments employing starwheels having 8, 10, 12 or 16 fins. The fins **124** need not curve in the direction opposite that of motion, but instead can have any shape necessary, including without limitation projecting straight from the body of the starwheel **110**, being partially straight and partially curved, and having any other shape necessary for receiving and transporting sheets **102** in

starwheel slots **108**. The fins **124** can have any width necessary for supporting the sheets **102**, including without limitation having a uniform width, becoming wider instead of tapering as they extend away from the center of the starwheel **110**, and having any other width or fin shape necessary to hold and transport the sheets **102**. The fins **124** can also be thicker or thinner than the thickness of the starwheel **110**. The configuration of the slots **108** is also variable to the extent the slots **108** are dependent upon the shape and number of the fins **124**.

The starwheel assembly **110** with which the present invention is employed can include a barrier **112** (FIG. 1) used to provide a force against one end of sheets **102** as they are transported in the starwheel **110**, causing the sheets **102** to be stopped by the barrier **112** and ejected from the slots **108** in the starwheel **110**. Once each sheet **102** is ejected from a slot **108**, it is stacked on a stacking platform **114** (FIG. 1) or other surface on other sheets **102** oriented in any manner (dependent at least partially upon the circumferential location of the barrier **112** and the resulting orientation of discharged sheets **102**). The starwheel assembly can have a single barrier **112** or can have additional barriers **112**, each located adjacent a starwheel **110**. As illustrated in FIG. 1, a plurality of barriers **112** allows for the passage of at least one starwheel **110** therebetween by providing a plurality of open spaces between each barrier **112** through which at least one starwheel **110** can move. The barrier **112** or series of barriers **112** can take a number of different forms, such as fingers, plates, rods, and the like of any cross-sectional shape, including without limitation rectangular, circular, semi-circular, triangular, and the like, without departing from the spirit and scope of the present invention.

A completed stack of sheets **102** can be removed to downstream equipment in any conventional manner. In some embodiments of the present invention employing a stacking platform **114** as described above, the stacking platform **114** can be a conveyor capable of transporting a completed stack of sheets **102** to make room for a new stack. In other embodiments, the stacking platform **114** is a bucket connected to a transport system (e.g., a pulley, chain, or cable transport system, a rail transport system, and the like). In still other embodiments, the stacking platform **114** is an elevator, movable toward and away from the starwheel **110** for transporting a completed stack away from the starwheel **110** and returning to a starting position to begin receiving sheets **102** of a new stack. In still other embodiments, the stacking platform **114** is a plate or frame capable of receiving a completed stack of sheets **102**, while additional equipment transports the completed stack away from the starwheel **110** to prepare the plate to receive a new stack. The stacking platform **114** can include any device and mechanism capable of receiving the stack from the starwheel, including without limitation a bucket, plate, box, arm, and the like, and can be movable to transport completed stacks of sheets **102** away from the starwheel feed apparatus **100** by conveying belts and pulleys, chains and sprockets, rolls, wheels, rotating bars, and any other conveying devices and mechanisms known to those skilled in the art.

Prior to describing the illustrated starwheel feed apparatus **100** in greater detail, it should be noted that a variety of materials can be fed into and stacked using the starwheel feed apparatus **100**. The starwheel feed apparatus **100** of the present invention can be employed to feed any material into one or more starwheels **110**. The term “web” is used herein with reference to such materials, and is understood to encompass any material that can be received within a starwheel, including without limitation paper, metal, plastic, rubber or synthetic material, fabric, and the like). In many cases, such material to be received in starwheels is found in sheet form

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(including without limitation tissue, paper toweling, napkins, foils, wrapping paper, food wrap, woven and non-woven cloth or textiles, and the like). Accordingly, sheets 102 of a paper web are described herein for illustrative purposes only. The term “web” as used herein and in the appended claims does not indicate or imply any particular shape, size, length, width, or thickness of the material.

Similarly, the term “sheet” as used herein and in the appended claims refers generally to a material that is longer and wider than it is thick. However, any shape and size of sheet 102 of any length, width, and thickness can be moved and manipulated by the starwheel feed apparatus 100 without departing from the present invention. Furthermore, a “sheet” can refer to a piece of web material that has been folded and not only single-sheet material. “Sheets” can also or instead refer to items in group form (e.g., bound and unbound signatures, sheets arranged in booklet form, etc.), multiple items of sheet material fed into each starwheel slot, and multiple items of sheet material in folded form (e.g., newspapers, etc.).

Throughout the specification and claims herein, sheets 102 are identified as forming a “stack.” This does not necessarily mean that the stack is vertically oriented. Instead, the stack can be horizontally oriented or oriented at any angle between horizontal and vertical orientations and on a downward or an upward slope.

In the following description of the exemplary starwheel feed apparatus 100 illustrated in FIGS. 1, 2, and 7-15, reference is made to a starwheel 110, a first feeding conveyor 104, a second feeding conveyor 106, and a number of other elements and features. Although several of these elements and features are referred to as singular elements and features, it should be noted that in many embodiments, a plurality of such elements and features are employed in the starwheel feed apparatus 100. In particular, FIGS. 2 and 7-15 show only a single starwheel 110, first feeding conveyor 104, second feeding conveyor 106, guiding conveyor 118 barrier 112, and other elements. Although some embodiments can have only those elements that are visible in FIGS. 2 and 7-15, other embodiments employ similar sets of elements not visible or otherwise shown in FIGS. 2 and 7-15. For example, some embodiments employ multiple starwheels 110 rotatable about the same axis (only one of which is therefore shown in FIGS. 2 and 7-15), multiple first feeding conveyors 104 and/or second feeding conveyors 106 (additional conveyor(s) being located behind the feeding conveyors 104, 106 shown in FIGS. 2 and 7-15, and therefore not shown in FIGS. 2 and 7-15) multiple guiding conveyors 118 (configured similarly to the feeding conveyors 104, 106), and the like. For purposes of simplified description, only one set of elements of a starwheel feed apparatus 100 is described below, it being understood, however, that when elements are referred to in singular form, the same description can apply to starwheel feed apparatuses 100 having multiple sets of the same elements.

With reference to the exemplary embodiment of FIGS. 1, 2, and 7-15, sheets 102 of web material, each having a leading edge and a trailing edge, arrive at the starwheel feed apparatus 100 from upstream processes via conveying equipment, and are subsequently fed, leading edge first, into the starwheel slots 108. In some embodiments, the upstream processes advance sheets 102 along at a relatively rapid pace. When the sheets 102 are inserted into the slots 108 of the starwheel 110, a variety of events can occur depending on the speed of the sheet 102 relative to the circumferential speed of the starwheel 110. A sheet 102 can enter a slot 108 so quickly, relative to the circumferential speed of the starwheel 110, that the sheet 102 hits the blind end of the slot 108 at a high speed and buckles, causing the sheet 102 to wrinkle and to be difficult to

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remove from the slot 108, thereby causing the starwheel 110 to become jammed or blocked. Alternatively, a sheet 102 can enter a slot 108 at a speed relative to the circumferential speed of the starwheel 110 that the sheet 102 hits the blind end of the slot 108 and bounces partially or fully out of the slot 108, in some cases causing the trailing edge of the sheet 102 to hang outside of the slot 108 and over an adjacent starwheel tip 128 as the starwheel 110 rotates. Trailing edges of sheets 102 can therefore snag on starwheel tips 128 and can rip, in some cases leaving a torn sheet 102 of poor quality and/or inadequate size. In addition, such sheets 102 can fly outward of the slots 108 by centrifugal force or can be at least partially removed due to friction between the overhanging trailing edge and surrounding equipment the trailing edge contacts as the starwheel 110 rotates. In other circumstances, sheets 102 will not be fed into the slot 108 completely and adequately, again causing the trailing edge of the sheet 102 to hang outside of the slot 108 and potentially snag on a starwheel tip 128 or be stripped out of the slot 108. Also, sheets 102 that are not properly positioned within the slots 108 can result in stacking imperfections when the sheets are later stripped from the starwheel 110.

Because of the above potential circumstances, the starwheel feed apparatus 110 of the present invention includes one or more guiding conveyors 118 to guide the sheets 102 (and in some embodiments, the trailing edges of the sheets 102) into the slots 108 without causing the sheets 102 to buckle, wrinkle, tear, or be stripped out of the slots 108. As will be discussed in greater detail below, several aspects and characteristics of the guiding conveyor(s) 118 can determine how the sheets 102 are guided into the slots 108, including without limitation the operation speed of the guiding conveyor 118 relative to upstream equipment and the starwheel 110, the amount of contact between the guiding conveyor 118 and the sheets 102 depending on the orientation and position of the guiding conveyor 118 (radially and circumferentially with respect to the starwheel 110), and shape, size and configuration of the guiding conveyor 118, and other factors.

Upstream conveying equipment delivering the sheets 102 to the starwheel feed apparatus 100 and the guiding conveyor(s) can be one or more sets of belts, chains, rolls, rollers, tabletop conveyors, shuttles with any cross-sectional shape, and any other product conveying equipment without departing from the present invention. By way of example only, a combination of rolls, rollers, and belts are shown in the embodiment illustrated in FIGS. 1, 2 and 7-15. As sheets 102 are delivered to the starwheel feed apparatus 100, the sheets 102 in some embodiments are directed into a nip 116 between a first feeding conveyor 104 and a second feeding conveyor 106 as shown in the various embodiments of FIGS. 1-15. The term “nip” as used herein and in the appended claims refers to an area or location between two or more winding or conveying elements, such as between two or more rolls, belts, a roll and a belt, or between any other combination of conveying elements known to those skilled in the art used to transport and support a sheet 102 of web.

It should be noted that the present invention need not necessarily include more than one feeding conveyor. In this regard, the starwheel 110 can be supplied via a single feeding conveyor 104, 106 which transports sheets 102 from upstream operations to a location adjacent the starwheel(s). Particularly, in some embodiments, the starwheel 110 of the present invention can be practiced with the use of only one feeding conveyor 104, 106, such as for sheets 102 resting upon a second feeding conveyor 106 without the first feeding conveyor 104 holding the sheets 102 in place thereon, or for sheets 102 held upon the first feeding conveyor 104 by

vacuum force (i.e., the first feeding conveyor being a vacuum belt). In other embodiments, one of the first and second feeding conveyors **104**, **106** comprises a fixed surface which contacts the sheets **102**. By way of example only, the first feeding conveyor **104** shown in the figures can comprise a fixed surface instead of a conveyor that faces the nip and contacts the sheets **102** as the second feeding conveyor **106** directs the sheets **102** toward the starwheel **110**. Although any combination of feeding conveyors **104** can be employed as desired, the use of feeding conveyors **104**, **106** in facing relationship with one another can enable the insertion of different types of materials (e.g., folded and unfolded materials, materials having varying thicknesses and material properties, etc.) into the same starwheel **110** having the same starwheel slot size.

As suggested above, the first and/or second feeding conveyors **104**, **106** can be one of several first and/or second feeding conveyors of any cross-sectional shape (whether square, rectangular, triangular, circular, and the like), such as a plurality of first and second feeding conveyors **104**, **106** running adjacent one another as shown in FIG. 1. Similarly, any number or a series of starwheels **110**, barriers **112**, guiding conveyors **118**, starwheel slots **108**, and stacking platforms **114** can be used without departing from the present invention.

The first and second feeding conveyors **104**, **106** can be oriented in any manner so as to adequately deliver sheets **102** to the starwheel **110** and to feed the sheets **102** into slots in the starwheel **110**. That is, the first and second feeding conveyors **104**, **106** do not need to be horizontally disposed as illustrated in FIGS. 1-15, but can instead slope upward or downward with respect to the starwheel **110**. In addition, the first and second feeding conveyors **104**, **106** need not necessarily run parallel to each other as illustrated in FIGS. 1-15. That is, the feeding conveyors **104**, **106** can form a nip **116** that tapers as it reaches the slot **108** or a nip **116** that widens as it reaches the slot **108**. Furthermore, in some embodiments, such as those shown in FIGS. 4 and 5, the sheets **102** can be fed by upstream sheet feeding equipment in one direction and fed by the first and second feeding conveyors **104**, **106** into the starwheel **110** in another direction.

The first and second feeding conveyors **104**, **106** can run any length within the starwheel feed apparatus **100**, can comprise any number of conveyors arranged to achieve a desired length, can be at least partially recessed between successive starwheels **110**, and can feed sheets **102** into slots **108** of the starwheel **110** from any angle and orientation desired (whether from the top of the starwheel **110**, the bottom of the starwheel **110**, or at any other location around the starwheel **110**). In some embodiments, as illustrated in FIGS. 3 and 4, the first and second feeding conveyors **104**, **106** are each comprised of more than one conveyor, and feed sheets **102** into starwheel slots **108** located between the 11 and 12 o'clock positions on the starwheel **110** (11:30 in FIGS. 4 and 5). In other embodiments, as illustrated in FIGS. 2, 3 and 6, the first and second feeding conveyors **104**, **106** are each comprised of one conveyor, and similarly feed sheets **102** into starwheel slots **108** located at approximately the 11 o'clock position on the starwheel **110** (as viewed in FIGS. 2, 3 and 6). By way of example only, the first and second feeding conveyors **104**, **106** can feed sheets **102** into starwheel slots **108** located at an 11:30 position on the starwheel.

Other embodiments of the present invention, not shown in the appended drawings but within the spirit and scope of the present invention, can comprise any number of first and second feeding conveyors **104**, **106** along the path of sheets **102** in the starwheel feed apparatus **100**, and run any length within the starwheel feed apparatus **100**.

The guiding conveyor **118** can be as few as one guiding conveyor or as many as desired. In some embodiments of the present invention, the guiding conveyor(s) **118** is/are positioned to guide the sheets **102**, from leading edge to trailing edge, into the slots **108** in the starwheel **110**. In other embodiments, the guiding conveyor **118** is defined by a plurality of conveyors positioned in series to guide and decelerate sheets **102** as they approach the slots **108**, and can continue guiding and decelerating the sheets **102** as they enter the slots **108** until the sheets are adequately positioned within the starwheel slots **108**. The guiding conveyor **118** can also have any number of cross-sectional shapes, including circular, square, rectangular, triangular, and the like.

Each guiding conveyor **118** used in the starwheel feed apparatus **100** of the present invention can run between two adjacent starwheels **110**, as shown in FIGS. 2, 4 and 6-15, and may or may not pass through a cylinder defined by the circumference of the starwheel(s) **110**. That is, in some embodiments, the guiding conveyor **118** can be recessed between successive starwheels **110**.

The shape of the guiding conveyor **118** or series of guiding conveyors **118** can determine how sheets **102** are guided into the slots **108**. In this regard, the guiding conveyor **118** (regardless of whether the guiding conveyor **118** is recessed between starwheels **110**) can be at least partially conformed to the periphery of the starwheel **110** to direct sheets **102** into slot **108** of the starwheel **110** after the sheets **102** are initially inserted into the slots **108**. The guiding conveyor **118** can conform to any portion of the periphery of the starwheel **110**, including without limitation a majority of the periphery, half of the periphery, a quarter of the periphery, an eighth of the periphery, and any other portion of the periphery necessary to adequately guide and/or decelerate sheets **102** as they enter slots **108** in the starwheel **110**.

As indicated above, in some embodiments, the guiding conveyor **118** is defined by more than one conveyor (e.g., more than one conveyor belt, roller, and the like) positioned to guide and/or decelerate sheets **102** entering the starwheel **110**. In such cases, the plurality of conveyors of the guiding conveyor **118** can be drivably connected so that they can be driven by a common motor or other driving unit. By way of example only, if the guiding conveyor **118** includes two or more conveyor belts arranged in end-to-end fashion, one of the conveyors can be drivably connected to another as shown, for example, in FIG. 5. This connection can be made in any conventional manner, such as by directly or indirectly connecting a rotating axle of one conveyor with the axle of another (e.g., by a belt or chain about the axles or pulleys, sprockets, or drums on the axles, by meshing gears on the axles, and the like). In such cases, the connected conveyors defining the guiding conveyor **118** can be driven by dedicated motors (or other conventional driving devices) or by a common motor. Similarly, the guiding conveyor **118** can be connected to one or more of the feeding conveyors **104**, **106** in a similar manner, whether to be driven by the feeding conveyor(s) **104**, **106**, to drive the feeding conveyor(s) **104**, **106**, or to be driven by one or more dedicated motors or other conventional driving devices. FIGS. 1, 2 and 4-6 illustrate embodiments of the present invention that employ this manner of driving connection between the first feeding conveyor **104** and one or more conveyors defining the guiding conveyor **118**.

The guiding conveyor **118** has a conveying surface **120** (whether defined by one conveyor or by a plurality of conveyors) that is located adjacent the periphery of the starwheel **110** or at least partially inside the periphery of the starwheel **110** (see FIGS. 2, 4 and 6, for example). The conveying

surface **120** can have a number of different surface shapes achieved in a number of different manners (see FIGS. **1**, **2** and **4-6**) for adequately guiding and/or decelerating sheets **102** as they enter slots **108** of the starwheel **110**. In some embodiments, such as the embodiment illustrated in FIGS. **4** and **6**, the conveying surface **120** of the guiding conveyor **118** running adjacent the starwheel **110** is a single and substantially flat surface oriented at an angle with respect to a sheet path defined by the feeding conveyors **104**, **106** to guide sheets **102** as they enter the starwheel slots **108**. Accordingly, the conveying surface **120** can be oriented at any angular amount with respect to the sheet path defined by the feeding conveyors **104**, **106**. The conveying surface **120** illustrated in FIGS. **4** and **6** is defined by a single conveyor. In some embodiments, the conveying surface **120** is oriented at an angle of less than 90° with respect to the feeding conveyors **104**, **106** to provide superior sheet guiding results. In other embodiments, such as the embodiment illustrated in FIG. **5**, the conveying surface **120** of the guiding conveyor **118** adjacent the starwheel **110** is substantially concave, at least partially conforms to the circumference of the starwheel **110**, and is achieved by using two conveyors positioned in series (in end-to-end relationship). In still other embodiments, such as the embodiment illustrated in FIG. **6**, the conveying surface **120** of the guiding conveyor **118** is again a flat surface oriented at an angle with respect to the sheet path defined by the feeding conveyors **104**, **106** to properly guide sheets entering the starwheel slots **108**, and is defined by a conveyor passed about more than two rotating elements (in the illustrated exemplary embodiment, thereby resulting in a triangular-shaped guiding conveyor).

Any number of other shapes of guiding conveyors **118** can be used in the present invention, and can be achieved by one or more conveyors that are located adjacent one another and/or are drivably connected, including without limitation rectangular, circular, trapezoidal, irregular, and any other shape or design capable of adequately guiding sheets **102** into slots **108** of the starwheel **110**. Additionally, any number of other surface shapes can be used for the conveying surface **120** of the guiding conveyor **118** presented to the sheets **102**, including without limitation convex, concave, flat, wavy or bumpy, corrugated, ribbed, and any other conveying surface **120** capable of guiding sheets **102** into the slots **108** of the starwheel **110**.

The guiding conveyor **118** (whether defined by one conveyor or a plurality of conveyors) is used to guide and/or decelerate sheets **102** as they enter the slots **108** of the starwheel **110**. The guiding conveyor **118** can be driven at a speed greater than that of the feeding conveyor(s) **104**, **106** to accelerate and feed thick sheets, for example, into the starwheel **110**. The guiding conveyor **118** can be driven at a slower speed than the feeding conveyor(s) **104**, **106** and thus decelerate advancing sheets **102**. The guiding conveyor **118** can be driven in this manner by one or more dedicated motors driven to run the guiding conveyor **118** at a slower speed than the feeding conveyors **104**, **106**. Alternatively, the guiding conveyor **118** can instead be driven in this manner by drivably coupling the guiding conveyor **118** to one or more of the feeding conveyors **104**, **106** by a conventional speed reduction connection (e.g., a pulley, sprocket, or drum on a feeding conveyor **104** driving a larger pulley, sprocket, or drum on the guiding conveyor **118** via a belt, chain, and the like). By way of example only, FIGS. **1**, **2**, **4**, and **6** show a guiding conveyor belt **118** rotating at one end about an axle drivably coupled to an axle of the first feeding conveyor **104** through a speed reduction. In some embodiments, such as the embodiment illustrated in FIG. **1** for example, the speed reduction connection

can be accomplished with the use of one drive belt to drivably couple the first feeding conveyor **104** and the guiding conveyor **118**.

Thus, the ratio of feeding conveyor velocity (or the velocity of upstream equipment) to guiding conveyor velocity can be greater than 1:1, and in some embodiments is within a range of between 1:1 and 4:1. In some embodiments of the present invention, the ratio of feeding conveyor velocity (or the velocity of upstream equipment) to guiding conveyor velocity is within a range of 1:1 and 3:1. In other embodiments, the ratio of feeding conveyor velocity (or the velocity of upstream equipment) to guiding conveyor velocity is approximately 1.75:1. Good results have been obtained when the ratio of feeding conveyor velocity (or the velocity of upstream equipment) to guiding conveyor velocity is approximately 2.27:1. Stated another way, good results have been obtained when the guiding conveyor velocity is approximately 44% of feeding conveyor (or upstream equipment) velocity.

Although the guiding conveyor **118** illustrated in the figures is defined by one or more belt conveyors, it will be appreciated that the guiding conveyor **118** can also be operated at a slower velocity than the feeding conveyors **104**, **106** if the conveyor(s) defining the guiding conveyor **118** were instead rolls, wheels, rotating bars, vacuum conveyors, vacuum rolls, and any other device or mechanism capable of conveying and/or guiding sheets **102** as described above.

As mentioned above, in some embodiments the guiding conveyor **118** can be driven independently from the other equipment (i.e., feeding conveyors **104**, **106**, upstream equipment, and the like). This manner of driving the guiding conveyor **118** also enables the guiding conveyor **118** to be driven at a slower velocity than the feeding conveyor(s) **104**, **106**, if desired. In some embodiments, the guiding conveyor **118** can even be directly or indirectly driven (in any manner described above) in a direction opposite that of the feeding conveyor(s) **104**, **106**, thus causing sheets **102** to decelerate as they approach and/or enter slots **108** in the starwheel **110**.

In some embodiments of the present invention, the guiding conveyor **118** is not solely responsible for decelerating sheets **102**, but rather the feeding conveyors **104**, **106** participate in the deceleration of the sheets **102**. The feeding conveyors **104**, **106** can act in decelerating sheets **102** by employing the same mechanisms and in any of the manners described above with regard to the guiding conveyor **118**. In this regard, the velocity of the feeding conveyors **104**, **106** can be between that of upstream equipment and the guiding conveyor **118** to thereby decelerate sheets **102** prior to reaching the guiding conveyor **118**. In such cases, the ratio of the velocity of the upstream equipment to that of the feeding conveyors **104**, **106** is greater than 1:1. Any ratio of the velocity of the upstream equipment to that of the feeding conveyors **104**, **106** that is capable of decelerating sheets **102** as they are fed toward the starwheel **110** can be selected as desired (similar to the case for the guiding conveyor **118**). Alternatively, the velocity of the feeding conveyors **104**, **106** can be greater than the velocity of the upstream equipment to provide a variety of other sheet feeding effects, including providing distance between successive sheets **102** to allow sufficient time to feed each sheet **102** into the starwheel **110**. Good results have been obtained when the ratio of the velocity of the upstream equipment to that of the feeding conveyors **104**, **106** is approximately 1.015:1.

Furthermore, the ratio of the velocity of a point on the guiding conveyor **118** to a point on the periphery of the starwheel **110** can be varied to accommodate a variety of sheet materials, shapes and sizes. This velocity difference can be accomplished by changing the rotational speed of the

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starwheel **110** (and/or the guiding conveyor **118**) and/or the size (i.e., diameter) of the starwheel **110**. In some embodiments of the present invention, the velocity of the guiding conveyor **118** is less than starwheel tip velocity (or the velocity of the periphery of the starwheel **110**). In other embodiments, the velocity of the guiding conveyor **118** is the same as the starwheel tip velocity, and in still other embodiments, the velocity of the guiding conveyor **118** is greater than the starwheel tip velocity. More specifically, in some embodiments of the present invention, the ratio of the velocity of the guiding conveyor **118** to the starwheel tip velocity is within a range of 1:1 to 5:1. In other embodiments, the ratio of the velocity of the guiding conveyor **118** to the starwheel tip velocity is within a range of 1:1 to 3.5:1. In other embodiments, the ratio of the velocity of the guiding conveyor **118** to the starwheel tip velocity is within a range of 1.5:1 to 2.5:1. In still other embodiments, the ratio of the velocity of the guiding conveyor **118** to the starwheel tip velocity is at least 1.2:1. In yet other embodiments, the ratio of the velocity of the guiding conveyor **118** to the starwheel tip velocity is less than 4:1. Good results have been obtained when the ratio of the velocity of the guiding conveyor **118** to the starwheel tip velocity is approximately 1.43:1. Good results have also been obtained when the ratio of the velocity of the guiding conveyor **118** to the starwheel tip velocity is approximately 3.2:1. Of course, these velocity ratios are dependent on the size (i.e., diameter) of the starwheel **110** and the number of slots **108** in the starwheel **110**. In some embodiments, the starwheel diameter is within a range of approximately 15" to 25". Good results have been obtained with a starwheel having a diameter of approximately 20".

In some embodiments, the starwheel **110** comprises 8 slots **108** (a 12" diameter starwheel **110**, by way of example only). In other embodiments, the starwheel **110** comprises 12 slots **108**. In yet other embodiments, the starwheel **110** comprises 16 slots **108**. Although the ratio of the feeding conveyors **104**, **106** to starwheel tip velocity can be impacted by the chosen diameter of the starwheel **110** and the number of slots **108** therein, in some embodiments, the ratio of the velocity of the feeding conveyors **104**, **106** (or upstream equipment) to the ratio of the starwheel tip velocity (or the velocity of a point on the periphery of the starwheel **110**) is at least approximately 4:1. In other embodiments, the ratio of the velocity of the feeding conveyors **104**, **106** (or upstream equipment) to the ratio of the starwheel tip velocity is at least approximately 3:1. In still other embodiments, the ratio of the velocity of the feeding conveyors **104**, **106** (or upstream equipment) to the ratio of the starwheel tip velocity is at least approximately 2:1. By way of example only, the ratio of the velocity of the feeding conveyors **104**, **106** (or upstream equipment) to the ratio of the starwheel tip velocity for an 8-slot starwheel **110** can be approximately 2:1. As another example, the ratio of the velocity of the feeding conveyors **104**, **106** (or upstream equipment) to the ratio of the starwheel tip velocity for an 12-slot starwheel **110** can be approximately 3.2:1. In still another example, the ratio of the velocity of the feeding conveyors **104**, **106** (or upstream equipment) to the ratio of the starwheel tip velocity for an 16-slot starwheel **110** can be approximately 4:1.

In other embodiments, the entering speed of the sheet **102** can be controlled to change the end location of the sheet **102** in the slot **108** as desired (e.g., to place the sheet **102** in any depth in the slot **108**, to cause the sheet **102** to bounce back from the bottom of the slot **108**, to avoid the sheet **102** reaching the bottom of the slot **108**, and the like). This control is enabled by controlling the amount of contact generated between the guiding conveyor **118** and the sheet **102**, which in

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turn is controlled by adjusting the position and orientation of the guiding conveyor **118** with respect to the incoming sheet **102**. In particular, by moving the guiding conveyor **118** closer to the starwheel **110** and/or in a position generating more interference with the path of the incoming sheet **102**, the guiding conveyor **118** can generate more deceleration of the incoming sheet **102**. Similarly, by moving the guiding conveyor **118** farther away from the starwheel **110** and/or in a position generating less interference with the path of the incoming sheet **102**, the guiding conveyor **118** can generate less deceleration of the incoming sheet **102**. In other embodiments, control of sheet speed by the guiding conveyor **118** is enabled by increasing or decreasing the speed of the guiding conveyor **118** with respect to the feeding conveyors **104**, **106**. This alternative manner of controlling sheet speed can be employed as an alternative or in addition to controlling sheet speed by guiding conveyor position and orientation described above. For example, the guiding conveyor **118** can be first positioned to obtain the desired interference and control, and secondly, the speed of the guiding conveyor **118** can be set to insert the sheets **102** properly into the slots **108**.

A number of different conveying devices can be used as first and second feeding conveyors **104**, **106** and a guiding conveyor **118** without departing from the present invention, including without limitation belts and pulleys, chains and sprockets, one or more rolls, wheels, or rotating bars, and any other device or mechanism capable of conveying and feeding sheets **102** into slots **108**, or of conveying, guiding and/or decelerating the sheet **102** approaching and/or entering a slot **108** of the starwheel **110**. As used herein and in the appended claims, the term "conveyor belt(s)" is employed to refer to and encompass any such conveying device. Furthermore, the conveying devices used for the first feeding conveyor **104**, the second feeding conveyor **106**, and the guiding conveyor **118** can be the same or different. In some embodiments of the present invention, as shown in FIG. 3, the sheet **102** can be guided into a slot **108** of the starwheel **110** simply by extending the first feeding conveyor **104** further adjacent a periphery of the starwheel **110** (i.e., a separate guiding conveyor **118** is not employed). Other embodiments of the present invention employ a guiding conveyor **118** or a series of guiding conveyors **118** in addition to feeding conveyor(s) **104**, **106** (see FIGS. 1, 2 and 4-6). Whether the guiding conveyor **118** is defined by a single guiding conveyor **118** or a series of guiding conveyors **118**, the guiding conveyor **118** defines a conveying surface **120** having a length along which the trailing edge of a sheet **102** is guided into a slot **108** of the starwheel **110**.

The feeding conveyors **104**, **106** and the guiding conveyor **118** can be driven by a number of different mechanisms (not shown), including without limitation electric, hydraulic, or pneumatic motors. In addition, the feeding conveyors **104**, **106** and the guiding conveyor **118** can be driven directly or indirectly (e.g., via one or more gears, belts, chains, and the like), whether from a folder or other upstream equipment or otherwise.

The sheet path defined by the conveyors **104**, **106**, **118** can have a number of different shapes, including without limitation straight, curved, circular, or zig-zag shapes, and any combination of such shapes. In short, the conveyors **104**, **106**, **118** can define any path shape in which sheets **102** are transported to the starwheel **110** and into slots **108** of the starwheel **110**.

In some embodiments of the present invention, one or more of the conveyors **104**, **106**, **118** can be moved to different positions with respect to the starwheel **110**. Such adjustability can be performed in a number of manners, such as by con-

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necting a frame or axle(s) of one or more conveyors **104**, **106**, **118** to a rail for movement and attachment at different locations along the rail, by connecting a frame or axles(s) of one or more conveyors **104**, **106**, **118** to one or more actuators (e.g., hydraulic or pneumatic cylinders, solenoids, screws, and the like) or to a carriage movable in any conventional manner (e.g., by one or more hydraulic or pneumatic cylinders, solenoids, screws, and the like), by connecting one or more conveyors **104**, **106**, **118** to an adjustable cam generating movement of the conveyor(s) **104**, **106**, **118** upon rotation of the cam, and the like.

In those embodiments in which one or more of the conveyors **104**, **106**, **118** are movable with respect to the starwheel **110** as just described, this movement can be to different orientations with respect to the starwheel **110** and/or different radial or circumferential positions with respect to the periphery of the starwheel **110** in the plane of the page of FIGS. 2-15.

In some embodiments, any one or more of the conveyors **104**, **106**, **118** are adjustable to different circumferential positions adjacent the starwheel **110**, to different orientations with respect to the starwheel **110**, and/or to different radial distances from the periphery of the starwheel **110**. The conveyors **104**, **106**, **118** can be positioned in different arrangements with respect to one another, such as to define a straight or substantially straight path to the periphery of the starwheel **110**, an arcuate or circular path to follow a portion of the circumference of the starwheel **110**, an angled path defined by a series of straight paths, and the like. In each such case, one or more of the conveyors **104**, **106**, **118** can be adjustable to different positions as desired in any conventional manner. For example, any one or more of the conveyors **104**, **106**, **118** can be rotatable or pivotable about an axis to be able to tip toward and away from the starwheel **110**. In still other embodiments, none of the conveyors **104**, **106**, **118** are adjustable.

In some embodiments, the first and second feeding conveyors **104**, **106** are secured in place with respect to the starwheel **110**, while the guiding conveyor **118** is movable to different positions with respect to the starwheel **110**. In other embodiments, the feeding conveyors **104**, **106** are movable to different positions with respect to the starwheel **110**, while the guiding conveyor **118** is secured in place with respect thereto. In yet other embodiments, one of the first and second feeding conveyors **104**, **106** is movable with the guiding conveyor **118** to different positions with respect to the starwheel **110**, while the second feeding conveyor **106** is stationary. Other conveyor configurations are also possible and within the spirit and scope of the present invention.

In some cases, one or more of the conveyors **104**, **106**, **118** are defined by a conveyor path in which the conveyor moves. By way of example only, the conveyors **104**, **106**, **118** in the illustrated exemplary embodiment employ belts passed about rotating elements to convey, guide, and/or decelerate sheets **102** as discussed in greater detail above. The paths of these conveyors overlap in some cases, and do not overlap in others. For example, the paths of the feeding conveyors **104**, **106** in FIGS. 2 and 4 do not overlap with the path of the guiding conveyor **118**. As other examples, the path of the feeding conveyor **104** in FIG. 5 overlaps with the path of the guiding conveyor **118** by virtue of their driving connection, while the path of the feeding conveyor **104** in FIG. 6 overlaps with the path of the guiding conveyor **104** by virtue of an end of the feeding conveyor **104** being located laterally adjacent the guiding conveyor **118**. In the embodiment of FIG. 6, the feeding conveyor **104** is extended further over the periphery of the starwheel **110**, and is drivably connected to the guiding

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conveyor **118** (of which one of the legs of the triangular guiding conveyor **118** defines the conveying surface **120** adjacent the starwheel **110**).

FIGS. 7-15 show the starwheel feed apparatus of FIGS. 1 and 2 in operation as a sheet **102** is advanced in the nip **116** between the first and second feeding conveyors **104**, **106** toward the starwheel **110**, inserted into one of eight slots **108** in an exemplary starwheel **110**, guided and decelerated into the slot **108** by the guiding conveyor **118**, transported clockwise (as viewed in FIGS. 7-15) in the starwheel **110**, abutted against the barrier **112**, ejected from the slot **108** as the starwheel **110** continues moving past the barrier **112**, and stacked upon at least one other sheet **102** on a stacking platform **114**.

FIG. 7 shows a sheet **102** approaching from upstream equipment and advancing in the nip **116** between the first and second feeding conveyors **104**, **106** to the right toward a starwheel **110**. In this embodiment, the sheet **102** is moving at the same speed as that of the upstream equipment and is about to be decelerated by the guiding conveyor **118**. The guiding conveyor in FIGS. 7-15 is capable of decelerating the sheet **102** as it guides the sheet **102** into a slot **108** of the starwheel **110**. In this regard, the guiding conveyor **118** in this embodiment is driven by the first feeding conveyor **104** at a speed slower than the first feeding conveyor **104** by a speed reduction assembly (e.g., small and large pulleys or sprockets on the axles of the first feeding conveyor **104** and the guiding conveyor **118**, respectively, and driven by a belt or chain about the pulleys or sprockets). The starwheel **110** is rotating clockwise about the axis S.

FIG. 8 shows the sheet **102** being fed from the nip **116** into a slot **108** in the starwheel **110** by the first and second feeding conveyors **104**, **106**. The sheet **102** is about to be decelerated and guided into the slot **108** by the guiding conveyor **118**.

FIG. 9 illustrates the sheet **102** as it is decelerated and guided into the slot **108** by the guiding conveyor **118** as the starwheel **110** is rotated clockwise.

FIG. 10 shows that upon entering the slot **108**, the sheet **102** almost reaches the bottom of the slot **108** without bouncing back out of the slot **108** or buckling on contact with the blind end of the slot **108**. The sheet **102** has been successfully inserted into the slot **108** without snagging on any fin tips **128**.

FIG. 11 depicts the sheet **102** travelling with the starwheel **110** while being supported in the slot **108** as the starwheel **110** is rotated clockwise. Due to adequate sheet insertion, the sheet **102** has not bounced back from the bottom of the slot **108** or been prevented from full insertion and remains in the proper position within the slot **108** as it is transported in the starwheel **110**.

FIG. 12 shows the sheet **102** with one end contacting the barrier **112** oriented vertically and located below the axis S of the starwheel **110**. The sheet **102** is about to be ejected from the starwheel **110** as the slot **108** holding the sheet **102** is transported past the barrier **112**.

FIG. 13 shows the sheet **102** before it has entirely exited the slot **108**. Due to the curve and orientation of the slot **108**, the sheet **102** is adequately positioned to be laid upon the stacking platform **114**.

FIG. 14 shows a sheet **102** being ejected from the slot **108** as the starwheel **110** is rotated. The sheet **102** is released and, due to the orientation of the illustrated exemplary embodiment, dropped upon a nearly completed stack **130** on the stacking platform **114**.

FIG. 15 shows the completed stack **130** being transported away from the starwheel feed apparatus **100** toward the downstream processes via a conveyor belt functioning as the stacking platform **114**. A new stack **130'** is about to receive another sheet **102** as it is ejected from a slot **108** in the starwheel **110**.

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The embodiments described above and illustrated in the figures are presented by way of example only and are not intended as a limitation upon the concepts and principles of the present invention. As such, it will be appreciated by one having ordinary skill in the art that various changes in the elements and their configuration and arrangement are possible without departing from the spirit and scope of the present invention as set forth in the appended claims. For example, the embodiments illustrated in FIGS. 1-15 show the starwheel feed apparatus 100 with the barrier 112 and the stacking platform 114 oriented such that they are located below the center axis S of the starwheel 110, with the conveyors 104, 106, 118 positioned above the starwheel 110 and running substantially horizontally. However, the starwheel feed apparatus 100 of the present invention need not necessarily be oriented in this way. In some embodiments (not shown, but described from the perspective of FIGS. 2-15, assuming clockwise rotation of the starwheel 110), the feeding conveyors 104, 106 feed sheets 102 into slots 108 of the starwheel 110 at the bottom of the starwheel 110, the guiding conveyor 118 guides and/or decelerates the sheets 102 into the slots 108 along any portion of the starwheel periphery between the feeding conveyors 104, 106 and the barrier 112, and the barrier 112 located vertically above the axis S forces the sheet 102 out of the slot 108 onto a stacking platform 114 located adjacent the starwheel 110 just below the barrier 112.

In other embodiments, the feeding conveyors 104, 106 direct sheets 102 radially into the starwheel 110 from a twelve o'clock position (from the perspective of FIGS. 2-15), running substantially vertically. In still other embodiments, the feeding conveyors 104, 106 direct sheets 102 into slots 108 in the starwheel 110 at a nine o'clock position on the starwheel 110, the guiding conveyor 118 guides and/or decelerates the sheets 102 as they travel in the starwheel 110, and the sheets 102 are discharged from the starwheel 110 on an opposite side of the starwheel 110 (at a three o'clock position in a substantially horizontal orientation, in which case the barrier 112 can perform the functions of both the barrier 112 and the stacking platform 114). In yet other embodiments, the feeding conveyors 104, 106 can be positioned to insert sheets 102 into slots 108 in the starwheel 110 at a ten o'clock position of the starwheel 110 (when viewed from the perspective of FIGS. 2-15), the guiding conveyor 118 guides and/or decelerates the sheets 102 along any portion of the starwheel 110 between the feeding conveyors 104, 106 and the barrier 112, and the barrier 112 can be positioned in a three o'clock position of the starwheel 110 such that sheets 102 are discharged from the starwheel 110 in a substantially vertical orientation and are stacked in a horizontal direction. The feeding conveyors 104, 106, the barrier 112, and the stacking platform 114 can be positioned at any angular location about the axis S independent of each other in order to feed sheets 102 into the starwheel 110 and to discharge the sheets 102 without departing from the spirit and scope of the present invention.

We claim:

1. A sheet guiding apparatus for guiding a sheet of web material as the sheet is fed into a starwheel from upstream sheet feeding equipment, the starwheel having slots and being rotatable to receive and discharge the sheet; the sheet guiding apparatus comprising:

- a conveyor belt located adjacent the starwheel at a location downstream of the upstream feeding equipment;
- a conveying surface defined at least partially by the conveyor belt, the conveying surface positioned to contact and guide a trailing edge of the sheet as the sheet enters the starwheel; and

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wherein the starwheel has a center and an outer radius, and wherein at least a portion of the conveyor belt is located at a radial position less than the outer radius of the starwheel with respect to the center of the starwheel.

2. The apparatus as claimed in claim 1, wherein the conveyor belt is one of a plurality of conveyor belts.

3. The apparatus as claimed in claim 2, wherein the plurality of conveyor belts is arranged end-to-end.

4. The apparatus as claimed in claim 3, wherein the conveying surface is defined by the plurality of conveyor belts arranged end-to-end, and is concave with respect to the starwheel.

5. The apparatus as claimed in claim 1, wherein the plurality of conveyor belts is arranged side-by-side.

6. The apparatus as claimed in claim 1, wherein the conveying surface is adjustable to different positions with respect to the starwheel, the conveying surface being adjustable toward and away from the starwheel to increase and decrease contact between the conveying surface and the sheet.

7. The apparatus as claimed in claim 1, wherein the starwheel has a periphery, and wherein a point on the conveyor belt moves at substantially the same velocity as that of a point on the periphery of the starwheel.

8. The apparatus as claimed in claim 1, wherein the starwheel has a periphery, and wherein a point on the conveyor belt moves at a velocity greater than that of a point on the periphery of the starwheel.

9. The apparatus as claimed in claim 1, wherein the starwheel has a periphery, wherein a point on the conveyor belt moves at a first velocity and a point on the periphery of the starwheel moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is at least 1.2:1.

10. The apparatus as claimed in claim 1, wherein the starwheel has a periphery, wherein a point on the conveyor belt moves at a first velocity and a point on the periphery of the starwheel moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is approximately 1.43:1.

11. The apparatus as claimed in claim 1, wherein the starwheel has a periphery, wherein a point on the conveyor belt moves at a first velocity and a point on the periphery of the starwheel moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is less than 4:1.

12. The apparatus as claimed in claim 1, wherein the starwheel has a periphery, wherein a point on the conveyor belt moves at a first velocity and a point on the periphery of the starwheel moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is approximately 3.2:1.

13. The apparatus as claimed in claim 1, wherein the upstream sheet feeding equipment moves the sheet at a first velocity and the conveyor belt moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is at least 1:1.

14. The apparatus as claimed in claim 1, wherein the upstream sheet feeding equipment moves the sheet at a first velocity and the conveyor belt moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is between 1:1 and 4:1.

15. The apparatus as claimed in claim 1, wherein the upstream sheet feeding equipment moves the sheet at a first velocity and the conveyor belt moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is between 1:1 and 3:1.

16. The apparatus as claimed in claim 1, wherein the upstream sheet feeding equipment moves the sheet at a first

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velocity and the conveyor belt moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is approximately 1.75:1.

17. The apparatus as claimed in claim 1, wherein the upstream sheet feeding equipment moves the sheet at a first velocity and the conveyor belt moves at a second velocity, and wherein the ratio of the first velocity to the second velocity is approximately 2.27:1.

18. A sheet guiding apparatus for guiding a sheet of web material as the sheet is fed into a starwheel from upstream sheet feeding equipment, the starwheel having slots and being rotatable to receive and discharge the sheet; the sheet guiding apparatus comprising:

a conveyor belt located adjacent the starwheel at a location downstream of the upstream feeding equipment; and
a conveying surface defined at least partially by the conveyor belt, the conveying surface positioned to contact and guide a trailing edge of the sheet as the sheet enters the starwheel;

wherein the conveyor belt is drivably connected to the upstream sheet feeding equipment.

19. The apparatus as claimed in claim 18, wherein the conveyor belt is drivably connected to the upstream sheet feeding equipment through a speed reduction.

20. A method of feeding sheets of a web material into a starwheel using a starwheel feed apparatus, the starwheel having at least one slot and the starwheel feed apparatus having at least one conveyor belt adjacent the starwheel; the method comprising:

moving a sheet to the starwheel with upstream sheet feeding equipment;

advancing the sheet along the at least one conveyor belt; feeding the sheet into one of the at least one slot of the starwheel with the upstream sheet feeding equipment;

contacting the sheet downstream of the upstream sheet feeding equipment with the at least one conveyor belt as the sheet enters the starwheel;

rotating the starwheel; and

contacting the sheet and guiding the sheet into the at least one slot with the at least one conveyor belt.

21. The method as claimed in claim 20, further comprising decelerating the sheet by operating the conveyor belt at a speed less than that of the upstream sheet feeding equipment.

22. The method as claimed in claim 20, further comprising: moving the sheet adjacent at least one barrier; ejecting the sheet from the at least one slot; and stacking the sheet upon at least one other sheet.

23. The method as claimed in claim 20, wherein the conveyor belt has a conveying surface and the conveying surface has a length, and further comprising guiding a trailing edge of the sheet along the length of the conveying surface into the at least one slot.

24. The method as claimed in claim 20, wherein moving a sheet to the starwheel with upstream sheet feeding equipment includes moving the sheet at a first velocity, and wherein advancing the sheet along the at least one conveyor belt includes advancing the conveyor belt at a second velocity.

25. The method as claimed in claim 24, wherein the first velocity is greater than the second velocity.

26. The method as claimed in claim 25, wherein the ratio of the first velocity to the second velocity is approximately 1.75:1.

27. The method as claimed in claim 25, wherein the ratio of the first velocity to the second velocity is approximately 2.27:1.

28. The method as claimed in claim 20, wherein advancing the sheet along the at least one conveyor belt includes advancing

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ing the sheet at a first velocity, and wherein rotating the starwheel includes moving a periphery of the starwheel at a second velocity different than the first velocity.

29. The method as claimed in claim 28, wherein the first velocity is at least 1.2 times the second velocity.

30. The method as claimed in claim 28, wherein the ratio of the first velocity to the second velocity is approximately 1.43:1.

31. The method as claimed in claim 28, wherein the first velocity is less than four times the second velocity.

32. The method as claimed in claim 28, wherein the ratio of the first velocity to the second velocity is approximately 3.2:1.

33. The method as claimed in claim 20, further comprising decelerating the sheet by operating the conveyor belt in a direction opposite that of the upstream sheet feeding equipment.

34. A starwheel feed apparatus for feeding sheets of web material into a starwheel, the starwheel having slots and being rotatable to receive the sheets in a first position and discharge the sheets in a second position, the slots positioned to receive and carry the sheets as the starwheel rotates, each sheet having a leading edge and a trailing edge; the starwheel feed apparatus comprising:

a feeding conveyor located upstream of the starwheel and movable to convey sheets toward the starwheel;

a guiding conveyor located adjacent the starwheel, the guiding conveyor having a conveying surface movable to convey sheets;

the conveying surface having a length and oriented to contact and guide the trailing edges of the sheets along the length of the conveying surface as the sheets enter the slots.

35. The apparatus as claimed in claim 34, wherein the feeding conveyor travels at a first velocity and the guiding conveyor travels at a second velocity.

36. The apparatus as claimed in claim 35, wherein the ratio of the first velocity to the second velocity is between 1:1 and 4:1.

37. The apparatus as claimed in claim 35, wherein the ratio of the first velocity to the second velocity is between 1:1 and 3:1.

38. The apparatus as claimed in claim 35, wherein the ratio of the first velocity to the second velocity is approximately 1.75:1.

39. The apparatus as claimed in claim 35, wherein the ratio of the first velocity to the second velocity is approximately 2.27:1.

40. The apparatus as claimed in claim 34, wherein the starwheel is one of a plurality of starwheels, and wherein at least one of the feeding conveyor and the guiding conveyor are located at least partially between starwheels.

41. The apparatus as claimed in claim 34, wherein the feeding conveyor is one of a set of feeding conveyors between which the sheet is moved toward the starwheel.

42. The apparatus as claimed in claim 34, wherein the guiding conveyor is one of a plurality of guiding conveyors.

43. The apparatus as claimed in claim 42, wherein the plurality of guiding conveyors is arranged end-to-end.

44. The apparatus as claimed in claim 43, wherein the conveying surface is defined by the plurality of guiding conveyors arranged end-to-end, and is concave with respect to the starwheel.

45. The apparatus as claimed in claim 42, wherein the plurality of guiding conveyors is arranged side-by-side.

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46. The apparatus as claimed in claim 34, wherein the guiding conveyor travels at a first velocity and a tangential velocity of the starwheel is a second velocity different than the first velocity.

47. The apparatus as claimed in claim 46, wherein the first velocity is greater than the second velocity.

48. The apparatus as claimed in claim 46, wherein the first velocity is at least 1.2 times the second velocity.

49. The apparatus as claimed in claim 46, wherein the ratio of the first velocity to the second velocity is approximately 1.43:1.

50. The apparatus as claimed in claim 46, wherein the first velocity is greater than the second velocity and is less than four times the second velocity.

51. The apparatus as claimed in claim 46, wherein the ratio of the first velocity to the second velocity is approximately 3.2:1.

52. The apparatus as claimed in claim 34, wherein the guiding conveyor is a conveyor belt.

53. The apparatus as claimed in claim 34, wherein the conveying surface is concave with respect to the starwheel.

54. The apparatus as claimed in claim 34, wherein the conveying surface is substantially tangential to the starwheel.

55. The apparatus as claimed in claim 34, wherein the guiding conveyor is drivably connected to the feeding conveyor.

56. The apparatus as claimed in claim 34, wherein the guiding conveyor is drivably connected to the feeding conveyor through a speed reduction.

57. The apparatus as claimed in claim 34, further comprising a barrier positioned to contact the sheet and cause the sheet to be discharged from the starwheel.

58. A method of guiding a sheet of web material into a starwheel, the sheet having a leading edge and a trailing edge; the method comprising:

transferring the sheet from a feeding conveyor to the starwheel, the feeding conveyor having a first velocity;
feeding the sheet into a slot in the starwheel with the feeding conveyor;
moving the sheet in the slot toward an inserted position;
contacting the sheet with a conveying surface downstream of the feeding conveyor as the sheet moves in the slot;
rotating the starwheel; and

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guiding the trailing edge of the sheet along a length of the conveying surface as the sheet enters the slot.

59. The method as claimed in claim 58, further comprising conveying the sheet with the conveying surface at a second velocity, and wherein the ratio of the first velocity to the second velocity is between 1:1 and 4:1.

60. The method as claimed in claim 58, further comprising conveying the sheet with the conveying surface at a second velocity, and wherein the ratio of the first velocity to the second velocity is between 1.5:1 and 2.5:1.

61. The method as claimed in claim 58, further comprising conveying the sheet with the conveying surface at a second velocity, and wherein the ratio of the first velocity to the second velocity is approximately 1.75:1.

62. The method as claimed in claim 58, further comprising conveying the sheet with the conveying surface at a second velocity, and wherein the ratio of the first velocity to the second velocity is approximately 2.27:1.

63. The method as claimed in claim 58, further comprising conveying the sheet with the conveying surface at a second velocity, and wherein rotating the starwheel includes moving the sheet in the starwheel at a third velocity measured as a tangential speed of the starwheel.

64. The method as claimed in claim 63, wherein the second velocity is greater than the third velocity.

65. The method as claimed in claim 63, wherein the second velocity is at least 1.2 times the third velocity.

66. The method as claimed in claim 63, wherein the ratio of the second velocity to the third velocity is approximately 1.43:1.

67. The method as claimed in claim 63, wherein the second velocity is greater than the third velocity and is less than four times the third velocity.

68. The method as claimed in claim 63, wherein the ratio of the second velocity to the third velocity is approximately 3.2:1.

69. The method as claimed in claim 58, wherein contacting the sheet includes contacting the sheet with a conveying surface of a conveyor belt.

70. The method as claimed in claim 58, wherein guiding the trailing edge of the sheet includes guiding the trailing edge of the sheet along a length of a plurality of conveying surfaces.

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