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O. A. HITT ET AL

3,407,784

APPARATUS FOR APPLYING FINISHING TO YARNS

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2 Sheets-Sheet 1

FIG. 1

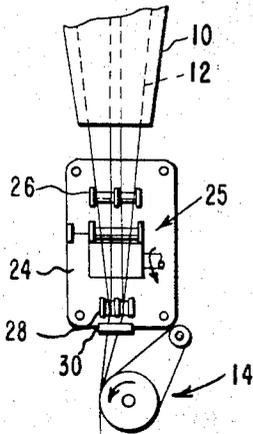


FIG. 2

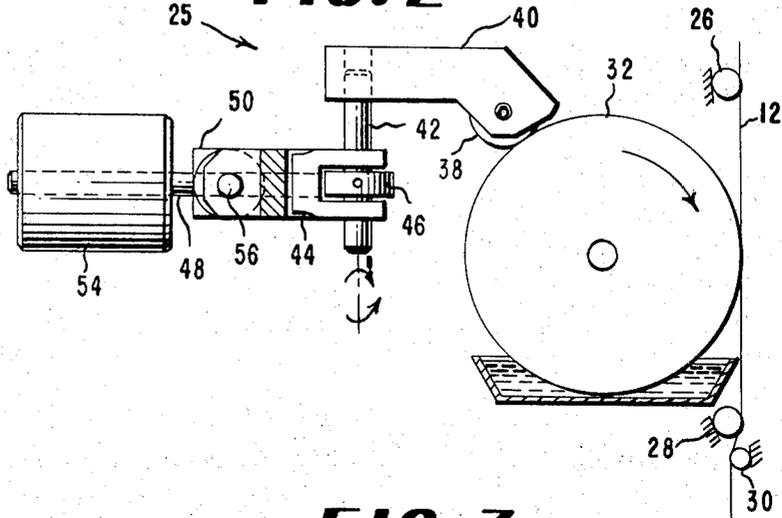


FIG. 3

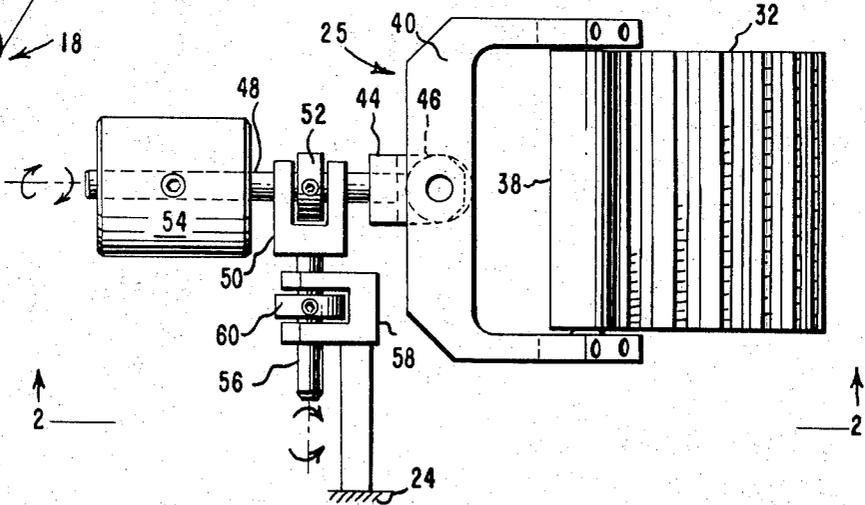
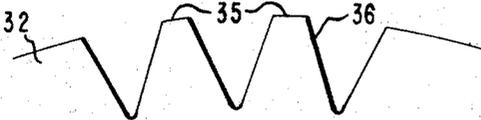


FIG. 4



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FIG. 5

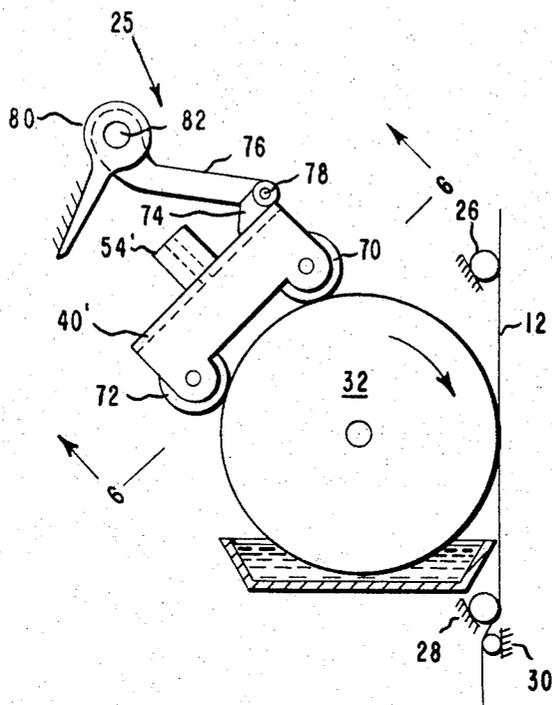
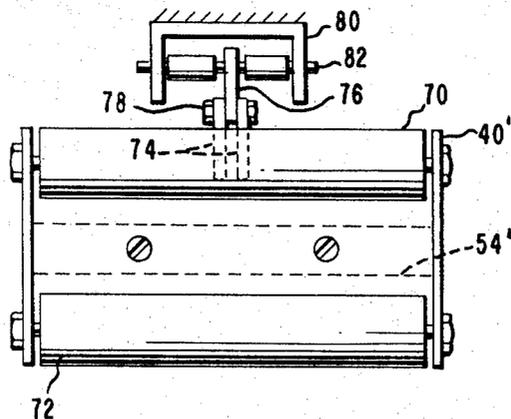


FIG. 6



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APPARATUS FOR APPLYING FINISHING TO YARNS

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ABSTRACT OF THE DISCLOSURE

An apparatus for applying liquid finish to moving filamentary yarns including a driven grooved finish roll partially immersed in a finish solution and an idler roll positioned in rolling peripheral contact with the finish roll. The idler roll is mounted for spacial three-dimensional movement with respect to the axis of the finish roll.

Background of the invention

This invention relates generally to the manufacture of synthetic filaments, yarns, threads and the like and, more specifically, to an apparatus for applying a liquid finish composition to a moving threadline.

In the manufacture of filamentary yarn from synthetic polymers by spinning, it is common practice to apply a liquid finishing composition to the yarn subsequent to solidification and prior to packaging. The finish functions principally to lubricate and protect the filaments from rubbing and abrasive action by contacted surfaces and to hold together the substantially parallel filaments into a cohesive yarn bundle so that it may be satisfactorily processed and packaged.

Normally, finish is applied by advancing yarn in contact with the exposed surface of an applicator roll coated with a thin layer of the liquid finish composition. The contacting surface of the roll may be smooth or roughened, for instance by etching, sandblasting, knurling, etc. The uniformity and thickness of the finish on the surface of the roll can be regulated by means of an idler roll which has freedom of movement toward and away from and is normally in rolling contact with the driven applicator roll such that the weight of the idler roll regulates the uniformity of the finish film prior to application to the yarn.

The prior art finish roll-idler combinations are not capable of compensating for the affects of finish roll eccentricity, askewness of the roll peripheral surface relative to the roll axis and roll surface irregularities and as a result variations in finish film thickness occur both around and across the peripheral surface of the finish roll. In high-level (e.g., above 1%) finish applications to yarns moving at slow speeds these variations in finish film thickness are of little noticeable consequence. However, when such an apparatus is used to apply low-levels of finish, e.g., 1% by weight or less of finish oils (minus diluent), to yarns moving at the high speeds, it is important that the finish film on the finish roll as regulated by the idler roll be very thin and of uniform thickness around the circumference, as well as across the width of the roll or irregularities in finish application result. In coupled, high-speed processes, irregularities in finish application are particularly detrimental since the brief intervals between application of the finish and subsequent yarn treatment such as drawing, heat-stabilizing, texturing, etc., does not permit such migration of the finish within and along the filament bundle to a more uniform level before subsequent processing, as occurs when such filaments are packaged and then subsequently drawn or treated in a separate process. Consequently, these finish

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irregularities lead to a deterioration in yarn quality as evidenced by an increase in frequency of broken filaments, fluctuation in and higher tensions during processing and drawing, variations in denier and greater variations in overall levels of physical properties obtained.

Nonaqueous finish and finish formulations without diluents are difficult to uniformly apply along the threadline at the low finish levels cited above, because the function of the water or diluent as a carrier or distributor of finish is lost. Nonaqueous finish application is also more difficult due to increased viscosity which reduces finish mobility, increases drag on the yarn and increases tendency for yarn adhesion to the finish rolls.

Summary of the invention

An object of this invention is to provide an improved apparatus for applying a liquid finish; either aqueous, nonaqueous or finish concentrates, to filamentary yarns and particularly to provide for more uniform finish application at low levels of finish-on-yarn on yarns traveling at high speeds used in commercial coupled spin-drawing processes for the manufacture of melt-spun synthetic fibers.

The objects of this invention are obtained with a finish applicator for applying a liquid finish to a textile yarn moving at high speed by tangential contact with a driven finish applicator roll partially immersed in a finish bath such that the filament contacting surface of the roll carries a film of finish, the surface speed of said roll being considerably slower than that of the yarn, by the improvement comprising multiple fine radially spaced grooves running axially across the peripheral surface of said applicator roll, guide means for bringing said yarn into contact with the roll periphery such that a plurality of said grooves are spanned by the contacting yarn, said grooves being sufficiently small to retain liquid finish therein by capillary action until coming into successive contact with the yarn, said grooves being dimensional to effect finish flow within groove to yarn, and means for uniformly removing substantially all of said finish from the yarn contacting surface on the roll. By "substantially all" is meant preferably a thickness of less than about 0.005 inch (.13 mm.). An effective means for regulating the finish thickness on the finish applicator roll is by means of at least one idler roll in rolling contact with the filament contacting surface of the applicator roll and means for regulating the contact pressure between said rolls to give the necessary removal of excess finish prior to the applicator roll coming in contact with said yarn. Preferably, the idler roll is axially mounted for rotation in a yoke which is in turn supported by a multi-point linkage connected to a fixed support to provide freedom for three-dimensional spacial movement of the idler roll with respect to the axis of the finish roll, i.e., concurrent lateral and angular movement with respect to the peripheral surface of the finish roll. Means are also provided for weighting (or counterweighting) the idler roll to regulate the pressure of the idler roll against the finish roll.

Groove spacing and dimensions are critical for achieving full potential of this invention. The grooves run substantially perpendicular to the filament contacting path and are spaced uniformly in a parallel relationship around the periphery of said applicator roll with a center-to-center distance of from about 0.004 to 0.30 inch (.10 to 7.6 mm.), have a width at the roll periphery of 0.010 inch to 0.0005 inch (.25 to .013 mm.) with their width being at least about as large as their depth. The narrow limits specified are suitable for the wide range of commercially important yarns which are expected to be used in the practice of this invention. The optimum center-to-center distance between grooves will vary depending on

finish roll diameter, yarn contact angle on finish roll and yarn characteristics such as denier and number of filaments. The center-to-center distance between grooves specified above will affect multichannel finish feed to the moving threadline for finish roll diameter ranging from 2 to 12 inches (50 to 300 mm.) and for contact angles from 3 to 20 degrees. Optimum groove dimensions are a function of yarn denier, number and size of filaments, finish characteristics and yarn to finish roll speed differential. The range of dimensions reported above are advantageously utilized for light denier textile yarns (20 denier), for industrial yarns (800 denier), and carpet yarns (3700 denier).

Brief description of the drawings

FIGURE 1 is a schematic illustration of a process installation into which the finish applicator of this invention has been incorporated.

FIG. 2 is an elevation of the finish applicator of this invention.

FIG. 3 is a top view of FIG. 2.

FIG. 4 is an enlarged partial elevation view of the finish applicator roll.

FIG. 5 is an elevation of another embodiment of the finish applicator of this invention.

FIG. 6 is a front view of FIG. 5 taken along 6—6.

Description of the illustrated embodiments

The process installation chosen for purposes of illustration in FIG. 1 includes a quenching chimney 10 to and through which filamentary yarn 12 is spun from a spinneret. From chimney 10, yarn 12 advances converged or as a converging bundle through a finish applicator assembly. The yarn is advanced by means of a feed roll assembly 14 and advanced in several wraps over a snubbing device 16 by draw roll assembly 18 and traversed onto a package 20. The finish applicator assembly includes support structure 24, a smooth cylindrical guide bar 26, a grooved convergence guide 28, a cylindrical guide 30 and intermediate apparatus 25 which has been detailed in FIGS. 2-4.

With reference to FIGS. 2-4, the intermediate apparatus 25 has a rotatably driven applicator roll 32 which dips into liquid finish contained in pan 34. The filament contacting surface of roll 32 contains a multitude of fine, uniformly spaced, axial grooves 36 (FIG. 4). Yarn guide means 26, 28 and 30 are positioned such that yarn 12 comes into tangential contact with roll 32 and remains in contact for a sufficient distance that it spans a plurality of grooves 36. Idler roll 38 is rotatably mounted on a yoke 40 which is attached to pivot arm 42, which is in turn rotatable in pivot yoke 44 and held therein by locking collar 46 fastened to arm 42.

A pivot arm 48 is attached at its one end to the closed end of the yoke 44 such that the axes of arms 42, 48 are in the same plane and perpendicular to each other. Arm 48 is axially rotatable in pivot yoke 50 and is held in place in the yoke by locking collar 52. A weight 54 is adjustably mounted to the other end of arm 48. A pivot arm 56, attached to the closed end of yoke 50 is axially rotatable in pivot yoke 58 and held therein by locking collar 60. Yoke 58 is fixed to support structure 24 so that the central axis of arm 56 is perpendicular to the plane common to the axes of arms 42, 48, as well as perpendicular to the axis of arm 48. In operation, the contact pressure of idler roll 38 against applicator roll 32 is dependent on the positioning and weight of the adjustable counterweight 54. The three point pivotal mounting (i.e., at pivot yokes 44, 50, 58) of yoke 40 maintains alignment between idler roll 38 and applicator roll 32 by permitting three dimensional spacial movement of the idler roll with respect to the axis of the finish roll. This three dimensional movement is both lateral and angular with respect to the finish roll axis to compensate for the effects of finish roll eccentricity, askewness of the roll

peripheral surface relative to the roll axis and roll surface irregularities thereby providing for the formation of a finish film of uniform thickness both across and around the peripheral surface of the finish roll. The action of idler roll 38 against applicator roll 32 removes all but a very thin film of the finish liquid from the peripheral surface or lands 35 of the latter. This prevents or limits formation of finish ridges, pools, or irregularities in the finish film thickness from occurring around the filaments or yarn by lateral movement of the yarn across the face of the roll by liquid surface tension and by the viscous drag of the yarn through a liquid film. Such irregularities in finish film thickness on the moving threadline cause gross variations in finish pick-up, particularly at very low levels of finish applications. On the other hand, if the film thickness is permitted to become too thin on a smooth roll, when the yarn is moving at high speed there is tendency to wipe the roll surface dry, again resulting in irregularities of finish pick-up and in yarn tension variations caused by intermittent dry roll friction. Such application of finish independently from multiple grooves acting as finish reservoirs greatly facilitates a more constant uniform application of finish to the threadline.

In another embodiment of the intermediate apparatus 25, shown in FIGS. 5 and 6, a pair of axially parallel idler rolls 70, 72 are rotatably mounted on a yoke 40' which is attached to a second link 76 by means of a bolt 78. Link 76 is connected to fixed support 80 by means of pin 82. A loose fit is provided between bolt 78 and links 74, 76 as well as between pin 82, link 76 and support 80 providing a three point linkage that permits three-dimensional spacial movement of idler rolls 72, 74 with respect to the axis of finish roll 32. This three-dimensional freedom for movement along with the two point contact with the peripheral surface of the finish roll provided by idler rolls 70, 72 mounted in yoke 40' facilitates parallel alignment of the idler roll axis with the finish roll axis. Weight 54' fastened to yoke 40' is of sufficient magnitude to maintain contact between the idler rolls and the finish roll.

Maximum beneficial results with the disclosed apparatus at finish application levels of less than 1%, are generally obtained with a finish film of less than 0.005 inch (.13 mm.) on the face or land surfaces of the finish roll. For light denier textile yarns even thinner films are preferred. Consequently, the tolerances required to uniformly maintain these requirements makes fabrication of the apparatus quite critical, particularly for multiend finish application to several threadlines over a single applicator roll. It is found the finish film thickness should remain uniform within 0.005 inch (.013 mm.).

To achieve this degree of uniformity, mounting of the idler roll in a manner which permits three-dimensional freedom for it to follow the surface of the applicator roll and thereby minimize affects of roll eccentricity, askewness relative to roll axis and roll surface irregularities has been found most effective.

Other means of limiting and maintaining a uniform finish film thickness can be employed. For example, the idler roll can be replaced by a doctor blade mounted in a similar manner. However, because of the greater friction and wear thus created, a rotating idler roll is preferred.

The dimensions and uniformity of the axial grooves 36 in the surface of the applicator roll 32 are critical for maximum product uniformity. The optimum dimensions are dependent upon each yarn count, yarn-speed to finish-roll speed differential, denier, number of filaments, filament configuration and finish composition employed. The grooves must be fine enough to retain or remain essentially filled with the finish composition by capillary action or surface tension until coming into contact with the yarn. The yarn riding across the top of the grooves provides sufficient attraction to the liquids that finish flows along the grooves to the yarn thus providing a supply of

finish for a greater period of time than is achieved by pick-up of finish from a smooth or randomly roughened surface. For textile yarns which cover the general denier range of 15 to 260 denier and filament deniers from about 1 to 20, preferred groove dimensions are from about 0.01 to 0.002 inch (.25 to .05 mm.) wide by 0.01 to 0.001 inch (.25 to .05 mm.) deep. For example, for a 70 denier 34 filament nylon yarn traveling at greater than 800 yards per minute and an aqueous base finish having a viscosity of less than 15 centipoises, grooved dimensions of 0.003 inch wide (.075 mm.) and 0.0017 inch deep (.043 mm.) with a center-to-center distance of 0.008 inch (.20 mm.) are found to be highly effective.

Groove spacing is important. A plurality of grooves in contact with the yarn is needed for best uniformity. Consequently, narrow spacing between grooves is desirable to effect this multifeed characteristic while maintaining a minimum roll contact distance to minimize drag on the threadline. Groove spacings are preferably between 0.004 and 0.30 inch (.10 to 7.6 mm.), depending on roll diameter yarn denier, groove dimensions, etc. A yarn contact angle of 7° with a 4-inch (10.16 cm.) diameter roll is appropriate and spacings of 0.008 to 0.012 inch (.20 to .30 mm.) have been found suitable.

Groove shape is not a limiting factor. While a V-shaped groove (FIG. 4) is generally preferred because of ease of fabrication and flow pattern, U-shaped or other shapes are suitable.

The grooves do not need to traverse the entire width of the applicator roll. The grooved surface of uniform width may be bordered by a smooth region on the roll periphery; the grooved width being adjusted to give the desired yarn contact area and amount of finish application. The applicator roll may have a plurality of such grooved surfaces, with smooth peripheral regions between, when it is desired to apply finish to more than one yarn end using a single applicator roll. Separation of the grooved contact surfaces for each yarn end provides better control and separation of each yarn contact area on the roll and also better control of finish application independently to each yarn.

The applicator rolls may be manufactured from any suitable wear resistant material such as ceramics or hardened materials as ALSiMag, Crystallon and other well-known materials for such applications. Wear resistance of the idler roll is not so critical and it may even be composed of suitable machined plastic materials such as nylon or poly(oxymethylene).

The pressure between the idler roll and the applicator roll in general need only be moderate, for example usually less than about 3.0 pounds (.136 kg.) for a four inch (10.16 cm.) wide roll. Higher pressures may be used but greater wear is thereby introduced.

The idler roll location must facilitate removal of the excess finish without contacting the threadline and without periodically permitting irregularities or a wedge of liquid to come to the filament contacting area. Preferably the applicator roll is of greater diameter than the idler roll. Use of a larger diameter for the applicator roll permits reduced angular deflection of the yarn across the roll while permitting contact with a greater number of grooves thus minimizing drag upon the threadline during application. The rotational speed of the applicator roll must be sufficiently fast to insure a continuous supply of finish to the threadline. Excessively high speeds magnify roll eccentricities, etc. Commonly used rotational speed is from 7 to 90 revolutions per minute, preferably 12 to 20, with yarn speeds of up to and exceeding 800 yards per minute.

The apparatus of this invention has permitted the manufacture of filaments at speeds up to and greater than 900 yards per minute with finish levels less than 0.5% by weight on yarn, the product having improved along-end denier uniformity, draw tension level and uniformity,

interlacing levels and uniformity, and along-end dye uniformity.

The use of this finish applicator is not limited to the application of a primary finish immediately after spinning. Its benefits can also be realized for applying a secondary finish, for example after-heat stabilization subsequently to drawing, or prior to a texturing or interlacing operation and so forth in a continuous spin-drawing process.

The improved finish application has been found to be an advantage not only when applied to undrawn yarns but also for application of a secondary finish to a drawn yarn immediately after heat stabilization in continuous processing. Its advantages have also been found for application to undrawn filaments when they have been converged prior to contacting the finish roll as well as for post-convergence.

Continuous process steps shown in FIG. 1 in addition to the drawing step shown may also include, prior to packaging, a second drawing step, heat-setting or heat-stabilization, relaxing application of a secondary finish, interlacing, texturing, etc. Accordingly the finish applicator disclosed herein is particularly advantageous in a coupled spin-draw process and particularly wherein a necessary characteristic of the initial finish is undesirable in the end product, thus making the application of a low level of finish on yarn highly desirable. Thus this apparatus facilitates the manufacture of filaments at higher spinning speeds with lower finish-on-yarn levels to give highly uniform products.

Variations and modifications of the illustrated finish applicator will occur to those skilled in the art without departing from the spirit of this invention which accordingly is intended to be limited only by the scope of the appended claims.

What is claimed is:

1. In a finish applicator for applying liquid finish to moving filamentary yarns including an axially mounted driven applicator roll partially immersed in a finish solution to apply a film of finish to the peripheral surface of the applicator roll and guide means for bringing the yarn into tangential contact with the peripheral surface, an apparatus for regulating the thickness of the film on the peripheral surface, said apparatus comprising:

at least one idler roll normally positioned in rolling peripheral contact and parallel axial alignment with said applicator roll, said peripheral contact being radially spaced from said tangential yarn contact, said peripheral surface being provided with a plurality of radially spaced lateral grooves.

2. In a finish applicator for applying liquid finish to moving filamentary yarns including an axially mounted driven applicator roll partially immersed in a finish solution to apply a film of finish to the peripheral surface of the applicator roll and guide means for bringing the yarn into tangential contact with the peripheral surface, an apparatus for regulating the thickness of the film on the peripheral surface, said apparatus comprising:

(a) a fixed support adjacent said applicator roll;

(b) at least one idler roll normally positioned in rolling peripheral contact and parallel axial alignment with said applicator roll, said peripheral contact being radially spaced from said tangential yarn contact;

(c) a yoke axially mounting said idler roll for rotation; and

(d) a multipoint linkage connected between said yoke and said support, said linkage providing freedom for three-dimensional spacial movement of said idler roll with respect to the peripheral surface of said applicator roll, said peripheral surface being provided with a plurality of radially spaced lateral grooves.

3. The apparatus of claim 2 wherein said three-dimensional movement of said idler roll is lateral and angular with respect to the axis of the applicator roll.

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4. The apparatus of claim 2 wherein is provided means connected to said yoke for regulating the force exerted by said idler roll on said applicator roll.

5. The apparatus of claim 2 wherein said grooves are V-shaped and equispaced radially.

6. In a finish applicator for applying liquid finish to moving filamentary yarns including an axially mounted driven finish applicator roll partially immersed in a finish solution to apply a film of finish to the peripheral surface of the roll and guide means for bringing the yarn into tangential contact with the peripheral surface, an apparatus for regulating the thickness of the film on the peripheral surface, said apparatus comprising:

(a) a fixed support adjacent said finish applicator roll;

(b) a pair of spaced idler rolls normally positioned in rolling peripheral contact and parallel axial alignment with said finish applicator roll, said peripheral contact be radially spaced from said tangential yarn contact, the peripheral surface of said finish applicator roll being provided with a plurality of radially spaced lateral grooves;

(c) a yoke axially mounting said idler rolls for rotation; and

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(d) a three point linkage connected between said yoke and said support, said linkage providing freedom for three-dimensional spacial movement of said idler rolls with respect to the peripheral surface of the finish applicator roll.

7. The apparatus of claim 6 wherein is provided means fastened to said yoke for regulating the force exerted by said idler rolls on said finish applicator roll.

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