April 30, 1968 J. N. GRAY 3,380,131

METHOD AND APPARATUS DEFLECTING AND DRAWING TOW

Filed July 13, 1964 3 Sheets-Sheet 1

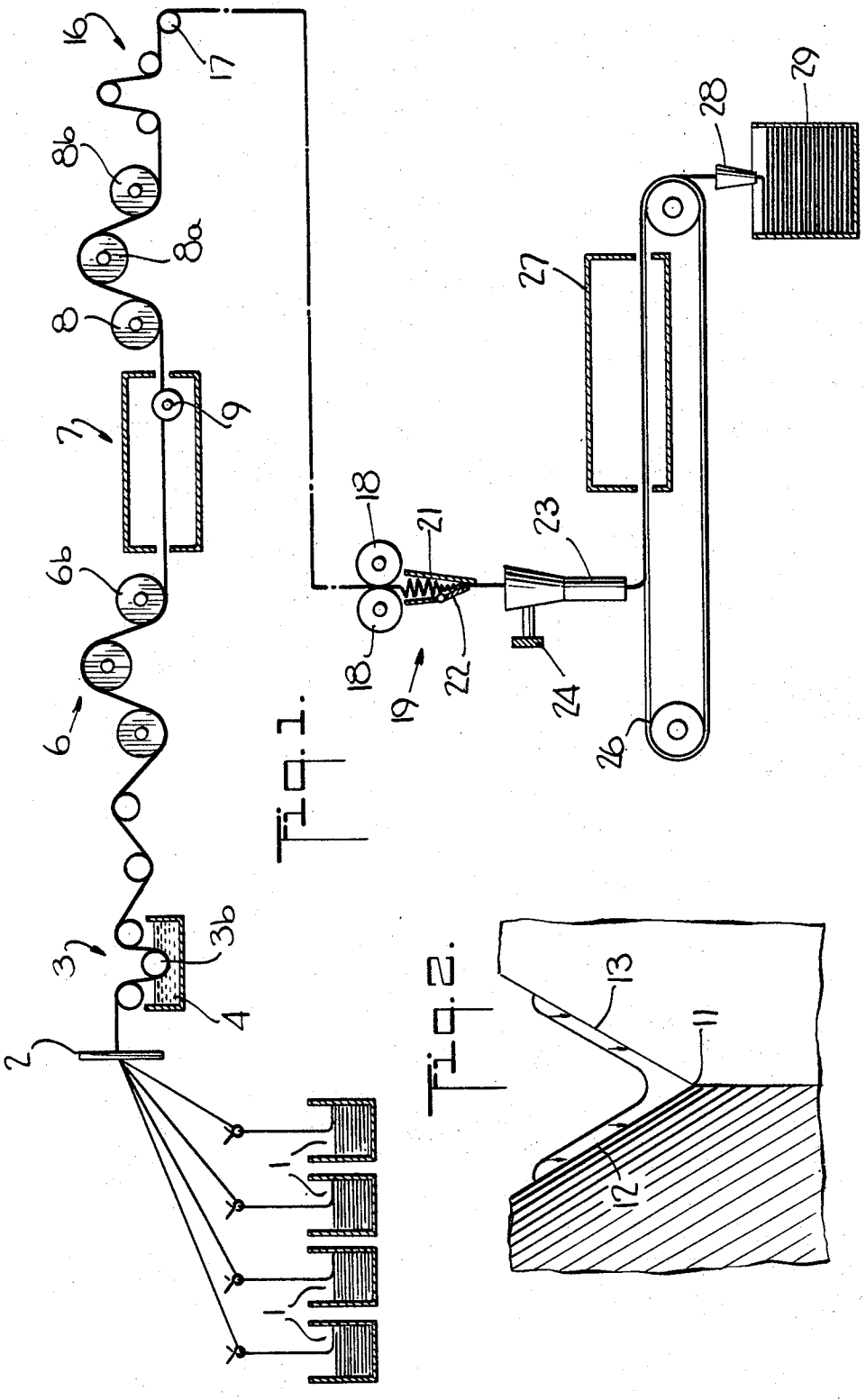

Fig. 1.

Fig. 2.

METHOD AND APPARATUS DEFLECTING AND DRAWING TOW

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Fig. 3.

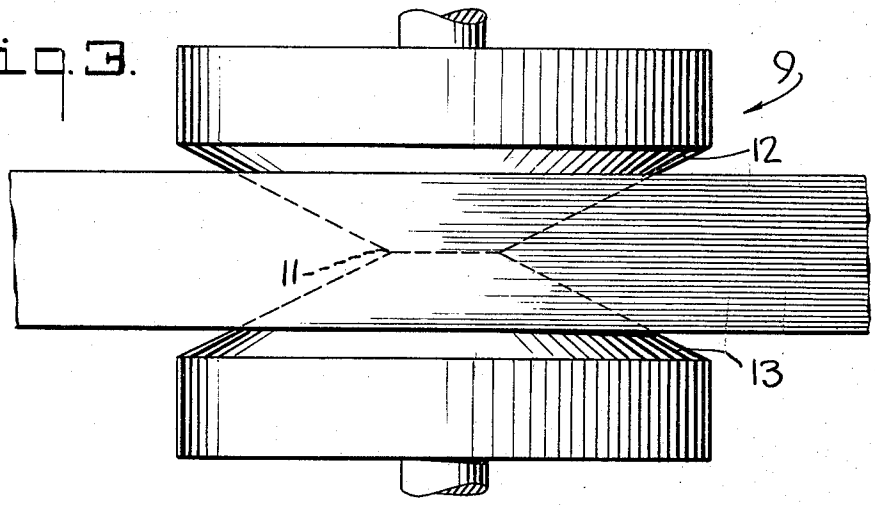
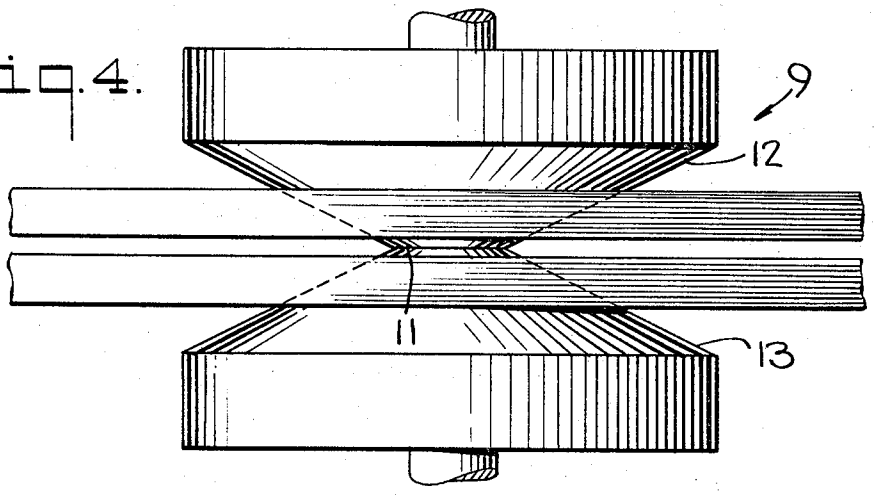


Fig. 4.



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METHOD AND APPARATUS DEFLECTING AND DRAWING TOW

Filed July 13, 1964 3 Sheets-Sheet 3

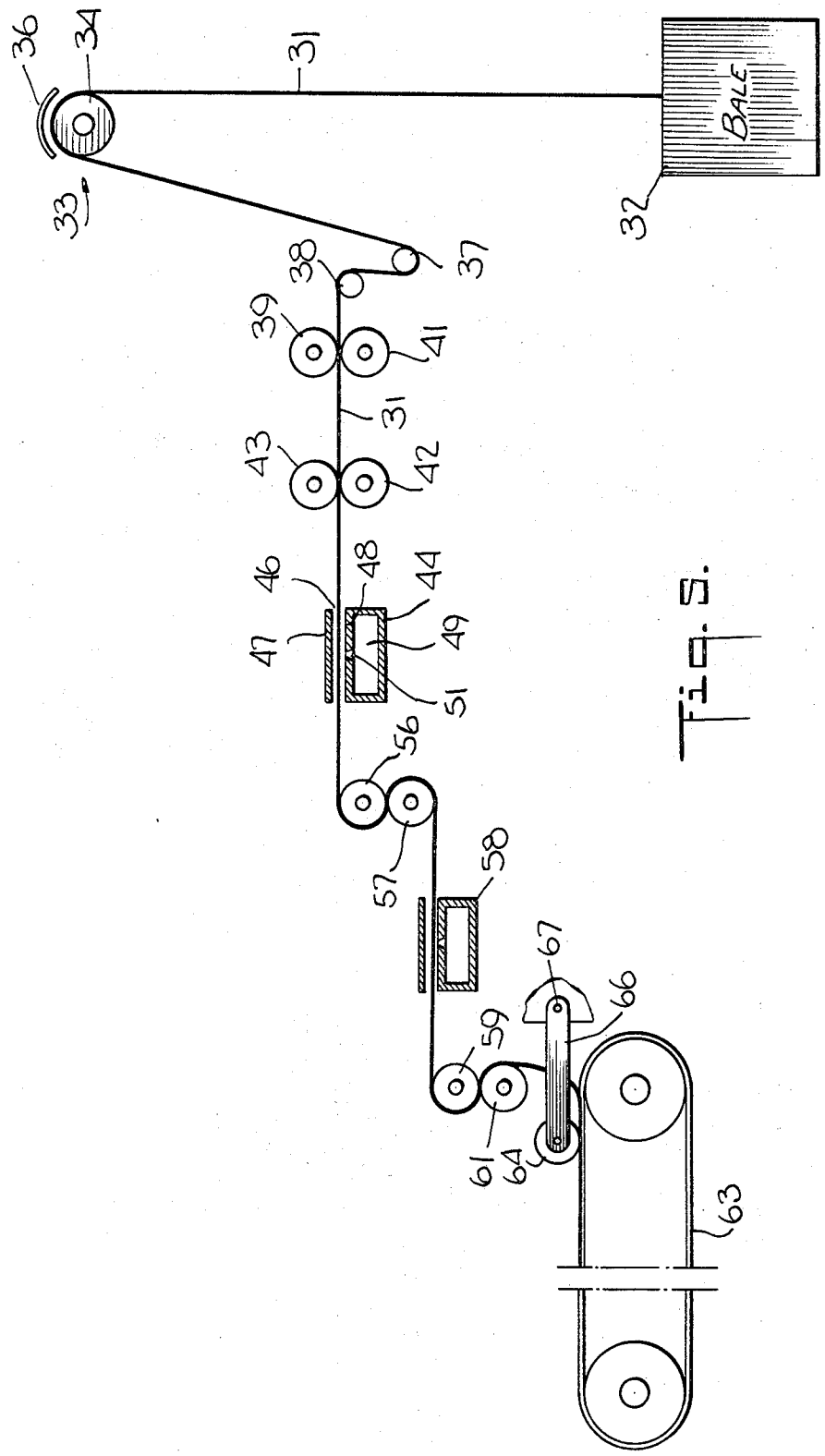

Fig. 5

United States Patent Office 3,380,131 Patented Apr. 30, 1968

3,380,131

METHOD AND APPARATUS DEFLECTING AND DRAWING TOW

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7 Claims. (Cl. 28—1)

ABSTRACT OF THE DISCLOSURE

A process and apparatus for the production of drawn tow in which a band of tow of drawable continuous filament is fed through a draw zone wherein a deflecting surface contacts the tow band and causes the filaments to intermingle.

This invention relates to tows of filamentary material and relates more particularly to the production of crimped tows of polyester filaments.

Man-made fibers which are to be cut into staple fiber length are often supplied as "tows" which are bundles of generally parallel continuous filaments, each such bundle containing a large number of such filaments, generally well over 500, e.g. 6,000 to 500,000. In one process for the manufacture of tows, suitable for use in making staple fibers, a number of sub-tows, each containing only a fraction of the filaments desired in the main tow, are first fed side-by-side to a draw frame where they are stretched, in a manner well known to the art (as discussed for example in Man-Made Textile Encyclopedia edited by J. J. Press pub. 1959 by Textile Book Publishers, Inc., pages 75 and 76), to develop the desired physical properties (e.g. high tenacity and stiffness); the resulting drawn tow is then fed to a crimping device, preferably a stuffer crimper, after which the crimp is set, as by feeding the band of crimped tow, in untensioned condition, onto a belt which transports it continuously through an oven maintained at a temperature sufficiently high to set the crimp permanently but not high enough to damage or melt the filaments. The crimped tow may then be cut into staple, baled and then opened and spun into sliver and then into yarn, as is now most commonly done, or it may be fed to a device such as a "Turbo Stapler" (U.S. 2,748,426) or a "Pacific Converter" (U.S. 2,438,-469) for direct conversion into a sliver of discontinuous filaments.

It is an object of this invention to provide a crimped tow which processes especially well during its direct conversion to sliver.

Other objects of this invention will be apparent from the following detailed description and claims. In this description and claims all proportions are by weight unless otherwise indicated.

In accordance with one aspect of this invention, a plurality of undrawn sub-tows are fed to a drawing zone and, while in the form of a band in said zone and under the drawing tension, are passed over a deflecting surface inclined to the direct draw path of said band so that the deflection from said direct draw path varies along the width of said band. The use of this process makes it possible to produce novel tows in which the degree of intermingling of the filaments is controlled and is relatively uniform across the width of the tow. Thus there can be produced tows with a limited degree of intermingling which perform especially well during direct conversion on the Turbo Stapler, producing a sliver which is uniform and has very few neps or entanglements which must be combed out. Such a tow can also be readily opened and deregistered on a patterned roll device of the type described in Canadian Patent No. 674,101 and can then be spread to form a wide uniform band by passing it through an air spreader, or series of air spreaders, in which a band of opened tow is passed through a confined zone while air is blown against one or both of the flat sides of the band.

In contrast, when the blending of the subtows is accomplished by laying one subtow on top of another, the resulting tow (after crimping) appears, when processed on the aforesaid patterned roll device, to be made up of distinguishable sublayers and the degree of intermingling across the width of the tow is so great that the processed tow is not significantly opened by the patterned roll device and is not spreadable on the air spreader.

In addition, the tows of this invention process exceptionally well on the Pacific Converter, particularly after they have been opened with the threaded patterned roll device previously mentioned. In fact, these tows when so opened produce excellent slivers and yarns even when the Pacific Converter is set to cut the filaments to very short lengths.

One aspect of this invention is illustrated in the drawing in which

FIG. 1 is a diagrammatic side view of an embodiment of the process for making a package of crimped tow,

FIG. 2 is a plan view of the tow band in the drawing zone,

FIG. 3 is a view showing the cross-section of the tow band as it passes over the deflecting surfaces,

FIG. 4 is a plan view, of a different embodiment, showing two tow bands in the drawing zone,

FIG. 5 is a schematic view of a tow opening and spreading procedure.

As shown in FIG. 1 of the drawing, a plurality of undrawn subtows **1** are taken from loose packages, each subtow being passed through its own aperture in a multi-apertured guideboard **2** and then to a series of smooth parallel stationary tension bars **3**, each of which is preferably a circular cylinder. In passing around the second tension bar **3***b* the tow dips into an aqueous bath **4**, preferably a very dilute solution or dispersion (e.g. of about 1% concentration) of a finishing agent, such as a lubricating and antistatic agent, in water. The wet tow passes from the tension bars **3** to a set of driven feed rolls **6** and then through a heated draw zone **7** to a set of driven draw rolls **8**, **8***a*, **8***b*, all of the draw rolls being driven at a peripheral speed appreciably greater than that of the feed rolls **6**. Each successive draw roll is preferably of slightly larger diameter (e.g. 0.05% larger) than the draw roll previously engaged by the tow so that although the draw rolls are all driven at the same rotational speed, the peripheral speed of these rolls, and the tow speed, increase as the tow moves over the draw rolls; the peripheral speeds of the feed rolls are similarly increased along the path of the tow.

Although the subtows, as fed to the first tension bar, are spaced along the length of said bar, and only some of the filaments of each of these multifilament subtows are in direct contact with said bar, the tension on the subtows engenders forces normal to the surfaces of the tension bars and feed rolls, which forces urge all the filaments of said subtows towards said surfaces, thus spreading the subtows until their outer filaments are in contact or even slightly overlapped. The tow leaving the feed rolls thus has the appearance of a unitary band.

In the embodiment shown in FIGS. 1 and 3 of the drawing, the deflecting surface which engages the band of tow between the feed rolls and the draw rolls is that of a double frustoconical roll **9** mounted for free rotation on an axis generally transverse to the path of the tow, preferably on an axis lying horizontally in a vertical plane perpendicular to the direction of movement

of the tow. The top of the crotch **11** of the deflector roll **9** is slightly above the direct draw path (which direct path, in the embodiment shown in the drawing, runs straight from the bottom of the last feed roll **6***b* to the bottom of the first draw roll **8**) while the upper shoulders **12** and **13** of the deflector roll **9** are obviously still further displaced from said direct path. The deflector roll **9** is so mounted that its crotch **11** is in the vertical plane of the center of the moving tow band. It will be seen that, because of the tenion on the tow band and the position of the deflector roll **9** in relation to the tow band, those filaments which are spaced from the surface of said roll and which are thereby not restrained by contact with said surface will tend to move relative to filaments at said surface as the tow passes over the deflector roll, as shown by the arrows in FIG. 2. By adjusting the position of the axis of the deflector roll **9** upwards or downwards, the tendency of the filaments to intermingle can be increased or decreased, respectively, as desired; in this manner the degree of cohesiveness of the resulting crimped drawn tow can be controlled, as desired. The degree of cohesiveness can also be increased or decreased by using deflecting surfaces of greater or lesser inclination to the direct tow path. As shown in the drawing the included angle at the crotch **11** is about 60°; suitably this angle may be in the range of about 30–150°, preferably within the range of 45–90°. Despite the fact that the filaments at the outer edges of the tow band are drawn through a longer path, by virtue of their passage over the deflector roll shoulders, than those at the center of the band, it is found that the filaments are relatively uniformly drawn throughout the band.

The tow passes from the draw rolls to a dancer roll arrangement **16** and over a guide **17** to the nip of a pair of positively driven delivery rolls **18** to a stuffer crimper **19** comprising a main body **21** which forms a V-shaped stuffing chamber, rectangular in horizontal cross-section, whose width is about the same as that of the tow band and whose depth (perpendicular to said width) is about 1¼ inch at the top, tapering downwardly over its length of about 5 inches. The outlet of the stuffing chamber is resiliently closed by a pivoted flapper **22**, biased to closed position in a manner well known to the art. The crimped band of tow leaving the stuffing chamber, still moist at this stage, is passed through a distributor **23** which may be of the usual type comprising a pivoted tube, generally of sufficient width to accommodate said band without folding, which is swung back and forth about its pivot **24** by any suitable mechanism to deposit the tow in a sinuous path across the width of a driven endless belt **26** which carries the tow, resting thereon in substantially tensionless condition, through an oven **27** which is desirably maintained at a temperature sufficiently high to set the crimp in the filaments of the tow, e.g. a temperature in the range of about 85 to 180° C. After passing through the oven the belt carries the tow some distance through ambient air, whereafter the tow is distributed (as by distributor **28**) back and forth and side-to-side in a carton **29** and is then compressed in said carton.

The preferred tow of this invention is a band of substantially parallel crimped drawn glycol terephthalate polyester continuous filaments of tenacity greater than 2 grams per denier, the crimps of adjacent filaments being in registry so that there are ridges, extending across the tow, formed from the crests and valleys of the crimps of adjacent filaments, said filaments having portions crossing over adjacent filaments at small angles of less than 1° to the general direction of said filaments, the filament density and degree of such crossing over being substantially uniform across the width of tow band, said band, after the crimps have been deregistered without further intermingling of the filaments, being readily spreadable laterally by a confined air stream to form a uniform web of a width at least six times the width of said band. Preferably the band is cohesive and non-delaminable throughout its thickness; i.e. it does not readily separate into layers without substantial filament breakage.

The following examples are given to illustrate the practice of this invention further.

Example I

7 undrawn subtows, each containing 3,530 filaments of polyethylene terephthalate of 23 denier per filament, were fed with their centerlines spaced ½ inch apart to the tension bars of an apparatus as shown in FIGS. 1 and 2. In the drawing zone the tow band was subjected to an atmosphere of a hot fluid, preferably steam. The draw ratio was about 4.6:1. The tow band leaving the last feed roll was 5 inches wide. The filaments necked down, under the drawing tension, at a point within the heated draw zone near the last feed roll **6***b*. The deflector roll, whose surface was of smooth metal, had a crotch 1½ inches in diameter and shoulders which sloped toward the crotch at an angle of 60° to the axis of said roll, forming a 60° notch. The horizontal direct draw path joining the bottom of the last feed roll and the bottom of the first draw roll was 8 feet long, and the uppermost part of the crotch of the delivery roll was located ¼ inch above this direct path, 16 inches forward of the axis of the first draw roll. The drawn tow, at its zone of contact with the deflector roll, was ¾ inch wide, measured horizontally; at the surface of the first draw roll it formed a band 1 inch wide, so that the total denier per inch of width was 128,000. At the deflector roll the outer edges of the tow band were about 1/32 inch thick, measured perpendicular to the surface of the sloping shoulder, this thickness increased gradually toward the center of the band; above the crotch of the deflector roll the tow band was ⅛ inch thick, measured perpendicular to the axis of the roll. In the stuffer crimper the tow was subjected to direct steam (supplied at 20 p.s.i.g.) and was given a fine crimp of 12 crimps per inch superimposed on a coarse crimp (of much larger amplitude) of about 3 crimps per inch. The crimp was set at a temperature of 150° C. for 20 minutes. The set tow band, when cooled, had a degree of crimp of about 60%; the percent crimp, as used herein, being

$$\left(\frac{Ls}{Lc}-1\right)\times 100$$

where Lc is the length of any predetermined portion of the tow and Ls is the average length of the filaments of said predetermined portion when under a tension just sufficient to remove the crimp. Its tenacity was 4.5 grams per denier.

The set tow band could be passed directly from the oven, after cooling, through a threaded roll opener to produce a uniform deregistered tow band, 8 inches wide, which could be spread easily to a width of more than 50 inches by passing it, indirectly after leaving the last of the threaded rolls, through two stages of air spreading. In each stage there was an air spreader made up of a pair of parallel horizontal plates between which the tow band passed, the plates being spaced apart slightly more than the thickness of the tow band, one of the plates being slitted and forming a wall of a plenum chamber which extended for the full area of the slitted plate and which was connected to a source of air under pressure so that air was blown through the slits in that plate in a substantially uniform manner across the whole width of the moving tow band. Between successive air spreaders the tow passed through tight nips of rolls driven at such a speed that the tow was pulled, under slight tension, through the spreaders. Even though the resultant web was extremely light, it was sufficiently cohesive that it would not split when a stream of air was blown against it by a fan, but instead ballooned out like a sail before the wind.

The tow opening and spreading procedure referred to in the above example utilizes the apparatus shown in FIG. 5, in the following manner: The tow band is drawn from a bale **32** through a banding jet **33** comprising a cylinder **34**, having a slit running lengthwise of the cylinder at its highest point, and a curved baffle member **36** parallel to, and spaced 1/10 inch from, the adjacent surface of said cylinder, so that the tow band **31** passes between said baffle member **36** and said cylinder **34**. Air under pressure is supplied to the interior of the cylinder **34** and emerges as a stream, from the slit of said cylinder, against the tow band and the baffle member **36**. The tow band **31**, now about 8 inches wide, passes around stationary tensioning bars **37**, **38** and then into the nip between a pair of rolls **39**, **41**, both rubber-surfaced, driven at a peripheral speed of 60 feet per minute and then horizontally to the nip between a rubber-surfaced roll **42** and a threaded steel roll **43**, driven at a peripheral speed of 102 feet per minute, said threaded roll having helical threads of 14 turns per inch cut about 1/16 inch deep into its outer surface. The tow entering the nip between rolls **42**, **43** is still about 8 inches wide. From these rolls it passes still in the same horizontal plane to an air spreader having a tow-receiving slot **46** which is 24 inches wide and 4 inches long. The tow-receiving slot **46** is defined by an upper wall **47** and a lower wall **48** spaced 1/10 inch apart. Below the lower wall **48** is a plenum chamber **49** supplied with air under a constant pressure of 3 p.s.i.g. from a suitable source (not shown) and communicating with the tow-receiving slot **46** through air slits **51**, each 0.007 inch wide at their outlet ends and tapered to said outlets at an included angle of 45°, said slits being each 5 inches long and so arranged that the end of one slit is aligned, in the direction of movement of the tow, with the end of the adjacent slit, so that air is supplied to the tow band across the full 2-inch width of the slot **46**. The slits are arranged at small angles (e.g. about 5°) to the line perpendicular to the direction of movement of the tow with the slits on opposite sides of the median line of the spreader being mirror images.

The tow band diverges uniformly from its 8 inch width at rolls **42**, **43** to the full 24-inch width at the exit of spreader **44**, the entrance of which is located 1 foot from the nip of rolls **42**, **43**. The tow is pulled through the spreader **44** by the action of a pair of rolls **56**, **57**, making an "S-Wrap" around these rolls, that is, passing 180° around steel roll **56** then passing through the nip between the rolls and then making another 180° wrap around rubber-surfaced roll **57**. The tow web keeps its 24-inch width during its travel to and around the rolls **56**, **57** which are moving a peripheral speed of 61 feet per minute.

From the lower portion of roll **57** the tow then passes to the entrance of air spreader **58** which is located 3 feet horizontally from, and one foot below, the entrance of air spreader **58**, which is located at the same horizontal level as the bottom of roll **57**. The spreader **58** is of the same design as spreader **44**, except that its tow-receiving slot is 50 inches wide, and it is operated under the same air pressure (3 p.s.i.g.) as spreader **44**. The tow web spreads uniformly in its horizontal passage to spreader **58**, at which it reaches its 50-inch width and then maintains the same width during its passage to a pair of rolls **59**, **61**, driven at a peripheral speed of 59 feet per minute, which serve to pull the web through the spreader **58**. Roll **59** is a rubber-surfaced roll while roll **61** is steel-surfaced; the top of roll **59** is on a level with the tow-receiving slot of spreader **58** and with the bottom of roll **57**. The tow makes an S-wrap about the rolls **59**, **61**, falling from the roll **61** in a freely hanging shallow catenary **62** onto the horizontal moving surface of a wide endless take up belt **63**. An idler roll **64**, mounted on lever arms **66** pivoted at **67**, extends across the full width of the tow web on belt **63**. The path of the belt is 2 feet below the bottom of roll **61** while the roll **64** is mounted 10 inches forward (in the direction of movement of the belt) of the center of roll **61**. The web on belt **63** has a width of 50 inches.

The bottom rolls of the roll pairs are each positively driven while the top rolls are spring pressed downward and are rotated by the movement of the tow passing through the nip, with no appreciable slippage.

Example II

Using the procedure and apparatus set forth in Example I there was produced an intermingled drawn polyethylene terephthalate tow having a total denier of 200,000 and a denier per filament of 1½, a crimp frequency of 15 crimps per inch and a percent crimp of 20%. In this example there were used 16 subtows, the draw ratio was 3.4:1, no steam (or other heat) was supplied during crimping, and the oven temperature was 112° C. After cooling, the tow was continuously laid into a carton and compressed to form a bale having a density of 20 lbs. per cu. ft. Bales of this tow were fed to a Turbo Stapler and there performed extremely efficiently, giving a sliver with very low count of neps or entanglements.

Example III

By raising the axis of the deflector roll so that its crotch was ½ inch above the direct draw path, and keeping all other conditions the same as set forth in Example I, the degree of intermingling was increased. The cross-section of the tow at the crotch of the deflector roll was much more compact, being substantially an equilateral triangle, approximately ¼ inch on each side. The tow was very cohesive and resisted opening and spreading; it was substantially uniformly intermingled throughout its thickness and showed no signs of separation into sublayers.

In the embodiment shown in FIG. 4, two spaced tow bands are separately deflected on the deflector roll **9** which is, in that embodiment, mounted with its axis and the upper part of its crotch below the direct draw path so that the two tow bands do not tend to converge at the crotch. Here the intermingling takes place, as in the embodiment shown in FIG. 2, by movement of filaments in a direction towards the crotch, but without the intermingling at the crotch which occurs in the embodiment shown in FIG. 2.

It will be understood that the arrangements shown in the drawings are illustrative and may be varied as desired. Thus, the deflector roll may be placed above the tow so that the tow passing over the deflecting surface is below the axis of the deflector roll; or the tow path from feed roll to draw roll may be generally vertical or inclined, with the deflector roll placed on either side of that tow path. A plurality of deflector surfaces successively engaged by the tow band may be used, and the inclination of the deflector surfaces may vary across the width of the band, e.g. by using surfaces which present a curved, rather than straight, line to the tow. In place of a freely rotatable deflector roll a stationary surface over which the tow slides may be employed. Thus, the roll may be stationary or it may be replaced by a V-shaped deflector bar which presents a similar surface to the tow band. Similarly, in place of the deflector arrangement shown in FIGS. 2 and 4, a pair of inclined deflector bars may be used; these may be both inclined in the same direction or oppositely inclined and both need not, of course, be in the same plane. By suitably increasing the number of deflector surfaces, a number of tows may be processed, separately and in parallel, on a single draw frame.

It is advantageous to increase the wear resistance and slip properties of the deflector surfaces by a flame-spraying procedure such as described in U.S. Patent 2,714,563. By the flame-spraying technique, a material such as aluminum oxide, chromic oxide, titanium oxide, and the like is heated in a molten state and sprayed upon the metallic deflector surface in the form of fine globules

which are thereby bonded to the metallic surface which may be of brass, stainless steel, aluminum, etc.

The invention is particularly suitable for the processing of tows of polyethylene terephthalate in which the weight of the drawn tow is above about 40,000 denier per inch of tow width on the first draw roll and the drawn filament denier is below 25. Advantageously, the filament denier is in the range of about 1 to 25, usually about 1½ to 18, preferably about 1½ to 8, and the number of filaments in the tow is over 1,000, e.g. about 2,500 to 300,000. The tow is advantageously given about 3 to 80 crimps per inch, preferably about 5 to 20 crimps per inch. The number of subtows used to produce a single tow in the process of this invention may be, advantageously, in the range of about 2 to 75 or more, advantageously 5 to 50.

The inventioin has been described particularly with respect to tows whose filaments are of polyethylene terephthalate. It will be understood that it is within the broad scope of the invention to carry it out with other tows, such as those made of other polyesters (e.g. the polyesters of terephthalic acid and other glycols such as dimethylol cyclohexane), polyamides (such as nylon 6 or nylon 6, 6), polyacrylonitrile and copolymers thereof, polyolefines such as isotactic polypropylene, etc. These polymers may, if desired, be of the more easily dyeable type containing groups, e.g. SO_3Na or NH_2 groups, which promote dyeability.

It is to be understood that the foregoing detailed description is given merely by way of illustration, and that variations may be made therein without departing from the spirit of this invention.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In the process for the production of drawn tow in which a band of tow of drawable continuous filaments is continuously fed through a drawing zone from a feed means to a draw means pulling said band at a speed higher than it is supplied by said feed means to stretch said band to increase the tenacity of said filaments, the improvement which comprises deflecting the moving tow band, in its travel from said feed means to said draw means, by deflecting surface contact at an inclination to the direct path of said band, the deflection from said direct path varying along the width of said band to intermingle the filaments of said band.

2. Process as set forth in claim 1 in which said tow is made up of filaments of glycol terephthalate having a melting point above 250° C., said tow band containing at least 1,000 filaments, the drawn denier of said filaments being in the range of about 1 to 25, the draw ratio being in the range of about 2.5:1 to 6:1, the density of the drawn tow band on said draw roll being at least 40,000 denier per inch, and said filaments being in substantially fully drawn condition before said deflecting surface contact.

3. Process as set forth in claim 1 in which the middle portion of the band is deflected less than the edges of said band.

4. In the process for the production of drawn tow in which a band of tow of drawable continuous filaments is continuously fed through a drawing zone from a feed roll to a draw roll pulling said band at a speed higher than it is supplied by said feed roll to stretch said band to increase the tenacity of said filaments, the improvement which comprises deflecting the moving tow band, in its travel from said feed roll to said draw roll, by passing the tow band in such travel over a deflecting surface inclined to the direct path of said tow, said surface being so arranged that the deflection from said direct path varies along the width of said band to intermingle the filaments of said band.

5. In the process for the production of drawn tow in which a band of tow of drawable continuous filaments is continuously fed through a drawing zone from a feed roll to a draw roll pulling said band at a speed higher than it is supplied by said feed roll to stretch said band to increase the tenacity of said filaments, the improvement which comprises deflecting the moving tow band, in its travel from said feed roll to said draw roll, by passing the tow band in such travel over deflecting surfaces oppositely inclined to the direct draw path of said tow, said surfaces being so inclined that the extent of deflection decreases progressively from the edges of said band to the middle thereof.

6. In an apparatus for the production of drawn tow, in which a band of tow of drawable continuous filaments is continuously fed through a drawing zone from a feed means to a draw means pulling said band at a speed higher than it is supplied by said feed means to stretch said band and to increase the tenacity of said filaments, the improvement which comprises, in combination with said draw means and said feed means, surface deflecting means for engaging and deflecting the tow band passing to said draw means under the drawing tension, to intermingle the filaments of said band said surface deflecting means engaging said band at an inclination to the direct path of said band and having sloping tow engaging sides based from said direct path and an intermediate tow engaging portion spaced from said direct path a lesser distance than said sides.

7. Apparatus as set forth in claim 6 in which said deflecting means is a roll having a central tow engaging crotch.

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LOUIS K. RIMRODT, *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,380,131 April 30, 1968

Jack N. Gray

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 57, "indirectly" should read -- directly --.
Column 5, line 36, "2-inch" should read -- 24-inch --.

Signed and sealed this 16th day of September 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents