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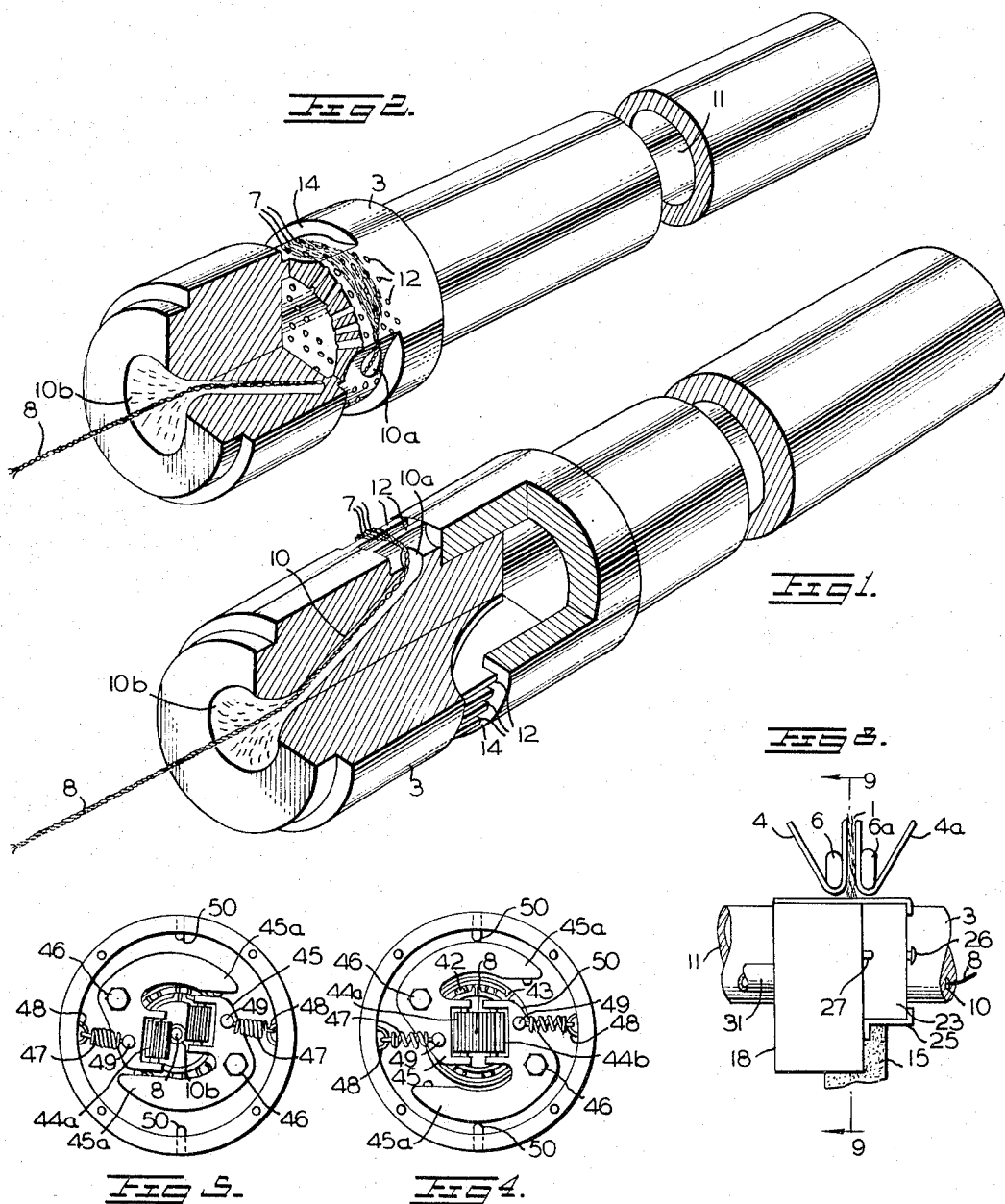
G. J. KYAME ET AL

3,295,307

METHOD AND MACHINE FOR MAKING YARN FROM STAPLE FIBER

Filed Oct. 5, 1964

2 Sheets-Sheet 1



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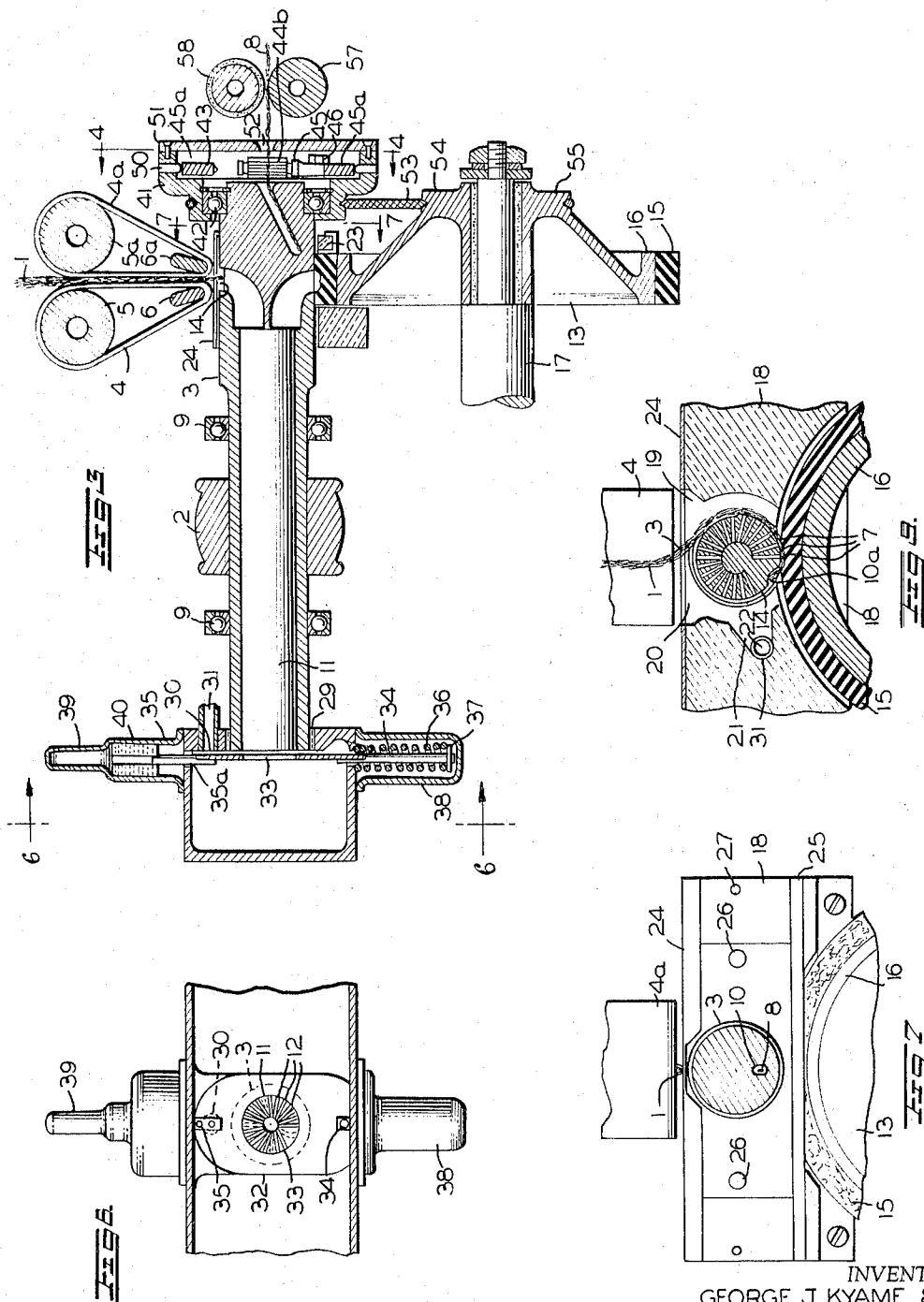
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METHOD AND MACHINE FOR MAKING YARN FROM STAPLE FIBER

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A nonexclusive, irrevocable, royalty-free license in the invention herein described, for all governmental purposes, throughout the world, with the power to grant sublicenses for such purposes, is hereby granted to the Government of the United States of America.

This invention relates to a machine and method for the production of yarns from staple fibers having spinning properties similar to cotton fibers.

Of the many methods that have been proposed for making yarn from staple fibers without using flyers, pots, rings and travelers, etc., none has been commercially acceptable for producing yarns having uniform cross section and adequate strength. In the majority of instances, this failure to produce uniform yarns is due mainly to a lack of control over the fibers as they are being delivered to the twist-inserting medium. The direct result of this lack of fiber control is a varying thickness of the yarn made, much as would be caused by nonuniformly drafting the roving strand in conventional spinning methods. For example in Keeler et al., U.S. Patent No. 2,926,483, fibers are drawn from an attenuated sliver or roving strand by means of suction with no assurance that the member of fibers transferring from the attenuated strand of the twist-inserting spinner will be the same, or nearly the same, at all times. Similarly, Gotzfried, U.S. Patent No. 2,911,783, uses whirling air currents to conduce and twist fibers into a strand, again without the assurance of constancy in the rate of fiber deposition onto the twisting free end of the forming yarn strand. Others, Strang et al., U.S. Patent No. 2,944,381, Kennedy, U.S. Patent No. 2,468,827, and Ogelsby et al., U.S. Patent No. 2,711,626 are similarly confronted with the problem of fiber control regardless of whether the medium for conveying the fibers to the spinner is air, fluids, electrostatics, or any other.

In U.S. Patent 684,714 and 3,132,465 staple fibers are converted into yarns at the surface of the spindle after which the yarn is withdrawn from the spinning zone along the surface and over the end of the spindle. This type of apparatus has disadvantages. In the first place the spindle speed is limited by the centrifugal action that results at higher spindle speeds. This centrifugal action causes the yarn to fly off the spindle. In one embodiment of U.S. Patent 3,132,465 this problem has been partially overcome by the use of tensioned belts which in themselves are also limited for the same reason.

In the second place, the belts hold the yarn to the surface of the spindle and impede the free run-back of the twist to the spinning zone, a factor which is essential in the successful production of commercially acceptable yarn. Even in our latest invention, U.S. Patent No. 3,110,150 complete fiber control is not attained because at least one end of each fiber transferred from the attenuated supply strand to the twist-inserting spindle is free at all times. As a result the yarn, though of reasonably good quality, still exhibits somewhat periodic fluctuations in diameter. Another disadvantage is the inability to maintain the spinning operation over long periods of time. This inability results from the fact that the woven-wire screen covering the suction opening in the twist-inserting spindle, loads with small, fiber fragments which wrap around the screen wires or wedge between the wires at the crossovers. This blocks the suction and interferes

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with the orderly passage of the fiber supply strand into the spinning chamber, thereby breaking the continuity of the spinning operation.

We have now found that by suitably restricting the freedom of movement of both ends of the fibers in the process of conversion into a yarn strand, yarn of uniform cross section can be made. We have found that the uniformity of cross section and the continuity of the spinning operation depend on the maintenance of a uniform, constant flow of fibers to the yarn-forming spindle.

The principal object of this invention is to provide means whereby a uniform flow of fibers is maintained between the fiber supplying source and the twist-inserting medium. Another object is to provide means for maintaining the continuity of said fiber flow. Still another object is to provide means for removing hooked or folded-over fiber ends, and for maintaining a substantially parallel alignment of the fibers within the yarn structure. A further object is to provide means for rapidly threading the apparatus when putting it into operation, and for rapidly rethreading whenever needed. These and other objects and advantages will appear in the following detailed description when taken in conjunction with the drawings which show, by way of example, a preferred embodiment of the invention.

In the drawings:

FIGURES 1 and 2 are three-dimensional views of two variants of the spinning spindle used to twist into yarn the fibers fed to it. The spindles are cut away in part to show internal details;

FIGURE 3 is a schematic assembly of the preferred embodiment of the invention;

FIGURES 4 and 5 are sections along line 4—4 of FIGURE 3, showing details of a false-twisting device which works in conjunction with the spinning spindle to control the amount of twist put into the yarn; the two views show the closed and open positions, respectively, of the yarn gripping rollers;

FIGURE 6 is a section along line 6—6 of FIGURE 3, showing details of the diaphragm valve used to control the vacuum conditions during operation of the invention; the valve is shown in the spinning position;

FIGURE 7 is a section along line 7—7 of FIGURE 3, showing a front view of the housing enclosing the yarn transfer region;

FIGURE 8 is a side view of the housing in FIGURE 7; and

FIGURE 9 is a section along line 9—9 of FIGURE 8 showing internal details of the housing in FIGURE 7.

In the machine described below, unspun fibers, preferably in the form of drafted sliver or roving, are brought into intimate contact with the free-end fibers of a yarn strand which is being turned about its longitudinal axis while its other end is held fixed against rotation. Twist resulting from said rotation of the free yarn end causes the free-end fibers to intermingle with the unspun fibers thereby forming a new increment of yarn. Simultaneously with the formation of new yarn increments, the yarn strand is drawn linearly away from the zone of fiber intermingling, and new fibers are introduced into said zone in number sufficient to maintain equilibrium between incoming fibers and outgoing yarn. During the yarn forming process, fiber hooks present in the fibers entering the zone of spinning activity are removed by the combined actions of the rapidly-rotating, twist-inserting spindle and the fiber-feeding system.

Referring to the drawings in greater detail, the invention is shown applied to spinning cotton sliver or roving 1, using a conventional power supply to turn the tape driven whorl 2 attached to spinning spindle 3. Sliver or roving from conventional supply sources is guided by the usual guide trumpet, not shown, into a drafting system

which terminates in feed apron pair 4, 4a, driven by drive roll pair 5, 5a, and guided at their lower ends by guide bar pair 6, 6a.

The drafting system, conventional in every respect except for its terminal feed aprons 4, 4a, attenuates the sliver or roving 1, drawing the fibers therein in substantially parallel alignment with the longitudinal axis of the strand, thereby facilitating the removal of individual fibers from the strand during the yarn forming operation which will be described below.

Spinning spindle 3 is one apparatus suitable for bringing together into intimate contact, the fibers drawn from the attenuated supply strand 1 and the free-end fibers 7 of yarn 8. Rotation of spindle 3 about its longitudinal axis twists the free end of yarn 8 causing the end fibers 7 to squirm and eventually rotate about the longitudinal axis of said yarn. Said squirming rotation of free-end fibers 7 brings about their intermingling and eventual entanglement with the fibers withdrawn from attenuated fiber supply strand 1, forming an increment of yarn with each fiber entanglement that takes place.

Spindle 3 is a capped, hollow cylindrical member with a circumference greater than the length of the fibers to be spun and, is rotatably supported in bearings 9 which, along with all other component elements of the invention, are assembled in a suitable supporting framework, not shown, by means well-known to those skilled in the art. The capped end of spindle 3 is provided with a smooth-walled yarn passageway 10, having an inlet opening 10a on the external surface of the spindle, extending inwardly and obliquely toward the axis of rotation of the spindle, and terminating in a flared outlet 10b in substantial alignment with said spindle rotation axis. Yarn passageway 10 is completely independent of and in no way joins the hollow interior 11 of spindle 3. Encircling the capped end of spindle 3, are a number of openings 12 which communicate with the spindle hollow 11 and are arranged in a narrow open, circumferential band which is aligned with and centered about yarn inlet 10a of passageway 10. FIGURES 1 and 2 show two variants of spindle 3. In FIGURE 1, openings 12 are closely spaced, radial slits approximately one-eighth inch long and aligned parallel to the axis of rotation of the spindle. The two-piece construction shown merely indicates one method of fabricating such a spindle; other methods, equally effective, are well-known to those skilled in the art. FIGURE 2, the second variant, illustrates a spindle of one-piece construction wherein openings 12 take the form of a band of small, closely-spaced, radial holes having a diameter of at least five mils, the band being about one-eighth inch wide. Other variants are readily conceived by those experienced along these lines.

To permit the drawing of individual fibers from the attenuated supply strand 1 for subsequent conversion to yarn increments, spindle 3 coacts with roller 13, to pluck said fibers from the grip of delivery aprons 4, 4a as the leading ends of the fibers reach the nip of the spindle-roller combination. To prevent the premature withdrawal of said fibers, spindle 3 is circumferentially recessed by a shallow groove 14. Said groove is superimposed on the band of openings 12, but encircles the spindle body to a lesser extent. The remaining ungrooved but perforated portion of the spindle body constitutes a fiber spinning zone since it is in this region that the unspun fibers and the yarn free-end fibers intermingle to form new yarn increments. The spinning zone should be no longer than the staple length of the fiber. Groove 14 is, preferably no wider than the axial width of the band formed by openings 12, has a depth that is greater than the thickness of the layer of fibers to be plucked, and starts at the trailing edge of yarn inlet opening 10a, encircling the spindle body in the direction of spindle rotation a circumferential distance preferably equal to or greater than the staple length of the fibers to be spun. These specifications of groove 14 are given by way of illustrating a

preferred embodiment only; they may be varied over a wide range without departing from the spirit of the invention. The shape of the groove may be flat-bottomed, rounded, V-shaped, etc.

The fiber plucking ability of roller 13 is facilitated by a substantially smooth-surfaced, resilient, friction-imparting covering 15 bonded to its rim 16. Said roller 13 is rotatably mounted on stud 17 outwardly extending from a slidable or pivoted support assembly, not shown, which serves to bring roller covering 15 in firm contact with the surface of spindle 3. One example of a sliding mount suitable for this purpose is described in U.S. Patent No. 2,732,682 by one of us; other methods for achieving the same objective are well-known to the art. Said assembly supports roller 13 axially parallel to spindle 3, and centers it directly over groove 14. The face width of rim 16 and its associated resilient cover 15 is greater than the width of groove 14 so that said cover contacts the surface of spindle 3, but never touches the bottom of groove 14.

Attenuated fiber supply strand 1 delivered by apron pair 4, 4a is kept under constant control by the novel housing assembly 18, detailed in its preferred form in FIGURES 7, 8, and 9. Housing 18 is a block-like structure bored transversely for a clearance fit on spindle 3. Its front face is recessed to form a yarn transfer region or chamber 19 which is substantially circular in shape and concentric with said transverse bore. In the assembled invention, said chamber is aligned with the band of openings 12 in spindle 3, and its depth is preferably equal to the axial width of said band of openings. The upper portion of said recess flares upwardly to form a substantially rectangular opening 20 at the top of housing 18, its width being equal to the depth of the recess and its length being slightly greater than the width of apron pair 4, 4a. Opening 20 serves as a port of entry for the passage of the attenuated fiber supply strand 1 into transfer chamber 19. Lateral extension 21 of chamber 19 connects said chamber with vacuum port 22 which is preferably located near to and on the downstream side of the spindle-roller nip. Said front face of housing 18 is further recessed for a clearance fit around roller 13 when said roller is in operating contact with spindle 3 as described above. Split cover plate 23, bored transversely for clearance fit around spindle 3, and recessed for clearance fit around roller 13, provides access to chamber 19 for maintenance. Guide runners 24, 25, rigidly attached to housing 18 and suitably cut out for clearance around spindle 3, fiber entry port 20 and roller 13, support cover plate 23 in slidable, substantially airtight engagement therewith. Knobs 26 permit retraction of the cover plate elements to expose the interior of chamber 19 for maintenance; and stops 27 limit the lateral movement thereof. Suitable conventional indexing means, not shown, hold the cover halves in the closed position during spinning.

Vacuum manifold 28, exhausted by conventional means not shown, is coupled in substantially airtight manner to the hollow end of spindle 3 by any of the many well-known rotatable coupling means, one of which is indicated schematically in the FIGURE 3 by close-fitting, sleeve bearing 29. Port 30, located just above vacuum seal bearing 29, is joined by duct 31 to vacuum port 22 in spindle housing 18, FIGURE 9. Diaphragm 32, with aperture 33 and rigidly attached actuating shafts, 34 and 35, is constrained by suitable slots, not shown, and shaft clearing holes 34a and 35a to slide vertically within said manifold. Normally, said diaphragm covers port 30 in airtight relationship therewith, and through its aperture 33, exposes spindle hollow 11 to the vacuum of manifold 28, being held in said normal position by compression spring 36 acting between the body of said manifold and flanged head 37 of shaft 34. Airtight cover 38 encloses the lower end of diaphragm 32 and its associated shaft and spring assembly, preventing atmospheric leakage into the vacuum manifold through said diaphragm guide slots and shaft

clearing hole 34a. Airtight cover 39, with electric solenoid 40 centrally oriented therein and rigidly attached to its inner walls, similarly seals the upper diaphragm guide slots and shaft clearing hole 35a against atmospheric leakage. When energized, solenoid 40 draws shaft 35 upward, lifting diaphragm 32 against the action of spring 36 to a new position wherein port 30 is exposed to the manifold vacuum through aperture 33, and spindle hollow 11 is covered and disassociated from said manifold vacuum. The vacuum manifold and its associated vacuum-controlling diaphragm assembly comprise only one of many usable combinations well-known to those skilled in the art. For example, diaphragm 32 could function just as effectively in a pivoted arrangement instead of a sliding one; said diaphragm could be actuated by other means, manual, pneumatic, hydraulic, electronic, etc.; instead of a single diaphragm, separate diaphragms might be used to control the vacuum to port 30 and to spindle hollow 11; valve types other than a sliding diaphragm could also serve the purpose. These and other combinations may be used without departing from the spirit of the invention.

Novel false-twist device 41, preferably rotatably and coaxially mounted on the capped end of spindle 3, provides means for temporarily adding extra twist to yarn 8 to facilitate fiber pickup in the zone of fiber intermingling mentioned earlier. Said device comprises in assembly: a hollow, substantially cylindrical housing 41; bearing 42; retaining rings 43; yarn gripping rolls 44a and 44b; pivoted bell-crank roll mounts 45; pivot studs 46; return springs 47; spring retaining hooks 48; spring attachment studs 49; adjustable stops 50; and cover 51 with yarn exit hole 52. To add the extra twist to yarn 8 it is necessary that false-twister 41 rotate in opposition to the rotation of spindle 3. Motive power for so driving false-twister 41 derives from roller 13 through the medium of belt 53 operating in groove 54 of said roller's offset hub 55 and groove 56 in housing 41 of said false-twister. Thus, as spindle 3 rotates, roller 13, in frictional contact therewith, rotates in the opposite direction and, through the medium of the aforementioned belt driving means, imparts its opposed rotation to said false-twisting device. Although we prefer to mount our false-twisting device directly onto our twist-inserting spindle, said false-twisting device may be independently supported and driven as we show in our U.S. Patent No. 3,110,150.

In operation, sliver or roving 1, drawn from conventional supply means, is passed through a conventional drafting system which attenuates the strand reducing it to a thin ribbon of substantially parallel fibers. Said drafting system, though conventional in operation, differs from the usual system in that the customary ribbon delivery rollers are replaced with delivery aprons 4 and 4a, the lower nip of which preferably parallels fiber entry port 20 in spindle housing 18, is centered thereover, and is set no farther away from the nip of the spindle-roller combination than the staple length of the fibers being processed, yet is as close to said fiber entry port as is possible without interfering with the free flow of air from the surrounding atmosphere into said port. Said fiber ribbon, delivered by aprons 4, 4a, enters yarn transfer chamber 19 through fiber entry port 20, being drawn there-through by suction. Suction at port 20 results from the combined evacuation of spindle hollow 11 and chamber 19 which creates pressure differentials at both, port 20 and suction openings 12 in spindle 3. Air rushing between the lower surfaces of aprons 4, 4a and the edges of port 20 to correct the unbalanced conditions existing at said port, sweeps fiber-ribbon 1 clear of the aprons and into the port. Similarly, air rushing from chamber 19 into suction openings 12 of spindle 3 transfers the leading end of said fiber-ribbon across chamber 19, and brings it into intimate contact with the free-end fibers 7 of yarn 8 which are already held against said openings by said suction.

With rotation of spindle 3, the rapidly moving yarn free-end fibers 7 and the slowly-advancing, attenuated roving ribbon 1 are subjected to a mutual brushing action because of their frictional contact with each other and with the edges of openings 12 in said spindle. Said brushing action teases out fiber hooks or foldovers present in the respective strands and improves the relative parallelism of their constituent fibers. As advancing ribbon 1 enters the nip of the aforementioned spindle-roller combination, the leading fibers are immediately plucked from the grip of apron pair 4, 4a and out of said ribbon. Said rapid withdrawal of fibers from the roving ribbon results in the removal of hooks or foldovers in the trailing ends of the plucked fibers. Since fiber plucking takes place only when the ungrooved portion of spindle 3 comes in contact with roller covering 15, fibers transferring from roving ribbon 1 to spindle 3 for subsequent conversion to yarn will deposit on the spindle surface in substantially parallel alignment with their leading ends lying in the fiber spinning zone and their trailing ends in or near groove 14. Thus, said fibers are in position to enter the yarn structure in precisely that orderly, substantially parallel arrangement essential to the formation of yarn with optimal physical properties. Twist imparted to yarn 8 by rotation of spindle 3 runs back along the yarn through passageway 10, forcing its free-end fibers 7 to rotate about the yarn axis. Said rotation of free-end fibers 7 increases their intermingling with the unspun fibers drawn from roving strand 1. Fiber entanglement resulting from said intermingling, ultimately leads to the incorporation of said unspun fibers within the forming yarn structure as new free-end fibers, replacing those with which they had formerly intermingled, and which are now an integral part of the formed-yarn structure 8.

As spindle 3 rotates and fibers 1 are fed to it, the yarn formed by the actions just described is withdrawn from the end of spindle 3 by yarn delivery roll pair 57, 58 for delivery to a conventional winding mechanism, not shown. By maintaining an equilibrium between the roving fiber input to and yarn withdrawal from spindle 3, a single, unbroken strand of yarn of any desired length can be spun; as the unbroken strand emerges from delivery roll pair 57, 58, it is free to be processed as one wishes. Thus, it can be wound into packages of any shape or size desired, or it may be physically and/or chemically treated prior to packaging. Suitable synchronized treating and/or winding units coupled to the output of our invention permit the treating and winding operations to be carried out in conjunction with the yarn forming process.

Evacuation of spindle hollow 11 results when spindle 3 is coupled to vacuum manifold 28 through seal 29 and aperture 33 of sliding diaphragm 32. During the yarn forming operation, sliding diaphragm 32 is held by spring 36 in position to align aperture 33 with spindle hollow 11 allowing air to be exhausted therefrom. If for any reason, threading of said spindle becomes necessary, solenoid 40 is energized by conventional means thereby shifting diaphragm 32 to a new position wherein spindle hollow 11 is covered, and aperture 33 exposes port 30 to the subatmospheric conditions of manifold 28. With said solenoid so energized, air is drawn from yarn transfer chamber 19 through ports 22 and 30 by way of coupling duct 31. With spindle 3 positioned to bring yarn inlet opening 10a substantially on a line joining the centers of spindle 3 and port 22, sufficient atmospheric air will be drawn through passageway 10 to suck therethrough a yarn free-end brought near yarn outlet 10b in the end face of spindle 3. To facilitate the threading operation even further, automatic indexing means such as are well-known to the art may be employed to bring spindle 3 to rest in the aforescribed threading position on stoppage of spinning.

From the description unfolded thus far, it is clear that yarn of uniform cross section can be spun on this invention in a single, unbroken strand that can be wound into

a package of any shape or size desired by suitable conventional winding units operating in synchronism with the spinning units. However, as we point out in our earlier Patent No. 3,110,150, undue frictional forces exist, that interfere with the free runback of twist to the end fibers 7 of yarn 8 during the normal spinning process. In our present invention, this frictional effect is overcome by utilizing novel, false-twist device 41 to introduce into yarn 8 sufficient added twist to make the twist runback forces exceed said interfering frictional forces. When spindle 3 is at rest, false-twist device 41 is also at rest and yarn gripping rollers 44a and 44b are drawn apart by the action of tension springs 47 on bell-crank mounting levers 45, exposing yarn outlet 10b in the end of spindle 3. The idle spindle is threaded in the manner described earlier, except that now the free end of the yarn is brought up to opening 52 in false-twister cover 51. Evacuation of chamber 19 via port 22 draws air from false-twister 41 through yarn passageway 10, lowering the atmospheric pressure within the false-twister and creating a pressure differential across opening 52 in cover 51. Air, rushing into opening 52 to correct the unbalanced pressure conditions, threads the spinning machine by conveying the yarn free end that has been brought under its influence first through opening 52, then in succession through: false-twister 41, yarn passageway 10, yarn transfer chamber 19, and finally port 22 in spindle housing 18.

As the threaded spindle is rotated, false-twister 41 is compelled to rotate in the opposite direction; whereupon, centrifugal forces cause weight arms 45a of roll mounts 45 pivoted on studs 46 to sling outward striking stops 50. Said pivoted movement of the bell-crank structures 45 causes yarn gripping rollers 44a and 44b to engage yarn 8, suspended therebetween, in clamping contact, imparting to said clamped yarn the rotation of false-twister 41. Thus, false-twister 41 adds its twist component to that segment of yarn in yarn passageway 10, and removes an equal amount of twist from that segment leaving said false-twister as the yarn is withdrawn by delivery rolls 57 and 58. It is in this manner that the extra twist needed to facilitate fiber pickup in the spinning zone of spindle 3, is temporarily given the forming yarn strand only to be removed almost immediately after it has served its purpose.

Yarn gripping rollers 44a and 44b may be of a wide variety of materials and cross-sectional shapes without departing from the spirit of the invention. It is preferred however, that said rollers have ridged surfaces, the ridges being substantially triangular in cross section, round-peaked and parallel to the axis of rotation of the rollers. Thus, as said rolls clamp on the yarn the ridges will mesh much as gear teeth do, thereby reducing the amount of yarn compression needed to effect yarn compliance with the rotation of false-twister 41. Adjustable stops 50 are set to limit said yarn compression so as to prevent undue crushing of the yarn.

In this invention, yarn production rates are governed by the same conditions prevailing in conventional spinning systems, viz., spinning spindle speed and twists per inch desired in the yarn. However, since the spinning spindle of this invention does not carry the yarn package as does the spindle of the conventional frame, and also, since no ring and traveler combination is employed, higher spindle speeds and therefore higher production rates are the rule. Spindle speeds of 100,000 r.p.m. or greater with corresponding increases in rate of production, are possible. The count or size of the yarn produced is determined by the size of the roving used and the overall draft of said roving, i.e., the ratio of the rate of yarn withdrawal to the rate of input of roving to the drafting unit. A novel feature of this invention is its adaptability to multiple spindle construction similar to conventional ring spinning systems.

It is apparent that the above description is given by way of illustrating a preferred embodiment of the invention, 75

and the various structures are subject to wide variations without departing from its scope. Some variations were pointed out as the description progressed; others will be readily conceived by those skilled in the art.

We claim

1. A yarn spinning machine comprising in combination a housing, a spindle mounted for rotation in the housing, the housing including internal surfaces parallel to the external surface of the spindle, and spaced from the external surface of the spindle to define a yarn transfer chamber extending about the spindle, means forming a fiber spinning zone on the spindle contiguous with the external surface of the spindle, the fiber spinning zone including means for holding unspun fibers on the fiber spinning zone, the spinning zone extending circumferentially of the spindle in generally perpendicular relation with the axis of rotation of the spindle and having a circumferential dimension substantially greater than its axial dimension, a roller mounted for contact with the spindle to rotate with the spindle as the spindle rotates and positioned laterally to overlap the fiber spinning zone; a recess in the spindle surface adjacent the spinning zone and aligned therewith and extending circumferentially of the spindle to include that circumferential portion of the spindle surface not occupied by the spinning zone, a yarn passageway including an inlet opening on the external surface of the spindle in circumferential alignment with the spinning zone, the yarn passageway extending from the inlet opening toward the axis of the spindle and axially of the spindle terminating in a yarn outlet in the end of the spindle and in substantial alignment with the central axis of the spindle, means for withdrawing spun yarn from the passageway, and means for introducing unspun yarn into the yarn transfer chamber, the last-named means including means forming a fiber entry port in the housing communicating with the yarn transfer chamber in substantial alignment with the fiber spinning zone.

2. A yarn spinning machine as defined in claim 1 in which means for introducing unspun fiber into the yarn transfer chamber includes a pair of endless delivery aprons moving about axes generally perpendicular to the axis of rotation of the spindle and traversing the fiber entry port, the delivery aprons being positioned adjacent the fiber entry port and having a width at least equal to the dimension of the fiber entry port perpendicular to the axis of the spindle.

3. A yarn spinning machine as defined in claim 1 in which the yarn inlet opening is in the recessed portion of the spindle surface adjacent the leading edge of the spinning zone.

4. A yarn spinning machine as defined in claim 1 in which a yarn false-twisting device is positioned between the yarn outlet end of the yarn passageway and the yarn withdrawing means.

5. A yarn spinning machine as defined in claim 1 in which the roller is an idler roller.

6. A yarn spinning machine comprising a housing, a spindle mounted for rotation in the housing, the housing including internal surfaces parallel to the external surface of the spindle and spaced from the external surface of the spindle to define a yarn transfer chamber extending about the spindle; means forming a fiber spinning zone on the spindle contiguous with the external surface of the spindle, the fiber spinning zone extending circumferentially of the spindle in generally perpendicular relation with the axis of rotation of the spindle and having a circumferential dimension substantially greater than its axial dimension, a roller mounted for contact with the spindle to rotate with the spindle as the spindle rotates, and positioned laterally to overlap the fiber spinning zone; a recess in the spindle surface adjacent the fiber spinning zone and circumferentially aligned therewith and extending circumferentially of the spindle to include that circumferential portion of the spindle surface not occupied by the fiber spinning zone; the spindle

including means forming an internal hollow cavity; means for holding unspun fibers and partially spun yarn on the fiber spinning zone and in the circumferential recess, the last-named means comprising a multiplicity of openings on the external surface of the spindle communicating with the internal hollow cavity of the spindle and distributed substantially uniformly over the fiber spinning zone and in the circumferential recess; a roller mounted for contact with the spindle as the spindle rotates and positioned laterally to overlap the fiber spinning zone; means for maintaining the internal hollow cavity of the spindle under vacuum; a yarn passageway having an inlet opening on the external surface of the spindle in circumferential alignment with the fiber spinning zone, the yarn passageway extending from the inlet opening inwardly toward the axis of the spindle and axially of the spindle and terminating in a yarn outlet in the end of the spindle and in substantial alignment with the central axis of the spindle; means for withdrawing spun yarn from the passageway and means for introducing unspun yarn into the yarn transfer chamber, the last-named means including means forming a fiber entry port in the housing communicating with the yarn transfer chamber in substantial alignment with the fiber spinning zone.

7. A yarn spinning machine as defined in claim 6 in which the means for introducing unspun yarn into the yarn transfer chamber includes a pair of endless delivery aprons moving about axes generally perpendicular to the axis of rotation of the spindle and traversing the fiber entry port, the delivery aprons being positioned adjacent the fiber entry port and having a width at least equal to the dimension of the fiber entry port perpendicular to the axis of the spindle.

8. A yarn spinning machine as defined in claim 6 including means for superimposing a false twist on the yarn withdrawn from the yarn passageway.

9. A yarn spinning machine as defined in claim 8 in which the means for superimposing false twist on the withdrawn yarn comprises a housing positioned between the yarn outlet end of the yarn passageway and the yarn withdrawing means and mounted for rotation about the axis of rotation of the spindle, a pair of coating squeeze rollers rotatably supported by means pivotally mounted in the housing, the last-named means comprising means for rotatably supporting the squeeze rollers between the pivot means and the axis of rotation of the housing and having integral weighted means located on the side of the pivot means away from the axis of rotation of the housing, and means for separating the rollers when the housing is at rest.

10. A yarn spinning machine as defined in claim 6 in which the yarn inlet opening is in the recessed portion of the spindle surface adjacent the leading edge of the spinning zone.

11. A yarn spinning machine as defined in claim 6 in which the internal hollow cavity of the spindle is connected to a vacuum source through a rotatable connection with the interior of the spindle.

12. A yarn spinning machine as defined in claim 6 in which the internal surfaces of the housing define a substantially circular cavity of a diameter greater than the outer diameter of the spindle to define an annular yarn transfer region between the spindle and the internal walls of the cavity.

13. A yarn spinning machine as defined in claim 12 including means for coupling the annular yarn transfer region to the vacuum source and means for decoupling the internal hollow cavity of the spindle from the vacuum source.

14. A yarn spinning machine as defined in claim 6 in which the yarn passageway is formed in the spindle.

15. A yarn spinning machine as defined in claim 6 in which the openings on the fiber spinning zone and in the circumferential recess and which communicate with the internal hollow cavity of the spindle are substantially rectangular, the longer dimensions being parallel to the axis of the spindle.

16. A process for producing yarn having a uniform cross section comprising the steps of dissociating a mass of staple fibers by plucking individual fibers from the mass, sequentially depositing the plucked fibers in intermingling engagement with the end fibers of a yarn strand lying on an arcuate spinning zone on the surface of a spindle, maintaining the deposited fibers in substantially parallel alignment with the yarn end fibers wherein the leading ends of the deposited fibers lie in the spinning zone and their trailing ends extend circumferentially beyond the free ends of the yarn end fibers, rotating the spindle to cause the yarn end fibers to rotate about the yarn axis whereupon they entwine with the plucked fibers deposited thereon to form a new increment of yarn, withdrawing the yarn strand and its newly formed increment circumferentially along the spinning zone in the direction of spindle rotation and into and through an internal passageway within the spindle, the inlet of said passageway being outside the spinning zone adjacent the leading edge of the spinning zone and circumferentially aligned therewith, and the outlet being in the end of the spindle and on the axis of rotation of the spindle, and thereafter packaging the thus produced yarn.

17. A process as described in claim 16 wherein the plucked fibers are subsequently deposited on and paralleled with the yarn and fibers by synchronizing the plucking action with the passage of the yarn end fibers through the plucking zone.

18. A process as described in claim 17 wherein a false twist is superimposed on the yarn withdrawn from the yarn passageway.

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FRANK J. COHEN, *Primary Examiner*.

D. E. WATKINS, *Assistant Examiner*.