

[54] APPARATUS FOR THE TREATMENT OF YARN

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226/118; 226/168

[51] Int. Cl. B65h 25/04; B65h 17/32

[58] Field of Search 226/44, 93, 94, 95, 96,
226/97, 113, 118, 119, 168, 170, 74, 80, 81,
193; 29/120; 28/1.4

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Primary Examiner—Richard A. Schacher

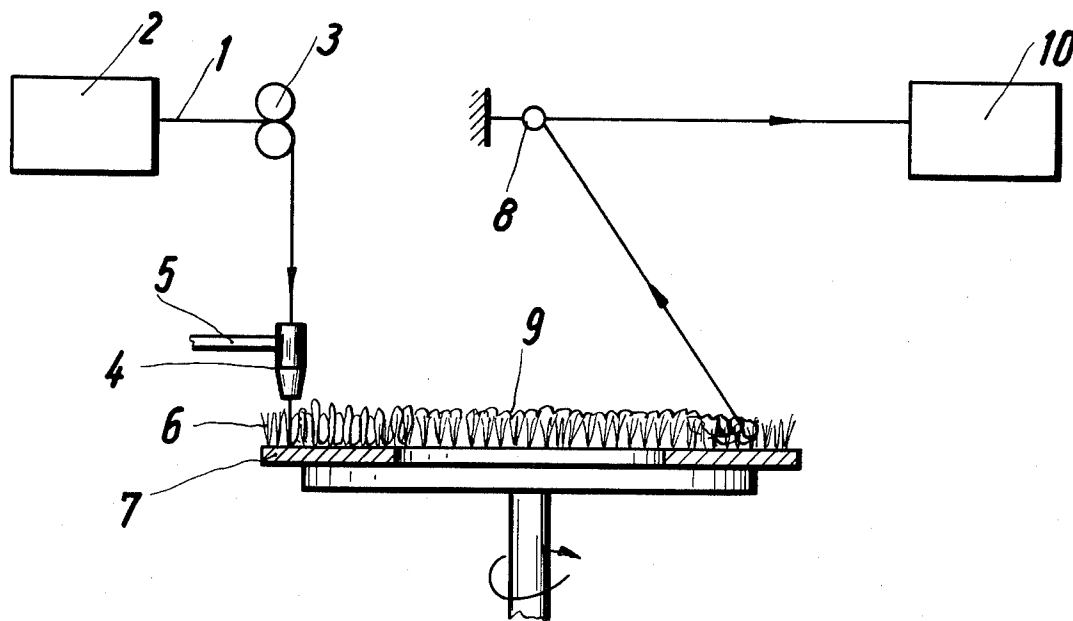
Attorney, Agent, or Firm—Karl F. Ross; Herbert
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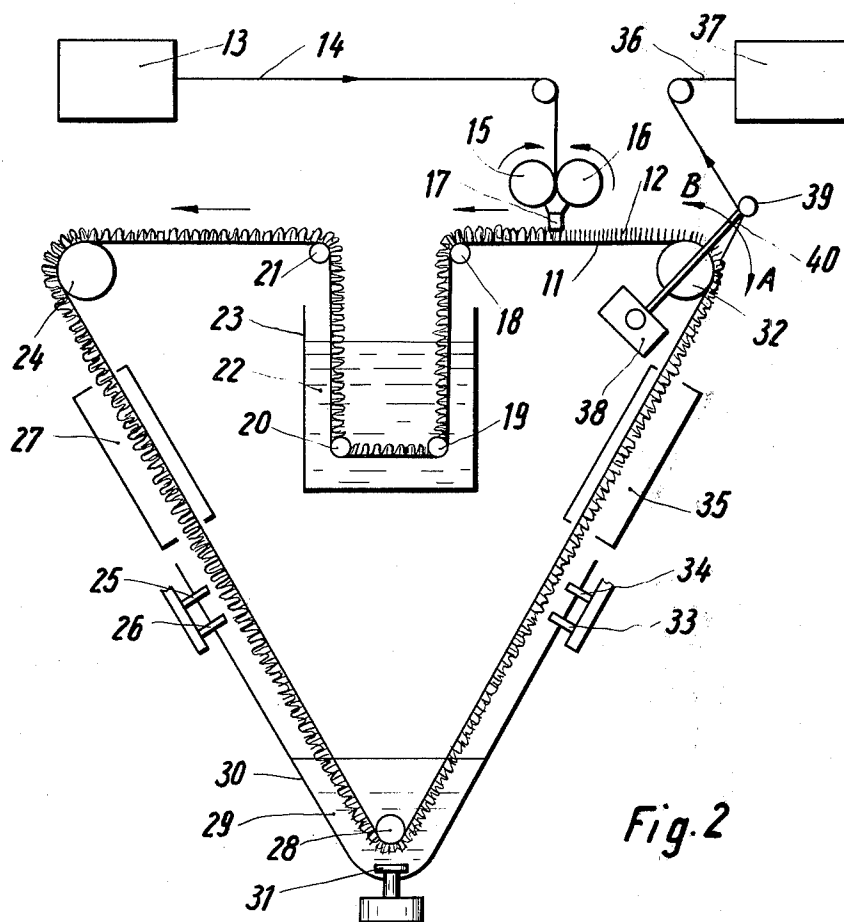
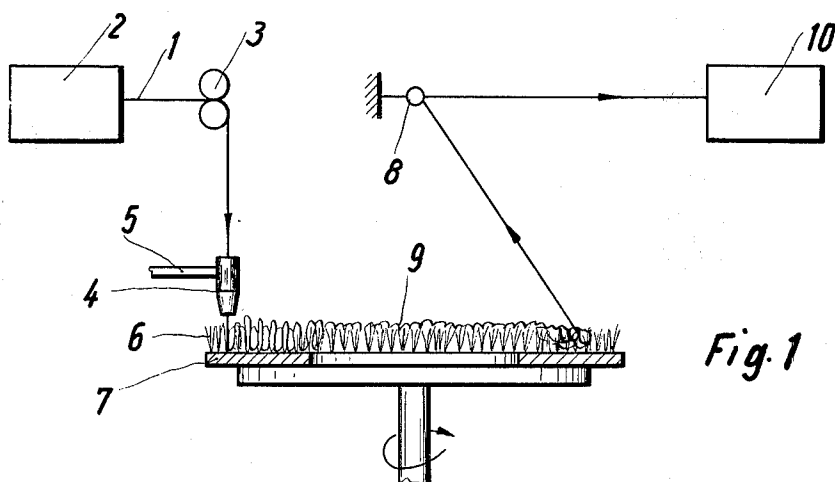
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ABSTRACT

An apparatus for the treatment of yarn comprises, between a yarn-supply device and a yarn-takeup device, a yarn-storage surface which is rotated or otherwise displaced along a closed transport path and is provided with means accessible to a fluid and to the yarn upon which the latter is laid. The last-mentioned means may include bristles, a roughened surface, a perforated surface under suction or the like upon which the yarn, advantageously in the form of loops, is retained substantially tensionfree over part of a closed travel path of the surface.

21 Claims, 27 Drawing Figures





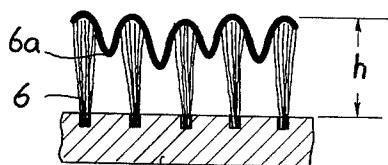


FIG. 1A

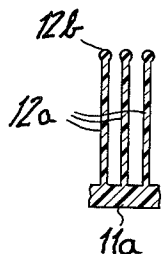


FIG. 2B

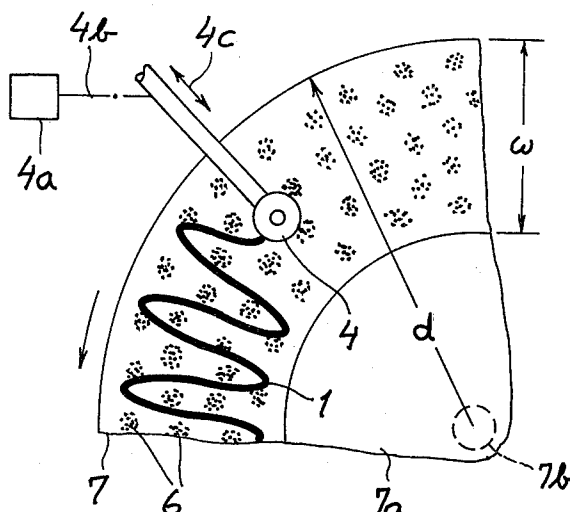


FIG. 1B

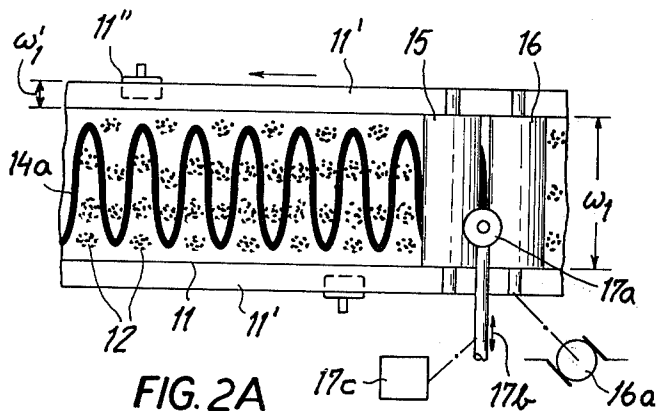


FIG. 2A

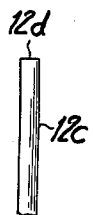


FIG. 2C



FIG. 2D

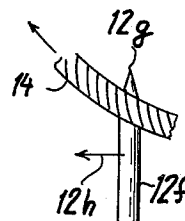
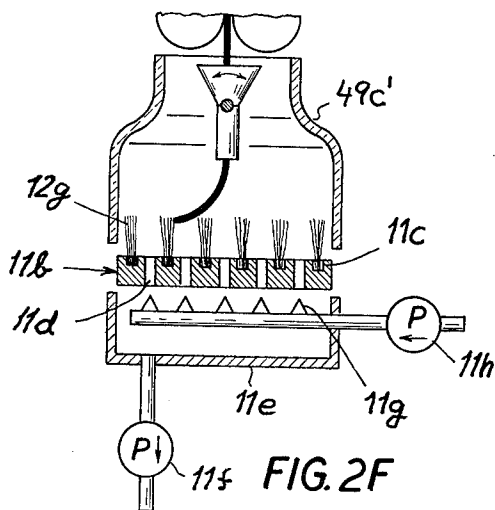
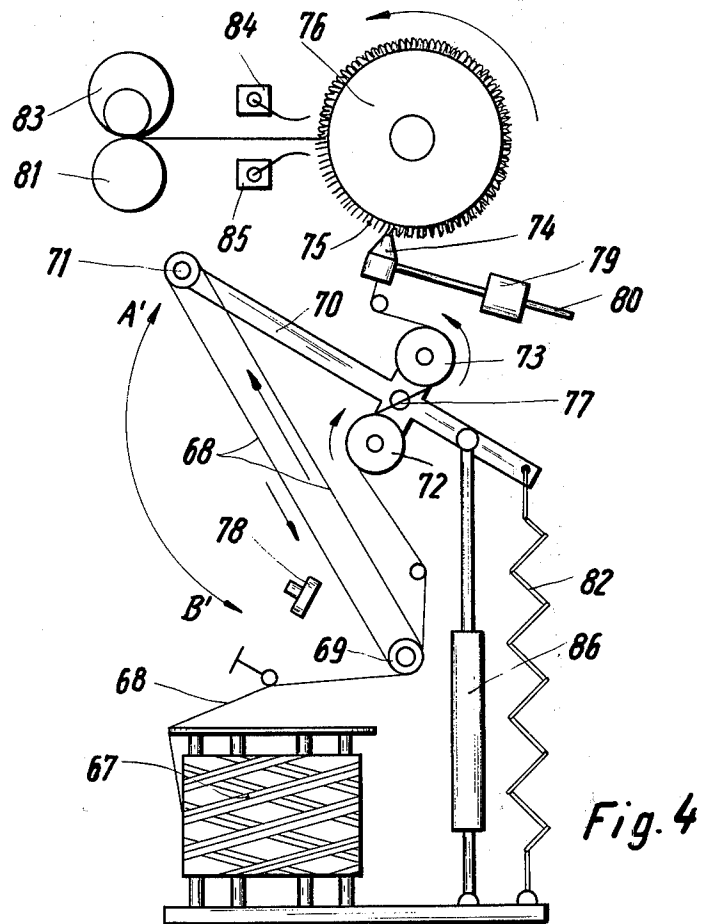
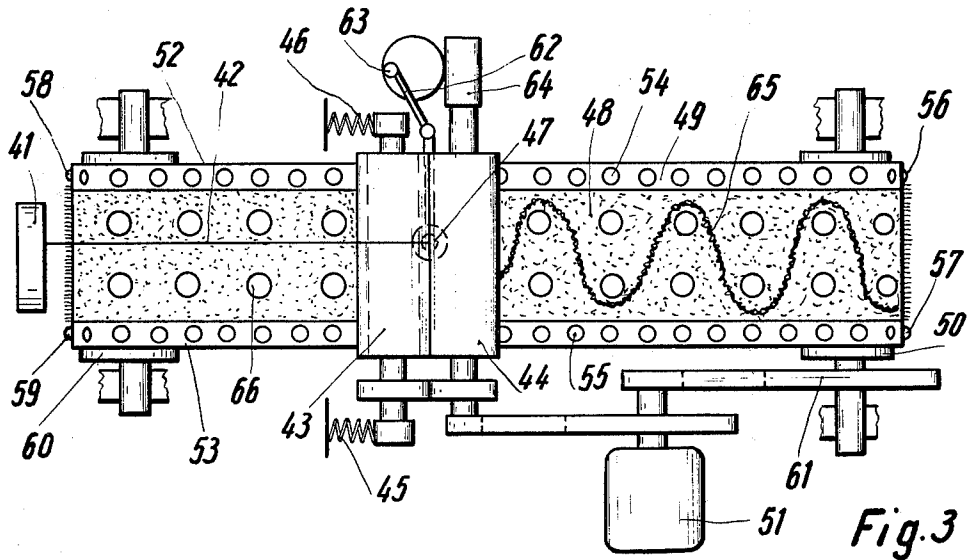


FIG. 2E





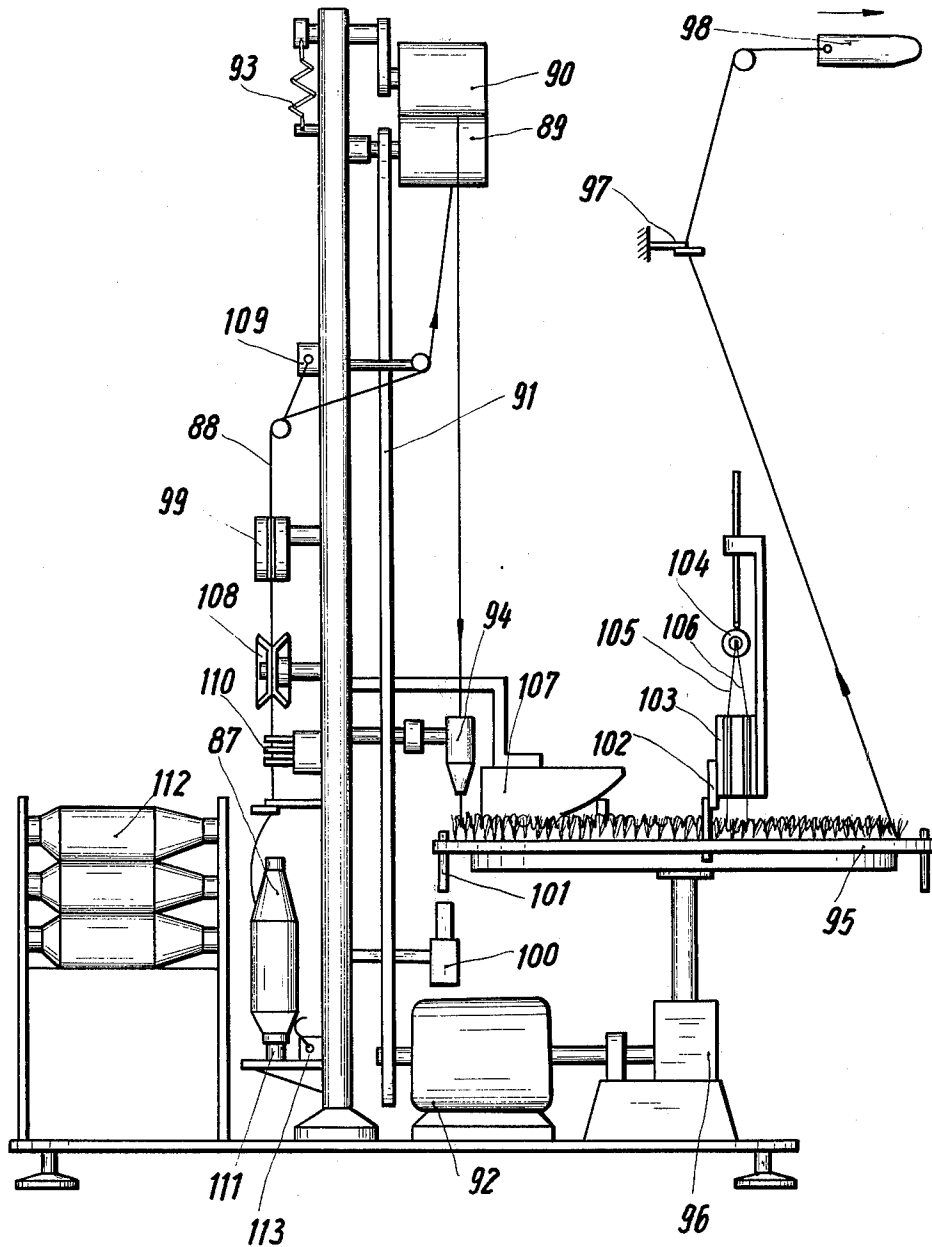


Fig. 5

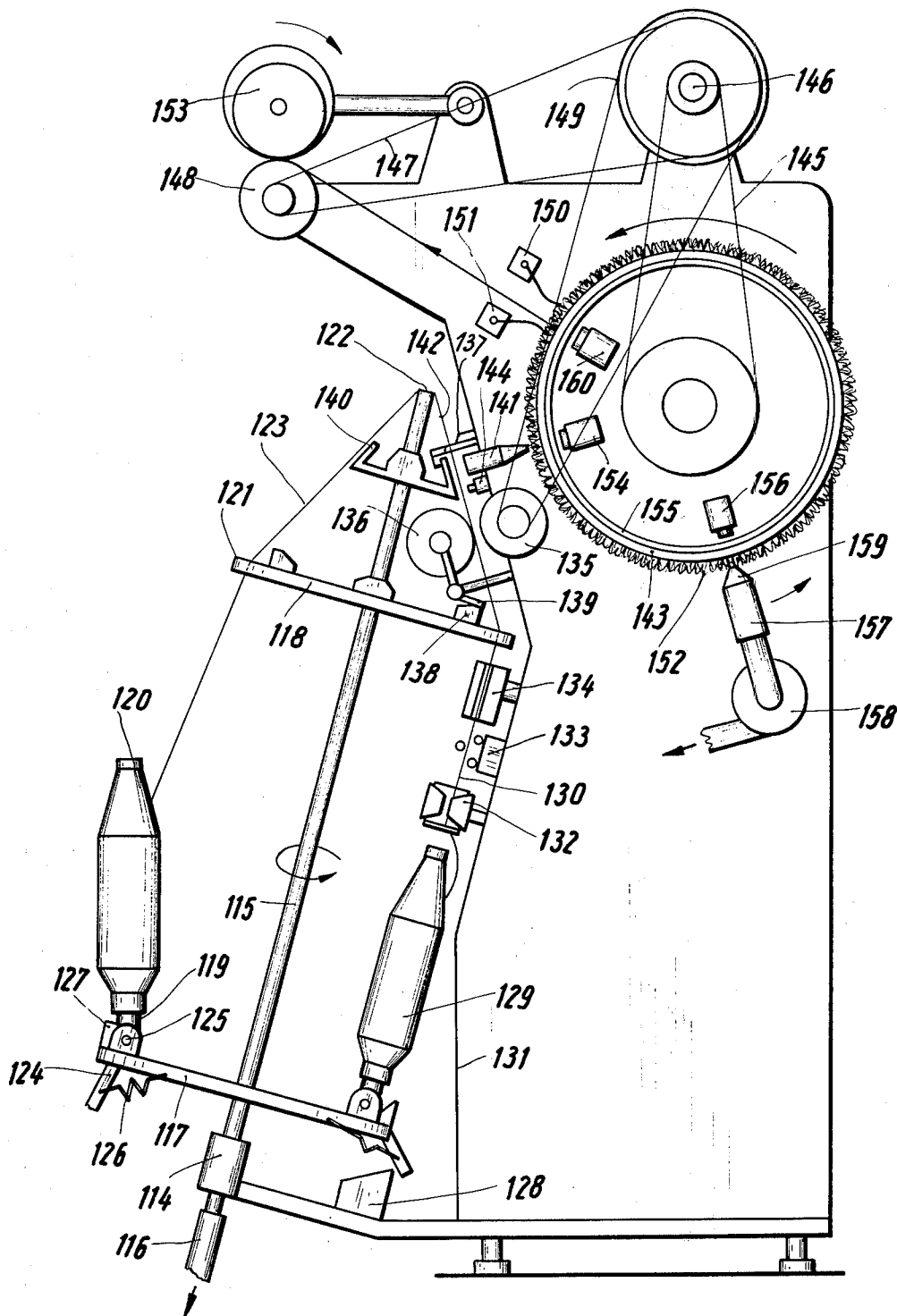
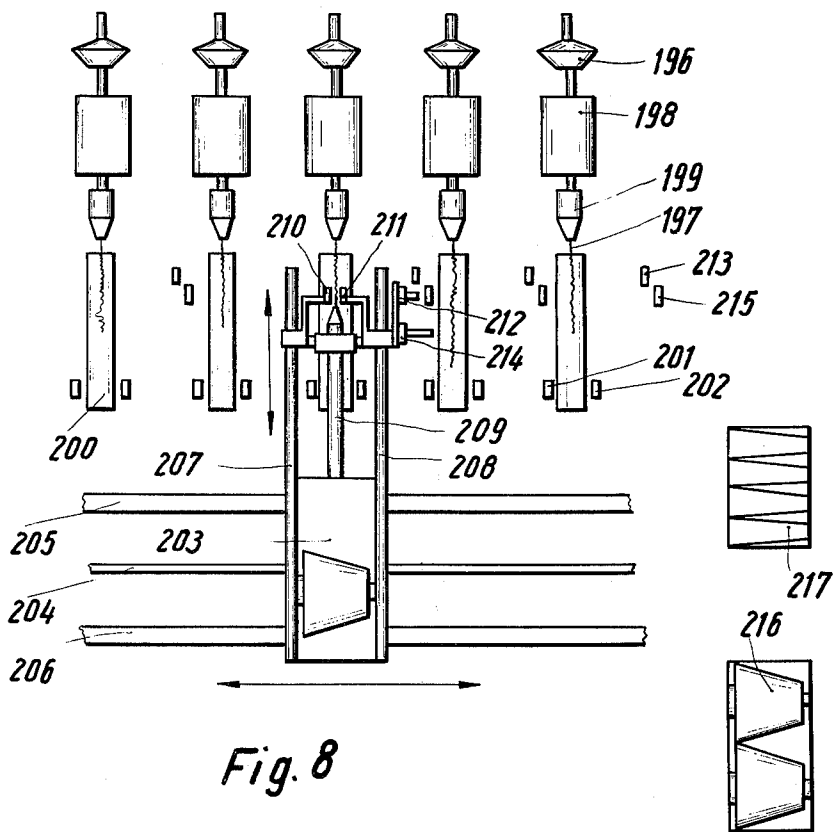
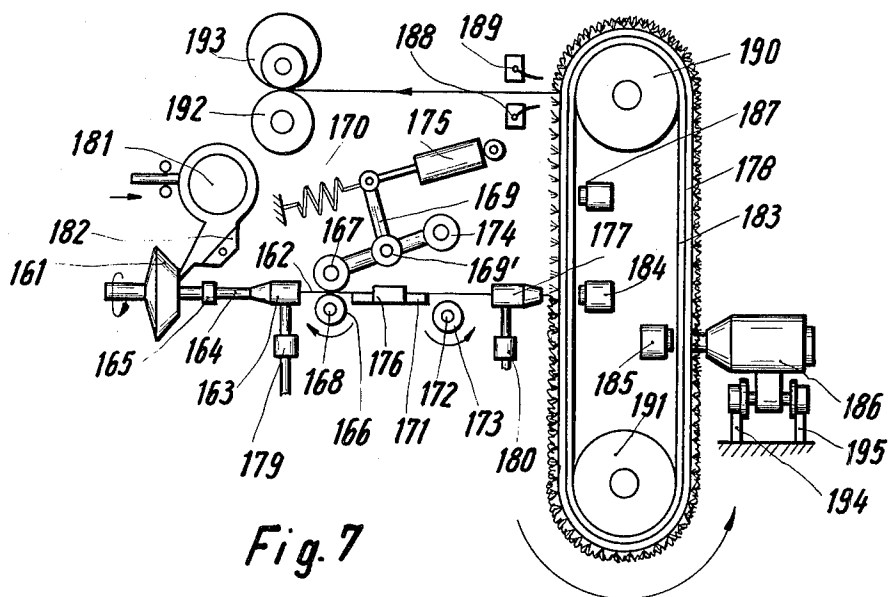
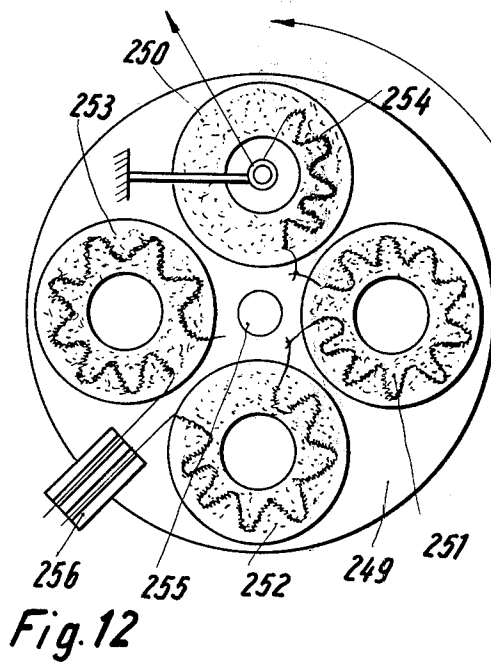
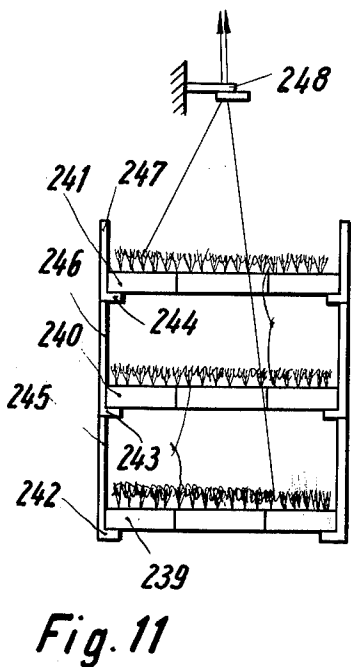
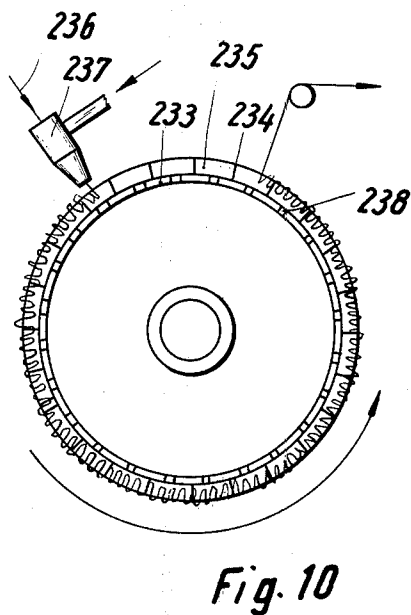
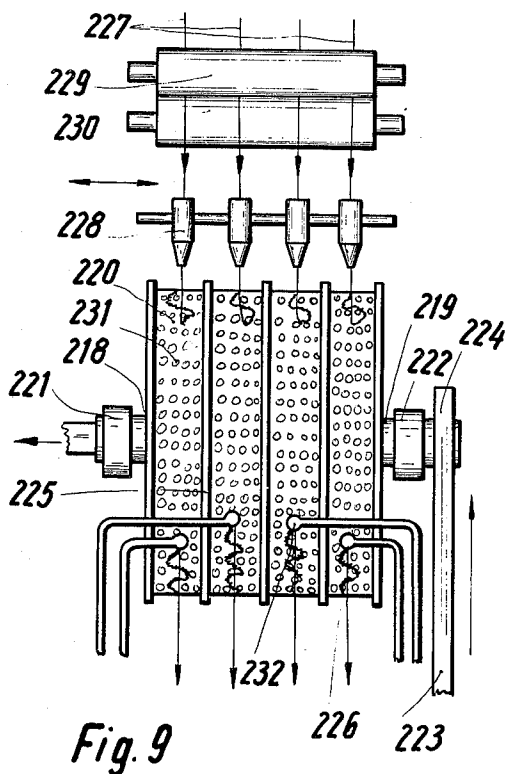


Fig. 6





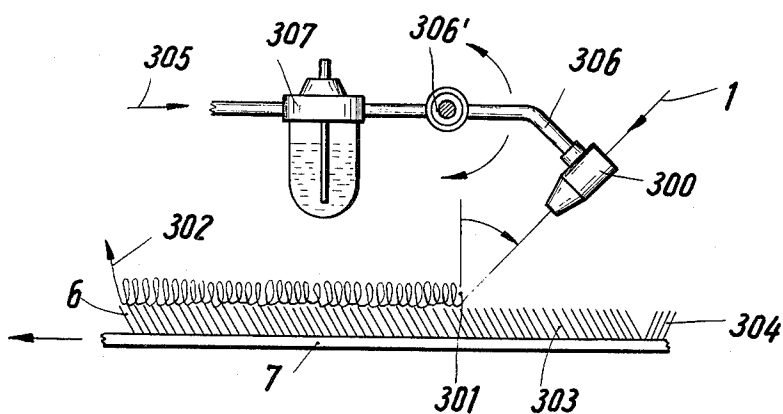


Fig. 13

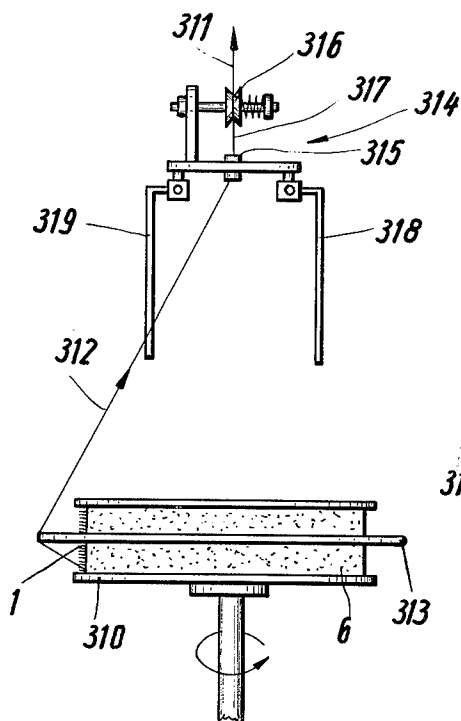


Fig. 14

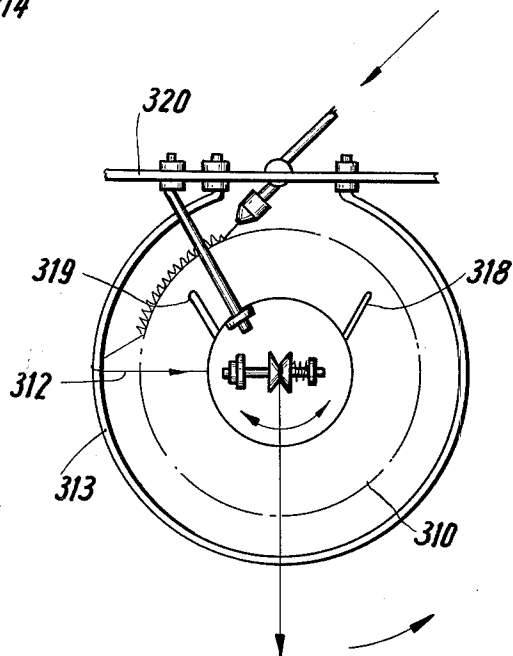
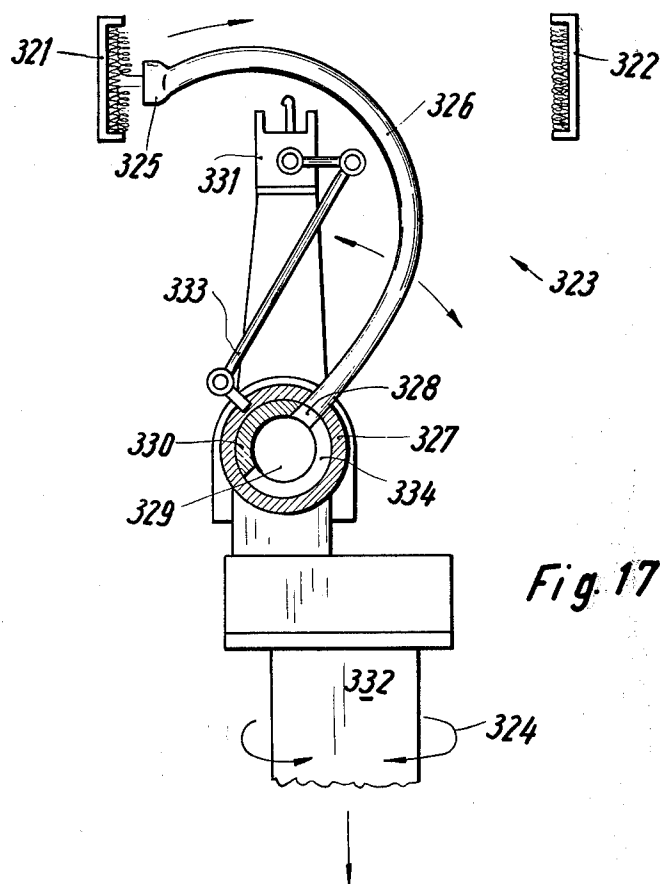
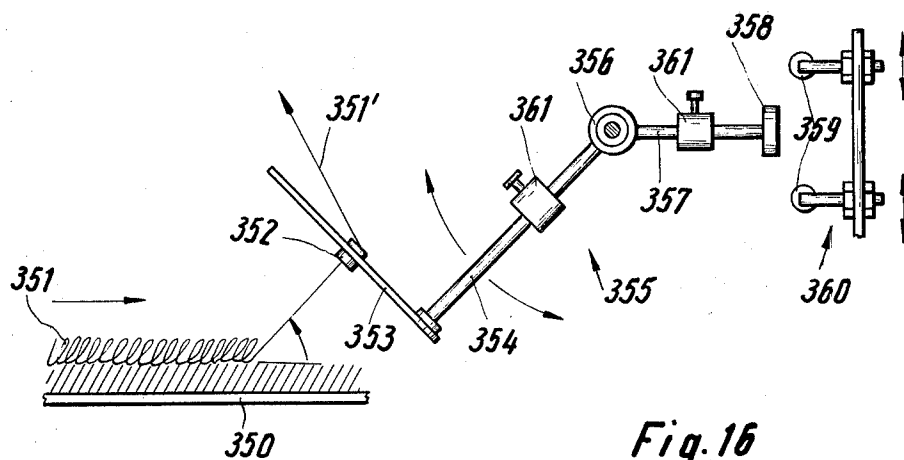


Fig. 15



APPARATUS FOR THE TREATMENT OF YARN

FIELD OF THE INVENTION

The present invention relates to an apparatus for the treatment of yarn and, more particularly, to a system, disposed between a yarn-supply device and a yarn-takeup device, for temporarily storing a large quantity of yarn and advantageously subjecting the same to a continuous treatment.

BACKGROUND OF THE INVENTION

In the treatment of yarn, a number of processes must be carried out thereon, generally with the aid of a fluid which can be a liquid or gas. For the purpose of the present invention, the term "yarn" is intended to refer to unspun or spun or twisted filamentary material, preferably containing a number of filaments but also including a single filament, to slub, sliver and roving, and includes a twisted thread or a thread precursor (untwisted or partially twisted plys) adapted to be incorporated into a fabric or like structure by weaving, knitting, crocheting or knotting.

In general, yarn as defined above is subjected to a number of treatments from the time the filaments are first gathered or produced and the time at which the thread is incorporated into the final structure, with fluids such as hot air or steam (as representative of gaseous fluids) or with such liquids as organic solvents, water and the like containing dyestuff, textile-finishing chemicals, detergents and the like. Typical treatments are dyeing, cleaning, dye-setting and impregnation with synthetic resins, antistatic compounds, fabric softeners and the like. Even drying and heat-setting, thermal crimping and the like, in which the yarn is subjected to heated air or vapors, are to be considered yarn treatments in accordance with the present principles, as are yarn plying, spinning, twisting and like yarn handling procedures.

It has been proposed to carry out yarn treatment with a fluid substantially continuously by admitting the yarn to one end of a generally cylindrical treatment vessel through which the yarn passes and in which the treating fluid surrounds the yarn. The yarn is withdrawn from the other end of the vessel which must have a length commensurate with the treatment duration. Furthermore, such devices have only proved to be successful for the treatment of yarn with gases since the presence of liquids within the vessel may interfere with physical characteristics of the yarn. Devices of this type have also proved to be unsatisfactory when the yarn is not self-supporting, i.e. when even gravitational action upon the yarn produces a tension which may bring about separation or breakage. The capacity of such devices is also relatively small for a given available space and it is frequently a problem that, within the cylindrical chamber, some compaction of the yarn occurs to prevent completely uniform treatment.

In order to increase the capacity of machines for the treatment of yarn, it has been proposed to automate the process especially from the spinning of the yarn into thread to the incorporation of the thread into woven, knitted or knotted fabric. These systems have the disadvantage that large machines are required with high capital expenditure and generally are not satisfactory in many respects. For example, between the spinning and fabrication stages, the yarn must undergo a number of steps including:

- a. the spinning of the yarn upon a traveling-ring or open end (OE) machine,
- b. the respooling of the spun yarn from the cops or bobbins or OE spools into soft dyeing coils or hanks with simultaneous cleaning of the yarn,
- c. the dyeing of the yarn coils and drying of the dyed coils,
- d. the respinning and/or or plying of the dyed yarn for a subsequent twisting step,
- e. the respooling of the yarn from the twisting bobbins onto conical cross-wound spools or yarn packages, and
- f. the rewinding of the yarn from the cross-wound spools or yarn packages onto shuttle bobbins for weaving in shuttle looms or upon appropriate bobbins for use in shuttleless looms.

OBJECT OF THE INVENTION

It is the principal object of the present invention to provide an improved system for the treatment of yarn whereby discontinuities which have hitherto characterized yarn-treatment systems can be obviated.

It is another object of the invention to provide a method of and an apparatus for the treatment of yarn which enables the treatment and yarn processing to be carried out substantially continuously.

Still another object of the invention is to provide a yarn-treatment apparatus having improved yarn-storage capacity and adapted to obviate the disadvantages, both in terms of cost and efficiency, of earlier systems.

It is also an object of the invention to provide improved yarn-storage means between a yarn-supply device and a yarn-takeup device, preferably wherein the first is a yarn-forming station and the latter is a fabric-forming station whereby the treatment of the yarn between the two stations is simplified.

SUMMARY OF THE INVENTION

These objects and others which will become apparent hereinafter are attained, in accordance with the present invention, by providing between a yarn-supply device and a yarn-takeup device a yarn-storage arrangement having a moving open or exposed (accessible) surface upon which the yarn is disposed and which is so designed as to allow substantially free allaround contact of the yarn with a treating fluid while supporting the yarn against mechanical stress (i.e. without tension) while the yarn is on the surface. Thus, a critical characteristic of the yarn-receiving surface is that it supports the yarn tensionlessly while affording substantially free access of a fluid to all parts of the supporting surface and to the yarn carried thereby while mechanically retaining the yarn with an adhesive-like or tentacle engagement so that the yarn, freely disposed upon this surface, will adhere thereto until it is withdrawn at a location downstream (in the direction of movement of the surface) from the location at which the yarn is disposed upon the surface.

According to a feature of the invention, the yarn-receiving surface is provided with closely spaced upstanding projections (tentacles) upon and between which the yarn is permitted to fall freely in loops with the yarn bodies supported at spaced-apart locations by the free ends of the projections such that the yarn can hang freely between the projections, or between which the yarn is disposed upon slight deflection of the bris-

ties. Since the projections may be relatively closely spaced, these loops in the yarn do not apply any significant stress thereto.

More particularly, the projections are bristles of a brush surface and the yarn-storage surface may be a brush-disk, band or conveyor, or drum having an exposed or outer surface which is continuously driven along an endless path and upon which, at a relatively upstream location along this path, the yarn is freely disposed upon the surface while, at a location downstream of this first location, the yarn is taken up from the brush surface.

It has been found to be desirable to conduct the yarn onto the adherent surface of the yarn-storage device by entraining it in a fluid which, of course, may be a yarn-treatment fluid, and for this purpose the yarn-deposition means at the first location may comprise a nozzle through which the yarn passes and into which a compressed fluid or a fluid otherwise pressurized (e.g. compressed air or steam) is admitted to surround the yarn and entrain it through the aperture of the nozzle while preventing severe frictional contact between the internal faces of the nozzle and the yarn. The nozzle may temporarily deflect the tentacles to seat the yarn between them.

While the brush configuration of the surface is preferred, as noted, other adhesive means can be provided to temporarily retain the yarn upon the surface. Such means may include a honeycomb configuration of the receiving surface such that the yarn loops are received in cells of the honeycomb, a multiplicity of perforations subjected to subatmospheric pressure (i.e. suction) so that the yarn is drawn against the receiving surface, magnetic portions of the receiving surface adapted to attract the yarn when the latter has been permeated with magnetic particles (the magnetic particles being removed subsequently upon removal of the yarn from the storage surface), or simply a roughened, felted, sawtooth (serrated) or other surface to which the yarn tends to adhere under its own weight and can be removed only by drawing the yarn away from the surface.

The system of the present invention can be provided between any two stages of a yarn-handling system and can be disposed between yarn formation and fabric-forming stages. Preferably it is provided between the spinning station and the fabric-forming operation and/or takes part in the spinning operation, as will be apparent hereinafter. The system can thus be used in the following way:

a. the yarn produced by open end spinning or emerging from a multiplicity of open end centrifuges can be simultaneously cleaned and wound upon a conical cross-wound package.

b. Between the spinning station and the winding station (and even prior to spinning, if desired) the yarn may be subjected to fluid treatment (i.e. continuously dyed), can be plied and twisted in a single operating step.

c. The coiling of the yarn subsequent to a treatment, as described above, or its delivery to the fabric-forming station without recoiling and yet without interruption of the fabric-forming operation which can be of the shuttleless type.

An important advantage of the present invention is that the yarn-supply device (sliver-forming, spinning or uncoiling mechanism) and the yarn-takeup device (e.g. continuously supplying yarn to a loom) may operate at

vastly different speeds so that the yarn accumulated upon the storage surface is a function of the speed difference. For example, it has been found to be necessary with looms of the shuttle type or of the shuttleless type to supply a weft cop or bobbin, and when the bobbin is empty, to replace the bobbin while substituting another bobbin by a complex mechanism. The reason for this complex system is that it is impossible with conventional systems to tie the thread end from a fresh bobbin to the trailing end of the previous bobbin without temporarily interrupting the loom operation. With the present system, however, the yarn-storage surface may supply yarn continuously to the loom while the trailing end of one length of yarn is knotted to the leading end of another length in the interval during which the first length continues to be drawn from its yarn storage surface.

The present invention permits yarn which is twisted or spun in a traveling-ring spinning device or an open end spinning device to be treated continuously, i.e. cleaned and plied, without interrupting the spinning operation and even permits the twisted and treated yarn to be fed continuously to the fabric-making machine without winding upon a yarn package or spool.

It has also been mentioned previously that the yarn-storage system, according to the present invention, permits the two machines between which the yarn-storage device is disposed to operate at vastly different speeds and even permits operation of one of the devices to be interrupted, for a greater or lesser time period, while the other continues to operate, the receiving surface merely accepting additional yarn or dispensing additional yarn during the interrupted service of one of the devices.

According to still another feature of the invention, the location of a defect in the yarn is indicated upon the yarn carrier or transport device and this location is sensed at a point downstream of the yarn-disposing means by an appropriate detector, the yarn is taken up at this location and knotted to eliminate the defect which may be an interruption in the continuity of the yarn or simply a defective length thereof which may be cut away concurrently with knotting.

The treatment may be mechanical, thermal, or chemical and may take place in addition to or in the absence of the defect-monitoring operation previously mentioned.

The receiving surface may be composed of a velvet-velour, slit fabric or looped or roughened fabric, may be simply a roughened or perforated plate, may be composed of metal, synthetic resin or wood, may have a metallic or synthetic resin surfacing coated, may be comprised of metal or synthetic resin wire mesh, may be composed of carding needle arrays, needle bars, needle strips or the like, or may be formed with sawtooth or serrated members.

According to another feature of the invention, the yarn is drawn from one or more receiving surfaces through a yarn guide located thereabove and associated with a thread clamp such that the thread, between the thread guide and the thread clamp, is only slightly tensioned. The yarn is thus easily drawn from the receiving surface and the movement of the various parts can be controlled readily.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages

tages of the present invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a side-elevational view of a storage device according to the invention provided between two yarn machines and provided with a storage surface upon a rotating disk;

FIG. 1A is a detail view, drawn to a larger scale and representing a section through the disk of the diagrammatically illustrated device of FIG. 1;

FIG. 1B is a plan view of a portion of the device of FIG. 1;

FIG. 2 is a diagrammatic side-elevational view, partly broken away, of a yarn-storage system using an endless belt as the receiving surface, for the continuous treatment of yarn;

FIG. 2A is a fragmentary plan view of a portion of the device of FIG. 2;

FIG. 2B is a vertical section through a portion of the bar of FIG. 2 showing one configuration of the bristles thereof;

FIGS. 2C through 2E are elevational views showing other bristle configurations for use in any of the systems described herein in which resiliently deflectable bristles are used;

FIG. 2F is a vertical section taken in a plane perpendicular to the plane of the paper in FIG. 2 and illustrating a modification thereof according to the invention;

FIG. 2G is a fragmentary plan view of another modification;

FIG. 3 is a plan view of a yarn-transport belt for the treatment of yarn or simply for the storage of yarn between two stations;

FIG. 4 is a side-elevational view, partly broken away and diagrammatically illustrating a system in which the yarn-storage device is a drum and is disposed between a coil of the yarn and a yarn package;

FIG. 4A is a plan view of the drum of FIG. 4;

FIG. 5 is a side-elevational view, partly in diagrammatic form, in which the yarn-storage device is used to feed a shuttleless loom and in which clearing of the yarn and removal of defects therefrom may be carried out;

FIG. 6 is a diagrammatic side-elevational view of a system for forming yarn packages from cross-wound spools according to the invention;

FIG. 7 shows a belt-type yarn-storage arrangement, according to the present invention, located downstream of an open end spinning turbine, the parts being shown diagrammatically;

FIG. 8 is a diagrammatic plan view of an automatic open end spinning machine having a plurality of open end spinning turbines operating with a single package-winding device or a number of package winding devices only one of which is shown;

FIG. 9 is a diagrammatic plan view of a drum-shaped yarn carrier according to another embodiment of the present invention;

FIG. 10 is a section taken along a radial plane of a drum-shaped carrier according to another embodiment of the present invention;

FIG. 11 is a side elevational view of a carrier provided with a plurality of yarn-receiving members and utilized for the plying of yarns;

FIG. 12 is a plan view of another yarn carrier provided with a plurality of carrier bodies according to the invention;

FIG. 13 is a diagrammatic elevational view of a movable yarn carrier provided with a yarn-deposition device thereabove;

FIG. 14 shows a yarn carrier having a yarn guide and clamp arrangement according to the present invention;

FIG. 15 is a plan view of the device of FIG. 14;

FIG. 16 is a detail view of a yarn takeup arrangement according to the present invention; and

FIG. 17 is an elevational view, partly in diagrammatic form and partly broken away of a knotting device for the tying of two threads.

SPECIFIC DESCRIPTION

In FIG. 1 of the drawing, I have shown a yarn-handling system in which the yarn 1 emerges from a machine 2 in which the yarn may have been prepared or has been previously processed, passes through the nip of a pair of feed rollers 3 and enters a nozzle 4 to which a fluid is supplied via a conduit 5.

The yarn-storage device comprises a disk 7a which is carried by a shaft 7b which may be rotated in the clockwise sense as represented by the arrow in FIG. 1. Along the outer edge of the disk 7a, there is affixed an annular disk-shaped brush member 7 having an array of up-standing bristles or bunches of bristles as shown in FIGS. 1, 1A and 1B, upon which the yarn 1 is disposed. The reference numeral 9 represents the layer of stored yarn, the latter having an undulating pattern as shown in FIG. 1B which is produced by shifting the nozzle 4 radially (arrow 4c) via a mechanism 4a which may be of the type shown in FIG. 3, i.e. a crank or eccentric mechanism. The coupling between this mechanism and the nozzle is shown in dot-dash line at 4b. The annular bristle strip has a radial width w , the disk has a radius d and the bristles have height above the receiving surface, as shown in FIG. 1A, of h . Between the bristles, the yarn hangs in loops 6a or rests upon the brush surface between the bristles. The disk 7 may be perforated (see FIGS. 2F and 3) and the perforations may communicate with a chamber below the disk to which a treating liquid is fed or from which the treating fluid may be withdrawn from the system. The fluid introduced at conduit 5 may also be a treating fluid or the device may simply constitute a yarn-storage means to permit the yarn-processing stations 2 and 10 to operate continuously when one or the other must be operated intermittently or one or the other must suffer an operative interruption. A thread-guide device 8 is provided to draw the yarn off the brush surface upon which it has been stored before the yarn enters the further processing device 10.

The yarn-deposition means 4 etc. may be constituted as described in connection with FIG. 13 while the yarn-takeup device may be constructed as described in connection with FIGS. 14 through 16.

In operation, the system of FIG. 2 permits the yarn to be fed from the yarn-processing machine 2 onto the rotating disk-shaped annular yarn support 7 and permits the machine 10 to draw the yarn from the support surface at a different speed. The yarn 1 is delivered by the feed rolls 3 to the nozzle 4 in which the yarn strand is surrounded by a sheath of the gaseous medium, preferably compressed air, at a pressure of 0.1 to 2 atms. gauge. The entrainment of the yarn by the air forces the yarn between the bristles of each brush or tuft so that the yarn is retained but is freely accessible even at the support locations to treatment by a fluid. The bristles

prevent the yarn from falling off the receiving surface so that even an intensively supplied fluid does not dislodge the yarn. Between the bristles the yarn may lie in loops as shown in FIG. 1A and, at random locations, pass between the tufts of bristles and lie upon the upper surface of the disk 7.

The bristles are composed of elastically deflectible or spring-like members so that, when the nozzle 4 blows the yarn onto these bristles, the latter are somewhat deflected apart and beyond the yarn-deposition station, tend to swing back to their original positions and thereby grip the yarn. The undulations or loops in the radial direction can be provided by controlled rotation of the disk so that centrifugal force acts upon the yarn and/or by the reciprocating movement of the nozzle previously described.

Upon a rotary table 7 of a diameter $2d$ of 500 mm and a brush crown of a width w of 150 mm and a brush height h of 8 to 15 mm, with the nozzle 4 shiftable in the radial direction, 10,000 to 12,000 meters of yarn (Nm 32/1) may be stored, i.e. a yarn quantity corresponding to the capacity of two or three spinning bobbins.

An important advantage of the system of FIG. 1 etc. is that the yarn during yarn takeup at 8, 10, does not form a thread balloon of the type having a detrimental effect on ordinary conventional systems by which the yarn is drawn off a yarn package, spool or spindle in the axial direction. The brushes constitute deflectible tentacles which hold the yarn only lightly so that on the support 7 the yarn is held in a tensionless manner and, as the yarn is withdrawn from the support surface 7, the tension remains small.

The yarn-storage device of FIG. 1 can be disposed between two machines for the processing of yarn operating at different speeds as noted, preferably with an intended lag of two thirds of the storage capacity of the device. Of course, it may also be provided with an unspooling feed device and a processing machine, may be part of a system for continuously processing the yarn unwound from the coil, may constitute a treatment stage ahead of a yarn-winding stage, may be disposed between a yarn-processing machine and a coiling stage, etc. The two devices or machines on either side of the yarn-storage mechanism may, of course, operate at the same speed with the aforementioned lag, in which case the quantity of yarn upon the table remains constant. When it is necessary to interrupt the feeding machine, the yarn from the storage table continues to supply the operating machine until the interruption is cured and thereupon the feed machine may be operated to again deposit the necessary quantity of yarn upon the storage table. Alternatively, upon interruption of the downstream machine, the yarn continuing to emerge from the upstream device accumulates upon the storage disk.

In the embodiment of FIGS. 2 and 2A through 2G, the yarn carrier has the form of an endless band or conveyor 11 which is provided along its upper surface with individual bristles or tufts 12 of bristles. The width of the band 11 can be, for example, 100 mm and I prefer to leave each of the portions 11' of a width W , or about 10 mm, free from bristles so that driving rolls 11'' can engage the band to advance the latter. While FIG. 2A shows a friction system for driving the band, it will be understood that the sprocket arrangement of FIG. 3 may also be used.

It has been found advantageous to constitute the band 11 of a material which is not subject to attack by the treating fluid or is unaffected by the treating conditions and the chemical composition of the yarn. For this purpose, the band may be composed of nylon or a similar polyamide with the bristles being integrally molded (e.g. injection molded) with the web from which they project. This has been illustrated in FIG. 2B from which the band 11a is seen to be monolithically molded together with the bristles 12a, the latter being cylindrical wand-like shapes with ball-shaped or spheroidal heads 12b. The bristles may also have as shown in FIG. 2C for the bristle 12c, a flat surface 12d. A conical bristle 12e is shown in FIG. 2D and the bristle 12f of FIG. 2E is seen to have a pointed tip 12g which facilitates deposition of the yarn 14 and is resiliently deflected in the direction of arrow 12h when the yarn is drawn away from the bristle.

If it is desired to increase the tenacity with which the bristles retain the yarn the surfaces may be roughed so that yarn tentacles adhere more strongly. In most instances, however, it is desirable to provide a smooth configuration for the bristles so that the loops of yarn hang freely or deposit freely between them.

In FIG. 2, moreover, I have shown a system in which the band carries the yarn through a number of yarn-treatment stations and wherein the band is located between a yarn-uncoiling device or a yarn-preparation machine 13, advantageously an open end spinning machine, a double bobbin or DD twisting machine, or a yarn-texturizing machine.

The yarn 14 from the machine 13 is fed in the direction of the arrows between a pair of idler rolls 15 and 16 which rotate in opposite directions and may be urged together with the spring means represented in FIG. 3. The rolls 14 and 15 may have outer surfaces of rubber, i.e. may be rubber jacketed or sheathed. Below the rolls 15 and 16, there is provided a funnel-shaped nozzle 17 which permits the yarn to cascade freely onto the bristles and which may be equipped with a compressed air nozzle system as shown at 4 in FIG. 1.

The lower extremity of the yarn-depositing funnel or nozzle 17, as seen in FIG. 2, extends below the tips of the bristles or wands forming the brush and deflects them to deposit the yarn 14 at the roots of the bristles, whereupon the inherently resilient bristles return to their original position to retain the yarn at the base of the band. The band may travel at a rate of 3 meters per minute in the direction of the arrows illustrated in FIG. 2 and hence entrains the deposited yarn continuously and at this rate along the band path. Of course, when the nozzle 17 is rocked (see FIG. 2F), the yarn may be deposited at a rate greater than 3 meters per minute.

In FIG. 2A, an embodiment has been illustrated wherein, in place of the nozzle 17, a yarn guide 17a is provided above the feed rolls 15 and 16 and is shiftable in the direction of arrow 17b to permit the yarn to form undulations or loops as illustrated at 14a in this Figure. The reciprocating drive 17c is provided to shift the nozzle 17a and a motor 16a is shown to be drivingly connected to the rolls. The latter may be sheathed with rubber as already noted and the transverse movement of the yarn prevents wearing a groove in the feed rolls with long-term use.

Referring again to FIG. 2, it may be seen that the band 11 is guided around rollers 18, 19, 20 and 21, defining a deviation of the band from a horizontal plane,

through a body of treating liquor 22 in a vessel 23. The treating liquor may be any liquid which may be applied to the yarn, e.g. a dyeing liquor, a cleaning solvent, or the like. The band as shown in FIG. 2 may be driven by a roll 24 coupled to a motor, e.g. the motor 16a of FIG. 2A, the band passing around the roller 24 and thence through a fixing chamber 27 in which the dyestuff applied to the yarn is fixed by conventional techniques.

Downstream of the fixing chamber, the closed path of the band is juxtaposed with supply nozzles 25 and 26 which train washing jets upon the yarn trapped within the bristles of the band but accessible to fluid on all surfaces since some movement of the yarn between the flanks of the bristles is possible.

The band then passes around a guide roller 28 below the level of washing liquid in a trough 30. The washing liquid may be aqueous, it may consist of water in which a detergent is dispensed and, when the washing liquid is of the non-aqueous type, it may consist of a conventional drying cleaning solvent (e.g. a chlorinated, fluorinated or chlorofluorinated hydrocarbon) containing minor quantities of moisture or free from moisture and likewise containing a detergent. The liquid within the trough 30 may derive from the nozzles 25 and 26 previously described or from a pair of rinsing nozzles 33, 34 disposed downstream of the body of liquid within trough 30. Intensive washing is guaranteed at the bottom of the trough by providing adjacent the band 11 an agitating device, here shown to be a plate 31 connected to an ultrasonic vibrator.

The band 11 then passes over a roller 32, the rollers 24, 28 and 32 being advantageously driven at the same speed.

The rinsing jets from nozzles 33 and 34 may contain substances which are desirably applied to the yarn, e.g. fabric softeners and finishing agents. Downstream of the nozzles 34, 35 the band 11 and the yarn carried thereby pass into and through a drying chamber 35.

As illustrated in FIG. 2, the system is provided with means for monitoring the rate at which the yarn is withdrawn at 36 from the band and supplied to the machine 37. It will be understood that a situation may develop, in the absence of such monitoring, in which yarn deposited on the band may be carried past the takeup station and beneath the depositing nozzle under certain circumstances, e.g. when the machine 13 feeds the yarn too rapidly or the machine 37 takes up the yarn too slowly. Conversely, the yarn may break, either of the machines may be rendered temporarily inoperative and the yarn stored upon the band may either accumulate without takeup or deliver same to the takeup side without replenishment.

To avoid difficulties in these instances, I continuously monitor the yarn takeup from the band and control the takeup speed, yarn-supply speed or the band speed, preferably all three, in a continuous manner.

The potentiometer 38 or other speed-control device is provided with an arm 40 having an eye 39 through which the thread is guided. The yarn then passes into the machine 37. When the yarn supply is deficient or the yarn takeup rate is excessive, the arm 40 is swung in the direction of arrow A (clockwise) and the resulting change in the potentiometer resistance is applied to a conventional control device to increase the speed of the band 11 or decrease the yarn takeup speed. When, however, yarn takeup is interrupted or slowed or the band 11 operates at an excessive speed, the arm 40

swings in the opposite sense (arrow B) and the potentiometer is adjusted to increase the takeup speeds or decrease the band speed. When the band speed is increased or decreased, the yarn-feed speed (control by rolls 15 and 16) is increased and decreased accordingly. In the embodiment illustrated, the control operates upon deflection of the arm 40 to either side of its intermediate position (illustrated in FIG. 2), although one sided control can be provided as well. For example, the band may initially have a speed which is greater than is necessary for delivery of the requested quantity of yarn to supply the takeup device and the potentiometer may be positioned only to increase the speed of the takeup device. The takeup device may be operated at a constant speed and the band set normally to operate at a high speed so that movement of the arm only reduces the band speeds. Of course, instead of the potentiometer 38, other sensors such as photoelectric, pneumatic and mechanical devices can be used and the control circuit may be mechanical, pneumatic, electro-mechanical and mechanical or electronic in accordance with conventional techniques.

FIG. 3 shows in somewhat greater detail a system which is generally similar to that of FIG. 2 and in which the yarn 42 coming from a machine 41 is fed between the rolls 43 and 44, beneath which a thread-guide funnel 47 is provided to introduce the yarn between the bristles or bundles thereof as shown at 48 for the yarn-carrying band 49.

At least one of the two rolls 43, 44 is provided with a soft coating, i.e. with a rubber sleeve.

The rolls 43 and 44 are lightly urged together by the springs 45 and 46 and are driven by a motor 51 which is connected to the drive roller 50 of the band 49.

Along the bristle-free edges 52 and 53 of the band, there are provided sprocket holes 54 and 55 in which the sprocket pins 56 and 57 of the drive roller 50 are received. The other rollers 60 along which the band is guided, are likewise provided with sprocket pins 58 and 59 which are received in the sprocket holes of the band. A chain-gear or belt drive 61 connects the drive roll 50 with the feed rolls 44 so that the band is driven at a slower speed than the yarn-feed rolls, the ratio of the yarn-feed speed to the band speed being 1:50 or less.

To obtain the greatest deposition of yarn per unit length of the band the nozzle 47 is shifted transversely to the band 49 via a rod 62 which is articulated to the nozzle and to a crank 63 operated by a worm drive 64 from the yarn-feed roll 44. The result is a generally sinusoidal deposition of the yarn upon the band 49 without permitting the yarn to groove the soft coating of roll 43.

As has previously been discussed in connection with FIG. 2, the yarn-carrier band 11 or 49 is composed of an elastic material such as nylon whereby the bristles can be injection molded medium simultaneously with the web of the band from which the bristles project. Alternatively, the band may be composed of a material, e.g. nylon or another synthetic resin, having blind or throughgoing bores in which the bristles or bunches of bristles are received. The bristles can be anchored in place by any of the conventional techniques heretofore used in brush-making technology. When the fluid medium to which the yarn is to be exposed is corrosive or highly reactive, or high treatment temperatures are to be employed it has been found to be advantageous to

constitute the band from stainless steel or other corrosive-resistant metal and likewise to constitute the bristles from stainless-steel wire. In addition, coatings such as polytetrafluoroethylene (Teflon) may be applied to the band or to steel wires constituting the bristles, the bristles may be made from Teflon filaments or the band and the bristles may be made from Teflon. In order to facilitate circulation of the fluids and heat into the region of the yarn carried by the band, the latter is provided with holes or bores 66 between the bundles of bristles. The principal is also illustrated in FIG. 2F in which the band 11b is shown to have blind bores 11c into which the bunches of bristles 12g are fitted and bonded and throughgoing bores 11d which facilitate fluid circulation. To this end, beneath the band 11b, there is provided a housing 11e communicating with the bores 11d and connected with a suction pump 11f through which the fluid may be drawn from the region above the bores 11d. When desired, supply nozzles 11g may be provided and connected with circulating pump 11h to force fluid upwardly through these bores.

It will be apparent that the system of FIG. 3 need not be used only for a fluid treatment of the yarn stored upon the band, but may merely serve as a storage device between machines or yarn-processing stations, e.g. to carry the yarn from one station to the other or to temporarily retain a quantity of yarn when either the yarn-feeding station or the yarn-takeup station has its operation interrupted. In these cases, the use of a fluid-change nozzle 4 can be eliminated and the band 49 may be of small width. To prevent contamination of the yarn transport, the band may pass through a channel constituted of a transparent synthetic resin. In FIG. 2G, for example, a narrow band 49a is provided to carry yarn 42a which is fed downwardly through a tubular boss or neck 49b in a transparent housing 49c forming a channel through which the band is displaced. A similar protective hood may be provided at 49c' to enclose the upper surface of the band in the system of FIG. 2f.

FIG. 4 mechanically illustrates a yarn-handling device (in side elevation) which has been found to be especially effective for the treatment of yarn as it is unwound from a supply spool onto another yarn package or spool. Of course, the same principle applies when yarn is to be unwound from a supply spool and fed into a yarn treatment station or yarn forming a treatment station is to be wound upon a spool. In this embodiment, the yarn-feed station is provided with a cross-wound yarn-supply spool 67 upon which the yarn may be nonuniformly wound, wound with different tensions of points of adhesion so that breakage has occurred in the yarn as it is drawn from the spool in conventional devices. With the system of the present invention, which allows for intervening storage of the yarn between the spool 67 and a yarn-takeup package 83, the danger of such breakage can be obviated.

The yarn 68 is withdrawn from the spool 67 by a moving frictional surface here shown to be constituted by a roll 69 which has a fixed axis but is journaled for rotation in the counterclockwise sense. The yarn 68 undershoots the roll 69 and passes upwardly engaging around a hydraulic roll 71 journaled at the end of a lever 70. The yarn may then pass downwardly again around the roll 69 prior to being fed upwardly onto the roll 72 rotating in the clockwise sense and likewise carried by the lever 70 in the region of its fulcrum. The yarn then passes about a roll 73, also journaled on the

lever 70 in the region of its fulcrum, before entering a nozzle 74 in which the yarn is entrained by an airstream into the bristle drum 76. The nozzle 74, in the manner previously described, deflects the bristles as they rotate past the nozzle to depose yarn between them, the drum 76 being driven in the counterclockwise sense by a motor not shown.

With relatively small yarn tension, the arm 70 is biased by the spring 82 into the position illustrated at A¹ so that the yarn must pass over a relatively long loop about the rolls 69 and 71. When the tension increases, however, the guide roll 71 is drawn downwardly toward the position represented at B¹ and the arc over which the yarn engages the rolls 72 and 73 decreases. As a consequent, the yarn is fed at a constant tension to the nozzle 74. Of course, as soon as the higher tension period passes, the arm 70 and the guide roll 71 return to the position represented at A¹, the arcs subtended by the yarn about rolls 72 and 73 increases and the yarn is again fed with a higher speed to the drum and drawn at a higher speed from the spool 67.

When high-tension points develop to the extent that the arm 70 is swung in the counterclockwise sense to an excessive extent, indicating the danger of breakage, the yarn extends between the rolls 72 and 73 (which may be driven) without contact and yarn feed is terminated. To prevent damage to the stretch of yarn between the nozzle 74 and the yarn carrier 76 the lever 70 in this extreme position (B¹) trips a sensor of the electrical contacts 78 closing a support to an electromagnet valve 79 feeding air to the nozzle 74 via a conduit 80, thereby terminating the flow of air. The same contacts may trip an electromagnetic clutch to terminate rotation of the yarn carrier 76 and the rolls 81 and 83 which effect rotation of the yarn package. After the difficulty has been corrected, the yarn is loosened and arm 70 is permitted to swing back toward its normal operating position A¹.

It has also been found to be advantageous to prevent over-filling of the yarn carrier 76 or operation of the latter in an empty mode. These conditions arise when a yarn is not withdrawn from the carrier at a sufficient rate or yarn is fed at an excessive rate to the yarn carrier, or when the yarn breaks between the nozzle 74 and the yarn package 83. To this end, a photoelectric yarn sensor or an electric feeder 84 is provided between the yarn carrier 76 and the yarn package 81. Since the yarn stretch between the package and the carrier 76 rides upwardly the sensor 84 is tripped and cuts off, via a conventional clutch not shown, further rotation of the yarn-takeup device 81, 83. Further operation of the latter device is effected when the yarn carrier continues rotation and the yarn swings downwardly. In the opposite case, when the yarn carrier 76 is filled excessively, the freshly deposited yarn overlies and builds up upon the previously deposited yarn. In this case, the stretch of yarn between the carrier 76 and the takeup device 81, 83 swings downwardly to apply a photoelectric pulse via switch or photoelectric sensor 83 to the electromagnet or solenoid 86 of lever 70 to render the roll 72 and 73 ineffective and causes the arm 70 to operate switch 78, thereby terminating further operation of the nozzle 74 and the yarn carrier.

As illustrated in FIG. 4, therefore, two sensors are provided for the limiting operating conditions. It is also possible to use a single sensor when, for example, the average yarn-supply speed to the carrier 76 is made less

than the yarn takeup speed and the yarn-takeup device **81, 83** is operated intermittently as controlled by the sensor **84**. When the average yarn-takeup speed is made less than the spool speed, only the sensor **85** need be used and the feeding can be intermittently turned on and off.

The previously described systems utilize the storage capability of the yarn carriers according to the invention for retaining larger or smaller quantities of yarn between two machines or between a yarn-supply spool and a machine or a yarn-takeup spool and the machine to compensate for short-term differences in the output or input of the yarn, thereby avoiding breakage of the yarn or allowing the machine to operate when another machine is temporarily out of service. They also have been shown to be useful for the transfer of yarn over large or small distances between yarn operations.

However, it is also an important aspect of the present invention that the yarn carrier may be used to avoid yarn breakage, to permit yarn lengths to be tied together, to supply a continuous yarn to a machine (c.g. a loom) hitherto supplied only with yarn in the form of bobbins, or to monitor the quality of a yarn and eliminate defective portions thereof.

In FIG. 5, however, I have shown an apparatus with the extended capabilities discussed immediately above. The apparatus is designed to feed a defect-free yarn to a shuttle of a weaving loom or to a weft-transport mechanism of a shuttleless loom with, preferably cleaning of the yarn prior to the feeding thereof to the fabric-making machine. The device illustrated in FIG. 5 permits the yarn to be supplied from spinning bobbins with the yarn ends to be attached together, without interfering with the continuous operation of the fabric-making machine in spite of the fact that the tying operation require immobilization of the two ends to be joined together. Since the system proceeds from the spinning bobbin to the fabric, it eliminates the need for cross-wound yarn packages as have conventionally been used in the fabric-production art. The fabric-storage device is here similar to that of FIG. 1, i.e. uses a bristle disk.

The yarn **88** drawn from a bobbin **87** mounted upon a spindle **111**, is drawn upwardly through a stationary thread guide between a pair of feed rolls **89** and **90**. The feed roll **89** is driven by a belt **91** from the motor **92** while the feed roll **90** is journaled for free rotation and has its soft-surface rubber-jacketed portion in contact with roll **89** so that it is entrained thereby. Via a crank arrangement shown as connected to one end of a tension spring **93**, the roll **90** is biased against the driven roll **89** about which the yarn **88** passes. The yarn-feed roll **89** is driven by a belt **91** from the electric motor **92**.

From the yarn-feed rolls **89, 90**, the yarn passes through the nozzle **94** which is supplied with compressed air as described in connection with FIG. 1. The nozzle **94** blows yarn **88** into the bristle-covered surface of a yarn-carried disk **95** which is rotated with substantially lower speed than the yarn-feed roll **89** by motor **92** via a transmission **96**. To utilize the storage capacity of the yarn carrier to the full, the nozzle **94** may be shifted in the radial direction, i.e. in the direction of the width of the bristle ring, as has been described in connection with FIGS. 1 and 3.

When a sufficient quantity of yarn has been deposited upon the yarn carrier, the yarn is passed through a stationary eye or thread guide **97** and is attached to

the weft mechanism **98** of a loom not otherwise illustrated. With a yarn supply of, for example, 12,000 to 15,000 meters of yarn on the carrier **95** and a weft-insertion speed of 600 meters per minute, the loom can operate for 20 to 25 minutes without introducing a new bobbin. Consequently, the loom operator has sufficient opportunity to remove the empty bobbin core, insert a full bobbin, and in the trailing end of the yarn on the carrier **95** to the leading end of the yarn on the new bobbin. The removal of the empty bobbin core, insertion of the new bobbin **112** and the knotting of the yarn may be effected automatically.

When the electric sensor **99**, through which the yarn **88** passes, is triggered by a defect in the yarn, the device is not shut down or interrupted, but the yarn continues to be deposited upon the rotating yarn carrier **95**. However, the electromagnet **100** of the yarn-defect detector **99** receives an electrical pulse which causes the displacement of a pin **117** (indexing pin) of an array thereof disposed along the outer periphery of the disk in a way similar to that in which the tabulator members of a typewriter are set. Thus, the actuated pin or lamella **101** represents a defect in the yarn at the corresponding location. When the tabulating element reaches a sensor **102** of the knotting device **103**, therefore, the knotter is operated to take up the yarn, remove the defective portion and knot the two ends thus formed together. The knotter comprises a yarn gripper **104** which is lowered into the yarn carrier to lift the defective portion from the bristles so that the two lengths of yarn **105, 106** flanking the defect are received in the knotter **103**, the surplus yarn (beyond the knot) being cut away after knotting.

Upon a break in the yarn between the thread brake **108** and the yarn-depositing nozzle **84**, the yarn monitor **109** provides a signal to an automatic threading machine so that a new length of thread is passed through the guides and the supply roll **89, 90** and is fed to the storage disk **95**. Simultaneously, the location at which the untied thread ends are deposited as marked by the tabulator device **101** and knotting is effected at **103** when this location reaches the knot. The threading of a new yarn end requires from two to three seconds and for this period it is advantageous to immobilize the yarn carrier **95**. This, of course, does not interfere with the continuous withdrawal of the yarn from the carrier and such withdrawal continues in spite of the temporary halting of the carrier.

In the case in which, as a result of an interruption in the continuity of the yarn, a yarn end from the bobbin **87** is not retained in the thread brake **108** and the bobbin is replaced, the electrical yarn monitor **110** provides a signal to a bobbin-change device (not shown) which ejects the empty or partially emptied bobbin sleeve or core from the bobbin holder **111** and replaces it with a full bobbin from a magazine **112**.

The new yarn end is then threaded through the device, as previously described. Because of the poor quality of the yarn at the end of each bobbin and to facilitate threading of the yarn through the device to the nozzle **94**, it is advantageous to replace the bobbin **87** on the holder **111** before the bobbin is completely emptied. Thus, a sensor **113**, responsive to the bobbin diameter, can be provided to produce the bobbin-eject and bobbin-insertion signal.

Because of the large yarn-storage capacity of the bristle-covered disk **95** between the yarn-supply bobbin

87 and the loom (98 etc.), the knotting or tying step may be carried out relatively slowly without interruption of loom operation. On the average, the repair of a yarn break requires two to three seconds of yarn-feed interruption, this period being increased to four to five seconds when accompanied by bobbin replacement. Thus, a large number of knotting or defect-repair steps can be carried out within the capacity of the disk without interrupting loom operation. Motor 92 driving the disk via the transmission 96 may be so controlled, as noted previously, that, even with the interruptions of yarn feed for knotting and defect repair, the yarn is deposited uniformly upon the bristle surface and the stored yarn quantity is constant.

In FIG. 6, I have shown in a diagrammatic side-elevational view, partly broken away, a machine for the automatic winding of a yarn package concurrently with the plying and/or twisting of a yarn or simply for the winding of a yarn package to a capacity equivalent to that of a number of bobbins having the respective yarn lengths connected end to end. As distinct from the system of FIG. 5, the system of FIG. 6 facilitates bobbin change and increases the bobbin-replacement rate so that the device may be brought to standstill during the bobbin change without interference with the overall operation.

The system of FIG. 6 comprises a hollow shaft 115 journaled for rotation in bearings 114 and communicating below the bearings 114 with a suction source as represented by the arrow but not further illustrated. A suction conduit 116 may be connected to the shaft 115 for this purpose. The shaft carries a pair of axially spaced disks 117 and 118, the lower disk 117 being provided with six angularly equispaced upstanding spindles or mandrels 119 upon which the tubular cores of bobbin 120 may be seated manually or automatically. As each bobbin 120 is seated upon the respective mandrel 119, its free thread end is brought upwardly through a guide slot 121 of the upper disk and introduced into the mouth 122 of the hollow shaft 115. The suction in shaft 115 suffices to retain the yarn end 123 in place but is not of such strength as to draw the yarn from the bobbins 120. Hence the yarn 123 between the tube mouth 122 and each bobbin 120 is held under light tension.

The mandrels 119 are each pivotally mounted at 125 upon the disk 117 and are urged by a tension spring 126 connected to a cam-follower arm 124 in the counterclockwise sense, as seen for the left-hand bobbin in FIG. 6, or in the clockwise sense, as seen for the right-hand bobbin, i.e. generally outward. A stop 127 is provided to limit the outward displacement of each bobbin.

Until the bobbins are brought into position to act as yarn-feeding spools, the springs 126 hold the bobbin so that its axis forms arcuate angle with the slightly tensioned yarn 123 and thereby frictionally prevents axial withdrawal of the yarn. However, when the bobbin is rotated into position to act as a yarn-feeding spool, a cam 128 engages the arm 124 to bring the axis of the bobbin into alignment with the thread guides, as shown for the right-hand bobbins in this Figure.

After each bobbin is emptied, the shaft 115 and the disk 117, 118, together forming a bobbin turret, is advanced in the sense indicated by the arrow through about 60° to bring the next bobbin 129 into the feed position and into engagement with the cam 128. The

slightly tensioned yarn 130 then passes into a yarn-engaging device which comprises a balloon breaker 132, a thread monitor 133, an electronic yarn-defect sensor 134, and a pair of feed rolls 135 and 136, all mounted upon the frame 131 of the machine. The turret may, of course, also be rotated to draw a bobbin away from the feed position when it yet carries a portion of the yarn for the reasons set forth earlier. The yarn also passes through a cutter 137 beyond the feed rolls 135, 136.

The spreading of the feed rolls 135, 136 is advantageously effected by cams 138 fixed to the disk 118 and engaging one arm of a bell-crank lever 139, the other arm of which carries the feed roll 136. In an analogous manner, cam 140 carried by the shaft 115, operates the movable blade of the cutter 137.

The cutoff end of the yarn 142 is drawn into nozzle 141 and is entrained by air into the bristle surface 152 of a yarn-storage drum, the yarn residue being drawn off by the suction source 116 and collected in a receptacle (not shown). The cams 138 and 140 are so deposited and constructed that just before the end of each partial rotation of the turret, the feed rolls 135 and 136 are spread apart and yarn 142 is cut by the blade 137, the feed rolls being thereafter permitted to move together to advance the cut end of the yarn.

When the process proceeds as stated, the electrical yarn sensor 144 is tripped by the yarn 142 drawn into the nozzle 141 to permit the package-winding operation to proceed normally. However, if for any reason the yarn 142 is not drawn properly into the nozzle 141, the device does not receive an enabling signal from the sensor 144 and the turret 115, 117, 118 is rotated through an additional 60° to bring a fresh bobbin into the yarn-feed position. This sequence continues until a yarn 142 is properly introduced into the nozzle 141. In practice, the bobbin-change sequence is permitted to continue through three bobbins before a switch device (not shown) illuminates a signal lamp or sounds a warning signal to alert the operator to the failure.

The yarn carrier 143 in the embodiment of FIG. 6 comprises a drum which is rotated by a chain or belt drive 145 from the main driveshaft 146 of the machine (the driveshaft of the number of yarn-package winding stations of the type shown in FIG. 6), or to an electric motor individual to the package winding stations. A belt 147 may also extend from the drive-shaft 146 to the lower roller 148 of the yarn-takeup means, this roller driving the package 153 in accordance with conventional principles. A further belt 149 may extend to the fixedly positioned yarn-feed roll 135 to drive the latter at a substantially higher speed than the angular velocity of the drum 143. A suitable relationship of the yarn-feed speed to the drum speed can be attained by appropriate dimensioning of the pulleys about which the belt passes.

The apparatus also comprises a device which temporarily accelerates the yarn-storage drum 143 after each knotting or bobbin-replacement operation, to ensure that the appropriate yarn quantity (as determined by the sensors 150 and 151) is delivered to the drum. Otherwise it is necessary that the yarn-feed rolls and the yarn-storage drum be stopped when the package-winding station 148, 153 is rendered temporarily inoperative.

In the simplest case, the various driving systems can be coordinated by providing individual electronically

controlled electric motors at each package-winding station. Alternatively, a number of package-winding stations may be provided for a single machine with a single controlled drive and/or controlled clutch connecting them to a common electric motor. These various modifications, of course, do not alter the basic process as described.

In the embodiment illustrated, the yarn from bobbin 129, in the feed position, is drawn from the bobbin via the feed rolls 135, 136, is blown by the nozzle 141 onto the drum 143, is entrained by the drum 143 in the counterclockwise sense, is withdrawn from the drum between the sensors 150 and 151 (respectively detecting a reduced storage quantity or excess storage) and is wound upon a cross-wound yarn package 153 driven by frictional contact with the roll 148.

In the event of a yarn defect, which is to be eliminated by cutting the defective portion from the yarn length and knotting the yarn thus formed together behind the defect, the yarn-defect detector 134 does not, as has been the case in earlier systems, but the yarn but merely marks the position of the defect by magnetically affecting a ferromagnetic band 155 fixed to the yarn carrier.

The apparatus comprises an electromagnet 165 which, upon detection of a yarn defect, briefly magnetizes the ferromagnetic band 155 at a location corresponding to the defect on the carrier 143 so that, when the magnetized band portion passes the pole of an electromagnetic detector 156, a pulse is induced therein to trigger the knotting operation. It will be appreciated that, upon bobbin change and the arrival of a trailing end of one yarn strand and the leading end of the oncoming yarn strand, a defect is registered which is knotted upon the magnetic band and initiates a tying operation.

The knotting device (see also FIG. 17) comprises basically a knoter 157, a suction source or pump 158 and a suction funnel 159. The suction funnel 159 penetrates among the bristles of the yarn carrier 143 to draw off from the latter the defective lengths of yarn, both stretches of the defective portion being received in the knoter 157 and being tied together. The loop or stretches beyond the knot is cut away and this waste portion of the yarn is received in a collector connected to the suction source 158.

The knotting process is carried out so rapidly that there need be no special interruption of yarn inlaying upon the carrier 143 or any interruption in the rotation thereof.

FIG. 7 shows the invention as applied to the spinning of yarn using a spinning turbine, an endless yarn-storage belt being provided to accumulate the yarn which is then fed to a cross-wound package forming device. The system may provide for substantially any desired yarn processing upon the endless carrier.

The yarn 163 emerging from a spinning turbine 161 is fed through a tube 164 and an auxiliary compressed-air nozzle 163, the tube containing a photo-electric or contact-type yarn monitor 165. From the tube 164, the yarn is passed between a pair of yarn-fed rolls 166, 167.

The yarn-fed roll 166 is mounted on a shaft 168 and is driven, with the latter, at a peripheral speed corresponding to the spinning speed in the direction of the arrow (clockwise). A rubber-sheathed yarn-feed roll 167 retains the yarn 162 against the roll 166 and is carried by a three-arm lever 169 fulcrumed at 169' to per-

mit the rolls to be spread apart to accommodate the yarn. A spring 170 biases the lever 169 in the counterclockwise sense, i.e. in the closed direction, so that the rolls normally are urged together under the force of spring 170.

The yarn guide 171 beyond the feed rolls 166, 167 is provided with an electronic yarn monitor 176 responsive to yarn defects. A thread-break reverse-feed roll 173 is rotated in the counterclockwise sense and is overshot by the yarn in a normal position thereof and is carried by a rotating shaft 172. The second arm of the lever 169 carries a second yarn-break reverse-feed roll 174 which is freely rotatable and normally does not contact roll 173.

Downstream of these rolls 173, 174, the device is provided with a yarn-depositing nozzle 170 which raises the yarn into the yarn carrier 178 which is here of the endless band-type (see FIGS. 2 and 3).

Upon a break in the yarn emerging from the spinning turbine 161 or in any yarn section between the spinning turbine and the feed rolls 166, 167, the yarn monitor 165 provides a signal to the electromagnetic valve 179 which disables the compressed-air supply to the auxiliary nozzle 163. At the same time, the electromagnet or solenoid 175 is energized which applies a force to the lever 169 in excess of that of spring 170 and, for a limited period, lifts the roll 167 while bringing rolls 173 and 174 together. During this interval, therefore, a yarn length is drawn from the storage band 178 in the direction opposite that at which the yarn is normally deposited and is fed back to the spinning turbine 161 in which the oncoming yarn fiber is twisted together with the returned end. For the duration of yarn feedback to the spinning turbine, it has been found to be advantageous to interrupt the air feed to the nozzle 177 via the electromagnetic valve 180.

The described operation takes only a brief time, e.g. a maximum of several tenths of a second, so that it is not necessary to limit the fiber feed to the spinning turbine 161. The junction between the feedback yarn and the newly spun fibers may be somewhat enlarged and this can be removed by a knotting-type defect removed operation, as will be described in greater detail below. In the event, the returned yarn end and the fibers normally fed to the spinning turbine exceed the capacity of the latter, the supply of fibers can be interrupted by temporarily halting the sawtooth wheel 181 of the fiber-supply device and/or by rotating the deflector or shield 182 by electromagnetic means, to direct the fibers away from the spinning turbine. In the event of failure in the feedback operation of the yarn end drawn away from the storage band 178 to connect to the fibers in the spinning turbine, the yarn monitor 165 detects the failure. In the event of such failure in three attempts a warning signal is generated to alert the machine operator.

The apparatus in FIG. 7 also comprises a ferromagnetic border 183 of the yarn-storage band 178, this ferromagnetic strip cooperating with an electronic defect-signaling electromagnet 184 designating a yarn failure at the appropriate location. The electromagnetic sensor 185, also juxtaposed with the band, generates a pulse to trigger the knotting device 186 when a defect registration of the band reaches the sensor 185. The electromagnet 187, energized with alternating current, erases the stored magnetic signal of the band 183 since the latter is no longer necessary. The knotting device

is represented at 186 and may function in the manner described in connection with FIG. 17. Yarn sensors 188 and 189 are provided to maintain constant the quantity of yarn upon the storage band 178 while rollers 190 and 191 are provided to support and drive the band. The package-forming device is represented at 192 and the cross-wound package is shown at 193.

The function of the yarn-storage band 178 in conjunction with the knotting device 176 and the defect detector 178 is similar to that previously described. Here, however, it will be apparent that the relatively slow spinning speed may be utilized to provide a number of spinning stations for servicing by a single package-forming device. In this case, rails 194 and 195 may be provided to permit the knotting unit 186 to service a number of bands 178 or the knotting unit and the band 178 to service a number of spinning stations. The spinning speed of an open-end spinning machine is generally between 40 to 60 meters per minute whereas the package winding speed can be more than 1000 meters per minute so that I may use yarn in storage bands to accumulate lengths of yarn which are thereupon successively taken up at high speed upon the package by a package-winding device shifting past the storage bands on rails of the type illustrated in FIG. 7.

The automatic apparatus for open-end spinning and package winding of the general type has been diagrammatically illustrated in FIG. 8 in plan view. It is an advantage of this device that relatively narrow yarn carriers of the belt type can be utilized to store large quantities of yarn from the spinning turbines and even to remove the defects in the yarn while a high-speed package-winding device is shifted from storage band to storage band. Of course, it is contemplated within the present invention to associate the package-winding device or yarn-pickup device with a defect-removing system of the type previously described, in which case the bands merely store the yarn and defects are eliminated as the package-winding station is successively positioned to cooperate with each band. For each ten spinning stations, for example, a single package-winding station, defect-detection device, knotting mechanism, etc. may be used. The open-end spinning turbine 196, from which the yarn 197 emerges and the associated structure already described in connection with FIG. 7 ahead of the nozzle 177 for each band 178 are here represented by the block 198. Each of the blocks 198 thus delivers the yarn to the respective nozzle 199 which applies the yarn to a bandtype tentacled carrier 200 having a storage capacity of about 300 grams of yarn. Each carrier is provided with a light source 201 and a photocell 202 at the end of a storage path of the respective band 200 so that the light beam is broken when the accumulated yarn reaches the end of the storage path.

The yarn-package winding device, represented generally at 203, is shiftable along the rails 205, 206 transversely to the bands 200 under the control of a chain 204. As each storage band 200 is filled, the signal from the associated photocell operates the drive for chain 204 to effect pickup of the yarn from the carrier.

The package-winding device 203 comprises a pair of guides 207, 208 which extend transversely to the direction of travel of the device and parallel to the direction of displacement of the bands to support a suction tube 209 for such transverse displacement. The suction tube 209 is provided with photoelectric beams in the form of a light source 210 and a photocell 211 spaced apart

across the mouth of the suction tube 209. As soon as the photoelectric detector senses a yarn end at the juxtaposed portion of the yarn carrier 200 with which the package-winding device 200 is aligned, the suction source is turned on and the yarn end, picked up from the storage band 200, is knotted to the trailing end of the yarn length previously wound upon the package and the yarn is drawn from the band 200 and coiled upon the yarn package, as previously described. As the yarn is drawn from the band 200, tube 209, which is controlled by its photoelectric sensor, shifts along the guides 207, 208 toward the nozzle 199 until the sensor 212 engages an abutment 213. The yarn is then cut and the package-winding device shifted to another yarn-storage band.

When the yarn pickup reaches a point just ahead of the nozzle 199, the package-winding device must be stopped, the yarn cut by the blade, and the suction tube 209 returned to the starting position. This can be accomplished by providing a further stop 215 for the sensor 214.

During the return of the tube 209 to its starting position, the package-winding device 203 is stepped by a pneumatic, electrical or electronic signal accumulator to cooperate with the mixed yarn-storage band 200 or any yarn storage band which has already reached the full condition. In general, the package-winding device will operate with the yarn-storage bands in succession.

To obtain an optimal utilization of the package-winding device 203, each such device may be associated with a large number of open-end spinning turbines or stations. A simpler construction provides a package-winding station which is advanced from one yarn-storage and spinning station to the next, e.g. from left to right and return, without sensing of the yarn quantity upon the respective storage bands. The spinning- and yarn-storage station can be cyclically arranged, as well, whereby the rail carries the package-winding device along a closed transport path.

At a particular point along this path, e.g. at an end of the track at which the package-winding device 203 is to be reversed, there is provided a package holder 216 and a core magazine 217. When the package has reached a predetermined diameter, a sensor similar to the one shown at 113 is effective to signal the control circuitry to carry the package-winding device 203 to the end of this path, bypassing other yarn-storage stations which remain in readiness for the next package-winding cycle. A spool-changing device (not illustrated) lifts the wound yarn package from the device 203 into the spool-storage rack 216 and places an empty sleeve or core from the magazine 217 upon the package-winding device 203 which returns to yarn-winding stations from the individual storage bands, as previously described.

Of course, instead of a single package-winding device 203, a plurality of such devices may be used at intervals and the package-winding devices 203 can be caused to circulate past the spinning positions, being out of the yarn-winding mode only for pickup of an empty core at an appropriate station. Some eighty spinning stations can be serviced in this manner.

The invention has also been found to be applicable for traveling-ring twisting machines and spinning systems. The single-ply, two ply or multiple-ply yarn from such devices may be wound upon a yarn package via one or more storage devices of the type previously de-

scribed. The system may use the principles described in connection with FIG. 5 whereby a supply bobbin may be provided for each ply with respective yarn carriers or yarn-storage surfaces. The yarn may be picked up from the yarn carriers by a package-winding device. It is also within the scope of the present invention to provide an array of yarn-storage surfaces moving along a closed path and to service these storage devices with a single yarn-supply device which may move upon rails for depositing successive lengths of yarn upon the respective yarn-storage surface. In other words, once the common yarn-feed device deposits a yarn upon a storage surface, the yarn is cut off and the yarn-feed device moves to the next empty yarn-storage surface to supply a yarn to the latter. The system may include fully automatic package-winding devices, having a suction tube, a sensor and a knoter and which picks up each yarn length in turn, connecting the length ends together, as previously described. While the spinning can take place with relatively slow speeds, using systems described above, the yarn can be delivered to the yarn carriers at speeds of about 1000 meters per minute.

Several spindles may be provided at each twisting location.

The invention also permits the clearing of the yarn from defects, the knotting of ends of lengths from successive bobbins, feeding of the yarn continuously to a fabric-making machine, coiling the yarn or cutting the latter into lengths in a substantially continuous manner without intervening winding of the yarns upon cross-wound packages. The system has been described in connection with the use of bristles, wires or bristle bundles as applied to plates, drums, bands or flat-surface yarn carriers. Other yarn carriers or yarn-storage devices may, however, be used.

In FIG. 9, for example, I show a yarn-storage device for a number of threads in diagrammatic elevational view, with associated parts being represented diagrammatically. The yarn carrier here comprises a perforated drum provided with stub shafts 218 and 219 by which the drum 220 is journaled for rotation. One or both of the stub shafts 218 is hollow and is connected with a suction fan or blower (not shown) which maintains an atmospheric pressure in the drum 220. The stub shafts 218 and 219 are journaled in the bearings 221 and 222 and are rotated by a chain drive 223 passing around the sprocket wheel on one of these shafts.

With an axial spacing of about 1 to 8 centimeters, the drum 220 carries separator rings 225 which define between them individual yarn-storage zones in which the individual yarn lengths 226 of a family or array of yarns 227 are stored. Each of the yarns is fed by a yarn-deposition nozzle 228 under compressed air, steam or other fluid of a pressure of 0.1 to 3 atms gauge, onto the respective zones of the yarn carrier 220. The individual threads of the set 227 are advanced by common speed arrangement comprising a pair of feed rolls 229 and 230 which may operate with substantially higher speeds than the rotary speed of the drum 220.

The drum 220 is provided with perforations 231 through which air, liquid and/or steam is drawn into or forced outwardly through the yarn layer deposited upon the drum. After the yarn has been carried through an arc of about 300° in the direction of the arrow (counterclockwise), it is withdrawn at 226 from the yarn carrier by a device which has not been illustrated in this Figure but may be of the type shown in FIGS. 14

and 16. The yarn-withdrawal rate is controlled by a pneumatic yarn sensor 232 comprising a tube whose opening is deposited immediately above the storage drum 220 while its other end is closed by a membrane.

The subatmospheric pressure developed in the drum or an elevated pressure produced in the membrane will be greater or less depending upon the presence or absence of a yarn. The pressure difference in the yarn sensor 232 is amplified by pneumatic, electrical, electronic or mechanical amplifier and is used to control the yarn withdrawal speed whereby the yarn quantity upon the drum is maintained constant. The drum 220 is composed preferably of stainless steel and has been found to be especially effective for a heat treatment, steam treatment, shrinkage treatment or liquid treatment of the yarn.

The yarn-storage device, according to the present invention, may also be composed of a perforated stainless steel or synthetic-resin band extending around two or more drive rollers and having sides which are flanked by shields or the like, defining for each individual yarn or for a yarn family a band of corresponding width.

In FIG. 10, the yarn-storage device comprises a perforated drum 233, the periphery of which is subdivided into zones by partitions 234 and 235 which define small cells, pockets or compartments in which the yarn 236 is stored. The floors of the pockets are perforated at 238 to permit the air emerging from the nozzle 237 to pass through. The yarn carrier 233 can also be provided in the form of a band which is guided over two or more rolls and driven thereby. Both ends of the drum 233 can be closed and the system may be connected as in the case of FIG. 9, to a suction blower whereby the adhesion of the yarn to the perforated surface is increased. Even without the suction force, however, the yarn is retained without tension and with substantially all around access to fluid when it is blown against the perforated floor of the pockets as described. In this case, the yarn may penetrate slightly into the perforations.

FIG. 11 shows an embodiment of the invention, partly in section, in which a yarn-storage body comprises a number of individual yarn carriers. Each of the yarn carriers may be as described in connection with FIG. 1, or simply a plate held upon a rack. In FIG. 11 the individual yarn carriers 239, 240 and 241 are held in ledges 242 through 244 of intermediate rings 245, 246, 247, the system being displaced so that the surface exposed to yarn deposition is constantly renewed and the yarn carried by the surface is constantly advanced to the yarn-takeup device.

The yarn ends on the individual yarn carriers are so tied that the stored yarn from the uppermost to the lowermost carrier or vice versa can be drawn off continuously through the yarn guide 248. It is also possible, however, to draw off two or more yarns from the respective yarn carriers 239-241 continuously simultaneously, for example, to ply the yarns. A yarn-plying system of this type has the advantage over earlier systems in that no yarn residue is left upon the yarn-storage carriers while, with the use of bobbins or spools, a yarn residue is permitted to remain on each bobbin or spool because of the defects normally present in the yarn first wound upon the spool or bobbin. Of course, the present system also has the advantage that yarn treatment, e.g. dyeing, can be carried directly on the yarn carrier.

The diagrammatic plan view of FIG. 12 shows another multiple surface yarn storage system, i.e. a yarn-storage system having a plurality of discrete yarn carriers each of which may be provided with bristles, tentacles, wands etc., receiving the yarn between them or on top of them. In this embodiment, a horizontal turntable 249 is seen to have four angularly equispaced rotatable-disks yarn carriers 250, 251, 252, 253 of which yarn carrier 250 is in a working position in which it is being emptied. Each of the yarn lengths carried by the different yarn carriers may be of different color when, for example, a multicolor weft is to be laid into a fabric.

The trailing yarn end of each carrier may be tied to the leading yarn end of the next carrier to be disposed in the yarn-takeup position. At the yarn-disposition and the yarn-takeup positions, the individual yarn carriers may be rotated as a compressed air nozzle (FIG. 1 or FIG. 13) lays the yarn at an angle in the bristles and a takeup device draws the yarn off. As each carrier 250, 251, 252, 253 is emptied, the next carrier is brought into the yarn-takeup position by a rotation of the turntable 249 through 90° about the axis 255 in the direction of the arrow. Preferably, however, no yarn-feed device is directly juxtaposed with the turntable 249, but the individual yarn carriers 250-253 are removably mounted on the turntable and can be lifted out (by means not shown) upon emptying for replacement by a filled yarn carrier. In the latter mode of operation, the empty yarn carrier may be returned to a spinning station and there charged with a yarn from a spinning nozzle or dyeing installation in the manner previously described. Of course, the yarn carrier can also be loaded at a DD twisting machine or other yarn source.

The systems described above permit many modifications within the principles of the present invention. For example, the surface of the yarn-storage device, which may be provided with brushes and/or a suction chamber, may be held stationary while the yarn is disposed thereon by movement of the yarn-disposition nozzle along a closed path while the surface is immobile. Of course, both the yarn carrier surface and the nozzle may be moved, especially in opposite directions. It has already been observed that a transverse displacement of the nozzle orthogonal to the direction of displacement of the surface will increase the quantity of yarn which can be disposed upon a surface of a given width because the yarn forms an undulating or zigzag pattern. This zigzag pattern can also be produced by transversely shifting the yarn-carrier surface while the nozzle is held stationary. This latter arrangement has the advantage that the knitter can be held stationary as the yarn of the carrier is shifted past it. This allows the knitter to follow the undulations of the yarn upon the carrier and to engage with facility the defective portions of separated ends of the yarn. The rotatable disk, band or drum structures, which are preferred, as noted earlier, need not be the only configurations of the yarn carrier which are effective and it has been found that rectangular bristle plates, perforated plates or cellular members can be employed.

FIG. 13 shows the invention as applicable to the feed of a yarn to a brush surface or other yarn carriers, according to further principles of the invention. The yarn carrier 7 is here provided with a yarn-gripping surface represented generally at 6 and which may be composed of fabric, a roughened coating or a magnetic surface or any of the other surfaces previously described as effective

in this regard. The surface is moved in the direction of the arrow (i.e. to the left) past a yarn-disposition nozzle 300 which may be of the compressed-air-type, as shown, or simply a funnel which seats the yarn against the surface. The nozzle is stationary and the yarn after disposition upon the surface can be removed at some distant location, as represented at 32. The stored yarn is shown at 301.

When the yarn carrier constitutes a magnetic surface, the yarn must be coated or permeated with a magnetic powder, e.g. iron powder or ferride powder, as a result of which the surface has an attraction for the yarn. Since some powder will collect upon the surface 6 of the yarn carrier 7, means must be provided to strip the magnetic powder from this surface, either mechanically or by a stronger magnetic force. The yarn removed at 302 must be subjected to a powder-reaction operation, e.g. in which a strong magnetic field strips the powder from the yarn.

In the preferred case, however, the adhering means 6 is an array of bristles, needles, loops of preferably elastic but also inelastic configuration which are inclined in the direction of displacement of the carrier 7, as represented in FIG. 13. In this case, the fingers of the carrier do not hook into the yarn and cannot be entangled therein.

In FIG. 13, the arrangement of the bristles for deposition of the yarn upon the surface of the yarn carrier is shown at 303, i.e. the bristles are inclined in the direction of movement of the carrier, while the orientation of the bristles upon removal of the yarn is represented at 304, i.e. with an inclination in the direction opposite that to which the yarn carrier 7 moves. In general terms, therefore, the bristles will have an orientation away from the location at which the yarn is deposited and toward the location at which the yarn is removed to facilitate deposition of the yarn and withdrawal without the difficulty which may arise from interleaving of the bristles with the filament of the yarn. The adhesion of the yarn during transport is so small that, upon a single yarn-carrier plate, drum or endless band, several layers of yarn can be deposited one upon the other, withdrawal can be effected starting with the upper or lower yarn end. In this case, of course, a previously deposited yarn layer may form the adhesion surface or means for receiving the yarn layers deposited thereon.

The yarn, when deposited in layers above the initial layer on the yarn carrier or in overlapping loops, should have loops or the like which rest (over at least half of their length) upon previously deposited yarn and not directly upon the yarn carrier. Of course, the initial layer may lie with a greater proportion of the length of each loop against the yarn carrier. The multiple-layer system described above also includes a configuration whereby the yarn is laid down in a multiplicity of overlapping loops, turns or undulations so that, after the first loop or turn has been deposited upon the yarn carrier, each successive loop or turn overlies and overlaps the previously deposited loop such that more than half of each loop length lies out of direct contact with the yarn carrier.

At the yarn-deposition station, the yarn-feed nozzle 300 is shown to be inclined to the direction of movement of the yarn carrier and to include an angle greater than 0° and up to 40° therewith. This may be achieved by mounting the nozzle 300 and its arm 306 upon a pivot 306'. The compressed air introduced at 305 to

the nozzle may be fed via a valve system at a rate such that, even with the inclination of the nozzle, the yarn is deposited in a substantially straight strand and stable stretch upon the yarn carrier. It has been found that a stable formation of the yarn loops can result when the yarn carrier is spaced up to 20 cm from the nozzle. The loops may be formed by angularly displacing the yarn carrier about its pivot 306'. The compressed air emerging from the nozzle assists in deflecting the bristles 303 into the inclination illustrated, in which they are held by the weight of the yarn loops thereon. The compressed-air duct may also be provided with a spray device, bubble tube or the like 8 in which the compressed air is saturated with water droplets used to condition the yarn. The droplets of water may contain a yarn-finishing agent. Of course, any conditioning or yarn finishing agent, e.g. to increase the smoothness of the yarn texture, may also be deposited upon the yarn carried by the bristles 303.

The yarn-storage system illustrated in FIGS. 14 and 15 comprises essentially a cylindrical disk, upon the cylindrical outer surface of which there is provided an adhesion means 6 of the aforescribed type. The yarn carrier is rotatable in the direction of the arrow and a yarn-takeup device is provided to withdraw the yarn at 311 from the apparatus. The yarn-takeup device may include a thread guide 313 over which a stretch 312 of the yarn passes, a thread eye 315 traversed by the yarn and a yarn clamp 316 of a yarn-takeup system, represented generally at 314. The yarn 312 is deflected over the guide 313 such that yarn withdrawal is substantially perpendicular to the yarn-carrier surface whereby the yarn is maintained under tension between the yarn guide 313 and the eye 315.

The yarn guide 313 is formed with a ring fixed to the yarn carrier 310 and composed of tubular stock or the like and which is spaced from 5 to 25 cm from the yarn-carrier surface 310. Of course, the yarn guide can also be deposited along the upper edge of the yarn carrier instead of centrally of the cylindrical surface thereof. The guide 313 may have any configuration geometrically similar to that of the yarn carrier. For example, when the yarn carrier is an endless band having a linear stretch at which the yarn is to be withdrawn, the yarn guide may consist of one or more rods parallel to this stretch. The light tension between yarn clamp 316 and the guide 313 ensures that the yarn can be engaged between these devices and eliminates the complex means which might otherwise be required for fixing the yarn end at a particular location for tying or the like.

In the embodiment of FIGS. 14 and 15, it is possible to provide within the range in which the yarn 312 can move, yarn sensors which are responsive to the position of the yarn 312 and control either yarn takeup or yarn disposition. FIG. 15 shows two yarn feelers or sensors 318, 319, between which the yarn 312 passes in the direction of the arrow. When the yarn is stored upon the yarn carrier in the region between the feelers 318, 319, the yarn 312 can be withdrawn — starting in the region of feeler 318 — until the yarn runs up against the feeler 319. The latter can then operate its switch to cut off yarn takeup so that the yarn carrier can be replaced by a full yarn carrier and replenished elsewhere. When the yarn carrier has a rotating surface, as described in connection with the Figures of the drawing previously described, the feeler 319 may accelerate or advance this surface until the yarn no longer contacts the feeler 319

and, in this way, continuously provide a supply of yarn in the region between the feelers 318 and 319. Of course, when the yarn reaches the takeup point more rapidly than the yarn is withdrawn from the yarn carrier, the strand 312 will contact the feeler 318 so that the switch or other electrical device operated thereby can decelerate the yarn carrier or temporarily immobilize it. The yarn guide 313 can also be constructed in such manner that it lies only in the region between the two yarn sensors 318, 319 and is fastened to a stationary part 320 of the machine.

The yarn-takeup device of FIGS. 14 and 15 may be used with the rotating-disk yarn carrier 7 of FIG. 1, the endless band yarn carrier of FIGS. 2 and 3, the rotating disk yarn carrier of FIG. 5 (between the loom and the yarn carrier thereof), the rotating drum yarn carrier of FIG. 6 and for the endless band yarn carriers of FIGS. 7 and 8 or the multiple-disk yarn carrier of FIG. 12. It is equally applicable to the cellular-drum yarn carrier of FIG. 10.

In FIG. 16 the yarn carrier 350 is movable or stationary and receives the stored yarn 351 in an overlapping series of turns, e.g. as the yarn is deposited by the device of FIG. 13. The yarn 351 is withdrawn through a yarn-guide eye 352 over a stretch 351' at an acute angle of 10° to 90° with respect to the yarn-carrier surface. The yarn-guide eye 352 is received within and is surrounded by a sheet metal plate 353 forming a baffle around the eye. The plate 353 lies in a plane perpendicular to the passage through the eye and hence to the stretch of yarn 351 between the receiving surface of the yarn carrier and the eye, at least in the normal position of the eye (i.e. the position in which the yarn is drawn off at a normal rate). The baffle 353 prevents blocking of the eye by yarn ends during the yarn-takeup process and facilitates passage of a yarn end through the eye.

The yarn-guide eye 352 and its baffle plate 353 are mounted on the free end of an arm or limb 354 of a two-arm lever 355 swingably mounted at a journal or fulcrum 356. The other arm or limb 357 of this lever carries a contact operator 358 (e.g. a magnet) for producing a control signal, as will be described hereinafter. The counterweight 351 on the arm 357 and a further counterweight 361 on the arm 354 may be shifted along the respective arms and held in place so that the arm is in metastable equilibrium in its normal position, as illustrated, and can be swung in the counterclockwise sense or the clockwise sense about its fulcrum by the yarn passing through the eye. Thus, with the yarn carrier moving to the right, as illustrated, the arm may be swung in one sense when the yarn supply upon the carrier is moving too rapidly past the takeup station, and in the opposite sense, when the yarn supply is not moving at a sufficient speed, thereby changing the angle at which the yarn passes into the eye and causing deflection of the lever 355.

The magnet 358 is juxtaposed with a pair of protective-gas switches 359 of a switching arrangement 360 which can be adjusted vertically in the direction of the arrow. The switches are of the magnetically actuatable reed type. In response to a pivoting motion of the lever 355, the magnet approaches one or the other switch 359 to reduce the speed of the yarn carrier, increase the speed of the yarn carrier or cut off yarn takeup completely, as previously described. Of course, the switches may also be connected to the yarn-supply device or may vary the speed of yarn takeup, as required.

The position of the lever 355 depends upon the extent to which yarn has already been withdrawn from the yarn carrier and the distance between the yarn supply on the carrier and the eye 352.

The yarn-takeup device of FIG. 16 may be used in conjunction with the yarn carrier of FIGS. 1 through 8, 10 and 12 and, of course, the yarn-deposition device of FIG. 13 may also be used in the structures of these Figures.

FIG. 17 illustrates a knotting arrangement which is disposed between a pair of yarn carriers 321 and 322, the knotting arrangement being represented generally at 323. The knotting arrangement 323 is movable in the direction of arrow 324 so that the suction nozzle 325 of its bent suction tube 326 can be brought into the region of the yarn-storage surface of a yarn carrier (321 or 322). A pivot ring 327 carries the bent-arm suction tube 326 at the end of which the nozzle 325 is provided and can be rotated in the clockwise or counterclockwise sense to introduce the nozzle more or less deeply into the yarn carrier and as close to the yarn stored thereon as may be desired.

The suction duct communicates via a connecting bore 328 with the interior 329 of a suction pipe 330 which can be evacuated by a conventional suction pump (not shown). When a subatmospheric pressure is generated in the interior 329 of the suction pipe 330, the nozzle 325 draws the defective length of yarn into the duct 326 or picks up the two ends of lengths of yarn to be knotted together. The knotting device represented at 331 may be a simple unit operating similarly to hand knotting and this is conventional in the art. When the nozzle 325 is swung past the knotter, it entrains two stretches of the yarn into engagement with the knotter fingers, the stretches being parallel and readily picked up by the knotter for tying. A cutter is provided within the knotter to sever the two stretches beyond the knot, the yarn residue being drawn through the nozzle 25 and duct 326 for collection in a receptacle, as described previously. The knotter 331 is disposed adjacent the suction pipe 330 upon the yarn-residue collecting duct 332.

The knotting device is preferably controlled, as described previously, by some means for signaling the presence of a defect at a location of the yarn carrier registering with the suction nozzle 325. This signaling means can be a pulse generator for marking or indexing the carrier, can be a register counting pulses representing displacement of the yarn carrier (the pulse train arriving at a higher frequency with a faster yarn carrier or a lower frequency with a slower yarn carrier), or a simple mechanical device designed to mark the location of the defect or the untied end. The signal is received by a controller which swings the duct 326 toward the marked location of the yarn carrier and causes the nozzle 325 to pick up the unknotted end or the defective length of yarn. The system has the advantage that it eliminates complex arrangements as have heretofore been necessary for control of the knotter and the yarn-engaging means therefor. The knotter operation is coupled with the pivoting action of the suction duct 326 via a lever linkage 333 connected to the ring 327 so that, when the yarn stretches are spanned across the knotter by the suction nozzle, the knotter fingers can engage the parallel yarn stretches and perform the knotting operation, as previously indicated.

The knotting device can be used for the knotting together of two lengths of yarn in the formation of a yarn package or for further yarn treatment or even further knotting of two yarn lengths from successive spinning stations or for feeding the yarn lengths to a fabric-making machine. The knotter, of course, operates without the need to place the yarn in spools after spinning or twisting since the yarn lengths are knotted together directly upon the yarn carrier. The yarn carrier may act as a buffer between spinning and twisting stations at which the yarn speeds may be different. It can take up spun yarn while the package receiving the twisted or plied yarn is changed. The time and speed compensation afforded by the yarn carrier also allows for various yarn treatments such as defect removal and knotting, as well as transport of the yarn between spinning and twisting machines. After the emptying of the yarn carrier, it is replenished with yarn during the replacement of the yarn spool.

The knotter of FIG. 17 and the suction head thereof may be used with the yarn carriers of FIGS. 1 through 12 and in conjunction with the yarn-feed device of FIG. 13 and/or the yarn device of FIGS. 14 through 16.

I claim:

1. A system for the manipulation of yarn comprising: a yarn-supply device including a nozzle traversed by a yarn; means for introducing a fluid at a pressure of substantially 0.1 to 3 atm.g. to said nozzle to entrain said yarn therefrom; a yarn-takeup device spaced from said yarn-supply device; a yarn-storage device receiving yarn from said yarn-supply device and delivering yarn to said yarn-takeup device, said yarn-storage device having an endless surface formed with a multiplicity of elastically deflectable bristles between which said yarn is deposited and which are deflected upon deposition of said yarn and spring back subsequent to such deposition, said nozzle being trained on said surface; means for displacing said surface along a closed path, said yarn-supply device and said yarn-takeup device being spaced apart along said path; and means for displacing said nozzle across said surface in a direction generally orthogonal to the direction of displacement thereof, said yarn-supply device being so constructed and arranged as to feed said yarn onto said surface at a speed greater than that of said surface whereby the yarn deposits in an undulating pattern of said surface.
2. The system defined in claim 1 wherein said surface is formed by a yarn-carrying disk rotatable about an axis perpendicular to a plane of said surface.
3. The system defined in claim 1 wherein said surface is formed on an endless yarn-carrier band.
4. The system defined in claim 1 wherein said surface has a central zone provided with said bristles, and a pair of marginal zones substantially free from said bristles, said means for displacing said surface including drive members engaging said marginal zones.
5. The system defined in claim 1 wherein said bristles are provided with end formations facilitating insertion of the yarn therebetween and retention of the yarn by said bristles.

6. The system defined in claim 1 wherein said surface is a cylindrical surface of a drum formed with cells under suction for receiving said yarn.

7. The system defined in claim 1 wherein said surface and said bristles are formed unitarily from a resilient noncorrodible material.

8. The system defined in claim 1 wherein said surface is provided with partitions spaced apart transversely to the direction of displacement of said surface but extending in the direction of displacement thereof, thereby subdividing said surface into a plurality of discrete zones each accommodating a yarn of a family of substantially parallel yarns.

9. The system defined in claim 1 wherein said yarn-supply device includes a yarn-guide member extending among said bristles and deflecting the bristles upon deposition of yarn, and means for feeding the yarn through said member for deposition upon said surface between said bristles whereby said bristles spring back beyond said member to retain said yarn.

10. The system defined in claim 1, further comprising sensing means responsive to the movement of the yarn at least at one of said devices for controlling an operating parameter of one of the devices.

11. The system defined in claim 1, further comprising yarn-sensing means responsive to the yarn at one of said devices for controlling one of said devices to regulate at least one parameter from the following:

- a. the speed at which said yarn is fed to said surface by said yarn-supply device;
- b. the displacement of said surface relative to said yarn-supply device;
- c. the displacement of said surface relative to said yarn-takeup device;
- d. the quantity of yarn on said surface; and
- e. the rate at which yarn is withdrawn from said surface at said yarn-takeup device.

12. The system defined in claim 1 wherein said yarn-storage device includes a rotatable yarn carrier forming said surface, said yarn-supply device comprising a nozzle for depositing the yarn upon said surface, means for retaining a yarn-supply spool, an arm swingable about an axis and provided with a pair of rollers rotatable about respective axes disposed at diametrically opposite locations on said arm across the axis of swing thereof, said yarn passing in opposite senses along each of said rollers whereby said rollers control the tension of the yarn fed to said nozzle and withdrawn from said spool, said arm being provided with a roll spaced from said rollers, said yarn-supply device further comprising a roll rotatable about a stationary axis relative to said arm, said yarn looping around said rolls prior to passage over and between said rollers whereby increasing yarn tension reduces the length of the loop between said rolls and reduces the surface area of said rollers in contact with said yarn and vice versa.

13. The system defined in claim 12, further comprising an electrical contact actuable by said arm upon excessive reduction in the length of said loop, said nozzle being connected to a source of compressed air, said yarn-supply device further comprising an electromagnetic valve operatively connected to said contact and cut off thereby upon actuation of said contact by said arm.

14. The system defined in claim 13, further comprising yarn-sensing means at said yarn-takeup device and responsive to an excessive accumulation of yarn upon

said surface, and electromagnetic means connected to said sensing means and acting upon said arm for swinging same about its axis to decouple said rollers from said arm.

15. The system defined in claim 1 wherein said yarn-storage device is provided with a plurality of such surfaces shiftable past the yarn-supply device and said yarn-storage device, and control means responsive to the quantity of yarn upon said surfaces for positioning the surface carrying the least amount of yarn at said yarn-supply device.

16. The system defined in claim 1 wherein said bristles are deflectable toward said yarn-takeup device at least for withdrawal of said yarn from said surface.

17. The system defined in claim 1 wherein said yarn-takeup device includes a yarn-guide bar juxtaposed with said yarn carrier, said yarn passing over said bar and a yarn clamp spaced from said bar, and engaging the yarn withdrawn from said surface beyond said bar.

18. The system defined in claim 17, further comprising a pair of yarn feelers straddling the stretch of yarn between said bar and said clamp and controlling at least one of said devices.

19. The system defined in claim 1 wherein said yarn-takeup device comprises a eye traversed by said yarn, an arm mounted swingably carrying said eye, a baffle plate surrounding said eye and lying in a plane generally perpendicular to the passage there through, and switch means actuatable by said arms at least to a device.

20. The system defined in claim 19 wherein said arm forms a limb of a double-armed lever, the other limb of said lever being provided with a magnet adapted to actuate at least one reed switch for controlling one of said devices, at least one of said limbs being provided with a weight adjustably positionable therealong to balance said lever.

21. A system for the manipulation of yarn comprising a yarn-supply device, a yarn-takeup device, and a yarn-storage device receiving yarn from said yarn-feed device and delivering yarn to said yarn-takeup device, said yarn-storage device being formed with a surface retaining said yarn substantially free from tension with a tripping action while affording access to said yarn on said surface, said yarn-storage device including a rotatable yarn carrier forming said surface, said yarn-supply device comprising a nozzle for depositing the yarn upon said surface, means for retaining a yarn-supply spool, an arm swingable about an axis and provided with a pair of rollers rotatable about respective axes disposed at diametrically opposite locations on said arm across the axis of swing thereof, said yarn passing in opposite senses along each of said rollers whereby said rollers control the tension of the yarn fed to said nozzle and withdrawn from said spool, said arm being provided with a roll spaced from said rollers, said yarn-supply device further comprising a roll rotatable about a stationary axis relative to said arm, said yarn looping around said rolls prior to passage over and between said rollers whereby increasing yarn tension reduces the length of the loop between said rolls and reduces the surface area of said rollers in contact with said yarn and vice versa, an electrical contact actuatable by said arm upon excessive reduction in the length of said loop, said nozzle being connected to a source of compressed air, said yarn-supply device further comprising an electromagnetic valve operatively connected to said

contact and cut off thereby upon actuation of said contact by said arm, yarn-sensing means at said yarn-takeup device and responsive to an excessive accumulation of yarn upon said surface, and electromagnetic means connected to said sensing means and action upon said arm for swinging same about its axis to decouple said rollers from said arm, said sensing means

including an excess accumulation feeler responsive to the presence of an excessive quantity of yarn on said surface for operating said electromagnet, and a low-level feeler disposed opposite said excess-accumulation feeler and operatively connected with said yarn-takeup device for inactivating same.

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