

TAPE REEL TURRET APPARATUS FOR A TAPE AND REEL MACHINE

Technical Field

5 The present disclosure relates generally to tape and reel machines configured for loading and/or unloading reels that carry a flexible tape having sealed pockets or wells in which components such as semiconductor devices reside. More particularly, aspects of the present disclosure are directed to a tape reel turret apparatus configured for carrying a plurality of tape reels, and selectively rotating a given tape reel to a feeding position such
10 that the tape reel can be loaded or unloaded by a tape and reel machine, while one or more other tape reels carried by the tape reel turret apparatus can be attached to or detached from from the tape reel turret apparatus.

Background

15 Tape and reel machines transfer components such as semiconductor devices (e.g., semiconductor die or packaged integrated circuit chips) onto a flexible linear tape, and concurrently feed the flexible linear tape to a tape reel while the reel is spun. As a result, the flexible linear tape is progressively circumferentially wound around the tape reel. This provides an efficient manner of storing the flexible linear tape and the components
20 carried thereby. Once a tape reel that is receiving the flexible linear tape is fully loaded with a given length of the flexible linear tape, this full reel must be replaced with an empty reel such that additional components can continue to be transferred to the flexible linear tape, and the flexible linear tape can continue to be fed to, wound around, and stored on a tape reel. That is, the full reel must be changed or swapped out for an empty
25 reel.

Manual tape reel changing involves removing a first full tape reel from the tape and reel system, and manually replacing this first full tape reel with a second empty tape reel. During manual tape reel changing, the tape and reel machine is not operating, resulting in
30 tape and reel machine interruption or downtime, adversely affecting throughput. Automated systems exist for changing tape reels. However, existing automated systems

for automatically changing tape reels (e.g., as described in US Patent Publication No. 2011/0220755 and US Patent Publication No. 2003/0046808) are highly complex from a mechanical standpoint, and correspondingly costly. A need exists for a mechanically simple, low cost, throughput efficient apparatus for a tape and reel machine, by which
5 multiple tape reels can be automatically managed.

Summary

In accordance with an aspect of the present disclosure, a tape reel apparatus for a tape and reel component transfer system configured for transferring components onto or off of a
10 flexible linear tape includes: a central hub rotatable about a first axis of rotation; a plurality of tape reels coupled to the central hub, including a first tape reel and a second tape reel; and a first actuator coupled to the central hub and configured to rotate the central hub about the first axis of rotation to thereby rotate the first tape reel away from a feeding position while simultaneously rotating the second tape reel toward the feeding
15 position. The feeding position corresponds to a location at which the flexible linear tape can be fed from the component transfer system to a tape reel positioned thereat, or fed from the tape reel positioned thereat to the component transfer system. The tape reel apparatus further includes a second actuator configured for spinning the second tape reel about a winding axis or an unwinding axis for respectively winding or unwinding the
20 flexible linear tape about the second tape reel when the second tape reel is disposed at the feeding position. While the second tape reel is disposed at the feeding position and the flexible linear tape is being wound about or unwound from the second tape reel, the first tape reel can be offloaded from the tape reel apparatus (e.g., and replaced with another tape reel).

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In accordance with another aspect of the present disclosure, a tape reel apparatus for a tape and reel component transfer system configured for transferring components onto or off of a flexible linear tape includes: (a) a multi-arm module having a central hub rotatable about a first axis of rotation; and a plurality of arms coupled to the central hub,
30 each of which radially extends away from the central hub, and each of which has a reel holder by which a tape reel can be attached to and detached from the arm; and (b) a first

actuator coupled to the central hub and configured for rotating the central hub about the first axis of rotation to thereby collectively rotate the plurality of arms about the first axis of rotation. The first actuator is configured for collectively rotating the plurality of arms such that one of the plurality of arms rotates toward a feeding position simultaneous with
5 rotation of another of the plurality of arms away from the feeding position, where the feeding position corresponds to a position of an arm at which the flexible linear tape can be fed from the component transfer system to a tape reel carried by the arm, or fed from a tape reel of such arm to the component transfer system.

10 Each reel holder of each arm is rotatable about a second axis of rotation parallel to the first axis of rotation to enable spinning of a tape reel held thereby for winding and/or unwinding of the flexible linear tape about the tape reel. While a first arm within the plurality of arms carrying a tape reel is disposed at the feeding position and the flexible linear tape is being wound about or unwound from such tape reel carried by the first arm,
15 a second arm within the plurality of arms disposed away from the feeding position can offload or receive a second tape reel. Rotation of the plurality of arms around the first axis of rotation as well as spinning of a tape reel carried by an arm disposed at the feeding position can be controlled by a set of instructions executed by a processing unit.

20 The tape reel apparatus can include a second actuator configured for selectively spinning a tape reel carried by an arm within the plurality of arms when the arm is disposed at the feeding position. The second actuator can include a rotatable shaft for engaging with the reel holder of an arm when the arm is disposed at the feeding position. The tape reel apparatus can also include a translation mechanism configured for selectively engaging
25 the rotatable shaft with and disengaging the rotatable shaft from a reel holder of an arm disposed at the feeding position.

The tape reel apparatus can further include a support structure configured to maintain the central hub at a predetermined position relative to the feeding position such that a set of
30 tape guide members is receivable between a first flange and a second flange of a tape reel carried by an arm disposed at the feeding position.

In accordance with an aspect of the present disclosure, a process for transferring components carried by a flexible linear tape between a plurality of tape reels and a tape and reel machine, where each tape reel is configured for receiving a length of the flexible linear tape by way of circumferentially winding the flexible linear tape thereabout, includes: providing a tape reel assembly having a plurality of arms rotatable about a first axis of rotation corresponding to a central hub structure, each of such arms configured for carrying a tape reel; and rotating the tape reel assembly about the first axis of rotation such that the plurality of arms collectively rotates to dispose a first arm of the tape reel assembly at a feeding position while simultaneously disposing a second arm of the tape reel assembly away from the feeding position. The feeding position corresponds to a location at which the flexible linear tape can be loaded from the tape and reel machine onto a tape reel, or offloaded from a tape reel to the tape and reel machine when an arm that carries the tape reel is disposed at the feeding position.

The first arm can carry a first tape reel, and the process can further include spinning the first tape reel about a second axis of rotation while the first arm is disposed at the feeding position, simultaneous with displacement of the flexible linear tape towards or away from the first tape reel to facilitate loading of the flexible linear tape onto or unloading of the flexible linear tape from the first tape reel, respectively. The process can additionally include disengaging a second tape reel from or receiving a second tape reel onto the second arm of the tape reel assembly simultaneous with the spinning the first tape reel (e.g., while the first tape reel is disposed at the feeding position).

When the second arm carries the second tape reel, the process can further include rotating the tape reel assembly about the first axis of rotation such that each of the plurality of arms collectively rotates to dispose the second arm of the tape reel assembly and the second tape reel carried thereby at the feeding position, while simultaneously disposing the first arm of the tape reel assembly away from the feeding position. The process can also include spinning the second tape reel about the second axis of rotation while the second arm is disposed at the feeding position, simultaneous with displacement of the

flexible linear tape towards or away from the second tape reel to facilitate loading of the flexible linear tape onto or unloading of the flexible linear tape from the second tape reel, respectively.

5 In accordance with an aspect of the present disclosure, a process for transferring components carried by a flexible linear tape between a plurality of tape reels and a tape and reel machine, where each tape reel is configured for receiving a length of the flexible linear tape by way of circumferentially winding the flexible linear tape thereabout, includes: (a) selectively rotating each of the plurality of tape reels about a common first
10 axis of rotation to (i) dispose a selected tape reel within the plurality of tape reels at a feeding position at which the selected tape reel can receive the flexible linear tape from or offload the flexible linear tape onto the tape and reel machine, while simultaneously (ii) disposing other tape reels within the plurality of tape reels away from the feeding position; (b) spinning the selected tape reel about a second axis of rotation to load the
15 selected tape reel with the flexible linear tape or unload the flexible linear tape from the selected tape reel; (c) identifying a next tape reel within the plurality of tape reels as the selected tape reel; and (d) repeating each of (a) through (c) on an ongoing basis during tape and reel machine operation. The process can further include (e) swapping out a tape reel disposed away from the feeding position with another tape reel while the selected
20 tape reel is disposed at the feeding position and the flexible linear tape is being wound about or unwound from the selected tape reel.

Brief Description of the Drawings

FIG. 1 is a schematic illustration showing a front perspective view of a representative
25 tape reel turret apparatus in accordance with an embodiment of the present disclosure, in which a first arm and a first tape reel carried thereby are disposed at a feeding position.

FIG. 2 is a schematic illustration showing a perspective view of the tape reel turret apparatus of FIG. 1, in which the first arm and first tape reel are being rotated away from
30 the feeding position, simultaneous with rotation of a second arm and a second tape reel carried thereby toward the feeding position.

FIG. 3 is a schematic illustration showing a perspective view of a representative tape reel turret apparatus of FIG. 2, in which the second arm and the second tape reel have been rotated to the feeding position.

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FIG. 4 is a schematic illustration showing a rear perspective view of the tape reel turret apparatus of FIG. 1.

FIG. 5 is a schematic illustration showing a plan view of a representative multi-arm module for a tape reel turret apparatus in accordance with an embodiment of the present disclosure.

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FIG. 6 is a schematic illustration showing a plan view of a representative multi-arm module for a tape reel turret apparatus in accordance with an embodiment of the present disclosure, in which each arm of the multi-arm module carries a tape reel, and a first arm and a corresponding first tape reel are disposed at a feeding position.

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FIG. 7 is a schematic illustration showing a front perspective view of the multi-arm module of FIG. 6.

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FIG. 8 is a schematic illustration showing a rear perspective view of the multi-arm module of FIG. 6.

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FIG. 9 is a schematic cross-sectional illustration through a plane containing both a first shaft axis of rotation ρ and a winding axis ω of a tape reel holder rod, showing a half-thickness cross section of a second shaft provided by a second actuator in a disengaged or withdrawn position relative to the rod, which corresponds to an arm disposed at a feeding position at which a flexible linear tape can be communicated between a tape reel carried by the arm and a tape transport unit of a tape and reel machine.

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FIG. 10 is a schematic cross-sectional illustration through a plane containing both the first shaft axis of rotation ρ and the winding axis ω of a tape reel holder rod, showing a half-thickness cross section of the second shaft provided by the second actuator in an engaged position relative to the rod, for the arm disposed at the feeding position at which the flexible linear tape can be communicated between the tape reel carried by the arm and the tape transport unit of the tape and reel machine.

Detailed Description

In the present disclosure, depiction of a given element or consideration or use of a particular element number in a particular FIG. or a reference thereto in corresponding descriptive material can encompass the same, an equivalent, or an analogous element or element number identified in another FIG. and/or descriptive material associated therewith. The use of “/” in a FIG. or associated text is understood to mean “and/or” unless otherwise indicated. The recitation of a particular numerical value or value range herein is understood to include or be a recitation of an approximate numerical value or value range (e.g., to within +/- 20%, +/-15%, +/-10%, or +/-5%).

As used herein, the term “set” corresponds to or is defined as a non-empty finite organization of elements that mathematically exhibits a cardinality of at least 1 (i.e., a set as defined herein can correspond to a unit, singlet, or single element set, or a multiple element set), in accordance with known mathematical definitions (for instance, in a manner corresponding to that described in *An Introduction to Mathematical Reasoning: Numbers, Sets, and Functions*, “Chapter 11: Properties of Finite Sets” (e.g., as indicated on p. 140), by Peter J. Eccles, Cambridge University Press (1998)). In general, an element of a set can include or be a system, an apparatus, a device, a structure, an object, a process, a physical parameter, or a value depending upon the type of set under consideration.

Embodiments of the present disclosure are directed to a tape reel turret apparatus for a tape and reel machine. As one having ordinary skill in the relevant art will readily understand, a tape and reel machine is configured for transferring components such as

semiconductor devices (e.g., packaged semiconductor chips) to and/or from a flexible linear tape that can be wound or coiled around a tape reel for purpose of efficiently storing the components carried by the flexible linear tape. The tape reel turret apparatus includes a plurality of arms that radially extend away from a central hub. Each arm
5 includes a tape reel holder that enables attachment of a tape reel to the arm and removal of the tape reel from the arm, and which facilitates spinning or circumferential rotation of the tape reel relative to the arm.

The tape reel turret apparatus is configured for collectively rotating the plurality of arms
10 about or around the central hub, such that each arm can be disposed or selectably or sequentially placed (e.g., under the direction of a set of program instructions executable by a processing unit) at a feeding position at which the flexible linear tape can be communicated between the tape and reel machine and a tape reel carried by an arm
15 disposed at the feeding position, in association with spinning motion imparted to the tape reel. More particularly, when a given arm resides at the feeding position, a tape reel carried by this arm can be spun in a first direction such that the flexible linear tape is loaded from the tape and reel machine onto the tape reel, or spun in a second direction such that the flexible linear tape is unloaded or offloaded from the tape reel to the tape
20 and reel machine. While a particular arm is positioned at the feeding position, one or more other arms within the plurality of arms which are not positioned at the feeding position can have tape reels removed therefrom or attached thereto.

FIGs. 1 – 4 are schematic illustrations showing aspects of a representative tape reel turret apparatus 100 in accordance with an embodiment of the present disclosure. The tape reel
25 turret apparatus 100 is configured to operate or interface with a tape and reel machine 10, portions of which are also illustrated in FIGs. 1 - 4. The tape and reel machine 10 can be conventional or substantially conventional (e.g., conventional, other than with respect to straightforward / minor structural modifications made thereto for purpose of
30 accommodating or interfacing with a tape reel turret apparatus 100 in accordance with an embodiment of the present disclosure).

The tape and reel machine 10 includes a tape transport unit 20 that provides a linear track 22 and along which a flexible linear tape 12 is displaceable toward or away from the tape reel turret apparatus 100, for instance, along or parallel to a tape input / output axis (e.g., an x axis) corresponding to the tape transport unit 20. In various embodiments, the flexible linear tape 12 includes (a) a carrier tape having a plurality of pockets or wells disposed therein along its length, in which components can be placed; and (b) a cover tape that overlays the carrier tape, and which seals the components inside the carrier tape wells in which they reside, in a manner readily understood by one having ordinary skill in the relevant art. The tape and reel machine 10 is typically configured for carrying a carrier tape reel from which the carrier tape is provided, and a cover tape reel from which the cover tape is provided, as one having ordinary skill in the art will readily understand. Furthermore, the tape and reel machine 10 additionally includes or operates in association with a pick and place apparatus (not shown), for instance, a turret-based pick and place apparatus, which is configured for transferring individual components from component source locations into individual wells of the carrier tape in association with a tape loading procedure; or transferring individual components from carrier tape wells to component destination locations in association with a tape unloading procedure. The tape and reel machine 10 additionally provides a conventional set of tape guide members 24a,b between and along which the flexible linear tape 12 can be guided into an empty tape reel 110, as will be understood by one having ordinary skill in the relevant art.

In various embodiments, the tape reel turret structure 100 includes a support structure or member 102 that carries each of a first actuator 150; a second actuator 160 and a translation mechanism 170 corresponding thereto; and a multi-arm module 120 having a plurality of arms 128a-c onto which tape reels 110a-c can be selectively and securely attached and from which tape reels 110a-c can be selectively detached or removed. The first actuator 150 can be directly mounted to the support structure 102; and the second actuator 160 and the translation mechanism 170 can be carried by a platform or ledge 104 that projects or extends away (e.g., perpendicularly, in a rearward direction) from the support structure 102.

The first actuator 150 includes a first shaft 152 configured for rotational engagement with the multi-arm module 120, such that the first actuator 150 can rotate the multi-arm module 120, and hence collectively rotate the plurality of arms 128a-c and tape reels 110a-c carried thereby, along, about, or around a circumferential path or direction toward or away from the tape and reel machine 10. Thus, revolution of the first shaft 152 in a given direction results in corresponding displacement of the tape reels 110a-c along a circular path in that direction. More particularly, the first actuator 150 is configured for collectively rotating the plurality of arms 128a-c such that each arm 128a-c can be selectively, selectably, or sequentially rotated around a first or common axis of rotation ρ to a feeding position at which the flexible linear tape 12 can be loaded onto or unloaded from a tape reel 110a-c carried by the arm 128a-c. As further detailed below, when a given arm 128a-c resides at the feeding position, the arm 128a-c is aligned relative to the tape input / output axis x and hence the tape transport unit 20, such that the flexible linear tape 12 can be communicated between the tape transport unit 20 and a tape reel 110a-c carried by the arm 128a-c located at the feeding position, in association with spinning motion imparted to the tape reel 110a-c by way of the second actuator 160.

FIGs. 5 – 8 are schematic illustrations showing aspects of a representative multi-arm module 120 according to an embodiment of the present disclosure. In an embodiment, the multi-arm module 120 includes a central region, portion, junction, section, member, structure, or hub 122 about which each arm 128a-c is symmetrically disposed, and from which each arm 128a-c radially projects or extends. While the embodiment shown includes three arms 128a-c, other embodiments can include two arms 128 or more than three arms 128. In general, an embodiment that includes three arms 128a-c and which can correspondingly carry three tape reels 110a-c is spatially efficient from a geometric tape reel packing perspective, as will be readily understood by one having ordinary skill in the relevant art.

Each arm 128a-c carries or includes a tape reel holding mechanism or holder 130 by which a tape reel 110a-c can be securely attached to and subsequently detached from the arm 128a-c, and which provides a second, additional, or winding / unwinding axis ω_{a-c}

about which a tape reel 110a-c coupled to the arm 128a-c can be spun. The tape reel holder 130 can include, for instance, a spindle or rod 132 that perpendicularly projects away from an exterior surface of the arm 128a-c, where the rod 132 is configured for selective mating engagement with and disengagement from the second actuator 160 to facilitate selective tape reel spinning, as further detailed below, including with reference to FIGs. 9 – 10.

Each arm 128a-c provides a predetermined reel positioning distance d_r between a center point 124 of the central hub 122 along a radial or elongate axis r_{a-c} of the arm 128a-c to the center of the tape reel holder's rod 132, or equivalently, to the winding / unwinding axis ω_{a-c} corresponding to the rod 132. Additionally, each arm 128a-c has a predetermined overall length l along its radial or elongate axis r_{a-c} , between the center point 124 of the central hub 122 and a terminal end of the arm 128a-c which is proximate or generally proximate to the arm's reel holder 130 and rod 132. In various embodiments, the tape reel turret apparatus 100 can accommodate tape reels 110a-c of particular predetermined sizes (e.g., corresponding to one, two, or more standard tape reel diameters), as will be readily understood by one of ordinary skill in the relevant art. In several embodiments, the multi-arm module 120 can be formed as a single piece of material (e.g., single piece of machined metal, such as aluminum), which can be coated or remain uncoated.

The central hub 122 is configured for secure coupling to or mating engagement with the first actuator 150, such that the first actuator 150 can circumferentially rotate the entire multi-arm module 120 about an axis of rotation ρ corresponding to the first actuator 150, or equivalently, (a) the plurality of arms 128a-c can be collectively rotated relative to a common axis of rotation ρ , or (b) the plurality of winding axes ω_{a-c} can be collectively rotated around the common axis of rotation ρ . For instance, the central hub 122 can include a centrally disposed aperture or opening 126 configured for secure mating engagement with the first shaft 152 of the first actuator 150. A central axis of the first shaft 152 (e.g., defined with respect to a center point of the first shaft 152, along the length of the first shaft 152) about which the first shaft is rotatable can define this

common axis of rotation ρ about which the plurality of arms 128a-c and the plurality of winding axes ω_{a-c} are collectively rotatable. Rotation of the first shaft 152 results in the simultaneous rotational displacement of each arm 128a-c in a given circumferential direction about this common axis of rotation ρ , in accordance with the rotational direction of the first shaft 152. This axis of rotation ρ can equivalently be defined as a central hub / multi-arm module axis of rotation.

The first actuator 150 is configured for selectively or selectably rotating the plurality of arms 128a-c such that as the arms 128a-c are rotated, the reel holder 130, rod 132 or terminal end of one of the arms 128a-c rotates toward the feeding position 102, and the reel holder 130, rod 132, or terminal end of at least one other arm 128a-c simultaneously or concurrently rotates away from the feeding position 102. The first actuator 150 can rotate the arm module 120 under the control of a set of program instructions executable by a processing unit or control module, such that each arm 128a-c can be selectively and/or sequentially rotated to the feeding position 102.

In various embodiments, when the first actuator 150 disposes a first arm 128a at the feeding position 102, the radial or elongate axis r_a of the first arm 128a is aligned parallel, substantially parallel, or generally parallel to the tape input / output axis x , and the first arm 128a is positioned closer to the tape transport unit 20 than a second and a third arm 128b,c that are not disposed at the feeding position 102. Correspondingly, when the first arm 128a resides at the feeding position 102, a first tape reel 110a carried by the first arm 128a also resides closer to the tape transport unit 20 than a second and a third tape reel 110b,c carried by the second and third arms 128b,c, respectively. Thus, while the first arm 128a is disposed at the feeding position 102, the second and third arms 128b,c are disposed further away from the tape transport unit 20 than the first arm 128a; their radial or elongate axes $r_{a,b}$ are not aligned parallel, substantially parallel, or generally parallel to the tape input / output axis x ; and second and third tape reels 110b,c carried by the second and third arms 128b,c, respectively, are disposed further away from the tape transport unit 20 than the first tape reel 110a.

While the first arm 128a is maintained at the feeding position 102, the flexible linear tape 12 can be positioned between a first flange 112a and a second flange 112b of the first tape reel 110a, and can extend between the first tape reel 110a and the tape transport unit 20. For instance, while the first arm 128a resides at the feeding position 102, if the first tape reel 110a is initially empty, the flexible linear tape 12 can be loaded or fed from the tape transport unit 20, between and along an upper tape guide element 24a and a lower tape guide element 24b extending between the first tape reel's first and second flanges 112a,b, toward and to a tape winding hub or core 114 of the first tape reel 110a. The flexible linear tape 12 can correspondingly be wound around and loaded onto the first tape reel 110a in association with spinning motion imparted to the first tape reel 110a in a tape reel loading direction by way of the second actuator 160, as the tape is fed from the tape transport unit 20 toward the first arm 128a and/or the first tape reel 110a. Analogously, while the first arm 128a is disposed at the feeding position 102, if the first tape reel 110a is initially full, the flexible linear tape 12 can be fed from the first tape reel 110a to the tape transport unit 20, and correspondingly unloaded from the first tape reel 110a in association with spinning motion imparted to the first tape reel 110a in a tape reel unloading direction by way of the second actuator 160 while the tape transport unit 20 concurrently displaces the tape away from the first arm 128a and/or the first tape reel 110a.

The second actuator 160 includes a second shaft 162 configured for selective engagement with a tape reel holder 130 of an arm 128 that is located at the feeding position. In various embodiments, a translation mechanism 170 selectively or selectably facilitates engagement of the second shaft 162 with and disengagement of the second shaft 162 from a tape reel holder 130 of the arm 128 disposed at the feeding position, such that the second shaft 162 can be selectively or selectably coupled to or decoupled from a tape reel 110 held by the arm 128, respectively, as further described in detail hereafter.

FIG. 9 is a schematic cross-sectional illustration through a plane containing both the first shaft's axis of rotation ρ and the winding axis ω of a tape reel holder's rod 132, showing a half-thickness cross section of the second shaft 162 provided by the second actuator 160

in a disengaged or withdrawn position relative to the rod 132, which corresponds to an arm 128 disposed at the feeding position at which the flexible linear tape 12 can be communicated between a tape reel 110 carried by the arm 128 and the tape and reel machine's tape transport unit 20. As indicated in FIG. 9, the tape reel holder's rod 132 is
5 configured for mating engagement with the second actuator's second shaft 162, such as by way of a cup or recess 134 formed in the rod 132.

When the second shaft 162 is in the disengaged position, a terminal portion 164 of the second shaft 162 is within and/or not fully engaged with the recess 134 formed in the
10 tape reel holder's rod 130. More particularly, as shown in FIG. 9, a distal end or tip 165 of the second shaft 162 is positioned outside of the recess 134 formed in the tape reel holder's rod 132, at a predetermined distance away from a base or bottom 135 of the recess 134.

In various embodiments, selective or selectable engagement of the second shaft 162 with
15 the tape reel holder's rod 132 occurs by way of displacement of the second shaft 162 across a predetermined distance toward the tape reel 110 in a direction along the winding axis ω of the tape reel holder's rod 130. Such displacement of the second shaft 162 occurs by way of the translation mechanism 170. In several embodiments, the translation mechanism 170 includes or is an actuator configured to translate or displace the entire
20 second actuator 160, and hence the second shaft 162, across a predetermined distance toward or away from the tape reel holder's rod 132 in a direction along this winding axis ω , such that the second shaft 162 can matingly engage with or disengage from the recess 134 within the tape reel holder's rod 132.

25 FIG. 10 is a schematic cross-sectional illustration through the plane containing both the first shaft's axis of rotation ρ and the winding axis ω of the tape reel holder's rod 132, showing a half-thickness cross section of the second actuator's second shaft 162 in a nearly engaged or sufficiently engaged position relative to the tape reel holder's rod 132. When in the engaged position, the second shaft 162 is matingly engaged with the rod
30 132, for instance, by way of the terminal portion 164 residing at a given depth within the recess 134 of the tape reel holder's rod 132. In some embodiments, such mating

engagement occurs when the distal end 165 of the second shaft 162 nearly abuts or abuts the bottom 135 of the recess 134 provided by the tape reel holder's rod 132.

Once the second shaft 162 is suitably securely engaged with the tape reel holder's rod 132, the second actuator 160 can rotate the second shaft 162 such that the tape reel 110 is circumferentially spun in a tape reel loading direction or a tape reel unloading direction about the winding axis ω to thereby facilitate tape reel loading or unloading, respectively, in a manner that will be readily understood by one having ordinary skill in the art based upon the description and FIGs. provided herein.

After an empty tape reel 110 has been loaded or filled with the flexible linear tape 12, or after a full tape reel 110a has been unloaded or emptied of its flexible linear tape 12, the translation mechanism 170 can disengage the second shaft 162 from the tape reel holder's rod 132 by displacing the second shaft 162 along the winding axis ω in a direction away from the tape reel 110. While the second shaft 162 is disengaged from the tape reel holder's rod 132, the first actuator 150 can rotate the multi-arm module 120 about its axis of rotation ρ , such that a second or next arm 128b and a tape reel carried thereby 110b can be rotated toward and to the feeding position. Such rotation of a first arm 128a and a first tape reel 110a away from the feeding position, and concurrent rotation of a second arm 128b and a second tape reel 110b toward and to the feeding position is illustrated in FIGs. 2 and 3.

In various embodiments, the rotation of any given arm 128a toward and to the feeding position; the engagement of the second shaft 162 with the tape reel holder's rod 132 corresponding to the arm 128a currently disposed at the feeding position; the spinning of a tape reel 110a maintained at the feeding position by way of rotation of the second shaft 162; the disengagement of the second shaft 162 from the tape reel holder's rod 132 corresponding to the arm 128a currently disposed at the feeding position; and the rotation of the multi-arm module 120 by way of rotation of the first shaft 152 such that a next arm 128b,c can be displaced toward and to the feeding position; and so on for each arm 128a-c on an ongoing, continued, or repetitive basis occurs under the direction of a control

unit, such as a computer system or computing device having a processing unit or microcontroller configured to execute program instruction sets that automatically manage or direct the selective rotation of the plurality of arms 128 about the axis of rotation ρ , and the selective spinning of a given tape reel 110 carried by an arm 128 disposed at the feeding position about the winding axis ω . Several embodiments in accordance with the present disclosure can include one or more types of sensors or sensing devices (e.g., optical sensors) to facilitate the determination of when a given arm 128 is disposed at the feeding position; and/or when a given tape reel 110 positioned at the feeding position is empty, full, or partially full, in a manner readily understood by one having ordinary skill in the relevant art.

If the first, second, and third tape reels 110a-c are each initially empty, a first arm 128a carrying the first tape reel 110a can be transitioned to the feeding position, after which the first tape reel 110a can be immediately receive and be loaded with the flexible linear tape 12. Once the first tape reel 110a is filled or loaded with the flexible linear tape 12, the first arm 128a can be automatically rotated away from the feeding position simultaneous with rotation of a second arm 128b carrying the second tape reel 110b toward and to the feeding position. After the second arm 128b, and hence the second tape reel 110b, arrive at the feeding position, the second tape reel 110b can immediately be filled or loaded with the flexible linear tape 12, thereby eliminating any tape and reel machine interruption or downtime associated with changing or swapping out the full first tape reel 110a for an empty reel 110a. Once the second tape reel 110b is filled or loaded with the flexible linear tape 12, the second arm 128b can be automatically rotated away from the feeding position simultaneous with rotation of a third arm 128c carrying the third tape reel 110c toward and to the feeding position. When the third arm 128c, and hence the third tape reel 110c, arrive at the feeding position, the third tape reel 110c can immediately be filled or loaded with the flexible linear tape 12, once again eliminating any interruption or downtime associated with reel changing. The fully loaded first and second tape reels 110a,b can be (a) removed from the multi-arm module 120, and (b) replaced with empty tape reels 110a,b while the third tape reel 110c is being filled or loaded, thereby maximizing the throughput of the tape and reel machine 10. Analogous

considerations apply when the flexible linear tape 12 is unloaded from multiple tape reels 110a-c.

Aspects of particular embodiments of the present disclosure address at least one aspect,
5 problem, limitation, and/or disadvantage associated with exiting manners of loading and
unloading tape reels in association with tape and reel machine operation. While features,
aspects, and/or advantages associated with certain embodiments have been described in
the disclosure, other embodiments may also exhibit such features, aspects, and/or
advantages, and not all embodiments need necessarily exhibit such features, aspects,
10 and/or advantages to fall within the scope of the disclosure. It will be appreciated by a
person of ordinary skill in the art that several of the above-disclosed systems,
components, processes, or alternatives thereof, may be desirably combined into other
different systems, components, processes, and/or applications. In addition, various
modifications, alterations, and/or improvements may be made to various embodiments
15 that are disclosed by a person of ordinary skill in the art within the scope and spirit of the
present disclosure.

Claims

1. A tape reel apparatus for a tape and reel component transfer system configured for transferring components onto or off of a flexible linear tape, the tape reel apparatus
5 comprising:
 - a central hub rotatable about a first axis of rotation;
 - a plurality of tape reels coupled to the central hub, the plurality of tape reels including
a first tape reel and a second tape reel; and
 - a first actuator coupled to the central hub and configured to rotate the central hub
10 about the first axis of rotation to thereby rotate the first tape reel away from a
feeding position while simultaneously rotating the second tape reel toward the
feeding position,
 - wherein the feeding position corresponds to a location at which the flexible linear
tape can be fed from the component transfer system to a tape reel positioned
15 thereat, or fed from the tape reel positioned thereat to the component transfer
system.
2. The tape reel apparatus of claim 1, further comprising a second actuator configured
for spinning the second tape reel about a winding axis or an unwinding axis for
20 respectively winding or unwinding the flexible linear tape about the second tape reel
when the second tape reel is disposed at the feeding position.
3. The tape reel apparatus of claim 2, wherein while the second tape reel is disposed at
the feeding position and the flexible linear tape is being wound about or unwound from
25 the second tape reel, the first tape reel is offloaded from the tape reel apparatus.
4. A tape reel apparatus for a tape and reel component transfer system configured for
transferring components onto or off of a flexible linear tape, the tape reel apparatus
comprising:
30 a multi-arm module comprising:
 - a central hub rotatable about a first axis of rotation; and

a plurality of arms coupled to the central hub, each of the plurality of arms radially extending away from the central hub, each of the plurality of arms having a reel holder by which a tape reel can be attached to and detached from the arm; and

5 a first actuator coupled to the central hub and configured for rotating the central hub about the first axis of rotation to thereby collectively rotate the plurality of arms about the first axis of rotation.

10 5. The tape reel apparatus of claim 4, wherein each reel holder of each arm is rotatable about a second axis of rotation parallel to the first axis of rotation to enable spinning of a tape reel held thereby for winding and/or unwinding of the flexible linear tape about the tape reel.

15 6. The tape reel apparatus of claim 4 or 5, wherein the first actuator is configured for collectively rotating the plurality of arms about the first axis of rotation such that one of the plurality of arms rotates toward a feeding position simultaneous with rotation of another of the plurality of arms away from the feeding position, wherein the feeding position corresponds to a position of an arm within the plurality of arms at which the flexible linear tape can be fed from the component transfer system to a tape reel carried
20 by the arm, or fed from the tape reel to the component transfer system.

25 7. The tape reel apparatus of claim 6, wherein while a first arm within the plurality of arms carrying a tape reel is disposed at the feeding position and the flexible linear tape is being wound about or unwound from the tape reel carried by the first arm, a second arm within the plurality of arms disposed away from the feeding position can offload or receive a second tape reel.

30 8. The tape reel apparatus of claim 6, further comprising a second actuator configured for selectively spinning a tape reel carried by an arm within the plurality of arms when the arm is disposed at the feeding position.

9. The tape reel apparatus of claim 8, wherein the second actuator includes a rotatable shaft for engaging with the reel holder of an arm within the plurality of arms when the arm is disposed at the feeding position.

5 10. The tape reel apparatus of claim 8 or 9, further comprising a translation mechanism configured for selectively engaging the rotatable shaft with and disengaging the rotatable shaft from a reel holder of an arm when the arm is disposed at the feeding position.

11. The tape reel apparatus of any one of claims 8 - 10, wherein

10 (a) rotation of the plurality of arms around the first axis of rotation; and
(b) spinning of a tape reel carried by an arm disposed at the feeding position
is controlled by a set of instructions executed by a processing unit.

12. The tape reel apparatus of any of claims 6 - 11, further comprising a support
15 structure configured to maintain the central hub at a predetermined position relative to the feeding position such that a set of tape guide members is receivable between a first flange and a second flange of a tape reel carried by an arm disposed at the feeding position.

13. A method for transferring components carried by a flexible linear tape between a
20 plurality of tape reels and a tape and reel machine, each tape reel configured for receiving a length of the flexible linear tape by way of circumferentially winding the flexible linear tape thereabout, the method comprising:

providing a tape reel assembly having a plurality of arms rotatable about a first axis
of rotation corresponding to a central hub structure, each arm within the plurality
25 of arms configured for carrying a tape reel; and

rotating the tape reel assembly about the first axis of rotation such that the plurality of
arms collectively rotates to dispose a first arm of the tape reel assembly at a
feeding position while simultaneously disposing a second arm of the tape reel
assembly away from the feeding position,

wherein the feeding position corresponds to a location at which the flexible linear tape can be loaded onto or offloaded from a tape reel carried by one of the plurality of arms.

5 14. The method of claim 13, wherein the first arm carries a first tape reel, and wherein the method further comprises spinning the first tape reel about a second axis of rotation while the first arm is disposed at the feeding position, simultaneous with displacement of the flexible linear tape towards or away from the first tape reel to facilitate loading of the flexible linear tape onto or unloading of the flexible linear tape from the first tape reel,
10 respectively.

15 15. The method of claim 14, wherein the method further comprises disengaging a second tape reel from or receiving a second tape reel onto the second arm of the tape reel assembly simultaneous with the spinning the first tape reel.

15

16. The method of claim 15, wherein the second arm of the tape reel assembly carries the second tape reel, and wherein the method further comprises rotating the tape reel assembly about the first axis of rotation such that each of the plurality of arms collectively rotates to dispose the second arm of the tape reel assembly and the second
20 tape reel carried thereby at the feeding position, while simultaneously disposing the first arm of the tape reel assembly away from the feeding position.

17. The method of claim 16, further comprising spinning the second tape reel about the second axis of rotation while the second arm is disposed at the feeding position,
25 simultaneous with displacement of the flexible linear tape towards or away from the second tape reel to facilitate loading of the flexible linear tape onto or unloading of the flexible linear tape from the second tape reel, respectively.

18. A method for transferring components carried by a flexible linear tape between a
30 plurality of tape reels and a tape and reel machine, each tape reel configured for receiving

a length of the flexible linear tape by way of circumferentially winding the flexible linear tape thereabout, the method comprising:

- 5 (a) selectively rotating each of the plurality of tape reels about a common first axis of rotation to (i) dispose a selected tape reel within the plurality of tape reels at a feeding position at which the selected tape reel can receive the flexible tape from or offload the flexible linear tape to the tape and reel machine, while simultaneously (ii) disposing other tape reels within the plurality of tape reels away from the feeding position;
- 10 (b) spinning the selected tape reel about a second axis of rotation to load the selected tape reel with the flexible linear tape or unload the flexible linear tape from the selected tape reel;
- (c) identifying a next tape reel within the plurality of tape reels as the selected tape reel; and
- 15 (d) repeating each of (a) through (c) on an ongoing basis during tape and reel machine operation.

19. The method of claim 18, further comprising (e) swapping out a tape reel disposed away from the feeding position with another tape reel while the selected tape reel is disposed at the feeding position and the flexible linear tape is being wound about or
- 20 unwound from the selected tape reel.