July 30, 1968 I. E. BENTOV 3,394,540

MEANS AND METHOD OF CONVERTING FIBERS INTO YARN

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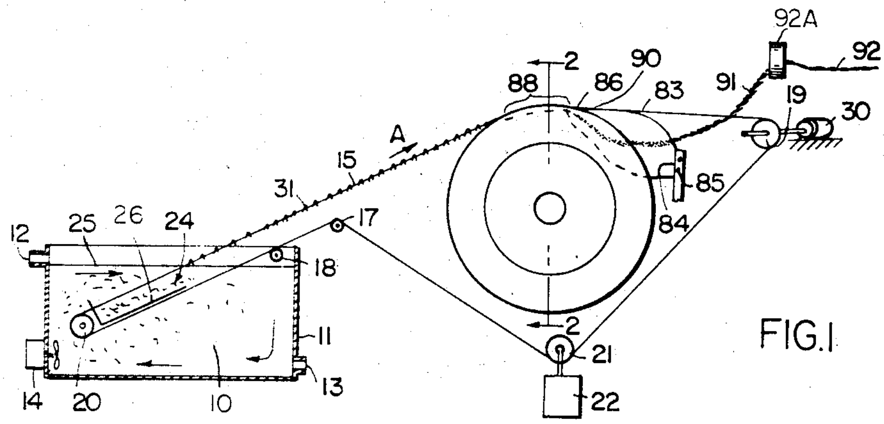



FIG.1

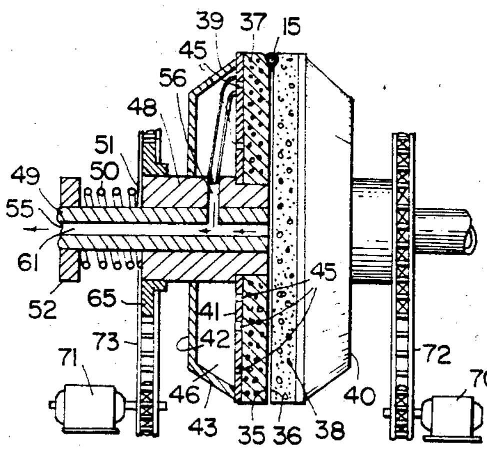



FIG.2

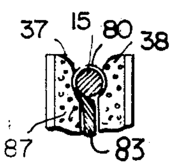



FIG.6

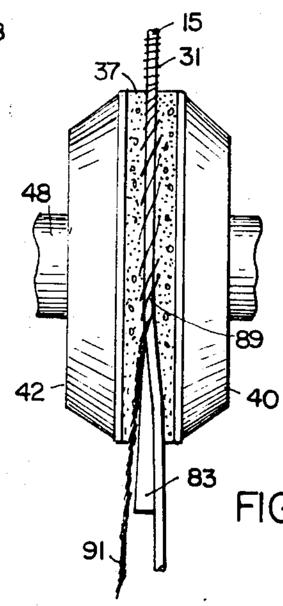



FIG.3

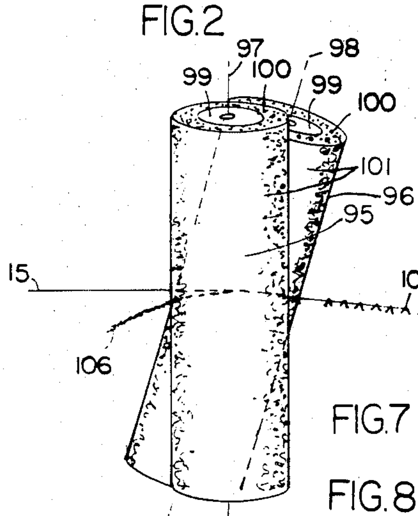



FIG.4

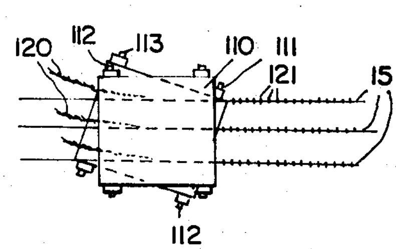



FIG.5

FIG.7

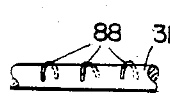
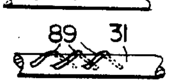



FIG.8

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MEANS AND METHOD OF CONVERTING FIBERS INTO YARN

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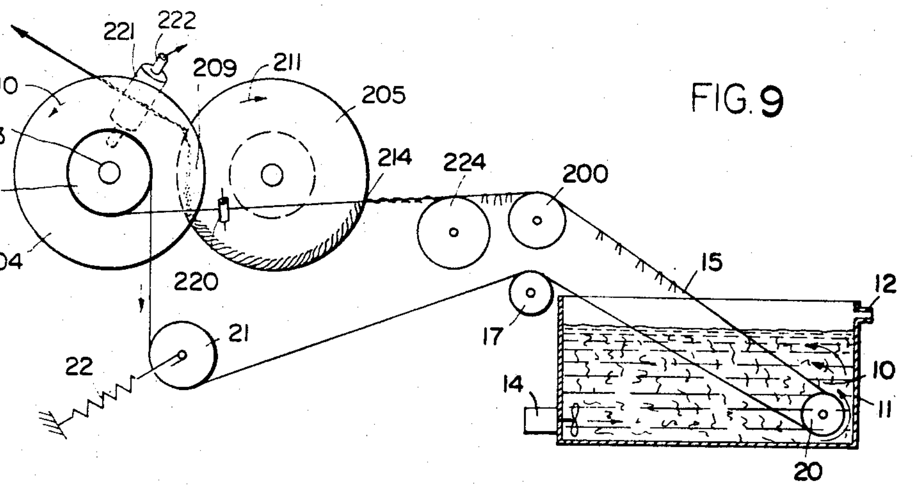


FIG. 9

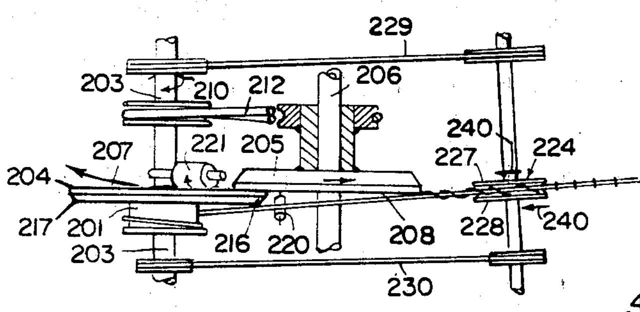


FIG. 10

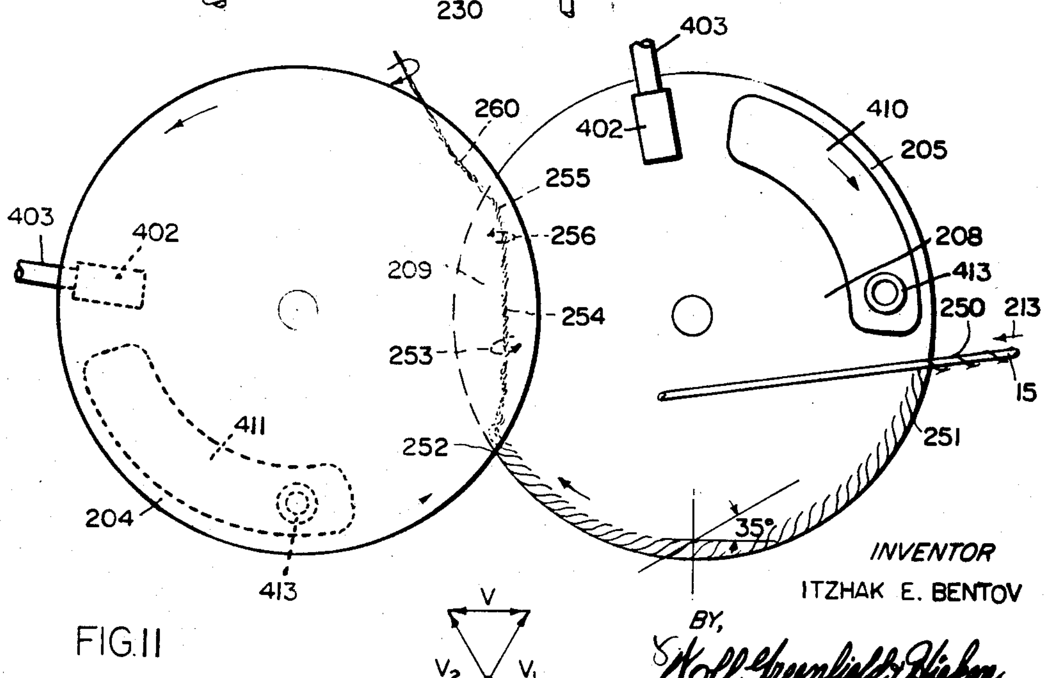


FIG. 11

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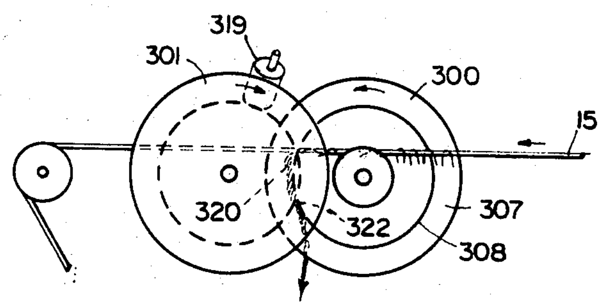


FIG.12

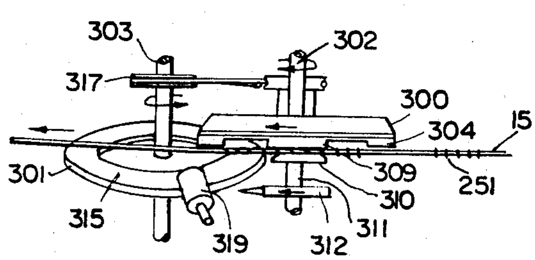


FIG.13

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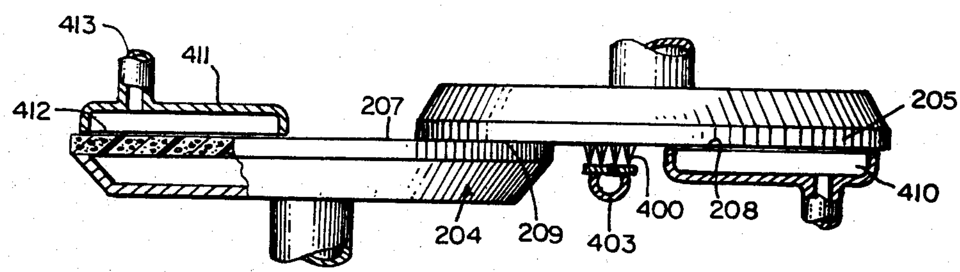
FIG. 14

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3,394,540

# MEANS AND METHOD OF CONVERTING FIBERS INTO YARN

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Continuation-in-part of applications Ser. No. 224,077, Sept. 17, 1962, and Ser. No. 350,939, Mar. 6, 1964. This application Aug. 18, 1965, Ser. No. 502,788
46 Claims. (Cl. 57—58.95)

This is a continuation-in-part of application Ser. No. 224,077 filed Sept. 17, 1962, now abandoned; and Ser. No. 350,939, filed Mar. 6, 1964, now abandoned. The present invention relates to a means and method for intertwining discrete fibers to produce roving or spun yarn.

Various methods have been used heretofore for converting discrete fibers into roving or spun yarn. Such processes include methods in which discrete or staple fibers are entrained in a stream between pairs of electrodes in such a way as to twist the fibers to yarn. Other processes include immersing staple fibers into a fluid which is then passed through a rotating conduit to twist the fibers suspended therein into roving which is drawn off as a continuous strand and separated from the fluid. These and other processes have certain limitations which are avoided in the present invention.

The present invention provides a means and method of forming roving or spun yarn from discrete fibers of various materials in an inexpensive, rapid and simple operation. The present invention moreover permits the use of relatively inexpensive fiber material, unusually short fibers and scrap fiber material which may not be useful in other processes. In particular the present invention is adapted for use in converting paper particles, strips or fibers as well as other natural and synthetic fibers and metal fibers into a spun yarn. A further object of the present invention is to provide a means and method of converting discrete cellulosic fibers from paper pulp form into a yarn without the necessity of processing the cellulosic fiber or pulp into paper before spinning it into a yarn.

A further object of the present invention is to provide a relatively inexpensive and efficient method of forming blended yarns of various different materials such for example as cotton and wool or combinations of organic and metal materials.

In the present invention an aqueous slurry containing a suspension of discrete fibers which are to form the yarn is provided. A length of wire is passed through the slurry preferably angularly upwardly in such a manner as to cause the fibers in the preferably directionally moving slurry to drape over the wire as it passes from the slurry with the fibers substantially parallel to one another and substantially normal to the length of the wire. The wire moves to means for removing the fibers from the wire and for intertwining the fibers into yarn.

In a preferred form of the invention the means for removing the fibers and intertwining them may comprise a pair of discs having parallel axes with the discs mounted for rotation in opposite directions. These discs have parallel hydrophillic surfaces with portions in facing contact. The wire moves angularly to and into contact with one disc which wipes the fibers from the wire and lays them on the periphery of the one disc at an angle such that as the laid-on fibers are moved between the discs they are twisted or intertwined to form a continuous length emerging from between the facing portions, from which it may be further twisted and dried by compacting and rolling means. These compacting and rolling means may engage or be used in conjunction with the discs. If desired, means may be used for preorienting the fibers on the wire before removal by engagement of the wire with the disc.



Alternate means for removing and twisting the fibers comprise a pair of coaxially mounted disc-like members having hydrophillic surfaces between which the fiber ladened wire moves. Means are provided for applying a suction through the members for purposes of drawing the fluid from the draped fibers as they are carried by the wire between the surfaces. The surfaces are preferably rotated in the same general direction with one surface moving slightly faster and the other running essentially at the same speed or slightly slower than the movement of the wire. The surfaces engage the ends of the draped fibers so as to reorient them to positions in which they lie substantially longitudinal with respect to the length of the wire with their ends overlapped or partially intertwined with adjacent ends. As the wire continues to move between the surfaces, a blade parallel to and interposed between the surfaces may be used to cause the partially interengaged fibers to separate from the wire. Continued movement of the partially interengaged fibers between the stationary and moving surfaces causes further intertwining and twisting of the fibers into a roving which may then be removed from between the surfaces as a continuous strand or sliver capable of being twisted into a spun yarn by a conventional spinning or twisting ring. Alternative mechanisms contemplate the use of parallel surfaces in the form of pairs of moving endless belts having their axes angular to one another and vertically oriented with respect to the wire. These belts may be mounted each on pairs of parallel axes or on a single axis provided a sufficient surface contacting area may be formed between the pairs of belts.

These and other objects and advantages of the present invention will be more clearly understood when considered in conjunction with the accompanying drawings, in which:

FIG. 1 is a partially schematic elevation of a mechanism embodying the structure of the present invention;

FIG. 2 is a partial cross-section taken along the line 2—2 of FIG. 1;

FIG. 3 is a top view of a detail of the apparatus shown in FIG. 1;

FIGS. 4 and 5 are fragmentary schematic views of modifications of apparatus embodying the present invention;

FIG. 6 is a detailed fragmentary cross-sectional view of the embodiment of FIG. 1;

FIG. 7 is a schematic illustration of fibers draped over a wire before being oriented;

FIG. 8 is a schematic illustration of fibers draped over a wire after being oriented;

FIG. 9 is a partially schematic elevation of a preferred mechanism embodying the structure of the present invention;

FIG. 10 is a top view of a detail of the apparatus shown in FIG. 9;

FIG. 11 is an enlarged schematic elevation of a detail shown in FIG. 9;

FIG. 12 is a partially schematic elevation of a modification of the embodiment shown in FIG. 9;

FIG. 13 is a top view of a detail of the apparatus shown in FIG. 12; and

FIG. 14 is a fragmentary top view of the detail shown in FIG. 11.

The present invention is useful in converting natural and synthetic organic and inorganic staple or discrete fibers from a loose random form into roving or spun yarn-like material. A wide variety of fibers may be used in connection with the present invention provided they are sufficiently flexible in nature as to be carried in preferably draped form over a moving wire. A wide variety of textile fibers may be used in the present invention and include such natural and synthetic fibers as cotton, flax, hemp, viscose and acetate, natural and synthetic protein fibers such as wool, silk or lanital and natural and synthetic inorganic or silicate fibers such as asbestos and glass fibers. Also contemplated is the use of very finely divided strips of paper. In preferred form the present invention is particularly useful in converting cellulosic paper fibers to a roving or spun yarn. The fibers may vary considerably in size depending upon the particular equipment used. A preferred embodiment of the invention contemplates fibers having a mean length between ⅛ and ⅝ of an inch with the fibers having a diameter of approximately 10 microns, the diameter depending at least in part on the fiber length and its stiffness. The length and diameter of the fibers are also in part dependent and interrelated to the diameter of the wire carrier, hereafter described. It is desirable to provide dimensions which permit a draping of the fiber evenly over the wire. For such purposes the length of the fiber should preferably be greater than half the circumference of the wire but preferably no greater than substantially its circumference. It has been found that if the fibers are substantialy longer than the circumference of the wire or longer than substantially ⅝ of an inch there is a tendency for the fibers to "ball-up" in the slurry or alternately snag on the carrier wire during the processing.

The slurry **10** is preferably an aqueous slurry comprising a mixture of water with 0.01% *to* 3% by weight of discrete fibers. As a specific example the slurry may consist of a .05% dispersion of cellulose fibers in water with the fibers having an average length of ¼″. The concentration of fibers in the aqueous slurry may vary depending upon the length of the fiber, the speed at which the slurry is pumped past the wire and the speed at which the wire carrier travels through the slurry and picks up fibers. If desired, various additives may be included in the slurry, such for example as a thickener resin which can be added to make the slurry more viscous and cause a more laminar flow of water. Also contemplated is the addition of a dispersing agent for purposes of keeping the fibers apart and preventing them from balling-up in the slurry. Suitable thickening resins include carboxymethyl-cellulose or acrylic base thickeners which may be added in an amount of between 0.01% and 0.05% by weight of the water. A suitable dispersing agent contemplated is a commercial product known as "Daxad 27" which is a sodium-lignin sulfonate type dispersing agent, produced by Dewey and Almy Chemical Company. Such dispersing agents may be added in the amount of ½% to 2%.

The slurry is contained within a suitable tank or container **11**. The tank should be provided with a suitable inlet and drain means **12** and **13** and a suitable agitator **14** which might comprise a motor operated impeller adapted to cause a circulating movement of the slurry so as to maximize the impingement of fibers onto the wire or wires **15** which pass into the slurry **10**. A set of water jets may also be used.

A preferably endless wire **15** is suitably supported so that a portion of it passes into the slurry **10**. While a plurality of such wires **15** may be used in tandem the invention is operative with but a single wire. For convenience in describing the invention it should be understood that a plurality of wires and associated mechanisms may be used in practicing this invention but for brevity a single wire and associated mechanism will be described. The wire **15** is suitably supported on a plurality of rolls or pulleys **17**, **18**, **19** and **20** with one of the rolls **20** suitably journaled within the tank **11** beneath the normal upper level of the slurry **10**. An idler roll **21** having a suitable tensioning means **22** may be provided in the preferably endless wire **15** arrangement. If desired an elongated but discrete length of wire may be used with suitable roll-up drums at its ends. The wire **15** has a portion **24** which extends down into the slurry beneath the upper surface **25**. Interposed between the portion of the wire **15** entering and the portion leaving the slurry **10** is a suitable deflector or damper **26** of a design such as to enhance the depositing of fibers onto the wire as it moves in the direction of the arrow A. The wire is moved in the direction of the arrow A at a suitable rate of speed which may be varied at will by a motor **30** suitably connected as schematically illustrated to one of the drive wheels, as for example drive wheel **19**. As the wire passes from the slurry it picks up a large quantity of discrete fibers from the slurry. These fibers are draped immediately adjacent one another over the wire **15** as illustrated at **31** in FIG. 7. The fibers lie with their ends at diametrically opposite portions of the wire and with the ends normally parallel to one another and to adjacent ends of adjacent fibers. The wire will normally center these fibers so that approximately one-half lie on either side of a plane passing vertically through the wire. Fibers from the slurry which engage the wire in a substantially lopsided fashion so that one end hangs substantially farther down than the other are normally swept off the wire by the circulating slurry. Most of the very short fibers which may be inadvertently be contained in the slurry will also be swept from the wire. The wire itself may vary in its cross-sectional shape. A circular cross-section is suitable for most purposes, however, a flat, or oval cross-sectioned, with its major cross-sectional axis lying vertically may be suitable for longer fibers.



The fiber loaded wire is passed betwen a pair of preferably hydrophillic surfaces **35** and **36**. These surfaces are parallel with one another and are closely spaced, and may if desired be substantially contiguous and touching one another. The surfaces lie in vertically oriented planes and are formed preferably by resilient hydrophillic disc-like members **37** and **38** made preferably of a soft sintered porous plastic material or porous metal. These disc members are each supported in hollow disc or cupped shaped chambers **39** and **40**. The chambers are formed with vertically oriented parallel walls **41** and **42** interconnected by a transverse wall **43**. The disc members **37** and **38** are cemented or otherwise suitably secured to the walls **41** which are perforated as indicated at **45** to permit passage of air and moisture from the foam material to the chamber **46**. The suction chambers are supported for rotation on a hub **48**, which in turn is journaled on the hollow shaft **49**. The surfaces **35** and **36** may be spring tensioned towards one another by a pair of helical springs **50**, each coaxially mounted on the shaft and engaging a hub **48** at one end **51** and a set nut or the like **52**, at the other end. The hollow shaft **49** is adapted to have one end **55** connected to a vacuum source. Passage means formed through the shaft at **56** interconnect the chamber **46** with the core **61** of the shaft so that a vacuum applied to the shaft **49** will draw moisture from the surfaces **35** and **36**. Gears **65** are fixed to each hub **48** and are adapted to rotate the surfaces **35** and **36**. Differential drive means which may comprise a set of motors **70** and **71** are connected respectively to each of the gears **65** by suitable sprocket and chain arrangements **72** and **73**. These motors are adapted to rotate the surfaces **35** and **36** about the shaft **49** at different rates of speed. Preferably both surfaces **35** and **36** are rotated in the same direction with one surface rotating slightly faster and the other rotating at essentially the same velocity as or slightly slower than the rate of speed of the wire **15** as it passes between the surfaces of the wire **15**. The wire **15** carrying the fibers **80** draped over it in parallel fashion passes between the surfaces **35** and **36** at substantially a tangential angle near its periphery over a limited arc, as best illustrated in FIGS. 1 and 2. A blade **83** may be supported on a frame **84** by suitable means such as bolts **85** and may lie symmetrical with respect to the surfaces **35** and **36** with portion of the blade **83** projecting between these surfaces. The blade **83** is formed with an upper edge **86** conformed to the cross-sectional shape of the wire **15**. One edge **87** of the blade **83** is adapted to direct the wire **15** towards and into one side of disc **38** which is the slower moving disc. At the same time the fibers are pushed from the wire by disc **38** and pass on to the other side of the blade and between the blade and disc **37**. In the embodiment illustrated, disc **37** is rotated at a greater speed than disc **38**. This causes the fibers **80** which have been pushed from the wire **15** to the left side of the wire, as viewed in FIG. 6, to be twisted between the blade and disc **37**. This action occurs after the fibers **80** have passed between the surfaces **35** and **36** for a selected distance as indicated at **88** in FIG. 1. Over the distance indicated at **88**, the fibers are reoriented from a position in which their ends lie parallel to one another and to adjacent fibers (FIG. 7) to a position in which the ends of the fiber are substantially nonplanar and lie generally longitudinally with respect to the length of the wire **15** as indicated at **89** (FIG. 8). In this position the fibers are slightly interengaged or intertwined with adjacent fibers and begin to have a roving configuration. At the time the fibers are separated from the wire they have formed a substantially continuous length. Continued movement of the fibers thus formed in the area indicated at **90** between the surface **36** and the blade causes a further twisting and/or interengagement and due to the rotary movement of the fibers along the blade thereby form the fibers into a self supporting continuous length. By proper adjustment of the blade and rotational speed of the discs and by controlling the lateral pressure of the discs towards one another a controlled amount of interengagement of the fibers mey be attained. These fibers are then drawn from between the blade and surface **36** and are fed into a conventional textile yarn twisting device which applies a further twist to the continuous length **91** to form a spun yarn **92**. The spinning ring or twisting ring may be of conventional design. In such a ring the roving passes between a pair of substantially parallel rollers having concave surfaces. These rollers are normally physically rotated about an axis lying in a plane symmetrical to the rollers with the axis having a center spaced from the rollers as the rollers themselves rotate about their own axis. Such a structure is schematically illustrated in FIG. 1 at **92A**. A single eyelet may be used in place of rollers. The yarn **92** may then be further treated by conventional processes for finishing purposes.

An alternate embodiment is illustrated in FIG. 4. In place of the surfaces **35** and **36** and the mechanism previously indicated associated with such surfaces there is provided a pair of rolls **95** and **96**. These rolls are suitably supported for rotation by journal means on nonparallel axis **96** and **98**. Suitable drive means (not shown) are provided for rotating these rolls at different speeds. Roll **95** may be rotated in a clockwise direction while roll **96** rotates in a counterclockwise direction. Each of these rolls may be formed of a hollow perforated metal drum **99** covered with a relatively thick, resilient, porous foam layer **100**. The layers **100** may be formed of the same material used in forming discs **37** and **38**. These rolls are positioned with their axes sufficiently close together so as to press against one another and form a continuous surface area **101**. Suitable means (not shown but similar to those described in FIG. 1) are provided in journaling these rolls on their axis **97** and **98** and for creating a suction or vacuum within the rolls. A wire **15** is supported and driven in a manner as heretofore explained and passes between the rollers **95** and **96** at a point of tangency. As previously indicated the axes **97** and **98** while lying in parallel vertical planes are not parallel to one another but intersect preferably at the longitudinal center of the rolls. For this reason the surface areas **101** of each roll **95** and **96** move in slightly different directions. The wire **15** passes between the rolls and is fed angularly between them in such a manner as to engage both rolls initially at their initial point of tangential contact. By rotating the rolls at differential speeds the fibers carried in parallel form as indicated at **104** are reoriented longitudinally of the wire as they pass between the surfaces **101** and are interengaged in the manner as previously described. In this modification however the blade used in separating the wire from the roving in the embodiment of FIG. 1 may be eliminated. This is due to the fact that while the fibers are being oriented longitudinally they are also rolled along the axes of the rolls slightly, due to the lateral component of motion resulting from the angle between the axes of the two rolls. This component also causes the separation of the roving from the wire. The roving thus formed by each of the rows of fibers carried by the wires **15** is then fed from between the rolls as indicated at **106** to a suitable spinning ring or the like.

A further modification of this invention is illustrated in FIG. 5 wherein a pair of endless belts **110** and **111** are mounted respectively on parallel rolls **112** and **113**. These rolls **112** and **113** are supported so that adjacent parallel faces of the endless belts **110** and **111** are vertically oriented with the wires **15** extending between the adjacent faces. The wire **15** is passed between the belts **110** and **111** in the same fashion as the wire **15** in the modification illustrated in FIG. 4. The belts **110** and **111** are pressed toward another by suitable spring tensioning means (not shown) so as to engage the sides of the fiber carried by the wires **15**. The belts **110** and **111** are driven at differential speeds in the same fashion as the discs illustrated in the embodiment of FIG. 1. The roving **120** which is formed by the fibers **121** carried on the wires **15** is then drawn from between the belts **110** and **111** and is suitably spun into yarn or the like in the manner as hereinbefore described. In this modification, water may be drained from the fibers by suction means of the type described connected to rolls **112** and **113**. In this arrangement the shafts supporting rolls **112** and **113** and rolls **112** and **113** are hollow with perforations in the walls of the shafts and rolls interconnecting the interior of the rolls, the shafts and the inner surfaces of the porous endless belt. A suction applied through the shaft will draw water from the belt as it passes over the rolls.

The preferred embodiment of this invention is illustrated in FIGS. 9 and 10. In this arrangement like numerals refer to similar components to those illustrated in the embodiment of FIG. 1. As illustrated the tank configuration, the wire **15** and the manner of picking up fibers from the aqueous slurry is similar to that as previously described. In this preferred embodiment, however, the wire **15** extends from the tank **11** over idler pulley **200** around pulley **201**, under pulley **21** and over pulley **17**. Pulley **21** may be suitably tensioned by tensioning means **22** of the type described. The wire may be driven from any suitable source such for example as a motor drive source driving shaft **203** on which pulley **201** is mounted. A pair of discs **204** and **205** are mounted respectively for rotation in opposite directions on shafts **203** and **206**. Each of these discs is made with a hydrophillic porous surface and means, not shown in specific detail, for applying suction to the surface of the discs. These means may comprise an arrangement such as shown in connection with FIG. 2 in which suction is applied to the disc surface through a hollow shaft on which the disc and a vacuum chamber are mounted. The outer surface should also have a degree of resilience such as may be attained by the use of a synthetic foam material, sintered porous plastic material, or the like.

The discs are mounted on their respective shafts **203** and **206** so that the facing surfaces **207** and **208** have an overlapping facing portion **209**. If desired the discs may be rotated in opposite directions as indicated by arrows **210** and **211** through a common drive source. Thus, for example a pulley and belt drive **212** between shafts **203** and **206** may be used to drive driven shaft **206** from the driving shaft **203** with the driving shaft **203** suitably connected to a power source, not shown.

The wire **15** is carried for movement in the direction of arrow **213** from the tank and is guided into nontangential engagement with the peripheral edge of disc **205** and preferably angular to the surface **208** at **214**.

The wire continues across and in spaced relation to the surface **208** of disc **205**, to a point **216** at which it angularly crosses and is engaged by the peripheral edge of disc **204** at its rear surface **217**. The wire **15** is pressed into firm contact with the rear surface of disc **204** at its peripheral edge at point **216** by a roller **220** which is suitably journaled for rotation on an axis extending transverse to the direction of the wire **15** at the point of engagement. As illustrated this roller **220** is positioned between shaft **206** and the peripheral edge of disc **204** with its axis at the upper end of the roll flared slightly outwardly from the plane of the inner surface **208** of disc **205**.

A compacting roller **221** may be suitably journaled for rotation with its surface in pressing contact with the hydrophilic surface **207** of disc **204**. Roller **221** is positioned with its axis substantially normal to the direction of movement of surface **207** at the point of interengagement of the compacting roller **221** and the surface **207**. The compacting roller **221** preferably has a hydrophillic surface through which suction is adapted to be applied by suitable means which may include a tubular shaft **222** on which the roller **221** is mounted with perforations in the shaft **222** within the roller **221** and with suitable suction mean (not shown) attached to shaft **222**.

An optional orienting unit **224** may if desired, be used for preorienting fibers on the wire before their removal on disc **205**. This preorienting unit **224** is constructed somewhat similar to the arrangement shown in FIG. 3. In this arrangement a pair of porous hydrophillic discs **227** and **228** are coaxially mounted for rotation in the same direction. Each disc may be provided with suction means of the type previously described in connection with FIG. 2. Each of these disc may be driven from shaft **203** by suitable pulley and belt arrangements **229** and **230**. Disc **227** rotates at a speed slightly faster than disc **228** and consequently the pulley and belt **229** will have different ratio than pulley and belt **230**.

Disc cleaning means for removing fiber remnants are provided for each of discs **204** and **205**. Such disc cleaning means, as shown in FIGS. 11 and 14, are important to minimize the likelihood of yarn breakage on the discs due to fiber remnant build up. These means comprise brushes **400** and **401** suitably supported on a frame (not shown) to secure each in wiping engagement with a surface of discs **204** and **205**. Brush **400** is radially positioned with its bristles engaging surface **208** of disc **205** just clockwise of overlapping facing portion **209** while brush **401** is radially positioned with its bristles engaging surface **207** of disc **204**, opposite of overlapping facing portion **209**. Brushes **400** and **401** have hollow backs **402** and a tubular connection **403** is in turn connected to a suitable water supply (not shown). The hollow backs **402** have apertures adjacent the bristles so that water may be supplied through connections **403** from an appropriate source to the bristles and the surfaces **207** and **208** of the porous material forming discs **204** and **205**. Water delivered in this manner is absorbed by these discs **204** and **205** after they have rotated past overlapping portions **209**. Positioned immediately counterclockwise of the brush **401** and immediately clockwise of brush **400** and associated with the same surface of each disc, as its adjacent brush, are a pair of vacuum heads **411** and **410**, respectively. These heads **410** and **411** are similar in construction and each comprise a hollow member having an open mouth **412** facing and closely adjacent the surface of the adjacent disc. These mouths **412** are arcuate in shape and are also arcuately aligned with the adjacent brush. Each vacuum head is provided with a connection **413** in turn connected to a suitable vacuum source (not shown) of sufficient force to rapidly and efficiently remove the water in the adjacent disc. Thus water passing into discs **204** and **205** will flow under fiber remnants and when withdrawn by the vacuum force applied through vacuum heads **410** and **411** will carry with it the fiber remnants lying on or impacted into the surface of the disc thereby cleaning the surface for subsequent movement into overlapping portions **209**.



In the operation of the preferred embodiment, the fibers are picked up by the wire **15** from the slurry in drape form in a manner as previously described. The fiber laden wire then moves over pulley or roll **200** into engagement with the orienting means **224** if such means are used. The wire enters between discs **227** and **228** which are rotating in the direction of arrow **240** with disc **227** rotating at a speed faster than the movement of wire **15** and disc **228** rotating at a slower speed. This causes the ends of the fibers adjacent disc **227** to be pulled forward and the other ends retarded. Simultaneously some of the fluid may be drawn from about the fibers by suction on the hydrophillic porous discs **227** and **228**. The partially oriented fibers are then carried forward to the disc **205** at which point they are removed. The fibers on the wire **15** will be partially preoriented or not depending upon whether or not preorienting means such as indicated at **224** are used. If the preorienting unit **224** is used the fibers will be picked up by the disc **205** from the wire **15** with slightly more control thon if the unit were not used. FIG. 11 illustrates the position of the draped fibers **250** when the preorienting means is not in use. In this arrangement the peripheral edge of the disc **205** at surface **208** wipes against the wire **15**. As the wire moves forwardly in the direction of the arrows **213** angular to the surface **208**, successive fibers **250** are engaged at the ends closest to surface **208**. These ends **250** are caught by the edge of the disc **205** and the fibers are laid out onto the surface **208** at an angle of approximately 25° to 35° with respect to a line of tangency to the periphery of the disc at the point at which ends **251** are positioned. It is preferable that the angle be within approximately this range and to this end the velocity of speed of disc **205** at its periphery should be greater than the speed of the wire. This speed differential stretches and lays the fibers out on surface **208** into a position illustrated in FIG. 11. The speed differential however should not be so great as to separate adjacent fibers from each other. The residual dampness of the fibers **250** from the aqueous slurry, and the hydrophillic action of the disc **208** causes these fibers to remain on the periphery of the disc **205** as it rotates about its axis to a point at which the twisting action of the fibers is commenced. The fibers may be picked up by disc **205** and laid on the surface **208** in an improved fashion if wire **15** is twisted slightly in a counterclockwise direction as viewed from the right of FIG. 9 at point **214**. This effectively raises end **251** into a better position for engagement with the disc **205**. This may be accomplished by pressure of roller **220** which presses wire **15** into engagement with rear surface of disc **204**. The engagement means that the counterclockwise movement of disc **204** as viewed in FIG. 4 imparts a slight twist to wire **15** along a section of its length including point **214**.

The oriented fiber mat or train is rotated on disc **205** as best illustrated in FIG. 11 to the lower end **252** of the overlapping portion **209** of discs **204** and **205**. Disc **204** is preferably rotated at a speed slightly faster than disc **205**. At the lower end **252** of the overlapping portion **209**, the velocity vectors of the discs in the overlapping portions which act upon the fiber mat or train may be considered as comprising the vectors $V_1$ and $V_2$ and the resultant vector V. The vector $V_1$ represents the velocity vector of disc **204** while vector $V_2$ represents the velocity vector of disc **205**. At the lower end **252** the resultant velocity vector V is in a horizontal direction which creates a shearing movement between the two discs. This resultant movement rotates the fiber mat, in the embodiment illustrated in FIG. 11, in a clockwise direction as indicated by the arrow **253**. At the center part of portion **209** in an area generally indicated at **254**, the resultant velocity vector V is in a direction parallel to or substantially parallel to the length of the partially twisted fiber mat or train because vectors $V_1$ and $V_2$ are substantially parallel. Consequently, little or no rolling action takes place in the center part or portion **209**. In the upper part **255** of portion **209**, the twisting and rolling of the fiber train is in a counterclockwise direction as indicated by arrow **256**. This is due to the reversal of direction of vectors $V_1$ and $V_2$ with a consequent reversal of direction of the resultant vector V in the horizontal plane.

Since the diameter or cross-sectional mass of the fiber mat or train at lower end **252** is relatively large due to retained water and lack of compaction, the amount of twist effected is not too great. However, the mat or train becomes progressively more compact through the loss of water and due to pressure compaction and rolling action of the discs. Thus as the mat or train moves upwardly and begins to assume a continuous integral shape, its effective diameter or cross-sectional area is significantly less at the upper end **255** than at the lower end **252**. The number of rotations of the fiber mat or train may be determined by dividing the horizontal component V by the circumference of the fiber mat. This means that effectively the train or mat will be rotated in a counterclockwise direction at the upper end more than it will be rotated in a clockwise direction at the lower end **252**. The difference in counterclockwise rotation at the upper end from the clockwise direction at the lower end of the mat or train is a net figure which is related to the net twist effected in the train that thereupon emerges as a partially finished by continuous yarn **260** at the upper end **255** of the overlapping portions **209**.

The yarn **260** may then be carried between the surface **207** of disc **204** and the compacting roller **221**. Suction applied to roller **221** removes residual water from the yarn and in addition applies further compaction which tightens and strengthens the yarn prior to its final treatment. The yarn may then be wound on any standard textile yarn take up unit such as a spindle rotating pot or spool, and may thereafter be imparted with additional twist during such an operation by means well known in the art.

A modification of the embodiment shown in FIGS. 9 and 10 is illustrated in FIGS. 12 and 13. In this arrangement elements not shown may be similar to those previously described in other embodiments. The discs **300** and **301** are mounted respectively on shafts **302** and **303**. Disc **300** is a rigidly backed disc having a vacuum chamber positioned behind a hydrophillic surface member **304** of the type previously described in connection with FIG. 9. Suitable suction means may be applied to the hydrophillic surface **304** which unlike the hydrophillic surfaces of the previously described discs is not uniformly smooth. In this embodiment the surface **304** is provided with an annular shoulder **307** which extends uniformly about the periphery of the disc and which has an inner edge **308**. The hub of the hydrophillic disc **304** may be formed with orienting means comprising a facing disc-like hydrophillic projection **309** integral with surface **304** and a facng parallel disc **310** mounted on and driven by shaft **311** by suitable driving means **312**. The disc **309** may rotate at a speed slightly greater than the disc **310** so as to orient the fibers in the manner schematically illustrated in FIG. 13 and as described above in connection with similar arrangements.

Disc **301** is preferably formed of a flexible material covered on surface **315** with a porous hydrophillic material. This disc **301** is suitably mounted on and rotated by shaft **303** by suitable drive means which may be driven from shaft **302** by suitable means such as the pulley arrangement **317**. The upper half of disc **301** is flared backward or away from wire **15** as illustrated in FIG. 13 by roller **319** suitably journaled and secured to flare the upper portion of the flexible disc **301** rearwardly and away from engagement with wire **15**. Wire **15** passes in front of the



surface of disc **304** and between discs **309** and **310** without engaging disc **304** except at its inner peripheral edge **308** at a point intermediate the shaft **302** and the shaft **303**. The fibers **251** are partially oriented as previously described between discs **309** and **310**. They are then laid onto the hydrophillic surface **304** at the inner periphery **308** and carried downwardly on rotation of the disc **304** as illustrated at **320** in FIG. 12. A mat or train of fibers is not disturbed by disc **301** until interengagement of the discs **301** and **300** at a point below the axes on which the discs are mounted. Thus there is a shearing action in one direction only in this embodiment in an area indicated at **322** which effects a twist of the overlapped fibers at that point. Preferably disc **301** travels at a slightly faster speed than disc **300** which generates a rolling and compaction action over the lower portion of the facing parts of the discs **301** and **302**. The velocity vector is entirely in one direction, not in more than one as is the case in the embodiment described in connection with FIG. 9.

The yarn thus partially formed which emerges from between the overlapping portions of disc **300** and **301** may then be further twisted by suitable or conventional means and may be taken up on conventonal take up means.

What is claimed is:

**1.** In a method of forming yarn of staple fibers the steps comprising

forming an aqueous slurry with a quantity of said fibers dispersed therein,

drawing a wire through said slurry so that said fibers are draped over the wire as it passes from the slurry,

mechanically interengaging adjacent fibers drawn from said slurry,

removing said wire from engagement with said fibers, and thereafter further treating said fibers including twisting said interengaged fibers into yarn.

**2.** In a method of forming yarn of staple fibers the steps comprising

forming an aqueous slurry with a quantity of said fibers dispersed therein,

drawing a wire through said slurry so that said fibers are draped over the wire substantially parallel to one another as it passes from the slurry,

subjecting opposite ends of said draped fibers to relative movement and into engaging relation with adjacent fibers, and removing said wire from said fibers.

**3.** In a method of forming yarn of staple fibers the steps comprising,

forming an aqueous slurry with a quantity of said fibers dispersed therein,

drawing a wire through said slurry so that said fibers drape over the wire with their opposite ends substantially parallel to one another and to the ends of adjacent fibers as said wire passes from said slurry,

subjecting said opposite ends of said fibers to relative movement into nonparallel relationship with each other and into interengaging relation with adjacent fibers, and

removing said fibers from said wire.

**4.** In a process of forming yarn the steps of dispersing staple fibers in a slurry and

drawing a wire through said slurry and angularly to the surface of said slurry so that said fibers drape over the wire with their opposite ends substantially parallel to one another and to the ends of adjacent fibers and forming said fibers into yarn.

**5.** A process as set forth in claim **4** wherein the mean average fiber length is greater than half the circumference of said wire and less than the circumference of said wire.

**6.** In a method of forming yarn of staple fibers the steps comprising,

draping said staple fibers over a wire in adjacent relation to one another,

subjecting said fibers for at least a portion of the time while draped on said wire to a reorienting movement whereby said fibers are rearranged from substantially U-shaped to elongated configurations with said rearranged fibers reoriented into positions generally longitudinal with respect to said wire and in overlapping relation with one another,

and thereafter twisting said length into a continuous length of yarn.

**7.** In a method of forming yarn of staple fibers the steps comprising,

draping said staple fibers over a wire in adjacent relation to one another and with the ends of the fibers generally normal to the length of the wire,

subjecting said fibers for at least a portion of the time while draped on said wire to a reorienting movement by engaging the ends of each of said fibers and moving them toward opposite longitudinal directions with respect to the length of the wire and with said ends in interengaging relationship with the ends of adjacent fibers,

and thereafter removing said interengaged fibers from said wire.

**8.** A method as set forth in claim **6** wherein said interengaged fibers are twisted and further interengaged on removal from said wire.

**9.** A method as set forth in claim **6** wherein said fibers are subjected to said reorienting movement by engaging opposite ends of each of said draped fibers and extending them longitudinally of said wire with surfaces having relative movement therebetween.

**10.** In a method of forming fibers into yarn the steps comprising,

forming an aqueous slurry with a quantity of discrete fibers dispersed therein,

drawing a wire through said slurry so that said fibers are draped over said wire with their opposite ends substantially parallel to one another and to adjacent fibers as said fibers pass from said slurry,

subjecting said fibers for at least a portion of the time while draped on said wire to a reorienting movement whereby the ends of adjacent fibers are arranged generally longitudinal with respect to the length of said wire and in overlapping relation with one another,

removing said reoriented fibers from said wire, and

thereafter twisting said reoriented fibers into a continuous length of yarn.

**11.** A method as set forth in claim **10** wherein said fibers are reoriented as said wire moves in a direction parallel to its axis, and said fibers are reoriented by engaging opposite ends thereof and undraping said fibers by moving said ends towards opposite longitudinal directions of said wire.

**12.** A method as set forth in claim **11** wherein said fibers are at least partially dried as they are engaged by said surfaces.

**13.** A method as set forth in claim **12** wherein said surfaces move in the same general direction as said wire with one surface moving at a faster rate than the other.

**14.** Means for forming staple fibers into yarn comprising,

a container adapted to contain an aqueous slurry of discrete fibers,

an elongated length of wire, means supporting said wire for movement through and out of said container whereby said fibers will drape over said wire as it moves from said container,

means for reorienting fibers draped on said wire to positions substantially longitudinal with respect to said wire and with ends of each fiber extending in opposite directions and with said fibers in overlapping interengaging relation, and

means for twisting said fibers into an intertwined continuous length from said overlapping interengaging relation.

**15.** Means for forming fibers into yarn comprising,



a container adapted to contain an aqueous slurry of discrete fibers,

an elongated length of wire, means supporting said wire for movement through and out of said container whereby said fibers will drape over said wire as it moves from said container,

means forming a pair of parallel adjacent surfaces between at least a portion of which said wire moves with said surfaces adapted to engage fibers on said wire,

means for moving said surfaces at different relative rates of speed whereby said fibers on said wire are reoriented into a position substantially longitudinal with respect to said wire, and

means for removing said fibers from said wire and for twisting said reoriented fibers into an intertwined continuous length.

**16.** A means as set forth in claim **15** wherein said surfaces are formed with hydrophillic properties.

**17.** A means as set forth in claim **16** wherein said surfaces are formed of absorbent resilient material,

shaft means normal to said surfaces, and

means supporting said material on said shaft for rotation in the plane of said surfaces.

**18.** A means as set forth in claim **16** wherein said surfaces are formed of absorbent resilient material,

at least one pair of shafts parallel to said surfaces, and

means supporting said surfaces on said shaft for movement in the planes of said surfaces.

**19.** A means as set forth in claim **15** wherein said surfaces are formed with porous water absorbent surfaces and with means for applying a suction through said surfaces for removing water absorbed by said surfaces.

**20.** A device as set forth in claim **19** having cleaning means comprising means for flowing water onto said surfaces at a point adjacent said portion between which said wire moves,

and means for removing said water flowed onto said surface in the same direction in which said water was flowed onto said surface.

**21.** In a means for forming fibers into yarn the combination comprising,

a pair of parallel closely spaced hydrophillic planar surfaces, means supporting said surfaces for movement in the planes of said surfaces,

a wire, and

means supporting said wire for movement between said surfaces.

**22.** In a means for forming fibers into yarn the combination comprising,

means forming resilient hydrophillic members having parallel closely spaced surfaces,

means supporting said members for movement in the planes of said surfaces,

a wire with means supporting said wire for movement between said surfaces,

means for draping a plurality of fibers on said wire before movement between said surfaces,

means for moving each of said surfaces and said wire at different rates of speed whereby said fibers are twisted into a continuous length between said surfaces, and

blade means interposed between said surfaces for removal and further twisting of fibers from said wire as said surfaces and wire are moved.

**23.** A means as set forth in claim **22** wherein the members are formed as discs, and said supporting means include rigid support means engaging said discs with a shaft extending normal to said planes.

**24.** A means as set forth in claim **23** wherein said rigid support means are hollow with passages interconnecting said discs and vacuum means whereby suction may be applied to said discs.

**25.** A means as set forth in claim **23** wherein said discs are resiliently urged toward one another.

26. A means as set forth in claim 22 wherein said members are formed of endless belts of absorbent material with each supported on an axis lying in parallel planes but extending angularly with respect to one another.

27. A means as set forth in claim 26 wherein said members are each supported on a single shaft.

28. A means as set forth in claim 26 wherein said members are each supported on a pair of shafts.

29. A means as set forth in claim 26 wherein said members are each supported with said surfaces lying in vertically oriented planes.

30. In a method of forming staple fibers into yarn the step comprising draping said staple fibers over an elongated means by moving said means through a moving aqueous slurry of said fibers at a rate different from the rate of motion of said aqueous slurry and out of said slurry through and at an angle to the surface thereof and forming said fibers into yarn.

31. In a method of forming staple fibers into yarn the step comprising draping said staple fibers over an elongated means by moving said means through a moving aqueous slurry of said fibers in a direction different from the direction of motion of said aqueous slurry and out of said slurry through and at an angle to the surface thereof and forming said fibers into yarn.

32. Means for forming fibers into yarn comprising,
- a container adapted to contain an aqueous slurry of discrete fibers,
- an elongated length of wire, means supporting said wire for movement through and out of said container whereby said fibers will drape over said wire as it moves from said container,
- means for continuously removing said fibers from said wire in a continuous train with said individual fibers extending angular to the length of the train, and
- means for engaging said train and for intertwining said fibers into a continuous yarn.

33. A means as set forth in claim 32 wherein said means for continuously removing said fibers from said wire comprise a disc having a surface with an edge engaging and extending across said wire whereby said fibers on said wire will be transferred to said surface.

34. A means as set forth in claim 33 wherein said surface is a hydrophillic surface and said wire extends angular to the plane of said surface.

35. A device as set forth in claim 34 having cleaning means comprising
- means for flowing water onto and subsequently removing said water by suction from said hydrophillic surface with said cleaning means adjacent the portion of said surface on which said fibers are deposited.

36. A device as set forth in claim 35 wherein said means for flowing water onto and subsequently removing said water comprises a brush having a tubular connection for passage of water therethrough, and
- a suction means positioned adjacent said brush for removal of said water and deposited by said brush.

37. A means as set forth in claim 34 having means for imparting a twist to said wire at the point of engagement of said wire and said edge.

38. A means as set forth in claim 37 wherein said means for imparting a twist comprises,
- means for rotating said disc in one direction,
- a second disc parallelly mounted with respect to said first mentioned disc,
- means for rotating said second disc in a direction opposite to the rotation of said first disc, and
- means for pressure engaging a portion of said wire with said second disc at a point at which the direction of angular movement of said second disc is different from the angular direction of movement of said first disc at the point of engagement of said wire with said first disc.

39. A means as set forth in claim 33 wherein said means for intertwining said fibers includes,
- a second disc parallelly mounted with respect to said first and having a surface closely spaced to said surface of said first disc, said surfaces having common overlapping facing portions,
- means for rotating said discs in opposite directions whereby the movement of said surfaces will impart a twisting action in said overlapping portions,
- means for maintaining said surfaces at a sufficient distance such that said removed fibers on one disc will be engaged by the other disc and twisted into a continuous length.

40. A means as set forth in claim 39 having a compacting roller adapted to engage twisted fibers as they move from said overlapping portions of said discs.

41. A means as set forth in claim 40 wherein said compacting roller comprises a roller having a hydrophillic porous surface.

42. A means as set forth in claim 39 having a preorienting means for orienting the fibers on said wire towards a direction substantially longitudinal of said wire.

43. A means as set forth in claim 42 wherein said preorienting means includes a pair of coaxially mounted discs having facing hydrophillic surfaces between which said wire moves, and
- means for rotating said discs at different speeds.

44. A means as set forth in claim 43 wherein said second disc is flexible with a portion thereof flexed to a position nonparallel with the said surface of said first disc.

45. A means as set forth in claim 39 wherein said edge on said disc is spaced inwardly from its periphery and said second disc engages said first disc at said edge with the resultant velocity vector of the velocity vectors of said discs in said overlapping portion extending in substantially one direction only.

46. In a means for forming staple fibers into yarn wherein a plurality of moisture laden fibers are draped over an elongated means,
- means for removing said fibers from said elongated means into a continuous train of fibers with said fibers angular to the length of the train comprising,
- means having a surface with an elongated portion positioned to engage said elongated means at a point and means for moving said elongated means and said portion relative to one another at said point whereby said fibers will be removed from said elongated means and deposited in a train onto said elongated portion with said fibers angular to the length of said elongated portion.

**References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 143,020 | 9/1873 | Lucas | 19—150 |
| 1,615,392 | 1/1927 | Little | 162—106 |
| 1,880,056 | 9/1932 | Sherman | 162—196 |
| 1,887,959 | 11/1932 | Sherman | 162—196 X |
| 2,698,972 | 1/1955 | Keeler | 19—150 |
| 2,817,947 | 12/1957 | Strang | 57—12 |
| 2,913,365 | 11/1959 | Osborne et al. | 19—156 |
| 3,156,084 | 11/1964 | Van Dijk et al. | 57—51.6 X |
| 3,161,920 | 12/1964 | Stalego | 19—.51 |


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