

Jan. 10, 1967

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3,296,677

CRIMPING APPARATUS AND PROCESS

Filed May 20, 1963

3 Sheets-Sheet 1

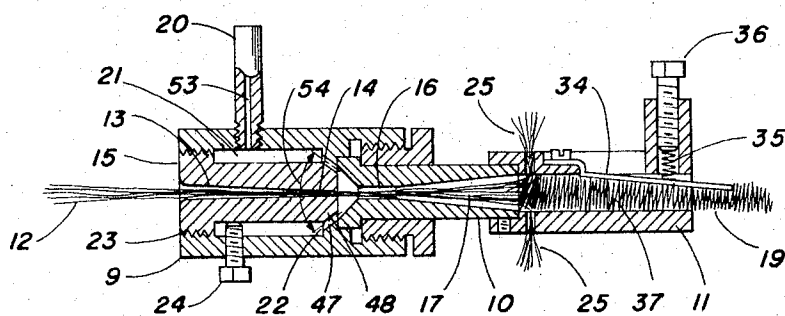


FIG. 1.

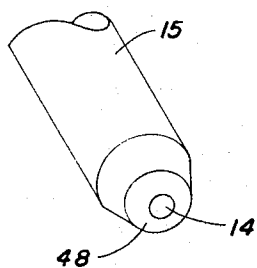


FIG. 1A.

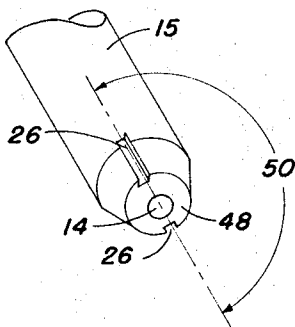


FIG. 1B.

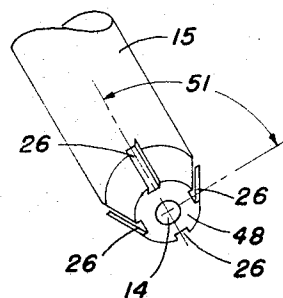


FIG. 1C.

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3 Sheets-Sheet 2

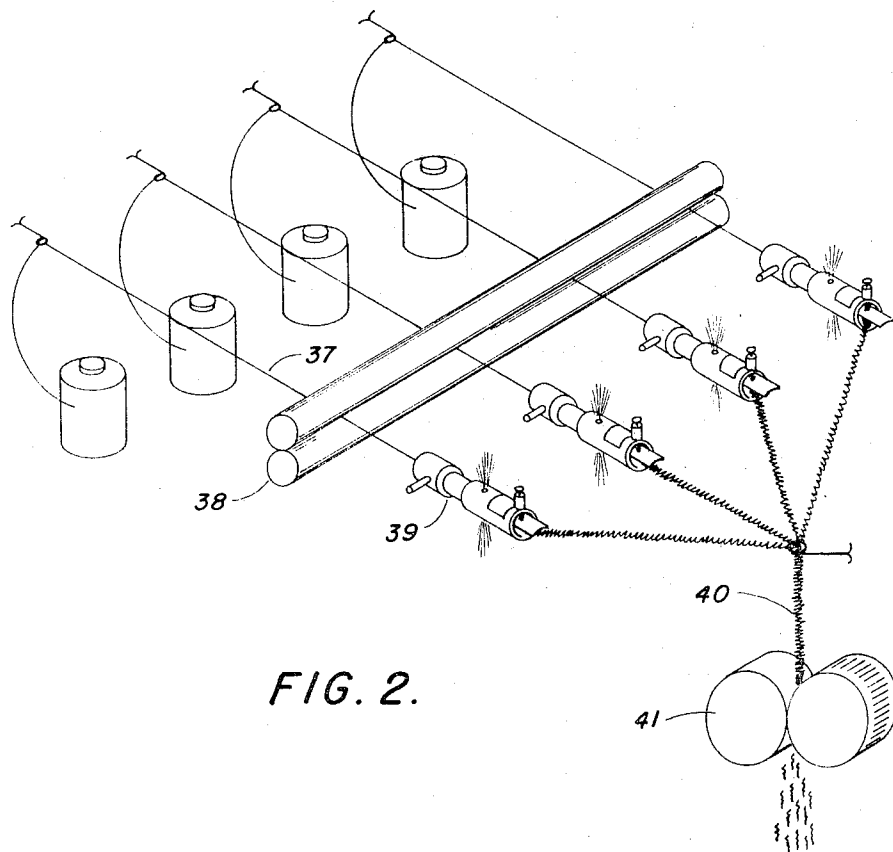


FIG. 2.

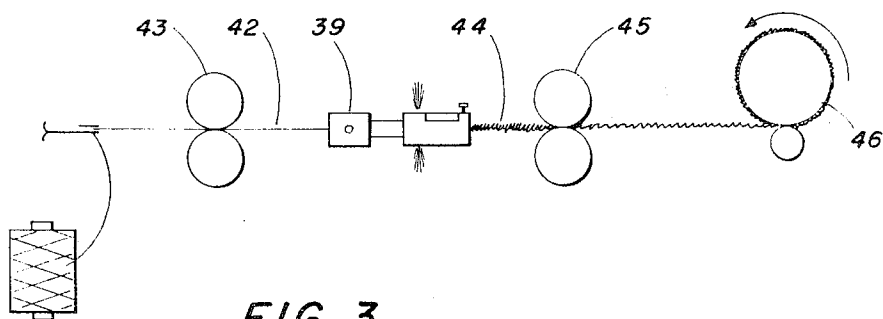


FIG. 3.

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3 Sheets-Sheet 3

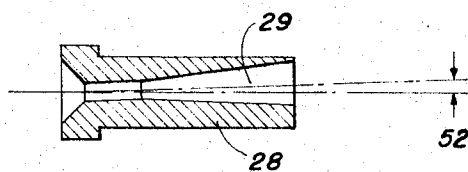


FIG. 4.

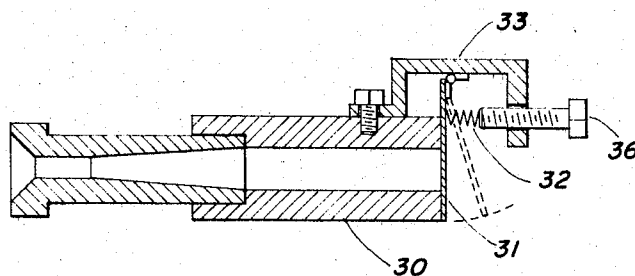


FIG. 5.

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1

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CRIMPING APPARATUS AND PROCESS

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3 Claims. (Cl. 28-1)

This invention relates to crimping apparatus and process useful for crimping any kind of filaments and fibers both natural and man-made. More particularly this invention concerns a new crimping apparatus particularly serviceable for the crimping and similar processing of man-made yarns and tows of polymeric compositions wherein an input of heat during the processing of such polymeric fibers may be beneficial.

It is common practice in the textile industry at the present time, and has been for many years, to crimp textile fibers of all types and kinds to impart thereto added resiliency, increased cover and for a number of other purposes. In the instance of man-made fibers which are usually straight and smooth as spun, crimping or the like treatment is employed to give such fibers, yarns and tows appearance and properties more like natural fibers as exemplified by wool. One illustrative situation where crimping is frequently employed is in the crimping of polymeric fibers used in the manufacture of rugs and carpets.

Prior to the present invention crimping apparatus has in general comprised the combination of a pair of rolls positioned against the entrance to a stuffer box or similar closable chamber. The exit or discharge from the box or chamber may be comprised of a clapper gate. These rolls feed the fiber into the compression of the stuffer box wherein crimping occurs and the clapper gate periodically functions to remove the pressure and opens up to permit the discharge of the crimped fibers from the apparatus.

Such prior mechanical crimping apparatus, while usually imparting a good crimp to the textile material, has presented some problems. Close tolerance and alignment of these feed rolls must be maintained to yield uniform crimp. In some prior art devices the means employed to provide relative movement of the feed rolls permits the axis of rotation to become mis-aligned.

Operation of the prior art rolls under such conditions soon causes the side plates of the stuffing chamber that are in contact with the side faces of the rolls to become grooved and worn thereby making it necessary to frequently replace the side plates in order to maintain the operating efficiency of the crimper. Unequal pressure distributed along the axes of the rolls in the crimping of the yarn or tow creates frictional heat which produces broken filaments in the tows or yarn strands and the trapping and fusing of filaments.

In the prior art, the setting of the crimp by heating or softening of the filaments before they enter the pinch rolls or by inducing steam or hot air into the crimp chamber has been somewhat unsatisfactory. If the yarn is heated prior to being fed to the crimp chamber, the pressure rolls may damage it. If the yarn is heated by steam in the crimp chamber, it is difficult to insure uniform heating of each filament in the tow. In addition, heating the crimp chamber causes changes in the clearances of the crimper parts due to thermal expansion.

The prior apparatus operates at relatively slow speeds and the crimped fiber generally requires a separate heat-setting operation. It is, therefore, apparent that the development of a highly efficient crimper, adapted for the curling or crimping and heatsetting of both natural and man-made fibers at relatively high speeds and eliminating

2

the input feed rolls and close tolerances of the prior art represents a highly desirable contribution of the art.

After extensive investigation, I have discovered certain novel devices which have utility for use in simultaneously crimping and heatsetting both natural and synthetic filament yarns or tows.

One object of this invention is to provide improved devices or apparatus for curling or crimping a yarn or tow of filamentary material. Another object is to provide a crimping apparatus which eliminates the feed rolls of the prior arts. Still another object is to provide a crimper wherein adjustments are readily maintained for extended periods of time. A further object is to provide a crimping device whereby wear is minimized. Another object is to provide a crimping device having novel and improved heating means for preparing and maintaining the tow or yarn at a proper temperature for crimping and heatsetting. Still another object is to provide a crimping device whereby each filament is crimped and heatset uniformly producing uniform dyeing properties. Other objects will appear hereinafter.

For assistance in the understanding of my invention, references will be made to the attached drawings forming a part of this application. In the drawings:

FIGURE 1 is a sectional, side elevation view of one of the preferred crimping devices in accordance with the present invention.

FIGURES 1A, 1B and 1C are pictorial views of the nozzle 15 in FIGURE 1.

FIGURE 2 is a schematic view of an apparatus arrangement using my new crimping device as applied to a continuous multifilament tow being crimped and cut into staple.

FIGURE 3 is a side elevation view of apparatus combination involving a single end multifilament yarn being crimped and packaged.

FIGURE 4 is a sectional view of a preferred Venturi tube useful in my apparatus.

FIGURE 5 is a sectional view of an alternate form of crimping chamber.

Referring to FIGURE 1, my new crimping apparatus comprises housing 9, yarn entrance nozzle 15, a Venturi section 10, and crimping chamber 11. The yarn or tow 12 enters the crimper by way of yarn inlet tube 13, in the nozzle 15 and then passes through a yarn control orifice 14 which is slightly larger than the yarn being crimped. The yarn then passes through Venturi tube 10 by way of uniform throat diameter 16, which is of sufficient size to exit the yarn, and is opened in section 17 which is of straight or diverging tapered shape. The yarn, upon leaving Venturi tube 10, is stuffed and heatset in crimp chamber 11 which is of novel design and will be described in detail hereafter. The curled or crimped and heatset yarn or tow 19 is then forwarded to any desired further operation such as cutting or winding.

A fluid plasticizing medium 53 such as steam or hot air enters tube 20 from a suitable source and passes into chamber 21 which acts as a distribution manifold. The fluid is then metered through a concentric ring orifice 22 which is formed by the coating surfaces 43 of the nozzle 15 and surface 47 of housing 9 and can be adjusted by screwing the nozzle 15 in and out of housing 9 by means of the threads at 23. Lock screw 24 can be used to lock the adjustment. The fluid then passes through Venturi tube 10 at high velocity and is exited through the holes 25 in crimper chamber 11.

The crimping chamber used for retarding the movement of the yarn consists of a clapper gate 34, and a screw 36 and spring 35 assembly for applying a force to the clapper gate 34. Entering chamber 11, which is a straight chamber but may be of converging or diverging

3

cross section, the yarn having been heated by the jet fluid is in a softened state and is crimped or curled by bunching of the yarn filaments against the mass of filaments built up in crimp chamber 11 due to the retarding force of the clapper gate.

FIGURES 1A, 1B and 1C show several nozzle tip shapes for the exit end of nozzle 15 in FIGURE 1. Referring to FIGURE 1A, yarn or tow leaves nozzle 15 by way of the straight exit hole 14 and is impinged upon circumferentially in a uniform manner by the jet fluid passing between surfaces 47 and 48 in FIGURE 1. The angle 54 is between 60°-90°, preferably 90°.

FIGURE 1B shows another nozzle tip wherein the treating fluid impinges through square or rectangular slots 26, cut into the surface 48 of the nozzle tip. Using this type nozzle, the nozzle may be screwed down so that the surface 48 is in a sealing relation to surface 47 of housing 9. This nozzle is more efficient in some cases than that shown in FIGURE 1A, in applying treating fluid to the yarn. Angle 50 is 180°.

FIGURE 1C shows another form of nozzle whereby the treating fluid impinges upon the yarn through four slits 26 equispaced at an angle 51 of 90°. In other cases, a single slot 26 may be used effectively.

FIGURE 2 shows an apparatus setup for carrying out a process for producing crimped staple fiber where a number of ends 37 are individually crimped by crimpers 39, being fed into the crimpers by rolls 38. As apparent, the crimpers are of a jet-stuffer box construction as described above. The crimped tow 40 is then cut into any desired staple length by a cutting device 41.

FIGURE 3 shows a single end of multifilament yarn 42 of the desired denier being fed into the crimper 39 by means of feed rolls 43. The crimped and heatset yarn 44 is fed after proper curling to a bobbin or tube winding operation 46 by output rolls 45. If desired, twist may be added as the yarn is wound on the bobbin. High operating speeds and uniform crimping and heatsetting are characteristic of this process.

FIGURE 4 shows an alternate type Venturi tube 28 whereby the axis of the yarn path 29 is offset as shown by angle 52 and which is about 2°-3°. It has been found in general that all the crimper parts preferably would be concentric and have a common longitudinal axis. Often, however, some eccentricity of the fluid flow or of passage-ways 13 and 16 in FIGURE 1 is encountered. By using a Venturi with an offset angle as just described, the effect of eccentric fluid flow forces on the yarn can be eliminated by turning the Venturi tube around its longitudinal axis until no swirling eccentricity of the fluid is encountered.

FIGURE 5 shows an alternate crimp chamber 30 in which the clapper gate 31 is mounted at the exit and vertical to the yarn axis and to which force is applied by a spring loading means 32. The clapper gate is hinged or pivoted at 33 and positioned to retard the exit of the yarn from the chamber. For a better understanding of my invention, reference will be made to the following examples which illustrate certain preferred embodiments.

Example I

A 1500 denier 400 filament multifilament polyester yarn was processed using a device similar to that of FIGURES 1 and 3. The filament cross sections were round. The input yarn speed was 333 y.p.m. and the winding speed was 225 y.p.m. The treating fluid was steam at a temperature of 247° C. and a pressure of 90 p.s.i.g.

The input yarn fed into the crimper was as follows:

Tenacity G/D	2.4
Percent elongation	15
Percent hot oven shrinkage (10 mins. @140° C.)	16

The physical properties of the crimped yarn were as follows:

Tenacity G/D	1.66
Percent elongation	48.7
Percent hot oven shrinkage (10 mins. @140° C.)	0.4
Crimps/inch	8.3

4

The individual filaments of the final yarn exhibited a three dimensional crimp with improved covering power, and the efficiency of the heatsetting on the yarn is shown by the differences in hot oven shrinkage values before and after crimping. This yarn was knitted into a sweater fabric of pleasing hand and texture.

Example II

A 2900 denier multifilament polyester yarn having 240 filaments was processed by the apparatus as shown in FIGURES 1 and 3. The input yarn speed was 915 y.p.m. and the packaging speed was 485 y.p.m. The treating fluid was steam at a temperature of 242° C. and a pressure of 112 p.s.i.g.

The following crimper dimensions were used in the production of this yarn:

Yarn inlet tube 13	3° taper included angle.
Yarn control diameter 14	0.052"
Fluid slit 26, FIGURE 1B	2-0.042" x 0.042"
Angle 54 (FIGURE 1)	90°
Venturi uniform section 16	0.11" diameter.
Venturi diverging section 39	10° taper included angle.
Venturi offset angle 52	2°
Crimper chamber diameter 37	0.5"
Crimper chamber length	2.375.

The properties of the yarn fed into the crimper were as follows:

Filament cross-section	Triangular.
Tenacity, G/D	2.37.
Percent elongation	11.
Percent hot oven shrinkage (10 mins. @140° C.)	12.

The physical properties of the crimped yarn were as follows:

Tenacity, G/D	1.57
Percent elongation	35.0
Percent hot oven shrinkage (10 mins. @140° C.)	3.4
Crimps/inch	10-12

The individual filaments of the crimped yarn were characterized by a three dimensional crimp with improved cover, hand, and resilience when tufted into a carpet.

Example III

A 2800 denier 355 filament yarn of cellulose acetate having a "C" cross-section, spun according to the teachings of my coworker, the late R. B. Hickey, in Serial No. 620,843 was processed as in FIGURES 1 and 3. The input yarn speed was 415 y.p.m. and the winding speed was 340 y.p.m. The treating fluid was steam at a temperature of 242° C. and at a pressure of 104 p.s.i.g. The crimped yarn was tufted into a bedspread type fabric which was characterized by improved cover and a desirable crimp memory upon dyeing and washing.

Example IV

A 2100 denier 160 filament polypropylene yarn having a triangular shaped filament cross-section was processed as in FIGURES 1 and 3. The input yarn speed was 383 y.p.m. and the packaging speed was 180 y.p.m. The treating fluid was steam at a temperature of 175° C. and a pressure of 150 p.s.i.g.

The properties of the yarn fed into the crimper were as follows:

Tenacity, G/D	3.4
Percent Elongation	75
Percent Hot Oven Shrinkage (10 Mins. @140° C.)	37

The physical properties of the crimped yarn were as follows:

Tenacity, G/D	1.16
Percent Elongation	226.8
Percent Hot Oven Shrinkage (10 Mins. @140° C.)	2.4
Crimps/Inch	13.7

5

The filaments of the crimped yarn were characterized by a curvilinear, three dimensional crimp which improved the cover, hand, resilience and resistance to shrinkage when tufted into a carpet. It is to be noted from the hot oven shrinkage values that heatsetting of the yarn was obtained at 140° C.

Example V

A 60,000 denier 1½ D/F tow of polyester was processed with the present invention as illustrated in FIGURE 2. The input tow speed was 365 y.p.m. and the cutter speed was 305 y.p.m. The treating fluid was steam at a temperature of 205° C. and a pressure of 95 p.s.i.g. The staple was cut into 2" lengths and processed satisfactorily on the cotton system into a 15/1's cotton count yarn.

In the prior art, adjustment of the feed rolls has been critical in prolonging the wear life of the side plates and controlling the crimp level along the tow. This invention has two adjustments which are not critical for crimping but are useful in obtaining desirable yarn quality; for example, uniformity of crimps per inch. The crimper of this invention will operate for extended operating time with uniform crimp and limited part wear.

For optimum crimping of fibers, the crimper parameters are preferably carefully determined. Referring to FIGURE 1, the yarn nozzle outlet diameter 14 is important in obtaining proper crimping action. The nozzle outlet diameter preferably is at least 15% larger than the yarn diameter to prevent the treating fluid from leaving the crimper by way of the nozzle inlet tubes 13 and 14 instead of through the Venturi.

Referring to FIGURE 1B, it is desirable for the yarn path 14 and the axes of the slots 26 to be in the same plane. Eccentricity of the axes produces a torque action on the yarn which affects crimping and quality.

The temperature and operating pressure should be specially controlled for obtaining the desired crimp and heatsetting. When crimping thermoplastic or polymeric filaments, the fluid temperature is regulated such that the yarn temperature does not reach the melting point of the filaments but should be high enough to adequately set the crimp in the filaments to the desired degree. The operating pressure varies according to the yarn and denier per filament sizes. For example, a 1.5 D/F yarn of polyester utilized about 95 p.s.i.g. fluid pressure whereas a 15 D/F yarn may utilize operating pressures of between 80-200 p.s.i.g.

It is desirable to have the various yarn and fluid passageways made of wear resistant materials to prevent excessive wear. High carbon steels and suitable ceramic materials can be used. The housing may be made of a softer material such as brass or stainless steel. The treating fluid used as the motivation force, softening agent, and heatsetting medium may be steam, air, or any other suitable and comparable media.

The new crimping device of this invention can be used to crimp or curl any natural or synthetic filamentary material. Synthetic filament yarns such as polyamides, polyesters, cellulose acetate, acrylics, modacrylics, polyolefins, and copolymers thereof and natural materials, such as wool, can be crimped or curled to give a curvilinear, three dimensional crimp. While the preferred form of material is in continuous filament, improved bulkiness can also be obtained when staple yarn is processed.

The crimper is useful in crimping both a wide range of deniers of yarn from 500 denier to 40,000 denier or more. The process is also adapted for crimping film in both fibrillated and unfibrillated forms. The process is not restricted in the case of synthetic materials to any one particular type of filament cross-section. The yarn passageway thus described has been a circular cross-section to permit crimping of a circular band of yarn or tow. The passageway thus described could be modified to permit crimping of a tow in sheet or ribbon form such as a rectangular yarn passageway, Venturi section, and crimp chamber.

6

While it is not desired to be bound by any theory of operation, the following further discussion may be of some assistance in an understanding of the functioning of my invention. Referring further to FIGURE 1, and to the yarn 12 being crimped, it is believed that my novel crimper may operate in the following manner: The yarn 12 after passing through a constant input feed device remains under tension through inlet tube 13, and the uniform diameter section 16 in Venturi tube 10. After leaving the throat 16 of the Venturi, the yarn is opened due to the expansion of the fluid whereby each filament comes into contact with the treating fluid producing an even heating effect on each filament. The individual filaments in a softened state are stuffed into the crimping chamber while the hot gas escapes through the holes 25 whereby crimp or curl is induced and as the yarn cools, the crimp is set in the filaments.

Although the invention has been described in detail with reference to preferred embodiments thereof, it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined by the appended claims.

I claim:

1. The process of crimping and similarly treating a compact multifilament yarn which comprises motivating the yarn to be thus treated into and through a jet zone supplied with a high velocity heated fluid, bringing said compact yarn into intimate contact with the heated fluid in a uniform cross-section passageway, the exit end of which is connected to a divergent passageway wherein the fluid expands rapidly causing said yarn to open and disengage into a non-compact fluid-porous mass of separated filaments, the diameter of said mass of separated filaments being substantially greater than the diameter of the compact yarn fed to the jet, then directly feeding said mass of separated filaments into a stuffer box crimper chamber wherein the separated filaments are caused to individually bend and fold upon themselves in said crimp chamber, exhausting at least a portion of said hot fluid through exhaust ports located closely adjacent the entrance of said crimp chamber, and retaining and passing the remainder of said heated fluid admixed with the yarn through the length of the crimp chamber and exhausting said remaining portion of said heated fluid with the individually separated and crimped filaments from the end of said crimp chamber, followed by withdrawing said crimped filaments from the stuffer box crimper and reforming them into a yarn.

2. The process of claim 1 which involves introducing the yarn under the influence of the fluid action into a first enclosed divergent elongated passageway wherein the yarn structure is caused to expand to its said greater diameter, the expanded yarn is then passed as a random mass of separate filaments into an enclosed stuffer box crimper passageway and forced therethrough by a portion of the fluid, the other portion of the fluid being exhausted laterally from the jet at approximately the juncture of the divergent passageway and the stuffer box crimper passageway.

3. A device for the crimping and like treatment of any kind of filamentary yarn comprised of the unitary combination of a fluid operated jet and stuffer box crimper, said device containing in its structure in series (1) a yarn entrance nozzle jet, (2) a straight enclosed chamber, (3) a divergent enclosed chamber having a downstream diameter substantially greater than its upstream diameter, (4) a stuffer box crimper chamber, (5) fluid inlet means circumferentially surrounding said yarn entrance nozzle jet, (6) lateral fluid exhaust means located adjacent the intersection of the downstream end of the divergent enclosed chamber and the upstream end of the stuffer box chamber, and (7) said stuffer box crimper chamber terminating in

a clapper gate mechanism whereby a multifilament yarn is motivated through the entrance jet section and is caused to be separated into a loose filamentary mass in the divergent chamber, which separated filaments may then be individually compressed and folded upon themselves in the stuffer box crimper chamber to impart crimp to the individual filaments and the crimped filaments discharged from the stuffer box crimp chamber and reformed into a yarn by take-up rolls and wind-up means positioned beyond the outlet end of said stuffer box crimper chamber.

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