

Jan. 5, 1965

R. C. WILKIE ETAL

3,164,069

PAPER YARN AND METHODS AND APPARATUS FOR MAKING SAME

Filed Sept. 17, 1962

2 Sheets-Sheet 1

FIG. 1

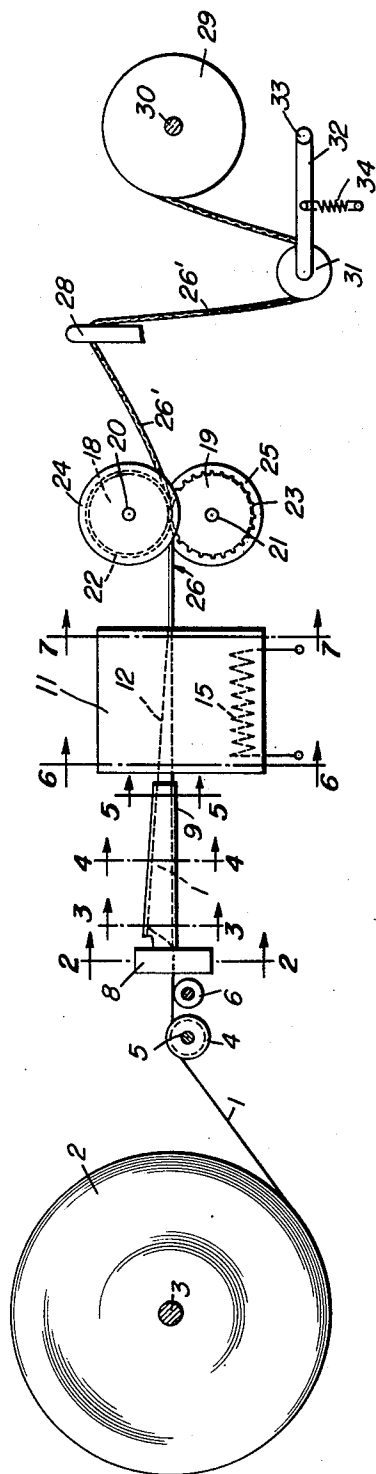


FIG. 2

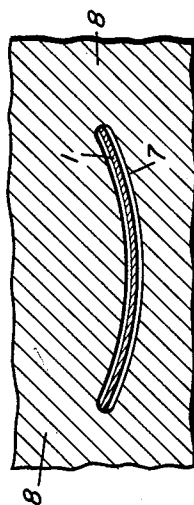


FIG. 3

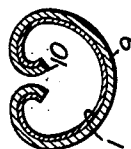


FIG. 4

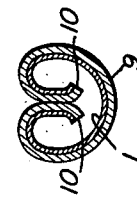
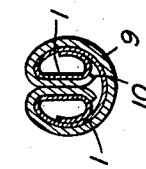


FIG. 5



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FIG. 9

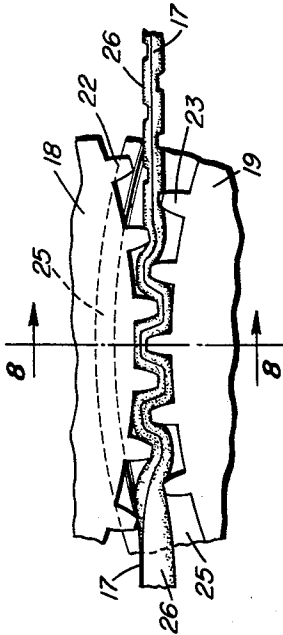


FIG. 7

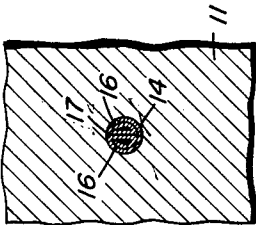


FIG. 6

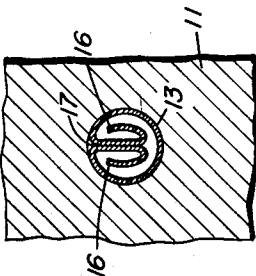


FIG. 10

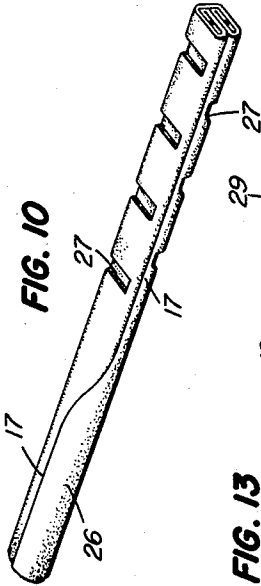


FIG. 13

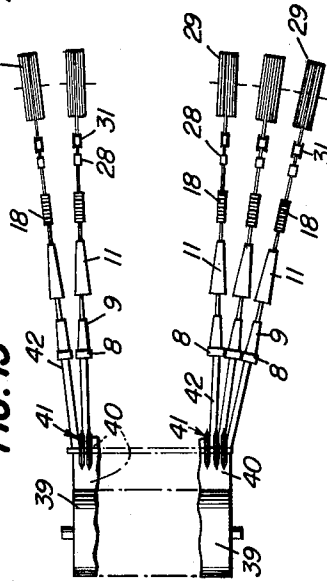


FIG. 11

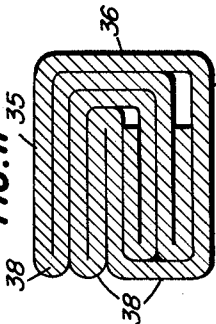


FIG. 12

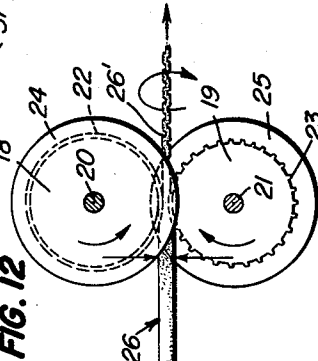
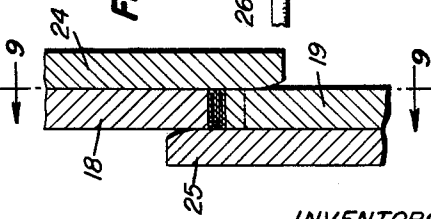


FIG. 8



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PAPER YARN AND METHODS AND APPARATUS FOR MAKING SAME

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7 Claims. (Cl. 93—84)

The present invention relates to improved paper yarn, and to methods and apparatus for producing such yarn.

In the past, twisted jute has been employed for the production of low cost yarns used in the fabrication of various products, for example, carpet backings, disposable garments, floor covering, electrical insulation and the like. The use of jute yarns in these fields presents disadvantages, for the reason that jute is not always readily available in desired quantities, and it is relatively expensive. Furthermore, such yarns have certain inherent physical disadvantages, for example, jute is characterized by an undesirable variation in tensile strength lengthwise of the yarn, which variation in some cases may be as much as 70% in different sections of the yarn.

Paper is readily available, substantially less expensive than jute and yarns made from paper avoid many of the inherent disadvantages of jute yarns, for example, yarns made from paper of uniform thickness and width have a substantially negligible variation in tensile strength lengthwise thereof.

Heretofore, paper yarns have been produced by employing a wet strength paper which is twisted while wet, and then dried after twisting. Wet strength is imparted to such paper by incorporating substantial amounts of relatively expensive resins such as methylol urea, and the like. The twisting operation presents problems reflected, for example, in a low rate of production and the necessity of using a small size bobbin. These disadvantages are the result of mechanical limitations in known apparatus for producing twisted yarns of any material such as jute or paper. Ordinarily, the production of twisted paper or jute yarn is limited to less than about 60 feet per minute, the usual production speed being in the neighborhood of 30–35 feet per minute. In order to insure adequate pliability for twisting, the paper must contain approximately 25%–30% of water, which water is subsequently removed, thus materially increasing production costs.

The present invention relates to a paper yarn which is formed from unwetted paper so that non wet-strength paper may be used, the character of the yarn being such that it may be bent, woven, braided, or otherwise manipulated without the formation of sharp bends or kinks, whereby to inexpensively form a smooth, strong, durable woven sheet adapted for various uses. Basically, the paper yarn of the present invention can be used in substantially any manner in which yarns of jute or other materials may be used, and at considerable less expense. Furthermore, it is to be particularly noted that the yarn of the present invention may be produced at extremely high speeds as compared with prior yarns, namely, speeds of the order of 750 to 900 feet per minute, employing bobbins of any desired size.

Whereas, by reason of the mechanism limitations imposed in the twisting of the yarn, such yarns can be produced only on bobbins designed to contain 2 to 3 pounds of yarn, and accordingly the free ends of the yarn of several of these bobbins must be knotted or spliced to provide commercial bobbins of 20–30 pounds capacity, the yarn of the present invention can be produced, without knotting or splicing, directly onto bobbins of 20–30 pounds capacity without difficulty. In accordance with the present invention, an improved paper yarn is produced by folding, compressing, wrinkling, and corrugat-

ing an unwetted paper strip to form a strong, compact, flexible yarn substantially square, or of other rectangular shape, in cross-section.

An object of the present invention is to provide an untwisted flexible paper having improved physical characteristics.

Another object of the invention is to provide an improved flexible paper yarn adapted to be readily woven.

Yet another object of the invention is to provide a compressed, flexible, compact paper yarn formed from inexpensive paper stock.

Still another object of the invention is to produce an untwisted paper yarn of substantially uniform tensile strength throughout its length.

A further object of the invention is to provide an improved and efficient process and apparatus for making untwisted paper yarn.

With these and other objects in view, which may be incident to our improvements, the invention consists in the parts and combinations to be hereinafter set forth and claimed, with the understanding that the several necessary elements comprising the invention, may be varied in construction, proportions and arrangements, without departing from the spirit and scope of the appended claims.

In order to make our invention more clearly understood, we have shown in the accompanying drawings means for carrying the same into practical effect, without limiting the improvements in their useful application to the particular constructions which, for the purpose of explanation, have been made the subject of illustration.

In the drawings:

FIGURE 1 is a schematic elevation of the apparatus, illustrating the successive steps of the method;

FIGS. 2, 3, 4, 5, 6, and 7 are sectional views on lines 2–2, 3–3, 4–4, 5–5, 6–6 and 7–7 respectively of FIG. 1, looking in the direction of the arrows;

FIG. 8 is a sectional view along lines 8–8 of FIG. 9;

FIG. 9 is a sectional view along lines 9–9 of FIG. 8;

FIG. 10 is a perspective view showing the general configuration of the yarn in the finishing stage;

FIG. 11 is an enlarged cross-section of the completed yarn, taken at random, illustrating the compacted completed fold pattern;

FIG. 12 is a diagrammatic view illustrating the manner in which the yarn is turned or positioned during the compacting and crimping stage; and

FIG. 13 is a schematic plan view of a modification.

Briefly, in accordance with the present invention, apparatus is provided wherein a continuous strip, or strips, of paper is drawn from a source of supply and passed through a series of stages in which the longitudinal edges of the strip are initially rolled inwardly into substantially symmetrical, oppositely disposed coils or convolutions to form a sleeve-like member of substantially circular cross-section, said member then being radially compressed and compacted to smaller diameter, the thus compacted strip subsequently being further compressed under lateral restraint and simultaneously crimped, whereby the various layers of paper are distorted and wrinkled, and the symmetrical coils or convolutions are modified and folded, the fold portions thereof being tightly compacted into interlocking engagement.

Referring to the drawings, and more particularly to FIG. 1, a strip of paper 1 is continuously withdrawn from a supply roll 2, supported on an axle 3 for free rotation thereon. The strip is led from the reel over a flanged nylon guide roller 4, supported for free rotation on an axle 5, and thence over a suitable lubricating roller 6 adapted for frictional engagement with the under surface of the paper strip 1, whereby to apply a lubricant thereto for the purpose of reducing friction between the

contacting surfaces of the paper layers during the forming and compacting stages of the yarn making process. The roller 6 may be formed of paraffin or other suitable material designed to apply a thin film or coating of such material to the strip as it passes thereover.

It will be appreciated that the lubricating step is not essential with all type of paper; some types of paper require lubrication others do not. For specific uses one or both sides of the paper could be lubricated with the same or different material for particular end and use requirements, and the form of lubrication can be obtained through the use of a solid, paste, or dispersed lubricant. The lubricants can be combined with polymeric materials, or polymeric materials alone can be used to achieve a wide variety of desired end use effects. This phase is considerably more adaptable to the system of making yarn in accordance with the present invention, as compared to twisted paper, wherein multiple stages of operations would have to be employed in such instances.

Prior to passage of the paper strip through a folding device, it may be found advantageous to slightly curve it concave upwardly, by passing it through an arcuate-shaped aperture 7 in a prefolding guide block 8 (FIG. 2). With reference to the prefolding step, it will be understood that it may or may not be employed, depending on the nature of the paper being processed. The folding device is preferably formed from sheet metal, and the entrance end thereof is substantially circular in cross-section. It will be noted, however, that its cross-sectional shape progressively changes from left to right, as viewed in FIG. 1, and as shown by the successive sectional views, FIGS. 3, 4, and 5, the edges 10 of the folding device are curled inwardly, and the cross-sectional areas of the device are progressively reduced.

As previously stated, the function of the folding device is to roll or turn the longitudinal edges of the paper strip inwardly into substantially symmetrical, oppositely disposed coils or convolutions of progressively decreasing cross-sectional areas, prior to further reduction of the cross-sectional area of the strip by radially compressing and compacting it to smaller diameter. Upon leaving the folding device 9 the strip is radially compacted by means of a compacting die 11, having a conical shaped passage 12 formed therein. It will be observed that the entrant of the passage in the left face of the die, as viewed in FIG. 1 is of greater diameter than the exit end thereof, and accordingly, the passage is of diminishing diameter in the direction of movement of the strip through the die. In the embodiment shown, the circular entrant 13 FIG. 6 is approximately $\frac{1}{8}$ " in diameter and the exit aperture 14 (FIG. 7) is approximately .040" in diameter. Ordinarily, it is unnecessary to heat the paper, however, under certain circumstances, depending upon the nature of the paper, it may be found desirable to heat the die, as for example, by means of a resistance coil 15 embedded in the die block, which block may be of brass or other suitable material.

The compacting die 11, by virtue of the taper of its passageway, compacts the sleeve-like member emerging from the folding device 9 by applying to the sleeve increasing radial pressure throughout the entire lateral area thereof. In its passage through the die the paper sleeve is continuously compacted with further folding upon itself, so that it issues in a highly consolidated and compacted state. As will be seen in FIG. 7, the product emerging from the die is of substantially cylindrical shape, each longitudinal edge portion 16 of the paper strip having been coiled or folded upon itself, with a center foldline 17 between the two coiled or folded sections.

In the next stage of the operation, the pre-formed yarn issuing from the compacting die is further consolidated and intrusively compacted into a dense, high strength yarn. The apparatus for performing these operations comprises a pair of synchronously driven toothed rollers 18 and 19, between which the pre-formed yarn is fed while being

consolidated and flexed, the rollers being adapted to corrugate or crease the strand sufficiently so that it will not open or unfold, the corrugations also imparting depressions which facilitate bending or impart flexibility into the formed strand. The rollers are supported on shafts 20 and 21, respectively, and as noted, are driven in synchronism by any suitable means, not shown. The shafts 20 and 21 are so spaced with respect to the diameter and tooth size of the rollers, that the teeth intermesh and overlap, but do not bottom, so that they provide between them a serpentine passageway through which the compressed yarn is drawn. In the illustrated embodiment, the rollers 18 and 19 are made from $2\frac{1}{2}$ " pitch diameter gears of 64 pitch and .032" width, with alternate teeth removed. The rollers are fixed on their shafts so that the teeth 22 of roller 18 are positioned intermediate the teeth 23 of roller 19, and the tip of the tooth of one roller is spaced from the bottom of the inter-tooth space of the other roller a sufficient distance so that at their closest proximity, during rotation, the yarn will be compacted and crimped, but not pinched to the extent of cutting or severing the same.

The roller 18 carries on its front face, as viewed in FIG. 1, a circular guide disc or flange 24 of slightly greater diameter than the roller, so that it overlaps the roller 19. Similarly, the roller 19 carries a circular guide disc or flange 25 on its far face as viewed in FIG. 1, which disc overlaps the roller 18. As shown in FIG. 8, the guide discs or flanges 24 and 25 serve to confine the travelling preformed yarn, designated generally by numeral 26, FIGS. 1, 9 and 13, to the rectangular passageway defined by the teeth of the rollers and the guide discs, which passageway serves to reform the circular preformed yarn 26 into square or other rectangular shaped cross-section, as shown in FIG. 8.

Referring to FIG. 12, it will be seen that as the pre-formed yarn 26 feeds into the space between the rollers, it is first engaged by the flanges or discs 24 and 25, the distance between the flanges being substantially less than the diameter of the yarn as it leaves the compacting die. This distance is normally of the order of about 20% less than the diameter of the exit orifice 14 of the die. The vertical components F_1 and F_2 of the forces exerted by the flanges 24 and 25, respectively, on the incoming yarn are such that there is tangential frictional contact between the flange 24 and the yarn, tending to move the yarn downwardly, and similar tangential frictional contact between the flange 25 and yarn, tending to move the yarn upwardly. This frictional contact has two definite observable effects. First, the oppositely rotating flanges tend to turn the yarn 26 as a whole so that, in the absence of other effects, the center fold line 17 of the yarn will be turned through an angle of 90° as shown in FIG. 10, it being understood that FIG. 10 illustrates a theoretical condition. Second, the oppositely directed frictional forces on the sides of the yarn also intrude and wrinkle the various paper layers, and distort and modify the symmetrical coils or folds which are present at the time the yarn leaves the compacting die. These consolidated folds or wrinkles appear at random, and apparently do not follow any set pattern.

As will be seen in FIG. 11, wherein one typical theoretical section of the yarn is shown, it will be seen that the upper and lower surfaces, and one side surface of the yarn are smooth, and that the fold line extends along the second side surface. In actual practice, due to the frictional action of the flanges, folds or wrinkles may be formed on any or all of the surfaces and these folds or wrinkles run longitudinally in a generally spiral direction along the yarn. The folds or wrinkles are completely at random and the number, location, and size of the folds or wrinkles may vary substantially within a length of an inch or less.

Also, since the turning effect of the flanges is dependent upon frictional engagement, very slight variations of fric-

tion will vary the amount of turning of the yarn as well as the amount and degree of folding or wrinkling. Consequently, the finished yarn does not emerge as a neatly folded and compressed strip as shown in FIGURE 10 but its cross-sectional shape or appearance varies constantly in an unpredictable random fashion throughout the length of the yarn.

As the preformed yarn passes between the spaced teeth 22 and 23, and through the serpentine passageway therebetween, it is compressed and compacted, repeatedly flexed or bent upwardly and downwardly to increase the flexibility of the yarn, and additionally the cross sectional area is sealed and kept from unfolding. During the travel of the yarn through the passageway the tips of the teeth 23 and 24 leave transverse impressions or crimps 27 on the faces of the yarn as it issues from between the rollers.

Desirably the shaft 20 (or the shaft 21) is carried in bearings which are free to move in a direction away from the shaft of the companion rotary toothed member and which are spring loaded to hold them against a fixed stop at the desired tooth spacing, so that the toothed rotary members may move apart to prevent breakage, if such movement should be necessary.

From the rotatable toothed members 18 and 19, the yarn is taken through a stationary guide 28, which may be an enamel coated pigtail or circular guide, and is wound onto a reel 29 driven by the shaft 30 on which it is supported. Preferably the winding mechanism is such as to wind the strip on to the reel 29 under minimal tension, as by means of a roller 31 carried on an arm 32 pivoted at 33 for free swinging movement, and biased by a spring 34 in a direction to maintain desired constant tension on the portion of the yarn between the guide 28 and the reel 29. This tension should be maintained at a minimum in order to prevent distortion of the yarn during the winding operation, and yet provide the proper density of package for customer requirements or end use.

One of the important features of the present invention is the construction and arrangement of the tooth roller members 18 and 19 and their respective associated discs 24 and 25, FIGS. 1 and 12, which function, in effect, as a self-opening mold. As will be observed in FIGS. 9 and 12, the counter-clockwise movement of toothed roller 18 in the vicinity of the exit end of the serpentine passageway exerts an upward thrust on the emerging completed crimped yarn 26', while the clockwise movement of the toothed roller 19 in the vicinity of the exit end of the passage exerts an equal and opposite thrust on the yarn, thus insuring free, unrestrained discharge of the compacted and crimped yarn from between the teeth of the rollers. In other words, by means of the above described improved roller-disc arrangement, the preformed, generally cylindrical shaped yarn 26 is, in effect, intruded at the entrant of the passageway and extruded at the exit end thereof. Accordingly, the only tension exerted on the yarn is that due to the pull required to advance the paper strip through the preforming device and the compacting die. Since this tension is relatively small it can be readily transmitted by the yarn without distortion or other undesired effects thereon.

Reference again being had to FIG. 11, it will be appreciated that the random cross-section illustrated therein shows the general completed fold pattern only. By reason of the complex arrangement and design of the secondary fold lines or creases and the wrinkles formed in adjacent faces of the paper layers, an intelligible illustration of the precise position and location of all of the creases and wrinkles would be most difficult, if not impossible. In connection with the cross-section shown in FIG. 11, it will be further appreciated that the positions of the top, bottom, and side faces 35, 36 and 37 may, in a neighboring random section, be found to be reversed, and that the number and position of the folds 38 varies in successive, spaced sections. Samples of the completed crimped yarn made in accordance with the present in-

vention exhibit the above described variations, as well as others, including a general spiralling of the fold line 17, and different relative positions of the crimp lines with respect to the fold line.

While the precise mechanics of the formation of the different fold patterns in different sections, taken at random, is not predictable, after considerable research and experimentation it has been found that several factors affect the position, location, and number of fold lines, as well as the resultant fold pattern. For example, it has been definitely established that the nature and character of the paper is one of the important factors affecting the fold pattern. So also variation of the frictional rubbing contact between the paper and the flanges has a noticeable effect on the fold pattern, and on the location of the fold lines as the yarn emerges from the compacting rollers. Another observable effect is the turning of the preformed yarn 26, which is ultimately reflected in the degrees of angular displacement of the fold line 17, as the yarn moves through the serpentine passageway between the teeth.

Preferably the paper stock is supplied in the form of a wide-width roll 39, FIG. 13. As the paper 40 is withdrawn from the roll it is passed through any suitable slitting device 41 by which it is separated into a plurality of ribbons or strips 42. Each strip 42 is then processed through apparatus as described, passing through a pre-folding guide 8, the folding device 9, the heating and compacting die 11, the toothed members 18, 19 and wound in reel 29, as previously described.

It will be appreciated that the paper stock may be of a different weight and composition from that mentioned above and that the strips may be of greater or lesser width, in accordance with the weight of yarn to be formed, from that described above. The paper stock and paper width described, is that which is adapted, when processed in the apparatus illustrated and described, to form a 14 pound paper yarn.

The term "paper" as used herein refers to various kinds, including laminated, which may be coated or otherwise treated to render it fireproof, mothproof and vermin-proof.

The process and apparatus of the invention are particularly effective in manufacturing paper yarn at speeds much higher than have been heretofore practicable with apparatus and processes heretofore available. Many of the prior paper yarn forming operations have involved a step of twisting or spinning the paper, which imposes a definite upper limit on the speed at which the strip may be processed. Also, many prior processes have required that the paper be prewetted so that it would have the very high moisture content necessary to the forming operations, twisting, etc. employed in these prior processes.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

In view of the difficulty of illustrating the fold patterns, creases and wrinkles, and also the location of the individual fold lines, for purposes of clarification and full understanding, there is attached hereto a sample of the yarn actually produced in accordance with the present invention.

This application is a continuation-in-part of our prior application Serial No. 148,388, filed October 30, 1961, now abandoned.

We claim:

1. Apparatus for making paper yarn from paper strip comprising a paper supply from which a strip of paper is continuously withdrawn, means for continuously folding

the opposite edge portions of the strip tightly upon themselves and conforming the strip into substantially circular cross-section; means for compacting and continuously reducing the diameter of the strip, means for drawing the paper strip from said supply through the folding and compacting means, comprising means for drawing the paper stock from said supply through the folding and compacting means comprises, a pair of rotatable members having opposed teeth which intermesh with each other but are spaced apart, each of the said pair of rotatable members having a circumferential flange extending beyond the teeth on the member, said spaced teeth and flanges defining a serpentine path through which the strip is drawn while being vertically and laterally compressed and crimped.

2. Apparatus in accordance with claim 1, in which the serpentine path is of generally rectangular cross-section, the distance between the flanges being substantially less than the diameter of the strip emerging from the compacting means.

3. Apparatus in accordance with claim 1, in which the serpentine path is of generally rectangular cross-section, the distance between the flanges being substantially less than the diameter of the strip emerging from the compacting means whereby the compacted strip entering the passageway is compressed laterally by the said flanges and is compressed vertically and crimped by the spaced teeth.

4. Apparatus in accordance with claim 1, in which the serpentine path is of generally rectangular cross-section.

5. Apparatus for making paper yarn from paper strip comprising a paper supply from which a strip of paper is continuously withdrawn, means for continuously folding the opposite edge portions of the strip upon themselves and conforming the strip into reduced, substantially circular cross-section, means for compacting and continuously reducing the diameter of the strip, means for drawing the paper stock from said supply through the folding and compacting means while vertically and laterally compressing the strip into substantially rectangular cross-section, said means comprising a pair of rotatable members having opposed teeth which intermesh with each other but are spaced apart, each of the rotatable members having a circumferential flange extending beyond the teeth on the member, said spaced teeth and flanges defining a serpentine passage through which the strip is drawn while being vertically and laterally compressed and crimped, means to rotate the toothed members, said tooth members and their associated flanges being constructed and arranged whereby movement of one

of the members exerts an upward thrust on the yarn in the vicinity of the exit end of the serpentine passage, while movement of the other member exerts an equal and opposite thrust on the yarn, thereby insuring free, unrestrained discharge of the compacted crimped yarn from between the teeth of the members.

6. The method of making paper yarn from paper strip which comprises continuously advancing a paper strip and folding the opposite longitudinal edge portions tightly upon themselves lengthwise of the strip, conforming the strip into reduced, substantially circular cross-section, progressively reducing the diameter of the strip by applying increasing radial pressure thereto in all radial directions, applying oppositely directed tangential forces to the strip in a direction normal to its direction of travel forming a path of generally rectangular cross-section, advancing the compacted strip along said path, while vertically and laterally compressing the strip into a yarn of substantially rectangular cross-section having consolidated internal folds formed with randomly spaced, longitudinal wrinkles, and crimping the compressed, compacted yarn at spaced intervals on two opposite surfaces transverse of its length.

7. The method of making paper yarn from paper strip which comprises continuously advancing a paper strip and rolling the opposite longitudinal edge portions tightly upon themselves lengthwise of the strip, conforming the strip into reduced, substantially circular cross-section, progressively reducing the diameter of the strip by applying increasing radial pressure thereto, the tightly compacted strip of reduced diameter being subjected to oppositely directed tangential forces applied thereto in a direction normal to its direction of travel, thereafter simultaneously compressing the strip laterally and vertically into a yarn of substantially rectangular cross-section, and crimping the compressed, compacted yarn at spaced intervals on two opposite surfaces transverse of the length of the yarn.

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