(57) D'après cette invention, des mécanismes d'attraction (106) et de coupe (130, 170) sont utilisés sur un tambour rotatif (100) afin de découper des segments de matériau de manière commandée dans une bande continue (4). Le tambour (100) tourne à une plus grande vitesse que la bande continue (4) de manière à conférer une tension à cette dernière. On peut également utiliser un mécanisme porteur (400, 460) comprenant au moins un porteur (57) Attraction (106) and cutter (130, 170) mechanisms are used on a rotatable drum (100) to controllably sever segments of material from a web (4), with the drum (100) rotated at a rate greater than that of the web (4) to provide tension in the web. A carrier mechanism (400, 460) may be used having at least one article carrier (410a-410c) pivotally coupled to a rotatable hub (409) and controlled via a camming mechanism (429, 442). A fluid
d'article (410a 410e) qui est couplé pivotant à un moyen rotatif (409) et qui est commandé par un mécanisme à cames (429, 442). On peut également utiliser un distributeur de fluide (1094) afin de diriger un flux de fluide vers un espace ment (1178) formé entre un rouleau d'adhésif (1092) et le tambour (1038), ceci depuis une position située en amont dudit espace ment (1178). On peut en outre utiliser une roue d'échappement (1020) comprenant un moyen rotatif (1204) ainsi qu'une surface de contact (1208, 1210) qui y est couplée de manière élastique et qui définit une pochette (1204) venant en contact avec un article. Une roue d'échappement et de déchargement (1042) peut enfin être utilisée afin de transférer les articles depuis l'extrémité de déchargement d'un guide arqué (1040) qui fait face au tambour de transfert d'étiquettes (1038).

dispenser (1094) may also be used to direct a flow of fluid toward a nip (1178) formed between an adhesive roller (1092) and the drum (1038), from a position upstream from the nip (1178). A starwheel (1020) may also be used including a rotatable hub (1204) and an engagement surface (1208, 1210) resiliently coupled thereto defining a pocket (1024) for engaging an article. Furthermore, a discharge starwheel (1042) may be used to transfer articles from the discharge end of an arcuate guide (1040) that opposes a label transfer drum (1038).
Attraction (106) and cutter (130, 170) mechanisms are used on a rotatable drum (100) to controllably sever segments of material from a web (4), with the drum (100) rotated at a rate greater than that of the web (4) to provide tension in the web. A carrier mechanism (400, 460) may be used having at least one article carrier (410a–410e) pivotally coupled to a rotatable hub (409) and controlled via a camming mechanism (429, 442). A fluid dispenser (1094) may also be used to direct a flow of fluid toward a nip (1178) formed between an adhesive roller (1092) and the drum (1038), from a position upstream from the nip (1178). A starwheel (1020) may also be used including a rotatable hub (1204) and an engagement surface (1208, 1210) resiliently coupled thereto defining a pocket (1024) for engaging an article. Furthermore, a discharge starwheel (1042) may be used to transfer articles from the discharge end of an arcuate guide (1040) that opposes a label transfer drum (1038).
LABELING APPARATUS AND METHODS THEREOF

Field of the Invention

The invention is generally related to labeling machinery, and in particular to adhesive application, web registration and article handling therewith.

Background of the Invention

In a great number of consumer product markets, particularly those which are low-margin and/or price-driven, an ongoing need exists for various manners of reducing product costs. For example, just-in-time manufacturing techniques, which reduce costs through minimizing inventory, have grown in prominence. In addition, improved packaging techniques and materials are constantly being developed to minimize the packaging component of product costs.

Just-in-time manufacturing can place significant demands on product manufacturing and packaging equipment due to the quick turnaround that is often required to timely fill customer orders. As a result, there is an ongoing need for a manner of increasing the speed of product manufacturing and packaging equipment so that inventory costs can be reduced without adversely impacting a manufacturer's ability to fill customer orders in a timely fashion.

For example, for bottled beverages such as soft drinks, beer, juice, liquor, etc., significant efforts have been expended in attempting to lower the costs associated with applying product labels to beverage containers such as glass bottles, plastic bottles, aluminum cans, and the like. A particularly cost-effective manner of labeling beverage containers utilizes a continuous web of pre-printed polymer label material that is cut into predetermined lengths, supplied with adhesive, and applied directly to the surface of a container. Adhesive costs may also be reduced by applying adhesive only to the leading and trailing edges of individual labels and wrapping the labels completely around the containers.

Label machines have been developed that are capable of relatively high-speed operation, e.g., as high as 750 containers/minute or more. However, such machines have been found to be limited in several respects.

One significant problem associated with such conventional labeling machines is that it is difficult to reliably control tension in a web of label material being processed at high speed. Among other concerns, a large roll of label material spun at high speed has a great deal of momentum, which often necessitates a dedicated tensioning mechanism between a supply of label material and a cutting mechanism. A tensioning mechanism, however, can introduce variable tensions at different points along the web, not to mention adding complexity and increasing the cost of the machines. Moreover, in
many conventional label machine designs, separate cutting and transfer (or vacuum) drums are utilized, with the web at least partially drawn to a downstream transfer drum prior to severing a label from the web with an upstream cutting drum — an arrangement that can introduce variable tension to the web before and after cutting.

As a result of these tensioning concerns, most conventional labeling machines require that a non-stretchable polymer film such as polypropylene or polystyrene be used as the web material. Stretchable polymer films such as polyethylene are often unsuitable for use with such machines because the varied tensions in the web can stretch such films lengthwise and introduce unacceptable positioning errors when cutting the web. Web material constructed from non-stretchable polypropylene or polystyrene, however, can be three or four times more expensive than a stretchable material such as polyethylene. As a result, many conventional labeling machines prohibit the ability of a producer to take advantage of the substantial savings that could otherwise be realized through the use of less expensive films.

Therefore, a significant need exists in the art for an improved manner controlling tension in a web of material, particularly when supplying a web of label material in high speed labeling machines and the like. Moreover, a significant need exists for a manner of controlling web tension such that less expensive stretchable polymer films may be utilized in high speed labeling applications.

The process of conveying articles such as containers past a label transport drum introduces another significant problem associated with conventional labeling machines, as well as with other machinery that utilizes multiple stations that require different transport parameters at different stations. For example, with regard to labeling machines, many conventional labeling machine designs utilize turrets or star wheels to convey individual articles past a label transfer drum at a controlled rate and with a controlled separation, or "pitch", between sequential articles so that each article is initially presented to the transfer drum at a position thereon where a leading edge of a label is located. A turret is typically a rotatable body that includes mechanisms disposed about the periphery for gripping articles from the top and bottom ends thereof. A star wheel is typically a rotatable body that includes pockets disposed around its periphery that contact the sides of articles to advance the articles through the machine. Articles moving past a transfer drum are typically rotated as they pass the transfer drum (e.g., by virtue of contact between the drum and a fixed guide) so that labels on the drum are wrapped around the articles.

Turrets typically provide the greatest degree of precision in handling and transporting articles. However, due to the additional components and coordinated movements required to bring top and/or bottom gripping mechanisms into contact with articles, turrets are relatively slow and expensive. Star wheels are typically faster and less expensive, but have the drawback that articles are not held as securely and can become misaligned within the star wheels.

For example, star wheels are typically used in conjunction with a moving conveyor that supports the articles and moves at a fixed linear velocity. A label transfer drum then rotates with its outer surface traveling in the same direction as the conveyor. The velocities of the pockets in the star wheel and the outer surface of the drum are typically matched so that an article contacts a label on the
drum while each is traveling at the same velocity. The articles may also be rolled or spun about its longitudinal axis to wrap the label around the article — typically by passing the article by a fixed guide or contacting the article with a relatively faster-moving belt.

Given that the leading edges of successive labels are spaced apart from one another along the outer surface of the transfer drum, it is often necessary for articles to be spaced apart with the proper pitch to ensure proper alignment of articles and labels. This typically requires that the star wheel and transfer drum rotate in such a manner that the articles and labels travel faster than the conveyor. However, unless the linear velocities of the articles are identical to that of the conveyor, the articles may become tilted within the pockets of the star wheel due to friction as the articles slide along the surface of the conveyor. As a result, applied labels may have loose or bunched-up portions due to the misalignment of the articles relative to the labels.

Moreover, other than when the labels are actually applied, it is often desirable to minimize the rotation of articles while disposed upon the conveyors so that the articles are conveyed in a more controlled manner. Conventional star wheels, which operate at a constant velocity, are often not capable of adequately controlling the rate of rotation of articles, which can result in label mis-registration and/or article jams at high speed.

Some conventional designs also incorporate feed screws at the entry and/or discharge ends of a label application station to convey the articles in a linear direction. The feed screws may also have variable pitches to control the linear velocity of the articles, and thus the separation between articles. However, feed screws also are unable to accurately control the rotational rates of articles, and thus, label mis-registration and/or article jams still remain a significant concern.

Therefore, a significant need also exists for an improved manner of conveying articles such as containers past a transfer drum in high speed applications, in particular so that the movement of such articles is carefully controlled.

High speed operation of continuous-feed labeling machinery also requires careful control over labels as they are fed from the supply roll, cut from the web, supplied with adhesive and applied to containers. In most continuous-feed labeling machinery, labels are transferred from station to station by a sequence of rollers and drums. A variety of mechanisms, including web tension, mechanical clamps and fingers, and vacuum surfaces, are typically used to assist in the transfer of labels (whether severed or unsevered from a web) from station to station.

Pressurized air is also used in some labeling machinery to improve label control. For example, pressurized air directed toward the leading edge of a label may be used to assist in directing the label from a cutter drum to a transport drum after the label has been severed from a web, or to assist in directing the label from a transport drum to the surface of a container. Also, in some applications pressurized air may be supplied to an unsupported portion of the backside of a seam formed between the leading and trailing edges of a label wrapped around a non-cylindrical article, to strengthen the bond between the leading and trailing edges.

One area of particular concern for many labeling applications is controlling the feed of labels during the application of adhesive. Adhesive applicators used are typically utilized to deposit an
adhesive material such as a hot melt or pressure sensitive glue composition to a label immediately prior
to placing the label on a container. Typically, such applicators include an adhesive roller that forms a
nip with a label transport mechanism such as a vacuum drum, and that is supplied with a source of
adhesive on its outer periphery such that adhesive is applied to a label supported on the transport
mechanism as the label is fed past the adhesive roller.

One difficulty associated with conventional adhesive applicators is that the leading edge of a
label can in some instances separate from the surface of the transport mechanism and follow the
adhesive roller as the leading edge of the label exits the nip formed by the adhesive roller and the
underlying transport mechanism. When this occurs, the label will often jam the adhesive applicator and
the remainder of the labeling machinery, resulting in defective product and downtime associated with
cleaning and restarting the machine.

To address this concern, some adhesive applicators utilize mechanical devices such as a series
of parallel wires adjacent an adhesive roller to keep the leading edge of a label from wrapping around
the roller. However, in many instances the parallel wires leave undesirable patterns on the adhesive
applied to each label. Further, glue droplets on the wires can contaminate both the labels and the
transport mechanism. Misadjusted wires can also wrinkle or displace labels on the transport
mechanism, resulting in defective labeled articles.

Other labeling machinery designs utilize mechanical hold down devices such as clamps or
fingers on a transport mechanism to hold down the leading edge of each label as the label passes an
adhesive applicator. Moreover, in some designs in which labels are transported past an adhesive
applicator via a vacuum drum, a relatively high level of vacuum is used to resist the adherence of labels
to the adhesive applicator. However, mechanical hold down devices and the like are often
mechanically complex and can negatively impact performance and reliability. Increased vacuum levels
can induce stretching of the label material and necessitate the use of larger and more expensive vacuum
pumps.

Another difficulty associated with conventional adhesive applicators is the overspray of
adhesive that often occurs during the application of adhesive to the trailing edge of a label. In
particular, when a label passes through the nip between an applicator roller and a transport mechanism,
the trailing edge (which is supported on the surface of the transport mechanism) may be separated from
the roller by a gap across which excess adhesive may spray. A portion of the adhesive may deposit on
the surface of the transport mechanism, resulting in contamination of the mechanism. Unless the
overspray is periodically cleaned from transport mechanism, the transport mechanism may jam and halt
the machine, requiring a more extensive and time consuming cleaning and restart operation. Given that
any downtime negatively impacts the efficiency and productivity of labeling machinery, cleaning
operations of any type are often highly undesirable.

Therefore, a substantial need exists in the art for an improved manner of feeding labels
through labeling machinery, and in particular to improve the reliability of the application of adhesive to
labels.
High speed operation of continuous-feed labeling machinery also requires careful control over the containers to which labels are applied. Considerable development efforts, for example, have been expended in improving the handling of containers, whether filled or empty, during a label application operation. Containers are typically fed to and from a labeling machine via a conveyor. Indeed and discharge mechanisms are typically used to transport containers from the conveyor, past a label transport mechanism, and back onto the conveyor.

Significant development efforts have been directed to the infeed mechanism at the head of a labeling machine, incorporating feed screws, starwheels, bolts and the like to remove containers from a conveyor and pass the containers past the label transport mechanism with a desired amount of separation. Starwheels, for example, are toothed wheels that carry containers around an arcuate guide within the gaps formed between adjacent teeth, also referred to as pockets. In some implementations, multiple starwheels are used, e.g., where a small flow starwheel introduces initial gaps between incoming containers so that the containers can be picked up by a relatively larger infeed starwheel for transportation past a label transport drum.

One potential problematic characteristic of a starwheel, however, is that in some instances gaps can exist between a container, the starwheel and the guide around which the container is transported. At high speed, the presence of gaps can introduce vibrations and jeopardize the stability of the containers fed through the labeling machine, possibly causing container misfeeds and jamming of the machine.

In addition, at the discharge end of a labeling machine, comparatively less attention has been devoted to the stability of containers transported back onto a conveyor after being labeled. With many labeling machines, for example, labels are rolled onto a container by sandwiching the container between a fixed arcuate guide and a rotating label transport drum. Once a label is applied, one or more moving belts located downstream of the drum contact the containers and attempt to cancel out the spinning of the container before the container is returned to the conveyor. However, at higher speeds, belts may not provide adequate stability, particularly with light-weight containers having relatively high centers of gravity (e.g., unfilled two liter plastic beverage containers). Misfeeds of containers may occur, jamming the machine and requiring a time consuming cleaning and restart operation.

Therefore, a significant need also continues to exist for an improved manner of reliably transporting containers through labeling machinery, and in particular, to improve the stability of containers transported by infeed and discharge mechanisms of a labeling machine during high speed operations.

US 5380381 generally discloses a labeling machine with a variable speed cutting head that severs labels from a web prior to transporting the labels to a vacuum drum.

DE 1255567 generally discloses a cutter drum with a radially-movable knife used to sever labels from a web prior to transporting the labels to a vacuum drum.

DE 4314142 generally discloses a device for folding wrappers around articles using cooperating pairs of arms driven by cam arrangements.

DE 3529716 generally discloses a device for transporting articles where slidable articles carriers are movable radially to discharge defective articles to an alternate conveyor.

AMENDED SHEET.
GB 2187163 generally discloses a labeling apparatus with vacuum ports and blow-off ports on a label drum.

DE-U 1961419 generally discloses an article transport with variable speed arms for transporting articles.

WO 97/10953 generally discloses a labeling machine with an infeed starwheel for transporting articles to a labeling station.
Summary of the Invention

The invention addresses these and other problems associated with the prior art by providing in one aspect an apparatus and method that utilize a rotatable drum implementing both an attraction mechanism and a cutter mechanism to controllably sever segments of material from a web. The drum is rotated at a rate greater than the rate at which the web of material is advanced so that the attraction mechanism supplies the sole source of tension in the web. Moreover, the cutter mechanism sever segments of material while at least a portion of the web of material engages the outer surface of the drum. As such, the outer surface of the drum tends to slide relative to the leading edge of the web, with the attraction mechanism operating to apply a controlled pulling force thereto. Among other advantages, this permits less-expensive stretchable web material to be utilized, thereby lowering material costs. Moreover, greater reliability at high speeds is also often realized — an important consideration for many just-in-time manufacturing applications.

The invention also addresses additional problems associated with the prior art by providing in another aspect an apparatus and method that dynamically control the relative rates of advancement of a web of material and an outer surface of a drum such that a predetermined length of material is advanced forward of a predetermined rotational position of the drum so that the predetermined length of material is severed from the web of material while at least a portion of the web of material engages the outer surface of the drum. The rate of advancement of the outer surface of the drum is different from that of the web of material such that relative slippage of the web of material and the outer surface of the drum is provided. As such, a web of material may be controllably severed into predetermined lengths using a relatively mechanically-simple configuration, which aids in accuracy and reliability, particularly in high speed applications.

The invention further addresses additional problems associated with the prior art by providing in another aspect an apparatus and method that utilize a carrier mechanism having at least one article carrier pivotally coupled to a rotatable hub and controlled via a camming mechanism that varies the angular velocity of the article carrier relative to that of the hub. The article carrier is configured to receive and transfer an article along an article engaging surface of a fixed guide. The hub rotates about a first axis, and the pivotal coupling between the article carrier and the hub defines a second axis that is substantially parallel to and separated from the first axis. The camming mechanism is operatively coupled between the article carrier and the hub and configured to pivot the article carrier about the second axis in response to rotation of the hub about the first axis to thereby vary the angular velocity of the article carrier relative to that of the hub.

Through the use of the above configuration, the carrier mechanism may be configured to match predetermined transport parameters associated with each of first and second stations that the carrier mechanism transports articles between. In one embodiment, the predetermined transport parameters may be based upon the pitch between sequential articles processed by each of the first and second stations so that the pitch of the articles transported by the carrier mechanism may be controlled to match that expected by each of the stations. In another embodiment, the predetermined transport parameters may be based upon the velocity of each article processed by the first and second stations so
that the velocities of the articles transported by the carrier mechanism may be controlled to match those expected by each of the stations. As a result, greater control is provided over transported articles to permit high speed operation with greater reliability.

Consistent with another aspect of the invention, a fluid dispenser is used in connection with an adhesive applicator to improve the reliability of label feed by a label transport mechanism during the application of adhesive to a label. The fluid dispenser is configured to direct a flow of fluid toward a nip formed between an adhesive roller on the applicator and the label transport mechanism, and from a position upstream from the nip. Among other advantages that will become more apparent below, doing so reduces the likelihood that the label will undesirably follow the adhesive roller upon the application of adhesive to the label.

Consistent with another aspect of the invention, a starwheel is provided including a rotatable hub and an engagement surface defining a pocket configured to engage an article. The engagement surface is resiliently coupled to the rotatable hub to move between first and second positions to vary a rotational position of the pocket relative to the hub. Among other applications, the starwheel may be used to control the flow of articles to a second, infeed starwheel in a labeling machine in such as manner that the clearance between the articles and the infeed components is minimized, thereby reducing article vibrations and improving stability.

Consistent with yet another aspect of the invention, a discharge starwheel is utilized to transfer articles from the discharge end of an arcuate guide that opposes a label transfer drum. The drum and arcuate guide adhere a label to an article by cooperatively wrapping the label around the article as the article rolls between the drum and arcuate guide. In some applications, careful control of configuration of the pockets on the discharge starwheel can improve the stability of discharged articles through reducing the spin imparted on articles by the label application process and/or decelerating the articles for pickup by a downstream discharge mechanism.

Consistent with still another aspect of the invention, a discharge starwheel may be utilized intermediate a label application station and a conveyor. The discharge starwheel may include a plurality of teeth defined about a perimeter thereof, with each tooth having a profile that decreases the separation between successive articles between the label application station and the conveyor. By reducing the separation between articles, greater stability on a conveyor may be obtained, as adjacent articles tend to support one another downstream of the label application station.

These and other advantages and features, which characterize the invention, are set forth in the claims annexed hereto and forming a further part hereof. However, for a better understanding of the invention, and of the advantages and objectives attained through its use, reference should be made to the drawings, and to the accompanying descriptive matter, in which there is described exemplary embodiments of the invention.
Brief Description of the Drawings

FIGURE 1 is a top plan view of a labeling apparatus consistent with the invention.

FIGURE 2 is a block diagram of the primary components of the label application assembly of

Fig. 1.

FIGURE 3 is an enlarged top plan view of the label applicator drum of Fig. 1, with portions
thereof cut away.

FIGURE 4 is a side cross-sectional view of the label transfer drum of Fig. 3, taken along line

4-4.

FIGURES 5A-5D are functional top plan views of the label transfer drum of Fig. 3 at different
rotational positions thereof, illustrating the steps in cutting a label, applying adhesive thereto, and
transferring the label to a container.

FIGURE 6 is a block diagram of the control system for the labeling apparatus of Fig. 1.

FIGURE 7 is a flowchart illustrating a dynamic web registration process for the labeling
apparatus of Fig. 1.

FIGURE 8 is a flowchart illustrating the steps of a startup process for the labeling apparatus of

Fig. 1.

FIGURE 9 is a timing diagram illustrating the timing of operations in the labeling apparatus of

Fig. 1.

FIGURE 10A is a side cross-sectional view of one of the carrier mechanisms of Fig. 1, with

only one article carrier illustrated for simplicity.

FIGURE 10B is a functional top plan view of the carrier mechanism of Fig. 10A, with only

one article carrier illustrated for simplicity, and with the hub thereof removed to facilitate viewing of

the camming mechanism utilized thereby.

FIGURE 10C is a functional side elevational view of the carrier mechanism of Fig. 10A.

FIGURES 11A-11E are functional top plan views of the carrier mechanism of Figs. 10A-10C
at different rotational positions thereof, illustrating the transfer of articles from a conveyor to an
applicator drum.

FIGURE 12 is a top plan view of an alternate labeling apparatus to that shown in Fig. 1,
utilizing a turret article transport mechanism.

FIGURE 13 is a top plan view of a labeling apparatus consistent with the invention.

FIGURE 14A is a top plan view of the label transfer drum and adhesive applicator of Fig. 13,
with portions thereof cut away.

FIGURE 14B is an enlarged fragmentary top plan view of a cutter assembly bushing in the
label transfer drum of Fig. 14A.

FIGURES 15A and 15B are functional top plan views of the label transfer drum and adhesive
applicator of Fig. 14A, respectively illustrating the application of adhesive to leading and trailing ends
of a label.

FIGURE 16 is a top plan view of the flow starwheel of Fig. 13, with resilient.
FIGURE 17 is a cross-sectional view of the flow starwheel of Fig. 16, taken through lines 17-
17.

FIGURES 18A-18F are functional top plan views of the article infeed portion of the labeling
apparatus of Fig. 13, illustrating the transfer of articles from the conveyor to the infeed starwheel by the
flow starwheel.

FIGURES 19A-19D are functional top plan views of the article discharge portion of the
labeling apparatus of Fig. 13, illustrating the transfer of articles from the drum to the conveyor by the
discharge starwheel.

FIGURE 20 is a functional top plan view of the article discharge portion of the labeling
apparatus of Fig. 13, illustrating the position of an article at a plurality of points during the rotation of
the discharge starwheel.

FIGURE 21 is a top plan view of an alternate flow starwheel to that of Figs. 16 and 17,
implementing a resilient outer surface.

FIGURE 22 is a top plan view of another alternate flow starwheel to that of Figs. 16 and 17,
implementing an inflatable body.
Detailed Description

Turning to the Drawings, wherein like numbers denote like parts throughout the several views, Fig. 1 illustrates a labeling apparatus 10 consistent with the principles of the invention. Apparatus 10 is principally used to apply labels in a continuous fashion to a plurality of articles 2 conveyed via an article transport mechanism (e.g., a conveyor 22) from an entrance end 22a to an exit or discharge end 22b. Apparatus 10 may be utilized with any number of article designs, including various containers with upright cylindrical portions, e.g., cans or bottles. The articles may be suitable for use in packaging beverages or foodstuffs, or any other type of packaged goods. For example, one suitable application of apparatus 10 is in applying labels to single-serving plastic soft drink bottles, among others.

Articles 2 are conveyed past a label application assembly or mechanism 25 using a pair of carrier mechanisms 400, 460, which are described in greater detail below. Carrier mechanism 400 transfers articles 2 along an arcuate guide 14 to a label application station 20 disposed opposite assembly 25. As will be discussed in greater detail below, carrier mechanism 400 operates to vary the separation between successive articles passing through guide 14 between a first separation proximate entrance end 22a to a second separation proximate station 20 that is dependent upon the separation between labels provided on an applicator drum 100 in label application assembly 25.

Application station 20 includes an arcuate guide 18 against which the articles are compressed by applicator drum 100 as labels are applied to the articles. Guide 18 includes a resilient friction surface to impart a rolling action to the articles as the articles pass through the label application station such that labels are wrapped around the articles.

Carrier mechanism 460 performs essentially the same operation as carrier mechanism 400 except that mechanism 460 operates to decelerate articles from a first predetermined separation that matches the separation of labels on applicator drum 100 to a second predetermined separation suitable for transport on conveyor 22. By doing so, this arrangement imparts greater stability to discharged articles by minimizing relative movement of the articles to the conveyor at the discharge end of track 16.

Labels are supplied to applicator drum 100 from a web supply 30 supplying a web 4 of labeling material. Typically, web 4 includes a pre-printed polymer material formed of a polymer such as polyethylene. Other materials, including polymers such as polypropylene and polystyrene (among others) may also be used, although polyethylene has the additional advantage in that it is significantly less expensive than other polymers. Polyethylene film tends to be more stretchable than other polymer films. However, due to the constant tension provided in web 4 by the unique design of label application assembly 25, the stretchability of this material does not adversely impact the quality of labels supplied by the assembly.

Web supply 30 includes a pair of supply rolls 32, 34 that supply web 4 to a measuring roller assembly 50. Only one of supply rolls 32, 34 is active at any time, and a conventional change-over mechanism (not shown) may be used to switch between the rolls with minimal down time.

Measuring roller assembly 50 operates as a linear feed rate sensor using a free-wheeling roller 52 coupled to a rotational position sensor 54. Roller 52 has a known diameter such that the linear
velocity of the outer surface thereof, and thus the linear feed rate of the web, may be calculated directly from the rotational speed of the roller. Sensor 54 may be any known rotational position sensor, e.g., an optical encoder.

Web 4 proceeds from assembly 50 to a web tracking control assembly 60 that is utilized to maintain lateral alignment of the web in assembly 25. Web 4 then proceeds to a registration sensor station 70 that detects the position of registration marks disposed on the web. Station 70 includes a roller 72 and a registration sensor 74 disposed opposite roller 72 at a lateral position relative to the web to detect registration marks disposed thereon. Registration sensor 74 may be positioned at practically any point between web supply 30 and applicator drum 100 in the alternative.

It should be appreciated that registration marks may take any number of forms, whether printed or otherwise formed in web 4. Printed registration marks may be disposed outside of a visible area on the labels, or may be integrated within the design printed on a label. Moreover, registration marks may be disposed at a cutting position for a label, or may be separated therefrom by a predetermined distance. Other registration mark designs may be utilized in the alternative.

From registration station 70, web 4 proceeds to the surface of applicator drum 100, where an attraction mechanism disposed on the outer surface of the drum applies a controlled tension to the web. Moreover, a pair of movable cutter assemblies 130, 170 disposed on drum 100 operate to sever labels from web 4 as each assembly 130, 170 passes a fixed knife 82 in a cutting station 80. As will be discussed in greater detail below, the rate at which web 4 is supplied via web supply 30 is controlled relative to the rotation of applicator drum 100 (which is driven by a main drive motor 85) such that a predetermined length of the web is disposed forward of a cutter assembly 130, 170 as the assembly passes fixed knife 82, whereby individual labels are severed from web 4 in a controlled manner.

An adhesive station assembly 90 is disposed beyond cutting station 80 to apply adhesive to leading and trailing ends of each label using an application roller 92. As will be discussed in greater detail below, adhesive is applied to the leading edge of the label prior to severing the label from web 4, such that the tension within the web assists in maintaining the leading edge of the label on the outer surface of applicator drum 100 as adhesive is applied to the leading edge thereof.

After adhesive is applied to the leading and trailing edges of a label, the label is presented to an article 2 via rotation of applicator drum 100, whereby rotation of applicator drum 100 through label application station 20 wraps the label around the article as the article rolls against guide 18.

Label Application Assembly

Fig. 2 illustrates the primary components involved in supplying and severing labels from web 4 in a controlled manner. Assembly 25 is under the control of a control system 200, which operates to control the supply rate of web 4 relative to the rotation of applicator drum 100. Applicator drum 100 is rotated via a main drive motor 85 coupled to the drum via a linkage diagrammatically represented at 86. The rate of rotation of drum 100 is measured via a rotational position sensor 88, which may be any type of known rotational position sensor such as an optical encoder. Control system 200 also receives the
output of sensor 54 to generate therefrom a measurement of the linear feed rate of web 4. Control
system 200 also receives a registration signal from registration sensor 74.

In response to these inputs, control system 200 controls a drive motor 36 to control the rate of
rotation of supply roll 32, and thus the feed rate of web 4. Drive motor 36 is typically a servomotor,
and as such, additional input is provided to control system 200 via a rotational position sensor 38 (e.g.,
an optical encoder) which provides feedback from drive motor 36. It should be appreciated that a
similar servomotor may also be used to drive supply roll 34 in a similar manner.

Assembly 25 is thus configured in a master-slave relationship, whereby the supply rate of web
4 is controlled relative to the speed of applicator drum 100. In the alternative, a reverse configuration
may be provided wherein the rate of rotation of applicator drum 100 is controlled relative to the feed
rate of web 4. In addition, it may be desirable in some applications to control both the feed rate of web
4 and the rotational rate of applicator drum 100. Therefore, the invention should not be limited to the
configuration illustrated herein.

One embodiment of the invention utilizes a servomotor with a built-in encoder such as the
FSM 460 servomotor from Centurion as the drive motor 36 and rotational position sensor 38, with an
HR 625-500-x-BE1 Optical Encoder from Dynapar coupled to a 50.93 mm diameter measuring ruler
used for rotational position sensor 54 and measuring roller 52, a Model NT-6 Optical Sensor available
from Sick for registration sensor 74 and an HR-625-2500-x-BE1 Optical Encoder from Dynapar used
for rotational position sensor 88. Rotational position sensor 54 may be geared with a ratio of 80:40 to
measuring roller 52 to provide a resolution of 0.0393 mm/count or 25.5 counts/mm. It should be
appreciated that these components are merely examples of a wide variety of other components that may
be utilized in assembly 25 in the alternative.

Figs. 3 and 4 illustrate applicator drum 100 in greater detail. Applicator drum 100 includes a
rotatable drum body 102 configured to rotate about a fixed shaft 120. Rotatable body 102 includes an
outer surface 104 having a plurality of vacuum ports 106 disposed thereon and supplied with a source
of vacuum and/or positive pressure through a set of distribution channels 108 coupled to a vacuum port
109 (Fig. 4).

Two sets of raised pads 110, 111 and 112, 113 are disposed on outer surface 104 to receive
leading and trailing edges of a label as the label passes an adhesive application station so that adhesive
may be applied to the opposing edges of the labels. An applicator roller (not shown in Figs. 3 and 4) is
offset from outer surface 104 such a distance that label material supported on any pad 110-113 will be
compressed against the roller, but material disposed between the pads will not. Thus, adhesive is
applied only to the material supported on a pad.

As will become more apparent below, pads 110 and 111, and pads 112 and 113 are separated
from one another around the circumference of drum 100 at a distance that is greater than the length of
the labels so that the leading edge of each label may have adhesive applied thereto prior to severing
the label from the web. This reduces the likelihood of a label sticking to the adhesive roller due to the
additional tension provided by the unsevered web.
It is desirable for drum body 102 to be a changeable component such that different predetermined lengths of labels may be accommodated in apparatus 10. Different lengths of labels are accommodated by utilizing different relative spacing between pads 110 and 111, and between pads 112 and 113. It may also be desirable to enable leading pads 110, 112 to be removed from outer surface 104 and positioned at various points thereon to support different label lengths. The separation of pads 110 and 112, and of pads 112 and 113 will vary depending upon a number of factors, including the desired length of labels, as well as the relative positions of cutting station 80 and adhesive station assembly 90. Determination of the desired separation for any given combination of parameters is well within the ability of one of ordinary skill in the art.

As shown in Fig. 3, two sets of pads, pads 110 and 111, and pads 112 and 113, are provided around the circumference of rotatable body 102, each matched with a cutter mechanism 130, 170. It should be appreciated that any number of cutter mechanisms and associated raised pads may be disposed around the circumference of drum body 102 in the alternative.

As best shown in Fig. 3, cutter mechanism 130 (which is configured in a similar manner to cutter mechanism 170) includes a rocker body 132 pivotally mounted to pivot about a shaft 134 that extends parallel to shaft 120. A spring 136 (Fig. 4) is mounted concentrically with shaft 134 to compensate for temperature expansion in the bearing (not shown) through which the rocker body is pivotally mounted about shaft 134. As shown in Fig. 3, at one end of body 132 is disposed a cam follower assembly 140 including a roller 142 rotatably mounted about an axle 143. Axle 143 is secured via a bolt 144 to a follower body 145, and a flexible boot 146 seals the assembly. Cam follower assembly 174 of cutter mechanism 170 (Fig. 4) is configured similarly to assembly 140.

Knife assembly 150 is disposed at the opposite end of rocker body 132 from cam follower assembly 140. A knife blade 152, having an edge 153, is secured to the end of rocker body 152 via a bolt or other securing mechanism 154. Edge 153 of knife blade 152 projects through an opening 114 in outer surface 104 of body 102, immediately following trailing pad 111 around the circumference of body 102.

A spring assembly 160 including a spring 162 extends perpendicular to shaft 120 and biases cutter assembly 130 toward an extended position, with knife blade 152 projecting through opening 114 beyond outer surface 104. A set screw 164 controls the tension of spring 162.

Roller 142 of cam follower assembly 140 rides along a cam 122 disposed on the outer surface of shaft 120. Cam 122 is circular in cross section with the exception of a recessed portion 124. Recessed portion 124 may have any number of profiles, e.g., a flattened profile as illustrated in Fig. 3. Recessed portion 124 is angularly oriented such that roller 142 engages the portion when knife blade 152 of knife assembly 150 is directly opposite fixed knife 82 of cutting station 80, thereby extending the knife blade at this position to shear a label from the web.

Figs. 5A-5D illustrate the steps in severing a label from web 4 and applying the label to an article 2 presented at label application station 20. As shown in Fig. 5A, a leading edge 4a of web 4 is shown as fed forward of knife 152 of cutter mechanism 130 to a position where the leading edge slightly overlaps pad 110 when the pad is disposed opposite roller 92 of adhesive application assembly.
90. When in this position, drum 100 rotates so that pad 110 sweeps under roller 92, sandwiching web 4 and applying adhesive 6 to the web proximate leading edge 4a. At this point, the label is still unsevered from the web, so the tension provided via the attraction mechanism generated by the vacuum ports in outer surface 104 of drum 100 assists in attracting leading edge 4a to the outer surface of the drum, and thus away from adhesive roller 92. As such, this often eliminates the need for a blow off mechanism on the adhesive roller or the need for an increased level of vacuum proximate the leading edge as is required on many conventional designs.

As also shown in Fig. 5A, knife blade 152 of cutter mechanism 130 is retracted as roller 142 rides along the raised portion of cam 122 on shaft 120.

Next, as shown in Fig. 5B, drum 100 has rotated to the point at which knife blade 152 is directly opposite fixed knife 82. Web 4, which is fed at a slower rate than the rate of rotation of drum 100, has been fed to the desired label length such that the precise point at which the web is to be severed is located between knife blade 152 and fixed knife 82. With roller 142 of cutter mechanism 130 contacting the recessed portion 124 of cam 122, cutter mechanism 130 is pivoted about shaft 134 to extend knife blade 152, and thereby provide a shearing action with fixed knife 82 to sever a label 5 from web 4.

Next, as shown in Fig. 5C, upon further rotation of drum 100, pad 111 sweeps under adhesive roller 92 to apply adhesive 6 to the trailing edge 4b of label 5. In addition, at this time an article 2 is brought into contact with leading edge 4a of label 5 such that the adhesive thereon adheres to article 2. The label is pinched between article 2 and outer surface 104 and is rolled about its longitudinal axis to wrap label 5 around the article. As may also be seen from this figure, a new leading edge 7a is formed for web 4.

Next, as shown in Fig. 5D, label 5 has almost completely wrapped around article 2, and will continue to do so until the adhesive 6 proximate trailing edge 4b of label 5 contacts the article. In addition, the new leading edge 7a of web 4 is at approximately the same position as leading edge 4a was in Fig. 5A, immediately prior to application of adhesive by virtue of roller 92 sandwiching the web against a leading pad 112. Upon further rotation, cutter mechanism 170 will therefore sever another label from web 4, and the process will repeat. Thus, with this configuration, drum 100 processes two labels during each full rotation of the drum. With other numbers of matched cutter mechanisms and raised pads, different numbers of labels may be handled by drum 100 in the manner described herein.

Control system 200 is illustrated in greater detail in Fig. 6. The control system is primarily controlled via a CPU controller 202, which may be, for example, a CSM/CPF 502-03- 853-03 digital processor from Gidding & Lewis, among others.

An operator interface and controls block 204 is shown interfaced with controller 202 through a discrete input module 206. Block 204 provides user interface for apparatus 10 with a operator, e.g., outputting status information to an operator through a video display and/or through various control panel indicators, as well as providing various operator controls, including “Start” and “Stop” buttons, “Jog” and “Auto” buttons, Label Feed “On” and “Off” Buttons and Adhesive “On” and “Off” buttons, among others.
Controller 202 provides output through a discrete output module 208 to generate a digital signal speed control to a main drive frequency control block 210 that controls the main drive motor 85 to operate in "fast" or "slow" modes. Block 210 receives a signal from a potentiometer 211 that controls the overall speed of the main drive, and is used by an operator to match the running speed of assembly 25 to the supply of articles. Moreover, block 210 outputs a control signal to analog speed signal control block 212 for controlling the speed of a conveyor motor 214 coupled to conveyor 22 (Fig. 1).

Controller 202 also interfaces with the various sensors utilized to provide web registration via an I/O module 216. Specifically, module 216 provides an interface between controller 202 and each of servo amplifier 42, encoders 54, 88 and registration sensor 74. Servo amplifier 42 is coupled to servo motor 36 and its associated encoder 38 (not shown in Fig. 6). Also shown is the servo amplifier's connection to a second servo motor 40 which drives a web supply roll 34 in a similar manner to servo motor 36. It should be appreciated that only one of motors 36, 40 is driven at a time based upon which supply roller is being run through assembly 25.

Module 216 also provides an interface with controller 202 to a vacuum drive frequency control block 218 that drives a vacuum motor 220. It is through this arrangement that the level of vacuum (or attraction) supplied to the outer surface of applicator drum 100 is controlled.

Blocks 210, 212 and 218 are all coupled to a main power source 222. Power is also supplied via block 222 to an oil pump motor 224, a turret up/down motor 226 (if so equipped) and a transformer 228. Transformer 228 provides the power signals for a bus 203 coupled between controller 202, servo amplifier 42, a power supply 230, web tracking control station 60, adhesive applicator 90 and an air conditioner/heat exchanger block 232. Power supply 230 provides power to operator interface and machine controls block 204 and input module 206. Web tracking control station 60 receives input from a web guide sensor 62 and outputs control signals to an actuator 64 to provide lateral alignment of the web, in a manner generally understood in the art. Adhesive applicator 90 provides control signals to a bar heater 94 and base heater 96, which respectively heat applicator roller 92 and a tank in applicator 90. These latter components are used in a number of conventional labeling apparatus designs, and will not be discussed in greater detail herein.

Fig. 7 illustrates a closed loop control algorithm 250 utilized in controller 202 to control servo motor 36 to provide web registration consistent with the invention.

Algorithm 250 utilizes a plurality of computational blocks 252, 254, 256, 258, 260, 262 and 264 to drive a control signal to servo amplifier 42 to operate servo motor 36. Blocks 252-256 are clocked by the leading edge of the output of registration sensor 74, while blocks 258, 260, 262 and 264 are clocked by a clock signal represented at 266, e.g., a 2 kHz clock signal.

Control algorithm 250 attempts to maintain a ratio of pulses between drum positioning encoder 88 and linear feed rate encoder 54 (designated E1 and E2) according to the equation:

\[ R_s = \frac{L_d}{\pi D(E2 \phi/E1 \phi)} \]
where $R_a$ is the nominal ratio, $L_a$ is the nominal label length, $D$ is the diameter of free-wheeling roller 52, and $E1_o$ and $E2_o$ are the total numbers of pulses, respectively, for full revolutions of encoders 88 and 54.

For each label $n$, block 252 receives the pulse train outputs (designated $E1$ and $E2$) of drum positioning encoder 88 and linear feed rate encoder 54 to generate a registration error signal $E$ that is the difference, expressed in pulses, between the position of the registration mark on the label sensed by the registration sensor 74 and the preset (or expected) position of the mark.

Block 254 calculates the length of a label $n$ from registration mark to registration mark in pulses of the linear feed rate encoder 54 (designated $E2_n$). This information is utilized in block 256 to calculate a ratio between encoders 88 and 54 for the next label ($n+1$) that is corrected for the registration error $E$, using the equation:

$$R_{(n+1)} = (E2_n + E)/E1_o$$

Block 258 calculates the actual ratio $R_a$ of the number of pulses of each of encoders 88 and 54 between time marks using the actual pulse trains from encoders 88 and 54, i.e.:

$$R_a = \Delta E2/\Delta E1$$

Block 250 calculates a ratio error $E$, that is the difference between the current ratio $R_a$ (i.e. $E2_o/E1_o$), and the actual ratio $R_a$ using the equation:

$$E_r = R_a - R_a$$

In addition, a command for the servo motor such to achieve the actual ratio in the next time interval is calculated, using the equation:

$$R = R_a \pm E_r$$

Next, block 62 generates from the command from block 260 the proportional and integrated feedback signals for controlling servo motor 36. This information is summed with the derivative gain feedback generated by block 264 based upon the feedback signal from servo motor encoder 38 (designated $E3$). It should be appreciated that simultaneous use of integrated, derivative and proportional feedback signals is well known in the art. Moreover, it should be appreciated that other control algorithms which utilize the aforementioned equations may also be used in the alternative.

A self-teaching start-up routine 280, executed by controller 202 of control system 200 to initialize apparatus 10, is illustrated in greater detail in Fig. 8. Routine 280 configures apparatus 10 to operate with a new roll of web material using a self-teaching process that often eliminates the requirement in many applications for the label length to be manually input by an operator. Routine 280
is executed by an operator after the operator installs a new web roll and feeds the leading edge of the web into assembly 25. The routine begins in block 284 by advancing the web (e.g., in response to user input received from an operator through controls 204) through assembly 25 until the registration sensor is in front of the first registration mark on web. At this time, the operator hits a “Stop” button to manually halt the apparatus. Next, in block 286, the web is advanced (e.g., in response to user input such as an operator depressing a “Start” or “Jog” button) until the registration sensor is proximate the next mark on the web. Then, the operator again hits the “Stop” button to halt the apparatus. During blocks 284 and 286, the output of the registration sensor and linear feed rate encoder are monitored to determine the number of pulses between the marks, and thus, the nominal length of the label (L₀) in terms of the output of the linear feed rate encoder.

Next, in block 288, the web is advanced in response to user input from an operator; however, in this block, the controller automatically advances the web and attempts to stop the web precisely at the next registration mark without any additional operator intervention. At this time, the operator may also be requested to indicate to the system whether the automatic advance successfully terminated directly at the next registration mark.

Assuming that this operation was successful, in block 290 the controller receives user input from an operator to manually rewind and/or advance the web to the desired cut position for the label (e.g., in response to an operator depressing suitable “Rewind” and “Advance” buttons). Next, the operator depresses a button or otherwise indicates to the controller that the cut position has been set. During the manual rewind/advance, the controller monitors the linear feed rate encoder output to set the cut position in units of the linear feed rate encoder pulses relative to the registration mark.

Next, in block 292, the controller attempts to operate the apparatus to cut the first label based upon the registration information calculated above for the web, e.g., in response to suitable user input from an operator. The controller halts the apparatus after the first label is cut, and in block 294, waits to receive acknowledgment from the operator that the label cut was acceptable. If not successful, a process similar to block 284-292 may be repeated, or the routine may terminate with a failure indicated. However, if successful, the controller stores the program in one of a plurality of program storage locations. After the program is stored, the apparatus is then ready to begin processing articles using the aforementioned closed loop control algorithm when suitable user input is received from an operator.

The sequence of logic signals in apparatus 10 is illustrated at 300 in Fig. 9, where each signal, timed according to the rotational position of the drum (i.e., from 0 to 360 degrees, with each complete rotation, or cycle, being designated A-D). A container detector signal 320 is shown being latched to “on” upon receipt of a each container into apparatus 10.

For example, during initiation of a label feed operation during a cycle A, a label feed logic signal 310 may be enabled, typically in response to an operator depressing an label feed “On” button on the apparatus, or in response to a signal provided by an external device such as a sensor that detects when one or more containers or articles are about to be received in the apparatus for labeling. Upon container detector signal 320 being latched to “on”, an internal label feed logic latch signal 330 then latches prior to the start of cycle B, so that it is effectively delayed one cycle from the label feed logic
signal. Then, after the knife has passed the cutting position (the 0 degree position) at the start of cycle B, a servomotor command signal 330 is asserted to start drive motor 36. The speed profile of drive motor 36 is illustrated at 360, including a minimal possible acceleration phase 362 that is encountered from about 15 to about 115 degrees, a minimal overspeed necessary phase 364 from about 115 to about 270 degrees, a deceleration to nominal speed phase 365 from about 270 to about 285 degrees and a nominal speed phase 366 thereafter that is related to a machine speed of $V_o = CPM$ (containers per minute) x L (label length).

Fig. 9 also illustrates a adhesive roller logic signal 370 that is initially illustrated as enabled to reflect that adhesive should be applied to any labels processed by apparatus 10. If adhesive application is enabled, immediately after the servomotor command signal 340 is asserted, an adhesive roller logic signal 380 is applied, and an adhesive roller solenoid (represented by signal 390) is asserted about 90 degrees delayed relative to signal 380 (so that adhesive may be applied to the last label whenever a labeling is stopped, as described below).

Assuming now, for example, that label feed logic signal 310 is disabled during cycle A. With the label feed logic signal 330 delayed one cycle relative to signal 310, signal 330 is not unlatched until just prior to the completion of cycle B. Then in cycle C, the speed profile 360 of drive motor 36 is altered to perform a stop down, including a minimal deceleration phase 367 from about 90 degrees to about 120 degrees and a rewind phase 368 that serves to withdraw the web a predetermined distance (e.g., about 2-3 mm behind the knife blade) and thus maintain the web in a ready state just beyond the still-rotating drum. After a rewind, the servomotor command signal 340 is shut off, and the drive motor speed goes to null in phase 369.

Also during cycle B, once label feed logic signal 330 is unlatched, adhesive roller logic signal 380 is unlatched to inhibit adhesive application, resulting in (after a delay of about 120 degrees to permit adhesive to be applied to the last label) the adhesive roller solenoid signal 390 being deasserted.

Fig. 9 additionally illustrates a restart of label application in cycle D, upon label feed logic signal 310 being enabled during cycle C. In this instance, label feed logic signal 330 is asserted just prior to the start of cycle D, and servomotor command signal 340 is applied to start drive motor 36 and cause the drive motor to follow the speed profile illustrated at 360. However, in this cycle, the adhesive roller logic signal 370 has been disabled, so regardless of whether the internal roller logic signal 380 being set to "on", solenoid signal 390 is not asserted, and no adhesive is applied to a label.

It should be appreciated that development of suitable control programs to implement the functionality described herein, and in particular in connection with Figs. 7-9, is well within the abilities of one of ordinary skill in the art. Therefore, no additional discussion thereof is provided herein.

**Carrier Mechanisms**

Figs. 10A and 10B illustrate carrier mechanism 400 in greater detail. It should be appreciated that carrier mechanism 460 may be similarly configured, albeit with a different cam profile suitable for its function, as will become more apparent below.
In general, each carrier mechanism is configured to sequentially transport articles such as a beverage containers along an article engaging surface of a guide and between first and second stations, while varying a predetermined transport parameter for the articles. In the embodiment described herein, the predetermined transport parameter is the pitch of the articles — that is, the separation between successive articles. The articles are carried by article carriers disposed at the ends of arms that are pivotably coupled to a central, rotating hub. A pitch varying mechanism utilized by each carrier mechanism relies on a camming action to rotate the arms relative to the rotating hub, whereby the pitch between transported articles may be controlled principally through rotary motion to provide reliable high speed operation for high throughput machines.

The first and second pitches may each be dependent upon a number of factors, e.g., the linear and/or rotational velocity of articles, the size of the articles, etc. As such, the parameters of the surrounding stations that may need to be matched to provide controlled pitch with a carrier mechanism may not be cast in terms of separation, but may instead be based upon velocity or another parameter, as will become more apparent below. However, given that pitch, velocity, article size, etc. are interrelated with one another, it will be appreciated that a carrier mechanism consistent with the invention may alternatively be configured to control other parameters.

As shown in Fig. 10A, carrier mechanism 400 includes a shaft housing 402 having a drive shaft 404 rotatably mounted therein via bearings 406. A cam housing 408 is fixedly coupled to shaft housing 402, and a hub 409 is fixedly coupled to drive shaft 404 to cooperatively rotate therewith.

As shown in Fig. 11a, for example, a set of five article carriers 410a, 410b, 410c, 410d and 410e are evenly spaced around hub 409 in the illustrated embodiment. Only one such article carrier 410a is shown in Figs. 10A and 10B to simplify the illustrations. However, it should be appreciated that any number of article carriers may be utilized on carrier mechanism 400 consistent with the invention.

Article carrier 410a includes upper and lower arms 412, 414 that respectively terminate with a gripping mechanism such as a pair of pockets 413, 415 integrally formed thereon for receiving an article 2 supported on conveyor 22. Pockets 413, 415 are sized and configured to circumscribe a cylindrical portion of article 2, and may utilize different profiles for other article configurations in the alternative. Moreover, other gripping mechanisms may be utilized as an alternative to pockets 413, 415 depending upon the type of article being transported. Moreover, in other embodiments, multiple axially-displaced pockets may not be required to reliably engage articles.

As best shown in Fig. 10A, arms 412, 414 are fixedly mounted on a rocker shaft 420 that is pivotably coupled to hub 409 through bearings 422. Rocker shaft 420 projects through apertures in a phaseable lid 425 and a seal lid 426 that overlap hub 409 and seal the inner components thereof.

A linkage member 428 is fixedly mounted at the lower end of rocker shaft 420, with a cam follower 429 disposed at a distal end thereof. In the illustrated embodiment, cam follower 429 is configured as a roller that engages an inwardly-facing wall 442 in cam housing 408 that functions as a cam for carrier mechanism 400.
As best shown in Fig. 10B, cam follower 429 and linkage member 428 are circumferentially spaced about rocker shaft 420 from arms 412, 414 to form an acute angle α relative thereto. In the illustrated embodiment, α is approximately 60 degrees, although other angles may be used in the alternative.

In addition, as best shown in Fig. 10C, it may be desirable to provide an angular offset between arms 412, 414 about rocker shaft 420 so that arm 412 slightly leads or trails arm 414 and thereby induces a controlled tilt to an article 2 engaged by pockets 413, 415. By doing so, improved label alignment, and a reduced likelihood of label misalignment, may result due to the ability to compensate for any imperfections in the containers and/or machined parts that might otherwise induce improper tilting of containers carried by the mechanism. In the illustrated embodiment, the angular offset is provided by manipulation of phaseable lid 425 (Fig. 10A), which is configured to be secured at different angular positions within a defined range to vary the angular offset between arms 412 and 414. Moreover, the angular offset of arms 412, 414 is typically set to impart a tilt to an article retained thereby to an angle β offset from vertical of about ±1 degree (the amount of tilt is exaggerated in Fig. 10C for illustrative purposes). Other degrees of tilt may be utilized in other embodiments, and may often be determined empirically based upon factors such as the type and configuration of the articles, among other factors.

Returning to Fig. 10A, hub 409 is considered to rotate about a first axis 451 defined along the longitudinal axis of drive shaft 404, while article carrier 410 is considered to pivot about a second axis 452 defined along the longitudinal axis of rocker shaft 420. In operation, therefore, as hub 409 rotates about first axis 451 in response to rotation of drive shaft 404, cam follower 429 rides along cam 442 to controllably pivot article carrier 410a about second axis 452. As a result, the angular velocity of article carrier 410a is controllably varied relative to the angular velocity of hub 409. It should be appreciated that a multitude of other known cam and linkage arrangements may be utilized in the alternative to impart a controlled angular offset of each article carrier relative to hub 409.

The profile of cam 442 is selected to provide a controlled pitch at first and second positions of carrier mechanism 400. For example, as shown in Fig. 11A, the first position is the position at which an article carrier (e.g., article carrier 410b) engages an article (e.g., article 2b) on conveyor 22. The second position is the position at which an article carrier (e.g., article carrier 410a) deposits an article (e.g., article 2a) against the outer surface of applicator drum 100. The pitch in this application is defined as the distance between center points of successive articles.

At the first position, the desired pitch is based upon the separation between articles supplied to apparatus 10 via conveyor 22. To assure a continual supply of articles, the articles are typically permitted to "queue up" on the conveyor in an abutting relationship. As such, the separation between articles is directly related to the size of each article. With each article being cylindrical in shape, the separation between articles is the sum of the radii of successive articles. In addition, assuming each article has the same radius, the separation may be expressed in terms of twice the radius of an article, which is equal to the diameter of the article, designated herein as $D_a$. Thus, the desired pitch at the first position, $S_1$, is therefore:
At the second position, the desired pitch is equal to the separation between the leading edges of labels supplied on the outer surface of applicator drum 100. Assuming an applicator drum that provides \( n \) labels evenly spaced about the drum's outer surface, the separation at the second position, \( S_2 \), would thus be equal to the circumference of the drum (which is equal to \( \pi \) times the diameter of the drum, \( D_{2b} \)) divided by the number of labels \( n \), or:

\[
S_2 = (\pi \times D_{2b}) / n
\]

Thus, for an applicator drum that supplies two labels per rotation thereof, the desired pitch at the second position is:

\[
S_2 = \pi/2 \times D_{2b}
\]

To achieve the desired separations at the first and second positions, it may also be desirable to configure the cam profile based upon the desired angular velocity of the article carriers relative to the processing rate of apparatus 10. For example, at the first position, it is typically desirable to match the angular velocity of the article carriers with the speed of incoming articles supplied to carrier mechanism to prevent line vibration and its associated problems. Moreover, to achieve the desired separation at the second position, the angular velocity is typically related to the angular velocity of the applicator drum. It should be appreciated that calculation of the desired angular velocity profile for the article carriers based upon the desired separations is well within the abilities of one of ordinary skill in the art.

With carrier mechanism 400 utilizing five article carriers 410a-410e, and with applicator drum 100 applying two labels per rotation, the hub of carrier mechanism 400 is coupled to applicator drum 100 and drive motor 85 to provide a 1:2.5 gearing ratio between mechanism 400 and applicator drum 100, whereby applicator drum 100 rotates five times for every two rotations of mechanism 400.

Also, as shown in Fig. 10B, for example, the cam profile of cam 442 defines two regions segregated at points \( A \) and \( B \). The first region, extending counter-clockwise from point \( A \) to point \( B \), has a fixed radius \( r \), that maintains a constant angular velocity for each article carrier having its associated cam follower 429 disposed therein. Coupled with the fixed gearing ratio between the carrier mechanism and the applicator drum, the desired pitch at the second position is assured.

In the second region extending counter-clockwise from point \( B \) to point \( A \), however, an article carrier is controllably decelerated to reduce the pitch of an article carrier proximate the first position to match that of the incoming articles, then accelerated to return to the pitch of the article carrier to match that of the labels on the applicator drum. The point in which the cam profile switches from decelerating the article carrier to accelerating the article carrier is labeled as point \( C \), and is typically disposed at an angular position that orients the article carrier at the first position (offset an angle \( \alpha \) from cam follower...
429). The cam profile therefore may decrease from point \( B \) to a minimum radius \( r \), proximate point \( C \), and then increase back to radius \( r \), proximate point \( A \).

Typically, the variations in the cam profile form smooth transitions to facilitate rapid movement of the cam followers along the cam. It should be appreciated that the design of a cam profile that meets the above constraints is well within the abilities of one of ordinary skill in the art, and may, if desired, be determined in whole or in part empirically. Moreover, any number of alternate profiles that provide the required pitches at the first and second positions may also be used consistent with the invention.

It should be appreciated that for carrier mechanism 460 (Fig. 1), which operates to transport articles from applicator drum to conveyor 22 at the discharge end 22b of labeling apparatus 10, an essentially complementary cam profile may be used, which transports articles from a first position that matches the separation of articles being discharged by applicator drum 100 (essentially the same separation as the second position for carrier mechanism 400) to a second position that matches the desired separation of articles discharged onto the conveyor (essentially the same separation as the first position for carrier mechanism 400). For carrier mechanism 460, it is desirable to return articles onto conveyor 22 at the same linear velocity as that of the conveyor to prevent any slippage or possible tilting of the articles as they are received onto the conveyor.

Returning to Fig. 1, it is important to note that in the illustrated embodiment, each article carrier is configured to transport an article along an article engaging surface defined by fixed guide 14, with the pocket disposed at the end of the article carrier merely operating to “push” the article along the guide. In many embodiments, for example, it may be desirable to abut or engage articles without actually gripping the articles (e.g., applying a compressive force to opposing sides of the articles or otherwise restraining the articles from motion in all directions). Instead, articles may effectively be trapped between the pockets and the guide so that the articles tend to “ride” along the guide under a motive force applied by the pockets — that is, the guide principally determines the path of travel for the articles, while the pockets simply accelerate and/or decelerate the articles as they travel along the guide. In different applications, it may be desirable to permit the articles to either roll or slide along the guide in a controlled manner (e.g., by selecting a material for the article engagement surface having appropriate frictional properties).

By cooperatively transporting the articles using the guide to determine the path of travel, the need for movable gripping mechanisms is often eliminated. As such, complexity may be reduced, often reducing cost and improving reliability. Moreover, higher speed operation is typically possible since the additional components, movement and coordination that would otherwise be required to ensure that articles are securely gripped and released at appropriate times would likely limit the overall maximum operational speed of a gripping-type article carrier.

Returning to Figs. 11A-11E, the sequence of transport for a plurality of articles 2a, 2b, 2c, 2d, and 2e is illustrated. As shown in Fig. 11A, article 2a is being discharged onto the surface of applicator drum 100 by article carrier 410a, with articles 2b, 2c and 2d queued up on conveyor 22 waiting to be transported to drum 100. Article carrier 410b has engaged article 2b, with article carrier 410c
beginning to be decelerated via the cam profile to match the linear velocity thereof with that of article 2c. Next, as shown in Figs. 11B, 11C and 11D, article carrier 410b is accelerated by the cam profile to increase the separation between article 2b and the following article 2c, while article carrier 410c continues to be decelerated to match the linear velocity with that of article 2c. Finally, in Fig. 11E, article carrier 410b has reached the second position, whereby the article carrier engages article 2b against a label disposed on the outer surface of applicator drum 100 with the desired pitch and in proper alignment with the label. Moreover, article carrier 410c engages article 2c in the first position in the same manner as described above for article carrier 410b and article 2b in Fig. 11A. Continued rotation of carrier mechanism 400 results in the same sequential controlled deceleration and acceleration of each article carrier 410a-410e so that articles are continuously transferred to applicator drum 100 with the requisite pitch therewith.

It will be appreciated that carrier mechanism 460 operates in a complementary manner to transport articles from applicator drum 100 and back onto conveyor 22. Moreover, it should be appreciated that various modifications may be made to either of carrier mechanisms 400, 460 consistent with the invention.

Alternate Embodiments

It will be appreciated by one skilled in the art that the label application assemblies and carrier mechanisms described herein may be utilized independently of one another. For example, as shown in Fig. 12, a labeling apparatus 500 may include a label application assembly 25' which includes a web supply 30', measuring roller assembly 50', web tracking control assembly 60', registration sensor station 70', cutting station 80', adhesive station assembly 90' and applicator drum 100'. Each component in label application assembly 25' may be configured similarly to the corresponding unprimed components in label application assembly 25 of labeling apparatus 10 of Fig.1, or may include any of the alternatives described above for any of such components.

Apparatus 500, however, includes an alternate article transport assembly to the arrangement of carrier mechanisms and conveyor for apparatus 10 of Fig. 1. Specifically, apparatus 500 includes a conveyor 502 that transports articles to and from apparatus 500. Articles 2 are received from conveyor 502 using a feed screw 510 that provides a controlled separation between articles. A first star wheel 520 transfers articles from feed screw 510 to a turret 540. Articles are then presented by turret 540 to drum 100' of assembly 25' for application of labels to the articles. Upon further rotation of turret 540, the articles are then transferred to a second star wheel 530, and then to conveyor 502 for transport out of apparatus 500.

It should be appreciated that the use and configuration of feed screws, star wheels and turrets are in general well known in the art. It should further be appreciated that other article transport assemblies may be used in the alternative, e.g., various other arrangements of feed screws, turrets and/or star wheels, among others.

It should further be appreciated that the carrier mechanisms described herein may be used independently of a labeling apparatus to transfer articles. In the packaging and/or bottling fields, for
example, such mechanisms may be used to transport articles such as containers with a controlled pitch therebetween in various applications such as bottling machines, filling machines, cleaning machines, packing machines, etc. Moreover, in other fields, the carrier mechanisms may be used in other applications to provide controlled pitch between articles transported thereby. Also, as discussed above, the parameter controlled by a carrier mechanism consistent with the invention may be another transfer characteristic related to pitch such as velocity. This would permit, for example, a carrier mechanism to be used to transfer articles from a first station that outputs the articles at a first velocity to a second station that receives the articles at a second velocity, among other applications. Therefore, the invention should not be limited to any particular field or application of the carrier mechanisms described herein.

Fig. 13 illustrates another alternate labeling apparatus 1000 consistent with the principles of the invention. With the exception of the specific modifications and enhancements discussed below, apparatus 1000 is similar in configuration and operation to the various designs discussed above.

Apparatus 1000 is principally used to apply labels in a continuous fashion to a plurality of articles 2 conveyed from an infeed mechanism 1002 to a discharge mechanism 1004 (here, both implemented by a common conveyor 1006). Other infeed and discharge mechanisms, appropriate for the particular articles conveyed to and from labeling apparatus 1000 may be used in other applications, e.g., feed screws, belts, etc. The term "infeed", as used hereinafter, refers to an upstream position or direction relative to the flow of articles and labels. Likewise, the term "discharge" refers to a downstream position or direction relative to the flow of articles and labels.

Articles 2 are conveyed from infeed mechanism 1002 to a label application assembly or mechanism 1010 using an infeed carrier mechanism 1012, and then to discharge mechanism 1004 using a discharge carrier mechanism 1014. Infeed carrier mechanism 1012 includes a flow starwheel 1020 and an infeed starwheel 1030. Flow starwheel 1020 includes a plurality of teeth 1022 that define a plurality of pockets 1024, with each pocket retaining an article 2 for transfer from infeed mechanism 1002 to infeed starwheel 1030 along a path defined between an infeed guide 1026 and an arcuate guide 1028. As will be discussed in greater detail below, flow starwheel 1020 includes a pair of resiliently coupled disks that minimize the clearance between a retained article and the flow and infeed starwheels during transfer of the article between the starwheels.

Infeed starwheel 1030 includes a plurality of teeth 1032 that define a plurality of pockets 1034, each for retaining an article 2 for transfer along arcuate guide 1028 to a label application station 1036 disposed opposite assembly 1010. As will be discussed in greater detail below, flow and infeed starwheels 1020, 1030 increase the separation between successive articles received from infeed mechanism 1002 to a distance suitable for applying labels provided on a label transfer mechanism (here label transfer or applicator drum 1038) in label application assembly 1010. Other label transfer mechanisms suitable for transferring a label to an article for application of the label thereto may be used in the alternative, including both rotary and linear-based transfer mechanisms such as belts, movable pads, magazines for cut labels, etc.
Application station 1036 includes an arcuate guide 1040 against which the articles are compressed by applicator drum 1038 as labels are applied to the articles. Guide 1040 includes a resilient friction surface to impart a rolling action to the articles as the articles pass through the label application station such that labels are wrapped around the articles.

Discharge carrier mechanism 1014, which incorporates a discharge starwheel 1042 having a plurality of teeth 1044 defining a plurality of pockets 1046, performs essentially the same operation as carrier mechanism 1012 except that mechanism 1014 operates to decelerate articles to a linear velocity suitable for transport by discharge mechanism 1004. By doing so, this arrangement imparts greater stability to discharged articles by minimizing relative movement of the articles to the discharge mechanism 1004. Articles are transferred by discharge starwheel 1042 along an arcuate guide 1048 and into a gap formed between guide 1048 and a discharge guide 1050 for discharge onto discharge mechanism 1004.

In the illustrated embodiment, guides 1026, 1028, 1036, 1048 and 1050 are all laterally adjustable (e.g., through set screw arrangements, not shown) to customize the width of the article path to accommodate different diameters of articles. For labeling machines that are used only with one type of article, such adjustments may not be required.

Labels are supplied to applicator drum 1038 from a web supply 1060 supplying a web 4 of labeling material. Web supply 1060 includes a pair of supply rolls 1062, 1064, that supply web 4 to a measuring roller assembly 1066. Measuring roller assembly 1066 operates as a linear feed rate sensor using a free-wheeling roller 1068 coupled to a rotational position sensor 1070, e.g., an optical encoder. Web 4 proceeds from assembly 1066 to a web tracking control assembly 1072 (including a roller 1073) that is utilized to maintain lateral alignment of the web in assembly 1010. Web 4 then proceeds to a registration sensor station 1074 that detects the position of registration marks disposed on the web. Station 1074 includes a roller 1076 and a registration sensor 1078 disposed opposite roller 1076 at a lateral position relative to the web to detect registration marks disposed thereon.

From registration station 1074, web 4 proceeds to the surface of applicator drum 1038, where an attraction mechanism (here a plurality of vacuum ports) disposed on the outer surface of the drum applies a controlled tension to the web. Moreover, a pair of movable cutter assemblies 1080, 1082 disposed on drum 1038 operate to sever labels from web 4 as each assembly 1080, 1082 passes a cutting station 1084 having a fixed knife 1086.

In some applications it may be desirable to utilize friction reduction mechanisms in one or more of the rollers 1068, 1073 and 1076 to minimize the amount of force required by the attraction mechanism on drum 1038 to draw web 4 from the supply rolls, particularly during initial startup of the labeling apparatus. For example, in one embodiment, it may be desirable to couple roller 1068 to an air turbine of conventional design, which may be used to in effect compensate for the friction and inertia of the other components feeding web 4 to drum 1038, thus enabling a lower vacuum to be used on drum 1038. In other applications, however, friction reduction in the web supply rolls may not be required.

An adhesive station assembly 1090 is disposed beyond cutting station 1084 to apply adhesive to leading and trailing ends of each label using an application roller 1092, after the label has been
severed from the web at cutting station 1084. As will be discussed below, a fluid dispenser 1094 may be used to direct a flow of fluid (e.g., pressurized air) toward the nip formed between roller 1092 and drum 1038, from a position upstream of the nip. Doing so reduces the likelihood of a label following roller 1092 after the application of adhesive thereto. Further, in some applications, the flow of fluid may permit a free portion of the trailing end of a label to wrap around roller 1092 prior to passing the free portion into the nip, which improves the application of adhesive to the trailing end, and often reduces any overspray of adhesive onto the outer surface of drum 1038. Moreover, by reducing the likelihood of the label following roller 1092, often the vacuum level provided to the outer surface of the drum can be reduced, minimizing stretching of the web, and often improving web tracking and cutting as well.

After adhesive is applied to the leading and trailing edges of a label, the label is presented to an article 2 via rotation of applicator drum 1038, whereby rotation of applicator drum 1038 through label application station 1036 wraps the label around the article as the article rolls against guide 1040.

As discussed above, apparatus 1000 incorporates a fluid dispenser to assist in the application of adhesive to labels, as well as unique flow and discharge starwheel designs to assist in both the infeed and discharge of articles to and from the apparatus. Each of these noted components will be described in greater detail below.

Adhesive Application With Fluid Assist

Fig. 14A illustrates applicator drum 1038 and adhesive applicator 1090 in greater detail. Applicator drum 1038 includes a rotatable drum body 1100 configured to rotate about a fixed shaft 1102. Rotatable body 1100 includes an outer surface 1104 having a plurality of vacuum ports 1106 disposed thereon and supplied with a source of negative and/or positive pressure through a set of distribution channels 1108.

Two sets of raised pads 1110, 1112 and 1114, 1116 are disposed on outer surface 1104 to receive leading and trailing edges of a label as the label passes adhesive roller 1092 of applicator 1090 so that adhesive may be applied to the opposing edges of the labels. Applicator roller 1092 is offset from outer surface 1104 such a distance that label material supported on any pad 1110-1116 will be compressed against the roller, but material disposed between the pads will not. Thus, adhesive is applied only to the material supported on a pad.

The leading edges of pads 1110, 1114, and the trailing edges of pads 1112, 1116, are respectively separated from one another around the circumference of drum 1038 at a distance that is approximately the length of the cut labels so that, once a label is severed from the web, the leading and trailing ends thereof are each disposed on a pad when the label passes under adhesive roller 1092. As a result, adhesive is applied only to the leading and trailing ends of each label. In the alternative, roller 1092 may be positioned, and pads 1110 - 1116 may be separated from one another, to apply adhesive to the leading edge of each label prior to the label being severed from the web.

Two sets of pads, pads 1110 and 1112, and pads 1114 and 1116, are provided around the circumference of rotatable body 102, each matched with a cutter mechanism 1080, 1082. Cutter
mechanism 1080 (which is configured in a similar manner to cutter mechanism 1082) includes a rocker body 1118 pivotally mounted to pivot about a shaft 1120 that extends parallel to shaft 1102. A bushing 1122 formed of carbon bronze matrix operates as a bearing surface against which shaft 1120 rotates. As shown in Fig. 14B, bushing 1122 includes a bearing surface 1123 with a recessed portion 1123a formed directly opposite the force vector (identified at "V") applied to rocker body 1118. The recess is adapted to bear shaft 1120 at two points to minimize lateral movement of the rocker body on the shaft, and thereby stabilize the rocker assembly. Through this configuration, greater cutting precision may be obtained than conventional bushing designs.

Returning to Fig. 14A, at one end of body 1118 is disposed a cam follower assembly 1124 including a roller 1126 rotatably mounted about an axle 1128. Axle 1128 is secured via a bolt 1130 to a follower body 1132, and a flexible boot 1134 seals the assembly. Cam follower assembly 1136 of cutter mechanism 1082 is configured similarly to assembly 1124.

Knife assembly 1138 is disposed at the opposite end of rocker body 1118 from cam follower assembly 1124. A knife blade 1140, having an edge 1142, is secured to the end of rocker body 1118 via a bolt or other securing mechanism 1144. Edge 1142 of knife blade 1140 projects through an opening 1146 in outer surface 1104 of body 1100, immediately following trailing pad 1112 around the circumference of body 1100.

A spring assembly 1148 including a spring 1150 extends perpendicular to shaft 1102 and biases cutter assembly 1080 toward an extended position, with knife blade 1140 projecting through opening 1146 beyond outer surface 1104. A screw 1152 controls the tension of spring 1150.

Roller 1126 of cam follower assembly 1124 rides along a cam 1154 disposed on the outer surface of shaft 1102. Cam 1154 is circular in cross section with the exception of a recessed portion 1156. Recessed portion 1156 may have any number of profiles, e.g., a flattened profile as illustrated in Fig. 14A. Recessed portion 1156 is angularly oriented such that roller 1126 engages the portion when knife blade 1140 of knife assembly 1138 is directly opposite fixed knife 1086 of cutting station 1084, thereby extending the knife blade at this position to shear a label from the web.

To further assist in maintaining each label on the outer surface of drum 1038 during adhesive application, a fluid dispenser 1094 is disposed in a position to direct a flow of fluid toward the nip formed between adhesive roller 1092 and drum 1038. Fluid dispenser 1094 in the illustrated embodiment includes an air bar 1170 mounted to a fixed post 1172. Air bar 1170 includes a vertical distribution channel 1174 coupled to a source of pressurized fluid (e.g., compressed air or other gas), and a plurality of nozzles 1176 adapted to direct the pressurized fluid (represented at 1180) toward nip 1178. In the illustrated embodiment, air bar 1170 is separated from nip 1178 by approximately four inches (10.16 cm), has 10 nozzles, each with 0.04 inch (1.016 mm) diameters, and is supplied with approximately 20 to 40 psi of pressurized air. Other separations, flow rates, directions of flow (e.g., angle of attack relative to the nip), and other fluid flow parameters may be utilized in other applications.

In operation, the label material is advanced by the web supply at a rate slower than the rotational rate of drum 1038, with the vacuum ports on the drum providing tension to withdraw the web from the web supply. Once an amount of web material suitable to provide a desired length of label is
withdrawn from the web supply, the leading edge of the web is supported on a leading pad 1110, 1114. At the same time, cutter mechanism 1080, 1082 passes fixed knife 1086, severing a label from the web. Upon further rotation of the drum, leading pad 1110, 1114 passes adhesive roller 1092 to apply a layer of adhesive to the leading end of the label. Continued rotation of the drum then results in the trailing pad passing the adhesive roller to apply adhesive to the label proximate the trailing edge. Cutting and adhesive application of the label is then complete, and further rotation of the drum (coordinated with the advancement of articles) results in the label being wrapped around an article at station 1036 (Fig. 13).

Figs. 15A and 15B generally illustrate the operation of fluid dispenser 1094 in assisting in the application of adhesive to a label in a manner consistent with the invention. First, as shown in Fig. 15A, when application roller 1092 is applying adhesive to a leading edge 4a of a cut label 5, the flow of fluid 1180 directed at nip 1178 assists in preventing leading edge 4a from following adhesive roller 1092 after exiting the nip. As a result, greater reliability is often obtained due to a reduced likelihood of jamming the apparatus as a result of a label misfeed during adhesive application. In addition, in some applications it may be possible to lower the vacuum supplied to drum 1038 while maintaining sufficient reliability, which may be advantageous due to better web tracking, reduced stretching of the web and better cutting performance.

In addition, as shown in Fig. 15B, when application roller 1092 is applying adhesive to a trailing edge 4b of label 5, the flow of fluid 1180 directed at nip 1178 may be used to assist in urging the trailing edge 4b to lift from trailing pad 1112 and wrap around roller 1092 before entering the nip. In particular, due to the separation between trailing pad 1112 and knife 1140, a portion of label 5 at trailing edge 4b is not supported on pad 1112, and thus is left free.

By directing the free end around the roller, adhesive is applied to the very end of the label, which would not otherwise occur since the free end would not be supported on pad 1112. Improved adhesive patterns result, improving the appearance and quality of a labeled article. Moreover, in some applications, directing the free trailing end of the label around the roller reduces the undesirable overspray of adhesive from roller 1092 onto drum 1038, reducing the frequency at which the drum must be cleaned and improving reliability due to reduced likelihood of oversprayed adhesive causing a label misfeed on the drum. Furthermore, in some applications, it may be desirable to increase the amount of free label material at the trailing end of a label to improve the adhesive pattern at the trailing end, e.g., by increasing the separation of a trailing pad from a knife and/or by eliminating one or more rows of vacuum ports from the trailing edge of a trailing pad.

Other fluid dispenser designs may be utilized in the alternative. For example, other configurations of nozzles and other types of fluid ports may be used. Moreover, other fluid sources, e.g., fan motors, airflow that is generated by the shape or other configuration of the drum, etc., may also be used. Other modifications will be apparent to one of ordinary skill in the art.
Returning to Fig. 13, articles 2 are supplied to apparatus 1000 via an infeed mechanism 1002. The flow of these articles into the apparatus is controlled by a flow starwheel 1020, illustrated in greater detail in Figs. 16 and 17, including a plurality of teeth 1022 forming a plurality of pockets 1024 for advancing articles into the apparatus.

Starwheel 1020 includes a rotatable hub 1200 mounted on a shaft 1202 and secured thereto in a keyed arrangement via a keyed member 1204 secured to the hub by fasteners 1206.

Shaft 1202 is coupled to a drive mechanism (not shown) used to drive the starwheel in a coordinated fashion with starwheels 1030 and 1042, as well as drum 1038, typically through a drive train providing a fixed relative rotation rate for each such component. For example, shaft 1202 may be coupled to a rotatable pulley through a universal linkage, with the pulley coupled via a belt to the other rotatable components in apparatus 1000. It may be desirable to provide a clutch mechanism in the drive for starwheel 1020 to permit the apparatus to be halted in a predetermined rotational position. Other drive mechanisms may also be used in the alternative.

Starwheel 1020 includes a unique engagement surface that is resiliently coupled to the rotatable hub to vary a rotational position of a pocket relative to the hub. By resiliently coupling the engagement surface to the hub, clearance between an article and either of starwheel 1020 and infeed starwheel 1030 (Fig. 13) can be minimized to reduce vibrations in the flow of articles and thereby improve the stability of the articles as they enter apparatus 1000.

Provision of a resiliently-biased engagement surface is made through a pair of disks 1208, 1210 rotatably mounted on opposing surfaces of hub 1200. Each of disks 1208 and 1210 and hub 1022 include cooperative profiles including a plurality of teeth defining a plurality of pockets therebetween. As used herein, therefore, an engagement surface is defined on each pocket of each disk 1208, 1210. Disks 1208 and 1210 are secured to one another by a plurality of shafts 1212 (e.g., five such shafts) retained within cooperating slots 1214 in hub 1200. One end of each slot 1214 defines a position of the cooperating shaft 1212 (and accordingly the disks 1208 and 1210) in which each tooth defined in the profile of each disk aligns with one of the teeth formed in the profile of hub 1200. When each shaft 1212 is disposed at the opposite end of each slot 1214, the teeth defined in the profiles of disks 1208, 1210 are disposed forward of the teeth defined on hub 1200 in the direction of rotation of starwheel 1020. Disks 1208, 1210 are biased in the forward position through the use of a sequence of springs 1216, each secured at one end to shaft 1212 and at the other end to an anchor 1218 disposed within an annular slot 1220 in hub 1200.

It should be appreciated that other resilient members, e.g., coiled or leaf springs, torsion springs, etc., may be utilized to resiliently bias the disks relative to the hub. Furthermore, it should be appreciated that only one disk may be utilized, and in addition it is not necessary in some applications for hub 1200 to have a cooperating profile with each disk 1208, 1210. For example, in other applications it may be desirable to simply utilize a pair of concentric hubs joined through an annular bearing and rotationally resilient coupling mechanism, with the inner hub mounted to the shaft and the outer hub providing the desired starwheel profile.
Other manners of providing a resiliently-biased engagement surface may also be utilized in the alternative. For example, rather than utilizing separate bodies for a hub and an engagement surface, an engagement surface may be resiliently coupled to a hub using a deformable body. As shown in Fig. 21, for example, a starwheel 1300 may include a hub 1302 having a deformable body 1304 (e.g., formed of a resilient material such as rubber) mounted about the periphery thereof to form an engagement surface 1306. Compression forces applied between the resilient body and indeed starwheel 1030 deform the resilient body to compress an article between such components.

Also, other forms of resiliently deformable members, e.g., inflated starwheel spokes and the like, may also be used to provide a resilient coupling between an engagement surface and a hub. For example, as shown in Fig. 22, a starwheel 1310 may include an integrally-formed inflatable body 1312 defining an engagement surface 1314 that is integrally coupled to a hub.

In general, it will be appreciated that a wide variety of resilient engagements, which essentially have the effect of retarding or advancing the rotational position of an engagement surface relative to a rotatable hub (even when such engagements move the engagement surface in a non-arcuate manner), may be used in the alternative.

The operation of flow starwheel 1020 in providing articles to infeed starwheel 1030 is illustrated in greater detail in Figs. 18A-18F. Shown in Fig. 18A are a pair of articles 1230, 1232 supplied to the path defined between guides 1026 and 1028 by an infeed mechanism. Article 1230 is illustrated as being picked up by starwheel 1020, with the article initially disposed on the trailing surface of a tooth on hub 1200. Absent any opposing force on starwheel 1020, disk 1208 (and disk 1210, although such disk is not shown in Figs 6A-6F) is biased to a forward position. As shown in Fig. 18B, further rotation of starwheels 1020, 1030 results in the leading edge of a tooth on disk 1208 engaging article 1230, driving the article forward but at the same time overcoming the resilient bias of the starwheel and rotating disk 1208 toward a position in alignment with hub 1200. Next, as shown in Fig. 18C, further rotation of starwheels 1020, 1030 brings article 1230 into contact with the outer surface 1031 of infeed starwheel 1030, and with the disk 1208 in a rearmost rotational position in alignment with hub 1200. Next, as shown in Fig. 18D, further rotation of starwheels 1020 and 1030 begins to draw article 1230 into pocket 1034 defined on outer surface 1031 of infeed starwheel 1030. However, as the article recesses into the pocket, the resilient bias of disk 1208 rotates the disk forward to maintain contact between article 1230 and disk 1208 as the transfer of the article from flow starwheel 1020 to infeed starwheel 1030 occurs. As a result, any gaps between the article and the respective outer surfaces of starwheels 1020 and 1030 are minimized.

Upon further rotation (Fig. 18E), article 1230 becomes seated in pocket 1034, with disk 1208 of starwheel 1020 positioned at its forward-most position relative to hub 1200. In addition, the next article in sequence, article 1232, is shown engaging the next pocket of starwheel 1020. Article 1230, however, is still compressed to an extent between disk 1208 and starwheel 1030. Fig. 18F next illustrates the release of article 1230 from starwheel 1020, with the article securely retained within in pocket 1034 of starwheel 1030. Article 1232 is then in position for transfer to the next pocket in sequence for starwheel 1030.
Through maintaining compression of an article between starwheels 1020 and 1030, vibrations in the articles are minimized, and as a result, the stability of the articles feeding into the apparatus is improved. It should be appreciated that the use of a resiliently-biased engagement surface as described herein may be utilized on other starwheels consistent with the invention, e.g., in any application in which it is desirable to transfer an article from a starwheel to another transfer mechanism such as another starwheel or the like. Other modifications will also be apparent to one of ordinary skill in the art.

Article Discharge

Returning to Fig. 13, once an article is collected by infeed starwheel 1030, the article is transported along guide 1028 to a gap disposed between an arcuate guide 1040 and the outer surface of drum 1038, whereby the article is rolled about a rolling axis (typically the longitudinal axis of an article taken through the center point of the circular cross-section of the article) and a label is wrapped around the article. Once at least a portion of a label is wrapped around an article, the article is fed from the gap between drum 1038 and guide 1040 by a discharge carrier mechanism 1014 including a discharge starwheel 1042 with a plurality of teeth 1044 defining a plurality of pockets 1046 therebetween.

Figs. 19A-19D illustrate the configuration and operation of discharge starwheel 1042 in greater detail, with a plurality of articles 1240, 1242, 1244 and 1246 illustrated at various points along the guide 1048.

Each pocket 1046 of discharge starwheel 1042 is defined by a series of arcs between adjacent teeth 1044. In the illustrated embodiment, the width of each pocket (defined by the separation between adjacent teeth) is greater than the diameter of each article such that the precision required to engage an article within a pocket is reduced. Furthermore, in the illustrated embodiment, each pocket is defined by first, second and third sections 1250, 1254 and 1252, with the first and second sections 1250, 1252 defined by leading and trailing edges of adjacent teeth, and having a radius of curvature that is less than that of the intermediate third section 1254. Section 1254, providing an engagement surface initially contacting an article, is provided with a relatively larger radius of curvature to minimize the coefficient of friction between the pocket and the article during initial contact with the article. Section 1250, however, has a lower radius of curvature to provide a relatively higher coefficient of friction with the article once the article is engaged with section 1250. Providing a higher coefficient of friction assists in canceling the spin induced on the article by the label application process. The transition from section 1254 to section 1250 is gradual, however, so that the coefficient of friction increases as the article slides back in pocket 1046, and a gradual deceleration of the rotational velocity of the article is obtained.

As shown, for example in Fig. 19A, article 1246 initially contacts a pocket of starwheel 1042 between adjacent teeth 1044. Then, as shown in Fig. 19B, the article 1246 is allowed to slide back into engagement with the trailing tooth 1044, with the rotation thereof canceled via the coefficient of friction with the section 1250 of the pocket.
Returning again to Fig. 19A, the configuration of starwheel 1042 is also specifically designed to stabilize the discharge of articles from guide 1048 onto the discharge mechanism (here conveyor 1004 of Fig. 13). Each tooth 1044 of starwheel 1042 is configured to impart a decreasing linear velocity to each article as it is discharged along guide 1050 to the conveyor. The rotation rate of starwheel 1042 is selected to provide a tangential velocity of articles transferred by starwheel 1042 that is initially greater than the linear velocity of the conveyor. However, by conveying the articles along a linear portion of guide 1050, and by providing a decreasing linear velocity through engagement with each tooth 1044, the linear velocity of the articles is decelerated below that of the conveyor, thereby permitting the conveyor to transport the articles away from the starwheel once the linear velocity thereof falls below that of the conveyor.

As illustrated, for example, by article 1242, the article is fully seated within a pocket of starwheel 1042 as the article engages arcuate guide 1050. Next, as shown in Fig. 19B, as the article is advanced by starwheel 1042, the linear velocity of the article along the direction of the conveyor decreases as the article is conveyed by the tip of the tooth 1044 against which the article rests. As shown in Fig. 19C, further rotation of starwheel 1042 results in a further decrease in velocity for article 1242, until the conveyor picks up the article and carries away from starwheel 1042, as shown in Fig. 19D.

Fig. 20 illustrates in another way the linear velocity imparted to an article transported by starwheel 1042 at equal time intervals during the rotation of starwheel 1042. The position of the starwheel and the container 1242 is illustrated at six points of time t₁ to t₆ with the linear movement of the article during each time interval theretbetween denoted as d₁ to d₆. The rate of advancement of the conveyor during the last two time intervals is illustrated at c₂ and c₆ (it being understood that the conveyor is advancing at the same rate during the earlier time intervals as well). It can be seen that from time t₄ to time t₆, the article is advanced at a linear rate that exceeds that of the conveyor. However, once the linear rate falls below that of the conveyor at time t₆, the article is advanced at the rate of the conveyor, and subsequently carried away from the discharge starwheel.

It should be appreciated that other starwheel profiles may be utilized in discharge starwheel 1042 consistent with the invention.

Furthermore, it will also be appreciated by one skilled in the art that the various enhancements to the herein described label application assemblies and carrier mechanisms may be utilized independently of one another in other applications.
What is claimed is:

1. An apparatus, comprising:
   (a) a web supply configured to supply a web of material including a sequence of
       unsevered labels;
   (b) a rotatable drum configured to receive the web of material, the drum including an
       outer surface;
   (c) an attraction mechanism disposed on the outer surface of the drum and configured to
       attract the web of material to the outer surface of the drum;
   (d) a drive mechanism coupled to the drum and configured to rotate the drum and
       advance the outer surface thereof at a rate greater than a rate at which the web of material is
       advanced from the web supply;
   (e) a cuttter mechanism coupled to the drum and configured to sever a label from the web
       of material while at least a portion of the web of material engages the outer surface of the drum, the
       cutter mechanism including a retractable knife disposed on the drum and configured to rotate with
       the drum; and
   (f) an adhesive applicator positioned proximate the drum to apply an adhesive to at least a
       portion of the label while the label engages the outer surface of the drum.

2. The apparatus of claim 1, wherein the web supply includes a second drive mechanism
   configured to advance the web of material at a predetermined rate.

3. The apparatus of claim 2, wherein the second drive mechanism includes a servo motor.

4. The apparatus of claim 2, wherein the second drive mechanism includes a rotational position
   sensor.

5. The apparatus of claim 4, wherein the rotational position sensor includes an optical encoder.

6. The apparatus of claim 2, further comprising a linear feed rate sensor disposed between the web
   supply and the drum, the linear feed rate sensor generating an output signal associated with a linear feed rate
   for the web of material.

7. The apparatus of claim 6, wherein the linear feed rate sensor includes a free wheeling roller
   having a fixed diameter and engaging the web of material between the web supply and the drum, and a
   rotational position sensor coupled to the free wheeling roller and outputting the output signal for the linear
   feed rate sensor.

8. The apparatus of claim 6, wherein the cutter mechanism severs the segment of the web of
   material when the drum is disposed at a predetermined rotational position, the apparatus further comprising
   a drum rotational position sensor coupled to the drum.
9. The apparatus of claim 8, wherein the rotational position sensor includes an optical encoder.

10. The apparatus of claim 8, further comprising a registration sensor, disposed between the drum and the web supply, the registration sensor configured to detect registration indicia located at predetermined positions on the web of material.

11. The apparatus of claim 10, further comprising a controller, coupled to the linear feed rate sensor, the drum rotational position sensor and the registration sensor, the controller configured to control at least one of the first and second drive mechanisms to coordinate rotation of the drum and supply of the web of material and thereby align the web of material relative to the cutter mechanism.

12. The apparatus of claim 11, wherein the controller is further configured to receive a length input associated with a desired length of the segment severed from the web of material.

13. The apparatus of claim 1, wherein the retractable knife is configured to sever the segment from the web of material at a predetermined rotational position of the drum.

14. The apparatus of claim 13, wherein the cutter mechanism further includes a knife retraction mechanism, coupled to the retractable knife and configured to selectively retract the knife within the outer surface of the drum.

15. The apparatus of claim 14, wherein the knife retraction mechanism includes:

(a) a fixed cam disposed about a rotational shaft of the drum; and

(b) a rocker assembly mounted to the drum and configured to pivot about a pivot axis parallel to a rotational axis of the drum, the rocker assembly including the retractable knife at a first end thereof and a cam follower at a second end thereof that follows the fixed cam as the drum rotates about the rotational shaft, wherein the retractable knife is selectively extended and retracted through rotation of the drum about the rotational shaft.

16. The apparatus of claim 15, further comprising a stationary knife disposed at the predetermined rotational position of the drum, where the retractable and stationary knives selectively engage one another during rotation of the drum and thereby sever the segment at the predetermined rotational position of the drum.

17. The apparatus of claim 16, further comprising a second rocker assembly mounted to the drum and configured to pivot about a pivot axis parallel to a rotational axis of the drum, the second rocker assembly including a second retractable knife, wherein the first and second retractable knives are evenly spaced from one another about the circumference of the drum.
18. The apparatus of claim 1, wherein the adhesive applicator is positioned to apply an adhesive at least to opposing ends of a severed label after the label is severed by the cutter mechanism, and wherein the knife retraction mechanism is configured to selectively retract the retractable knife within the outer surface of the drum proximate the adhesive applicator.

19. The apparatus of claim 18, wherein the outer surface of the drum includes raised pads for engaging the opposing ends of a severed label from the web of material.

20. The apparatus of claim 1, further comprising a conveyor configured to pass a container past the drum to engage the segment after the application of adhesive and thereby transfer the segment to an outer surface of the container.

21. The apparatus of claim 1, wherein the attraction of the web of material to the drum is the sole source of tension between the web supply and the drum.

22. A method of severing segments of predetermined length from a web of material, the method comprising:
   (a) advancing a web of material toward a rotating drum;
   (b) attracting the web of material into engagement with the outer surface of the drum;
   (c) severing a segment from the web of material while at least a portion of the web of material engages the outer surface of the drum using a retractable knife coupled to the drum and configured to rotate with the drum;
   (d) rotating the drum and advancing the outer surface thereof at a rate greater than the rate at which the web of material is advanced from the web supply; and
   (e) applying an adhesive to at least a portion of the segment while the segment is disposed on the outer surface of the drum.

23. The method of claim 22, further comprising:
   (a) driving a web supply with a drive mechanism; and
   (b) sensing the rate of rotation of the drive mechanism.

24. The method of claim 23, further comprising sensing the rate of rotation of the drum.

25. The method of claim 24, wherein severing the segment from the web of material includes severing the segment from the web of material at a predetermined rotational position of the drum, the method further comprising dynamically controlling at least one of the rate of rotation of the drive mechanism and the rate of rotation of the drum such that a predetermined length of material is advanced forward of the predetermined rotational position of the drum as such time as the drum is positioned at the predetermined rotational position.
26. The method of claim 22, further comprising sensing a linear feed rate for the web of material using a rotational sensor coupled to a free wheeling roller having a fixed diameter and engaging the web of material upstream of the drum.

27. The method of claim 22, wherein severing the segment includes severing the segment when the drum is disposed at a predetermined rotational position.

28. The method of claim 22, further comprising detecting registration indicia located at predetermined positions on the web of material at a location upstream of the drum.

29. The method of claim 22, further comprising receiving a length input associated with a desired length of the segment severed from the web of material.

30. The method of claim 22, further comprising retracting the retractable knife proximate an adhesive applicator used to apply the adhesive to the segment.

31. The method of claim 22, further comprising transferring the segment from the drum to a surface of a container after application of adhesive.

32. The method of claim 22, wherein the attrition of the web of material to the drum is the sole source of tension between the web supply and the drum.

33. An apparatus, comprising:

(a) a first station configured to transport articles with a first pitch therebetween;
(b) a second station including a label application assembly and configured to supply labels with a second pitch therebetween for the application of labels to articles;
(c) a fixed guide including an article receiving surface extending from proximate the first station to proximate the second station; and
(d) a carrier mechanism configured to transport articles along the article receiving surface of the guide and between the first and second stations, the carrier mechanism including:

(1) a hub configured to rotate about a first axis;
(2) an article carrier configured to receive and transport an article along the article engaging surface of the guide, the article carrier operatively coupled to the hub through a pivotal coupling that defines a second axis substantially parallel to and separated from the first axis; and
(3) a camming mechanism coupled to the article carrier to controllably pivot the article carrier about the second axis during rotation of the hub about the first axis and thereby vary the angular velocity of the article carrier relative to that of the hub, the camming mechanism configured to controllably pivot the article carrier to a first angular position about the second axis when the hub is oriented at a first angular position about the...
first axis based upon the first pitch of the first station, and to controllably pivot the article
carrier to a second angular position about the second axis when the hub is oriented at a
second angular position about the first axis based upon the second pitch of the second
station.

34. The apparatus of claim 33, further comprising a second article carrier configured to receive an
article, the second article carrier operatively coupled to the hub through a second pivotal coupling that
defines a third axis substantially parallel to and separated from the first axis, wherein the second and third
axes are circumferentially spaced from one another about the first axis.

35. The apparatus of claim 33, wherein the first and second axes are oriented in a vertical
direction.

36. The apparatus of claim 33, wherein the article carrier includes a pocket disposed at a distal end
from the pivotal coupling, the pocket configured to abut the article while the article abuts the article
engaging surface of the guide.

37. The apparatus of claim 36, wherein the pocket is configured to abut the article without
gripping.

38. The apparatus of claim 33, wherein the article engaging surface faces the first axis and has a
concave cross-section along a plane perpendicular to the first axis, and wherein the article engaging surface
defines a path of travel for the article.

39. A method of transporting an article between a first station configured to transport articles with
a first pitch therebetween and a second station including a label application assembly and configured to
supply labels with a second pitch therebetween for the application of labels to articles, the method
comprising:
(a) receiving an article proximate the first station with an article carrier pivotally coupled
to a rotating hub on a carrier mechanism, the hub configured to rotate about a first axis, and the
article carrier operatively coupled to the hub through a pivotal coupling that defines a second axis
substantially parallel to and separated from the first axis;
(b) transporting the article along an article receiving surface of a fixed guide to the second
station;
(c) while transporting the article between the first and second stations, controllably
pivoting the article carrier about the second axis during rotation of the hub about the first axis to
match a predetermined carrier parameter for the article carrier respectively with the first and second
pitches when the article is disposed at the first and second stations; and
(d) applying a label to the article at the second station.
40. The method of claim 39, wherein the first and second axes are oriented in a vertical direction.

41. The method of claim 39, wherein the article carrier includes a pocket disposed at a distal end from the pivotal coupling, the pocket configured to abut the article while the article abuts the article engaging surface of the guide.

42. The method of claim 41, wherein the pocket is configured to abut the article without gripping.

43. The method of claim 39, wherein the article engaging surface faces the first axis and has a concave cross-section along a plane perpendicular to the first axis, and wherein the article engaging surface defines a path of travel for the article.

44. An apparatus, comprising:
   (a) an adhesive applicator including an adhesive roller;
   (b) a label transport mechanism configured to transfer a label past the roller to apply adhesive to the label; and
   (c) a fluid dispenser configured to direct a flow of fluid toward a nip formed between the adhesive roller and the label transport mechanism from a position upstream from the nip.

45. The apparatus of claim 44, wherein the label transport mechanism includes a label transfer drum, the drum including an outer surface configured to support the label as the label passes the adhesive roller.

46. The apparatus of claim 45, wherein the drum includes an attraction mechanism configured to adhere the label to the outer surface of the drum.

47. The apparatus of claim 46, wherein the attraction mechanism includes a plurality of ports disposed on the outer surface of the drum and coupled to a source of negative pressure.

48. The apparatus of claim 46, wherein the drum includes a cutter mechanism configured to sever the label from a label web, the apparatus further comprising a label supply configured to supply the label web to the drum, wherein the attraction mechanism is the sole source of tension in the label web between the drum and the label supply.

49. The apparatus of claim 46, wherein the drum includes raised leading and trailing pads disposed on the outer surface thereof and respectively configured to support the label proximate leading and trailing edges thereof, and wherein the trailing edge of the label is unsupported and extends beyond the trailing pad; whereby the flow of fluid from the fluid dispenser causes the trailing edge of the label to engage the adhesive roller upstream of the nip as the label passes the adhesive roller.
50. An apparatus, comprising:

(a) an adhesive applicator including an adhesive roller rotatable about a first axis;
(b) a label transport drum rotatable about a second axis that is substantially parallel to the
first axis, the drum positioned to form a nip with the adhesive roller;
(c) a nozzle facing the nip and positioned upstream of the adhesive roller generally about
the second axis; and
(d) a source of pressurized gas in fluid communication with the nozzle.

51. The apparatus of claim 50, wherein the drum includes a plurality of ports disposed on an outer
surface thereof and coupled to a source of negative pressure to adhere the label to the outer surface of the
drum.

52. The apparatus of claim 51, wherein the drum includes a cutter mechanism configured to sever
the label from a label web, the apparatus further comprising a label supply configured to supply the label
web to the drum, wherein the negative pressure supplied to the outer surface of the drum is the sole source
of tension in the label web between the drum and the label supply.

53. The apparatus of claim 51, wherein the drum includes raised leading and trailing pads disposed
on the outer surface thereof and respectively configured to support the label proximate leading and trailing
edges thereof, and wherein the trailing edge of the label is unsupported and extends beyond the trailing pad;
whereby the flow of gas from the nozzle causes the trailing edge of the label to engage the adhesive roller
upstream of the nip as the label passes the adhesive roller.

54. The apparatus of claim 50, wherein the nozzle is disposed on an air bar including a plurality of
nozzles.

55. A method of applying adhesive to a label disposed on a label transport mechanism, the method
comprising:

(a) transferring a label past an adhesive roller while the label is disposed on a label
transport mechanism; and
(b) directing a flow of fluid toward a nip formed between the adhesive roller and the label
transport mechanism from a position upstream from the nip while the label is being transferred past
the adhesive roller.

56. The method of claim 55, wherein the label transport mechanism includes a label transfer drum
including an outer surface, the method further comprising adhering the label to the outer surface of the drum
as the label passes the adhesive roller.

57. The method of claim 56, wherein adhering the label of the outer surface of the drum includes
supplying a source of negative pressure to a plurality of ports disposed on the outer surface of the drum.
58. The method of claim 57, further comprising:
   (a) severing the label from a label web while the label is at least partially adhered to the
       outer surface of the drum; and
   (b) maintaining tension in the label web using the source of negative pressure supplied to
       the plurality of ports disposed on the outer surface of the drum.

59. The method of claim 56, further comprising:
   (a) supporting the label on leading and trailing pads disposed on the outer surface of the
       drum with a trailing edge of the label unsupported and extending beyond the trailing pad; and
   (b) wrapping the trailing edge of the label to the adhesive roller prior to passing the
       trailing edge of the label into the nip in response to the flow of fluid directed toward the nip.

60. A starwheel, comprising:
   (a) a rotatable hub configured to rotate about an axis of rotation; and
   (b) an engagement surface defining a pocket configured to engage an article, wherein the
       engagement surface is resiliently coupled to the rotatable hub to move between first and second
       positions to vary a rotational position of the pocket relative to the hub.

61. The starwheel of claim 60, wherein the engagement surface comprises a disk including a
    plurality of teeth disposed about a periphery thereof, wherein the disk is rotatably coupled to the hub, and
    wherein the pocket is defined between a pair of adjacent teeth.

62. The starwheel of claim 61, wherein the first position leads the second position in the direction
    of rotation of the hub, and wherein the disk is resiliently biased toward the first position.

63. The starwheel of claim 62, wherein the disk is resiliently coupled to the hub using at least one
    spring.

64. The starwheel of claim 62, further comprising a second disk including a plurality of teeth and
    rotatably coupled to the hub to rotate between first and second positions, the first and second disks coupled
    to one another to cooperatively rotate relative to the hub.

65. The starwheel of claim 64, wherein the hub further includes a plurality of teeth disposed about
    the periphery thereof, wherein the plurality of teeth on the hub are interposed between the first and second
    disks, and wherein each tooth on the hub is configured to lag a corresponding pair of teeth on the first and
    second disks in the direction of rotation of the hub when the first and second disks are disposed in the first
    positions thereof.
66. The starwheel of claim 60, wherein the engagement surface is defined on a deformable member coupled to the hub to provide the resilient coupling between the engagement surface and the rotatable hub.

67. The starwheel of claim 66, wherein the deformable member comprises a rubber material disposed about an outer perimeter of the rotatable hub.

68. The starwheel of claim 66, wherein the deformable member comprises an inflatable tooth coupled to the rotatable hub.

69. An apparatus, comprising:
   (a) a label application station configured to apply a label to an article;
   (b) an arcuate guide having infeed and discharge ends, the discharge end disposed proximate the label application station;
   (c) a first starwheel rotatably coupled opposite the arcuate guide, the first starwheel configured to transport an article between the infeed and discharge ends of the arcuate guide; and
   (d) a second starwheel disposed proximate the infeed end of the arcuate guide to control the flow of articles to the first starwheel, the second starwheel including:
      (i) a rotatable hub configured to rotate about an axis of rotation; and
      (ii) an engagement surface defining a pocket configured to engage an article, wherein the engagement surface is resiliently coupled to the rotatable hub to move between first and second positions to vary a rotational position of the pocket relative to the hub.

70. The apparatus of claim 69, wherein the first and second starwheels oppose one another proximate the infeed end of the arcuate guide, wherein the first position leads the second position in the direction of rotation of the hub, and wherein the engagement surface is resiliently biased toward the first position to minimize clearance between an article and each of the first and second starwheels when the article is transferred between the first and second starwheels.

71. A method of transferring an article, the method comprising:
   (a) transferring an article to a first starwheel with a second starwheel, the second starwheel including a rotatable hub and an engagement surface upon which is defined a pocket for receiving the article, the engagement surface resiliently coupled to the hub to move between first and second positions and thereby vary a rotational position of the pocket relative to the hub; and
   (b) minimizing clearance between the article and each of the first and second starwheels while the article is being transferred by moving the engagement surface relative to the hub in response to compression of the article between the first and second starwheels.
72. The method of claim 71, wherein the engagement surface comprises a disk including a plurality of teeth disposed about a periphery thereof, wherein the disk is rotatably coupled to the hub, wherein the pocket is defined between a pair of adjacent teeth, wherein the first position leads the second position in the direction of rotation of the hub, and wherein the disk is resiliently biased toward the first position.

73. The method of claim 72, wherein the second starwheel further includes a second disk including a plurality of teeth and rotatably coupled to the hub to rotate between first and second positions, the first and second disks coupled to one another to cooperatively rotate relative to the hub, wherein the hub further includes a plurality of teeth disposed about the periphery thereof, wherein the plurality of teeth on the hub are interposed between the first and second disks, and wherein each tooth on the hub is configured to lag a corresponding pair of teeth on the first and second disks in the direction of rotation of the hub when the first and second disks are disposed in the first positions thereof.

74. An apparatus, comprising:
(a) an arcuate guide having infeed and discharge ends;
(b) a label transfer drum including an outer surface configured to support a label, the drum rotatably coupled opposite the arcuate guide to adhere the label to an article supplied to the infeed end of the arcuate guide by wrapping the label around the article as the article rolls between the drum and the arcuate guide; and
(c) a discharge starwheel rotatably coupled proximate the discharge end of the arcuate guide to transfer the labeled article from the drum.

75. The apparatus of claim 74, further comprising a second arcuate guide disposed opposite the discharge starwheel and including infeed and discharge ends, the infeed end disposed proximate the drum and the discharge end disposed proximate a discharge mechanism disposed proximate the apparatus, wherein the discharge starwheel is configured to transfer the labeled article along the second arcuate guide between the infeed and discharge ends thereof.

76. The apparatus of claim 75, wherein the discharge starwheel includes first and second teeth disposed around the periphery thereof and forming a pocket therebetween configured to retain the labeled article as the article is transferred along the second arcuate guide, and wherein the first tooth of the discharge starwheel is configured to engage the labeled article at least during a portion of the transfer of the labeled article along the second arcuate guide.

77. The apparatus of claim 76, wherein rolling the article between the drum and the arcuate guide imparts a rotational velocity to the article about a rolling axis, and wherein the first tooth is configured to provide a higher coefficient of friction with the labeled article than that provided by the second arcuate guide to reduce the rotational velocity of the labeled article as the labeled article is retained in the pocket of the discharge starwheel.
78. The apparatus of claim 77, wherein the first and second teeth are peripherally spaced from one another a distance that is greater than a diameter of the labeled article defined perpendicular to the rolling axis of the article.

79. The apparatus of claim 77, wherein the pocket is defined by first and second sections disposed at opposite ends of a third section, the first section disposed on a leading edge of the first tooth, and the second section disposed on a trailing edge of the second tooth, and wherein each section includes a radius of curvature, the radius of curvature of the third section being greater than either of the first and second sections.

80. The apparatus of claim 76, wherein the discharge mechanism includes a conveyor having a linear velocity, and wherein the first tooth is configured to decrease the linear velocity of the labeled article along the direction of the conveyor.

81. The apparatus of claim 80, wherein the first tooth is further configured to decrease the linear velocity of the labeled article below that of the conveyor proximate the discharge end of the second arcuate guide; whereby the conveyor will convey the labeled article from the pocket once the linear velocity of the labeled article imparted by the discharge starwheel falls below that of the conveyor.

82. A method of labeling an article, the method comprising:

(a) wrapping a label around an article by rolling the article between an arcuate guide and a rotating label transfer drum; and

(c) transferring the labeled article away from the arcuate guide and drum using a discharge starwheel rotatably coupled proximate a discharge end of the arcuate guide.

83. The method of claim 82, wherein transferring the labeled article using the discharge starwheel, includes transferring the labeled article along a second arcuate guide to a discharge mechanism.

84. The method of claim 83, wherein transferring the labeled article using the discharge starwheel includes retaining the labeled article within a pocket defined between first and second teeth disposed around the periphery of the discharge starwheel, and engaging the labeled article with the first tooth of the discharge starwheel at least during a portion of the transfer of the article along the second arcuate guide.

85. The method of claim 84, wherein the first tooth is configured to provide a higher coefficient of friction with the labeled article than that provided by the second arcuate guide, and wherein transferring the labeled article using the discharge starwheel includes reducing a rotational velocity of the labeled article about a rolling axis thereof through engagement of the labeled article with the first tooth.
86. The method of claim 85, wherein the first and second teeth are peripherally spaced from one another a distance that is greater than a diameter of the article defined perpendicular to the rolling axis of the article, and wherein transferring the labeled article using the discharge starwheel includes initially contacting the labeled article intermediate the first and second teeth.

87. The method of claim 84, wherein the discharge mechanism includes a conveyor having a linear velocity, and wherein transferring the labeled article using the discharge starwheel includes decreasing the linear velocity of the article along the direction of the conveyor.

88. The method of claim 87, wherein decreasing the linear velocity of the article along the direction of the conveyor includes decreasing the linear velocity of the article below that of the conveyor.

89. An apparatus, comprising:

(a) a label application station configured to apply labels to a plurality of articles, with successive articles separated by a first separation;

(b) a conveyor configured to transport labeled articles with a second separation that is less than the first separation; and

(c) a discharge starwheel rotably coupled intermediate the label application station and the conveyor, the discharge starwheel including a plurality of teeth defined about a perimeter thereof, each tooth having a profile that decreases the separation between successive articles between the label application station and the conveyor.

90. The apparatus of claim 89, further comprising an arcuate guide disposed opposite the discharge starwheel, the arcuate guide including an infed end proximate the label application station and a discharge end proximate the conveyor, wherein the conveyor is configured to transfer articles at a predetermined linear velocity, and wherein each tooth on the discharge starwheel is configured to decrease the linear velocity of the labeled article along the direction of the conveyor below that of the conveyor proximate the discharge end of the arcuate guide; whereby the conveyor will convey the labeled article from the tooth once the linear velocity of the labeled article imparted by the discharge starwheel falls below that of the conveyor.