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Kwon et al.

[11] **3,874,044**

[45] **Apr. 1, 1975**

[54] **APPARATUS AND PROCESS FOR SIMULTANEOUS CRIMPING AND COMMINGLING OF YARNS**

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[21] Appl. No.: **449,409**

[52] **U.S. Cl.** **28/1.3,** 28/72.11

[51] **Int. Cl.** **Do2g 1/20**

[58] **Field of Search** .... 28/1.3, 1.4, 1.5, 72.11, 28/72.12, 72.14; 57/34 B, 157 P; 226/7, 97; 264/168

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3,763,525 10/1973 MacKnight 28/1.3

Primary Examiner—Louis K. Rimrodt

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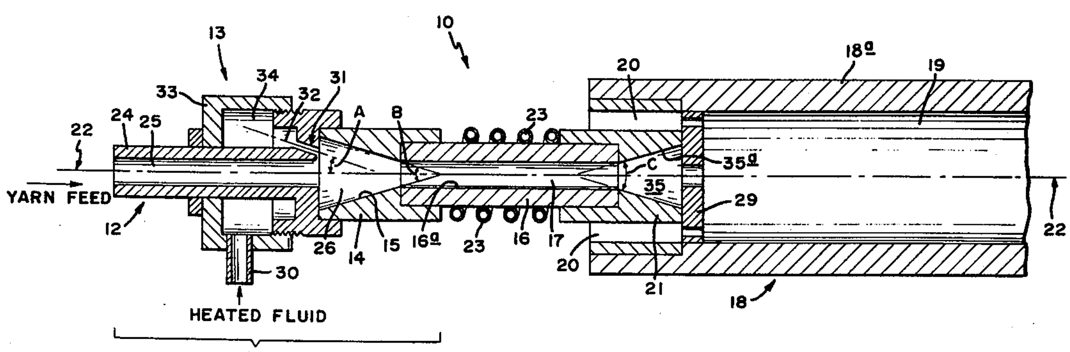
[57] **ABSTRACT**

Apparatus and process for simultaneous crimping and commingling of continuous filament yarns are provided. The yarn is introduced as feed into a contact chamber in which the yarn is contacted with a heated fluid, such as steam, at an angle of not greater than about 85° with respect to the yarn passage axis, and at a fluid velocity sufficient to vibrate the yarn and cause it to impact upon an impacting surface. The impacted yarn, together with the heated fluid, is then directed into an energy tube wherein the impacted yarn absorbs heat from the heated fluid. The heated yarn then passes into a stuffer tube wherein the flow of yarn is impeded, thereby establishing a yarn plug from which crimped and commingled yarn is subsequently removed.

11 Claims, 7 Drawing Figures



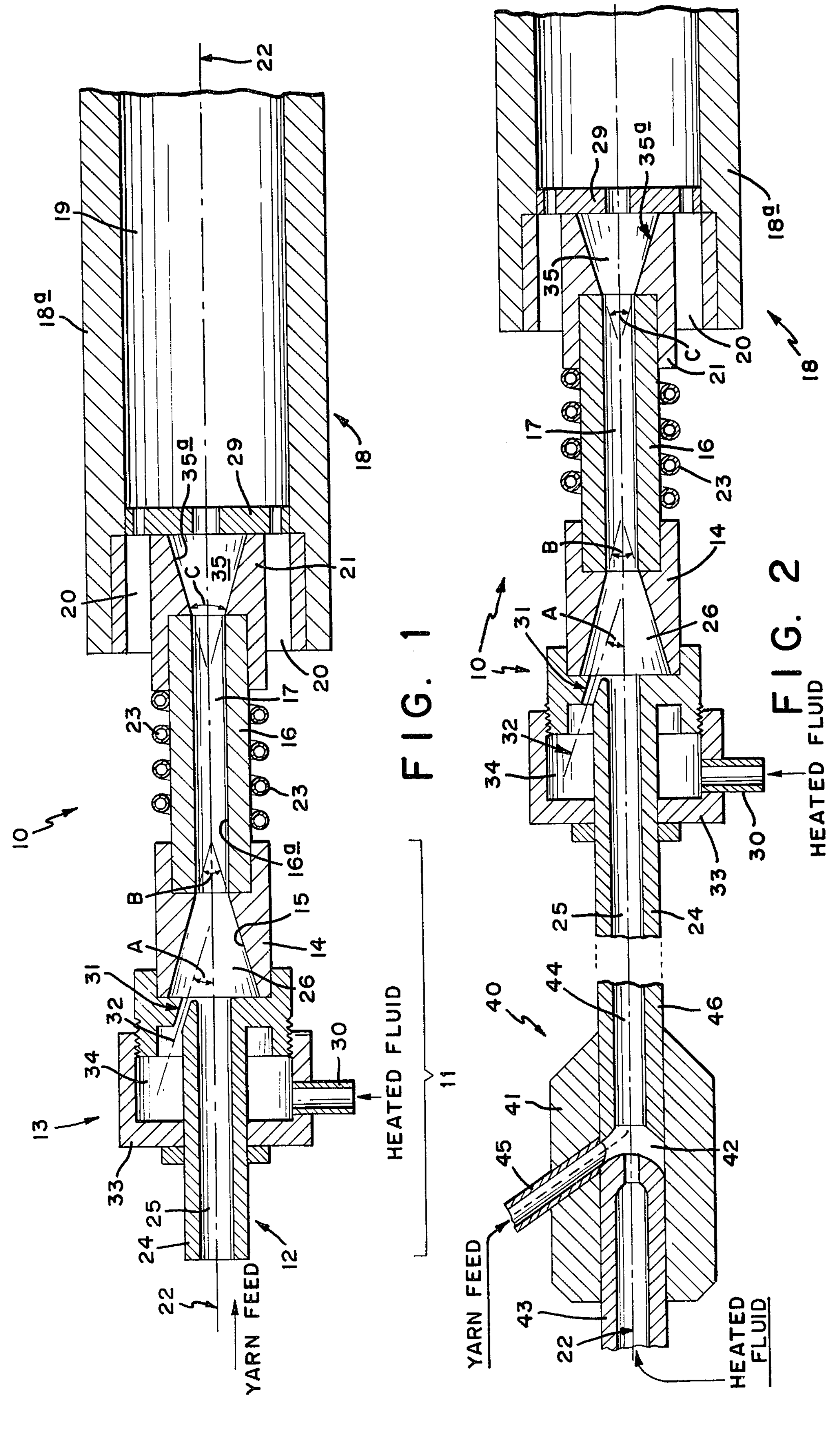
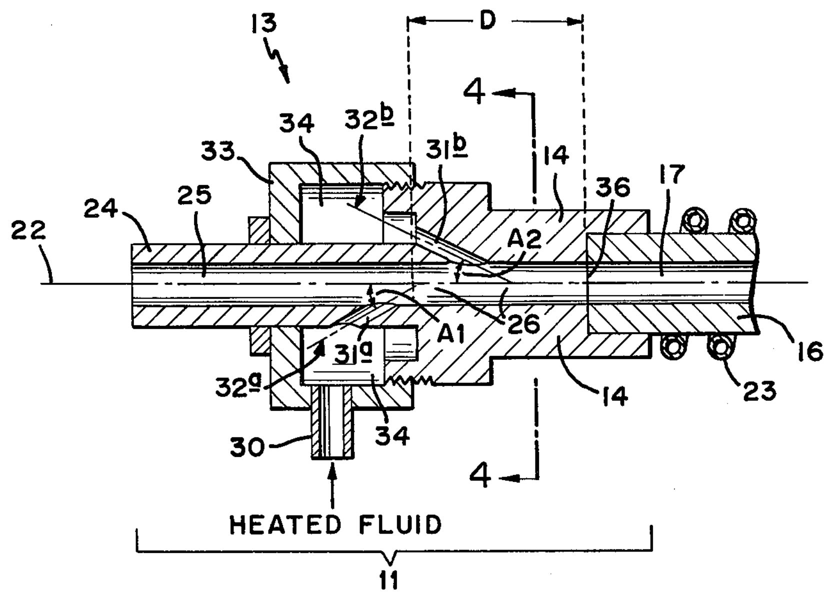


FIG. 1
FIG. 2
HEATED FLUID
YARN FEED
HEATED FLUID
YARN FEED
HEATED FLUID

FIG. 3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D
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36
17
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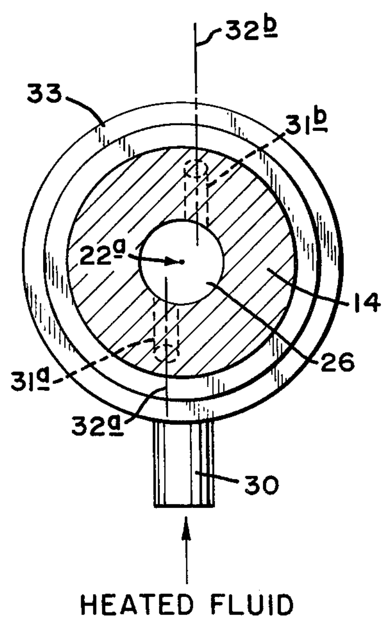
HEATED FLUID
11

FIG. 4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32a
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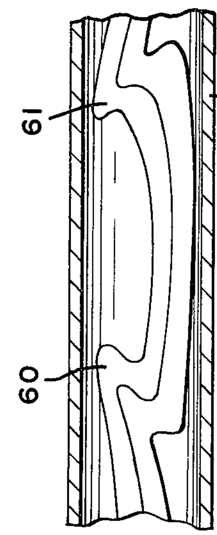

FIG. 7

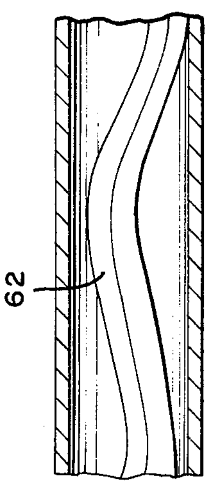

FIG. 6

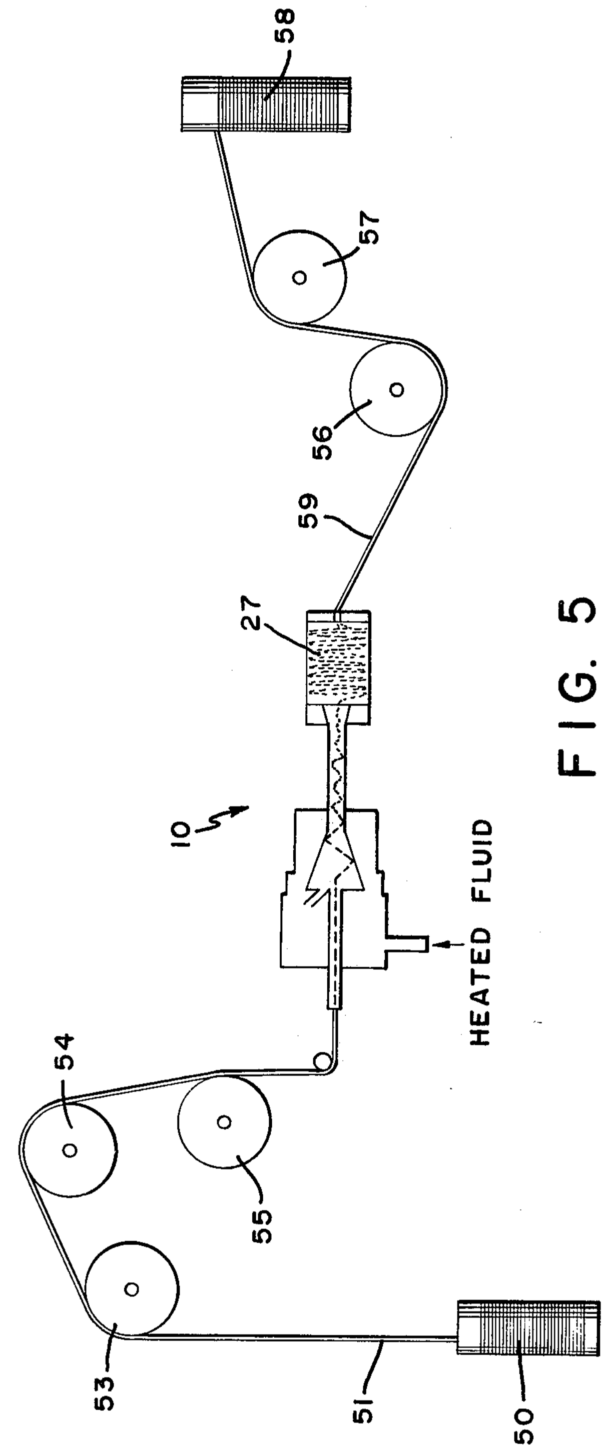

FIG. 5

APPARATUS AND PROCESS FOR SIMULTANEOUS CRIMPING AND COMMINGLING OF YARNS

CROSS-REFERENCE TO RELATED APPLICATION

This application is related to our co-filed application "SIMULTANEOUS CRIMPING AND COMMINGLING YARNS," Attorney's Docket No. 7000-1089.

BACKGROUND OF THE INVENTION

This invention relates to process and apparatus for simultaneous crimping and commingling of continuous filament yarns.

DESCRIPTION OF THE PRIOR ART

Synthetic fiber yarn to be employed in fabric, such as in carpets and wearing apparel, is frequently subjected to a crimping process to generate curvilinear twists on the yarn so as to impart elastic stretch and bulk to the yarn. Such yarn is also subjected to a commingling process whereby entanglements are inserted between adjacent yarn filaments to enhance cohesiveness between these filaments. In addition, commingling helps to prevent stray filaments from snagging machine guides during subsequent processing and to prevent the separation of individual yarn ends in jet texturizing processes which require more than one yarn end per jet.

In conventional process, the crimping and commingling functions are carried out separately in different steps. Such a division of functions increases process costs and generates increased equipment requirements. Previous attempts to simultaneously crimp and commingle yarn have been unsuccessful in imparting the desired crimp and commingling properties. Typical dual-function apparatus are those disclosed in U.S. Pat. No. 3,409,956 (issued in 1968 to Longbottom et al.) wherein yarn is contacted with a steam jet positioned coaxially with respect to the yarn passage axis, U.S. Pat. No. 3,303,546 (issued in 1967 to Van Blerk) and East German Pat. No. 17,786 (issued in 1960 to Bruetting) wherein yarn is contacted by steam emitted from an annular opening which is coaxial to the yarn passage axis, and U.S. Pat. No. 3,611,698 (issued in 1971 to Horn) wherein pairs of facing steam jets impact on a common plane at an angle perpendicular to the yarn passage axis. In the apparatus of U.S. Pat. Nos. 3,303,546 and 3,490,956 and East German Pat. No. 17,786, coaxial contact of the yarn with steam has the disadvantage of failing to impart any significant amount of commingling to the yarn. In the apparatus of U.S. Pat. No. 3,611,698, the steam jets do not impart any portion of their force in the direction of the yarn travel through the apparatus, thereby necessitating the use of a mechanical pulling device to cause the yarn to pass through the apparatus. The use of such mechanical pulling for this purpose is not desirable because it tends to destroy any crimp that has been previously imparted to the yarn.

However, most significantly, these prior art apparatus for simultaneous crimping and commingling of yarn have failed to provide the levels of crimp and commingling previously achieved when these functions were carried out in separate steps. Thus, the dual-function apparatus fails to simultaneously perform commingling and crimping functions while maintaining the desired levels of crimp and commingling which separate-function apparatus had previously achieved.

SUMMARY OF THE INVENTION

In accordance with the present invention, there are provided apparatus and process for simultaneous crimping and commingling continuous filament yarn. The apparatus of the present invention comprises: a contact chamber assembly including a contact chamber, yarn inlet means for feeding yarn into said contact chamber and fluid supply means for introducing heated fluid into said contact chamber along an axis which forms an angle of not greater than about 85° with respect to the axis of yarn passage through said contact chamber; an energy tube for imparting heat to the yarn passing therethrough from said contact chamber; and a stuffer tube assembly communicating with said energy tube for yarn passage therethrough and including a stuffer tube for texturizing the yarn.

The process of the invention comprises feeding yarn into a contact zone; contacting the yarn in said zone with a stream of heated fluid, preferably steam, at an angle of not greater than about **85°** with respect to the yarn passage axis, and at a fluid velocity sufficient to vibrate the yarn and cause the yarn to impact upon an impacting surface; passing said impacted yarn and said heated fluid into an energy (i.e., a heat absorbing) zone wherein the yarn absorbs at least a portion of the heat from said heated fluid; and passing the heated yarn and said fluid into a texturizing zone wherein the flow of yarn is impeded, thereby establishing a yarn plug, and wherein the heated fluid imparts a portion of its mechanical energy to the yarn contained in the yarn plug. The heated fluid is discharged from the texturizing zone, and crimped and commingled yarn is removed from the texturizing zone.

It has been found that the present invention enables simultaneous achievement of levels of commingling which are comparable to, and levels of crimp which are superior than, the levels which result from conventional processes in which crimping and commingling steps are sequentially performed. In addition, the process and apparatus of the present invention have the advantage of imparting such improved crimp and commingling properties in a single apparatus, thereby decreasing equipment requirements and reducing processing costs by as much as 50 percent.

In addition, it has been found that by employing a conventional crimping assembly to pre-crimp the yarn which is fed to the simultaneous crimping and commingling apparatus of the present invention, independent control of the levels of crimp and commingling can be achieved. Further, by employing a precrimping assembly it has been found that increased yarn speeds through apparatus of the present invention may be achieved when higher denier yarns are treated. In a more specific embodiment, wherein a pre-crimping assembly is employed which emits heated fluid coaxially to the longitudinal axis of the assembly, additional force is imparted to the yarn to cause the yarn to move through the apparatus of the present invention, thereby further decreasing the necessity for mechanically pulling the yarn therethrough.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of one embodiment of the apparatus of the present invention.

FIG. 2 is a cross-sectional view of the apparatus of FIG. 1 employed in combination with a conventional device to pre-crimp the yarn.

FIG. 3 is a cross-sectional view of the contact chamber assembly and energy tube of another embodiment of the apparatus of the present invention.

FIG. 4 is a cross-sectional view of the contact chamber of FIG. 3 taken along the line IV—IV of FIG. 4.

FIG. 5 is a diagrammatic illustration of a typical process employing the apparatus of the present invention.

FIG. 6 is an illustration of the vibration of yarn in the energy tube of the prior art apparatus of U.S. Pat. No. 3,409,956.

FIG. 7 is an illustration of the vibration of yarn in the energy tube of the apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

As indicated above, the process and apparatus of the present invention allow the simultaneous crimping and commingling of continuous filament yarn. In the present invention, the yarn is contacted in a contact zone with heated fluid, e.g., steam, supplied by a pressurized source at an acute angle of not greater than 85° with respect to the yarn passage axis, thereby causing the yarn to vibrate and to impact upon an impacting surface. The term "yarn passage axis" is herein defined as the axis along which the yarn is fed to the contact chamber. Since it is desirable that yarn be fed to the contact chamber along the longitudinal axis thereof, in the preferred embodiment, the yarn passage axis corresponds substantially to the longitudinal axis of the contact chamber.

The term an "impacting surface" is herein meant to define that portion of the interior walls of the yarn passages of the present apparatus upon which the yarn first impacts after being contacted with the heated fluid. In the preferred embodiment, the impacting surface comprises the chamber wall which defines the contact zone. The impacting surface may also comprise the interior wall of the energy tube which defines the heat absorbing zone.

The heated fluid used to treat continuous filament yarns in the present invention may be air, steam or any other compressible fluid or vapor capable of plasticizing action on the yarn. Hot air will give sufficient plasticization in the contact zone for many fibers although it may be desirable for certain fibers to supplement the temperature effect with an auxiliary plasticizing medium. Actually, steam is preferentially used in the subject process since it is a cheap and convenient source of a high pressure fluid with a compound plasticizing action.

The temperature of the fluid medium must be regulated so that the yarn temperatures do not reach the melting point of the fiber. However, with fibers made from fusible polymers, the most effective bulking and the greatest productivity are obtained when the temperature of the heated fluid in the impacting zone is above the melting point of the fiber. In this case, the yarn speed should be great enough so that melting does not occur. In a preferred embodiment, the yarn to be crimped and commingled is contacted in the contact zone with steam supplied at a temperature within the range of about 150° to 500°C., and preferably 200° to 450°C. and at a pressure of from about 5 to 200 psig., and preferably 5 to 125 psig.

The velocity, herein termed the "fluid velocity," at which the heated fluid contacts the yarn in the contact zone must be sufficient to vibrate the yarn and to cause the yarn to impact upon an impacting surface. As will be apparent to one skilled in the art, the precise velocity which is sufficient to vibrate the yarn and to cause it to impact on an impacting surface varies widely with the yarn denier, the rate of yarn travel through the contact zone, the nozzle alignment, the shape and size of the contact zone, the density of the heated fluid, and other factors. Typically, the fluid velocity of the heated fluid, which contacts the yarn in the contact zone, is sufficient to contact the yarn with a force of from about 0.01 to 50 lbs_f/in^2, and preferably from about 0.1 to 30 lbs_f/in^2.

With reference to the drawings wherein like numerals refer to the same or similar element, in the embodiment of FIG. 1 the apparatus of the present invention is indicated generally at **10** and includes: contact chamber assembly **11** which includes yarn inlet means, indicated generally at **12**, for feeding the yarn thereinto, heated fluid supply means, indicated generally at **13**, for supplying heated fluid thereto and contact chamber **14** which includes contact zone **26**, defined by chamber wall **15**; energy tube **16** defining passage **17**; and stuffer tube assembly, indicated generally at **18**, including stuffer tube **18***a* defining texturizing passage **19**, and stuffer tube receiver **21**, which includes heated fluid escape vents **20**.

Yarn inlet means, indicated generally at **12**, for feeding the yarn into apparatus **10** comprises feeder tube **24** which defines yarn feeder passage **25**. Tube **24** is positioned substantially concentric to longitudinal axis **22** and communicates contact zone **26** with a yarn source (not shown) to provide for passage of yarn into zone **26**. As discussed more fully below, yarn feeder tube **24** may cooperate with a conventional pre-crimping assembly to receive pre-crimped yarn to be fed to apparatus **10**.

Heated fluid supply means, indicated generally at **13**, for introducing heated fluid into apparatus **10** comprises fluid supply housing **33** which defines heated fluid chamber **34**, nozzle **31** and heated fluid inlet **30** which communicates heated fluid chamber **34** with a heated fluid supply source (not shown). While preheating the yarn introduced into chamber **14** is not required, fluid supply housing **33** may be disposed substantially concentric to feeder tube **24** so as to pre-heat yarn passing through feeder tube **24** to a temperature of from about **50°** to 200°C., and preferably from about 80° to 170°C., prior to the yarn's entry into contact zone **26**. Nozzle **31**, which communicates heated fluid chamber **34** with contact zone **26**, is disposed so that longitudinal axis **32** of nozzle **31** forms fluid contact angle A with the yarn passage axis, which is illustrated in FIG. **1** to coincide with longitudinal axis **22**. Fluid contact angle A is not greater than about 85°, preferably not greater than about 45°, and is most preferably between about 5° and 45°. Nozzle **31** is aligned so as to cause the heated fluid emitted therefrom to contact the yarn at a point downstream from nozzle **31**, thereby causing the yarn to pass through apparatus **10**. Longitudinal axis **32** of nozzle **31** may intersect the yarn passage axis, as illustrated in FIGS. **1** and **2**, or may be offset from the yarn passage axis, as illustrated in the embodiment in FIGS. **3** and **4**, as discussed below. While it has been found that a single nozzle **31** is sufficient to impart the desired crimping and commingling properties to yarn, multiple nozzles may be employed so long as the above nozzle-alignment requirements are met, i.e., the nozzle axis of each such nozzle forms an angle of not greater than about 85° with respect to the yarn passage axis, i.e., axis **22** in FIG. **1**, and the heated fluid emitted from each nozzle contacts the yarn at a point which is downstream from the nozzle itself. In addition, when such a multiple nozzle arrangement is employed, the nozzles must, of course, be positioned so as to cause the vibrating yarn to impact upon an impacting surface (as for example, contact chamber wall **15**, as shown in FIG. **1**). Therefore, where multiple nozzles are employed, directly opposing pairs of nozzles intersecting axis **22** at a common point should not be used since such an arrangement tends to suspend the yarn so contacted between directly opposing fluid streams and does not effect the desired impacting of the yarn upon an impacting surface.

Inner surface **15** of chamber **14** may be either flat or curved and, as preferred, defines zone **26** to converge in the downstream direction, i.e., in the direction of yarn passage through apparatus **10**. However, as illustrated in FIGS. 3 and 4, inner surface **15** of chamber **14** may also define zone **26** to be substantially cylindrical. When inner surface **15** is curved, contact zone **26** may be in the geometric shape of a hyperbola, ellipse or parabola, for example. However, contact zone **26** is preferably substantially conical as illustrated in FIG. **1**, and defines conical angle B which is generally not greater than about 85° and preferably not greater than about 45°.

Energy tube **16** is positioned about axis **22** and communicates contact zone **26** with energy tube passage **17** to provide for yarn passage therethrough. The diameter of energy tube passage **17** preferably substantially corresponds to the diameter of contact zone **26** at the interface between zone **26** and passage **17**. While preheating of energy tube **16** is not required, tube **16** may be heated by a suitable external heating means, as for example, steam heating coils **23**, to maintain a temperature of from about 40° to 300°C. in energy tube passage **17**, so as to further heat yarn passing therethrough and to increase the level of crimp imparted therein.

While the yarn in apparatus **10** of FIG. **1** is shown to impact upon contact chamber wall **15**, in the desired levels of crimping and commingling may also be achieved by aligning nozzle **31** within the above-discussed nozzle alignment requirements so as to cause the yarn thereby contacted with heated fluid to first impact upon a portion of interior wall **16***a* of energy tube passage **17**, which comprises the heating absorbing zone of apparatus **10**.

Stuffer tube receiver **21** is housed in stuffer tube assembly **18** and defines passage **35**, which preferably has a diameter at its interface with passage **17** substantially corresponding to the diameter of passage **17**. Passage **35** may be of a uniform cross-section or, as is preferred, diverges in the direction of yarn passage therethrough. When passage **35** diverges in such a manner, inner surface **35***a* of passage **35** may be either flat or curved. Thus, passage **35** may be of various geometric shapes such as, for example, cylindrical, semi-spherical, parabolic, conical, hyperbolic and elliptical, with the conical and parabolic forms being preferred. When passage **35** is conical, as illustrated in FIG. **1**, conical angle C is defined and is generally less than about 85° and preferably less than about 45°. Particularly outstanding results are obtained when conical angle C is from about 10° to 20°. A fluid exit plate **29** is located at the discharge end of passage **35** and is provided with slots, holes or a combination of both to allow the passage of heated fluid and yarn therethrough. The construction of such a plate is well known and is described, for example, in U.S. Pat. No. 3,409,956.

Stuffer tube **18***a*, which defines texturizing passage **19**, is adapted to contain a compacted yarn mass, designated as yarn plug **27** in FIG. **3**. Heated fluid escape vents **20** housed in stuffer tube receiver **21** are preferably positioned concentric to axis **22** and communicate passage **19** with the atmosphere to allow escape of heated fluid from passage **19**. In the preferred embodiment, vents **20** are disposed so as to cause the exiting heated fluid to be released from passage **19** in a direction substantially opposite to the yarn path travel through apparatus **10** and parallel to longitudinal axis **22**. The term "substantially opposite," as used herein includes heating fluid discharged from texturizing passage **19** at an angle of 135° to 180° measured on the basis of the longitudinal axis **22** and countercurrent to yarn path travel. While such a concentric arrangement of fluid escape vents is preferred, it is not intended to be limiting. Thus, stuffer tube **18***a* may be provided with apertures (not shown) communicating with texturizing passage **19** along the length thereof to permit heated fluid to escape therefrom. In addition, tube **18***a* may be constructed of a gas permeable material such as a steel mesh screen or micro-porous steel to allow escape of heated fluid from passage **19**. While not critical to the present invention, texturizing passage **19** may have a larger diameter than the diameter of energy tube passage **17**, so as to form an annulus between the inner periphery of texturizing passage **19** and the outer periphery of energy tube passage **17**, as described in U.S. Pat. No. 3,409,956. Contact zone **26**, energy tube passage **17**, passage **35**, and texturizing passage **19**, which comprise the "yarn passages" of the apparatus of the present invention, are preferably each disposed substantially concentric to a common longitudinal axis, designated as axis **22** in FIG. **1**, which is the longitudinal axis of the apparatus. In addition, it is preferred that inlet means **12** for feeding yarn to apparatus **10** comprise feeder tube **24** disposed substantially concentrical to axis **22** to facilitate yarn feed to apparatus **10**.

Yarn is preferably fed to impacting zone **26** along an axis, i.e., the yarn passage axis, which substantially coincides with the longitudinal axis **22** of impacting zone **26**. However, the yarn passage axis may also be parallel to axis **22** while not coinciding therewith.

Referring to the embodiment shown in FIG. **2**, apparatus **10** is employed in combination with a pre-crimping assembly, indicated generally at **40**. Pre-crimping assembly **40** includes: housing **41** which defines zone **42**; pre-crimp feeder tube **45** which communicates zone **42** with a yarn source (not shown) for passage of yarn thereinto; nozzle **43** adapted to supply heated fluid under pressure to zone **42** along longitudinal axis **22** of assembly **40**; and pre-crimping tube **46**, defining pre-crimping passage **44** and communicating zone **42** with passage **44** to provide for yarn passage therethrough. In addition, pre-crimping tube **46** communicates pre-crimping passage **44** with feeder passage **25** of apparatus **10** to provide for passage of yarn pre-crimped by assembly **40** into apparatus **10**. Nozzle **43** is positioned substantially coaxial to axis **22** to contact the yarn in zone **42** along axis **22** and to cause the yarn to be passed into crimping passage **44** and thence into feeder passage **25** of apparatus **10**. Pre-crimping tube **46** is also positioned coaxial to axis **22**. By increasing the temperature of the heated fluid which contacts the yarn in precrimping assembly **40**, the crimp of the yarn entering apparatus **10** can be increased, thereby providing independent control of the levels of crimp of the yarn fed to apparatus **10**.

Referring to FIG. **3**, an embodiment of the apparatus of the present invention is illustrated which includes: contact chamber assembly **11** having contact chamber **14** which includes substantially cylindrical contact zone **26**; and fluid supply means, indicated generally at **13**, for supplying heated fluid to contact chamber **14**, which comprises fluid supply housing **33** having heated fluid chamber **34** and heated fluid supply line **30** for allowing heated fluid to pass from a fluid source (not shown) into chamber **14**. Contact chamber **14**, which is coextensive in FIG. **3** with feeder tube **24**, houses multiple offset nozzles **31***a* and **31***b* for passage of heated fluid from chamber **34** into contact zone **26**. Contact zone **26** is of longitudinal dimension D, extending from (1) the point along the yarn passage axis, defined in FIG. **3** to coincide with axis **22**, at which heated fluid emitted from nozzle **31**a contact yarn, to (2) upstream interface **36** of energy tube passage **17**. Longitudinal nozzle axes **32***a* and **32***b* of nozzles **31***a* and **31***b*, respectively, form fluid contact angles A_1 and A_2, respectively, with the yarn passage axis, i.e., axis **22** in FIG. **3**. Each of angles A_1 and A_2 are not greater than about 85°.

FIG. **4** illustrates the offset of nozzles **31***a* and **31***b* of FIG. **3**. When a nozzle, such as nozzles **31***a* and **31***b* of FIG. **3** and **4**, is employed which is "offset," the longitudinal axis of such nozzle does not pass through center **22***a* of contact zone **26**, i.e., the nozzle axis does not intersect axis **22**. It has been found that the desired levels of crimping and commingling may be achieved employing an offset nozzle, either alone, in combination with other nozzles whose longitudinal nozzle axes pass through center **22***a* of zone **26** or in combination with other offset nozzles, so long as the positioning of each such nozzle satisfies the above-discussed nozzle alignment requirements. When an apparatus of the present invention employs an offset nozzle, the fluid contact angle which the longitudinal nozzle axis forms with the yarn passage axis is, as would be apparent to the skilled practitioner, defined in the view of the apparatus in which the angle between (1) the plane formed by the longitudinal nozzle axis and (2) the yarn passage axis is maximized.

Referring now to FIG. **5** wherein a process employing apparatus of the present invention is illustrated, continuous filament yarn **51** is unwound from yarn supply spool **50** and passed to feeder and draw rolls **53, 54** and **55** and is then passed to apparatus **10** wherein the yarn is treated and forms yarn plug **27** as described previously. Crimped and commingled yarn is then removed from apparatus **10** by tension supplied by end rollers **56** and **57**, and then wound on winding roller **58**. As has been previously described, yarn **51** after having been passed over rollers **53, 54** and **55** may be fed into a conventional pre-crimping assembly, such as that illustrated in FIG. **2**, which cooperates with apparatus **10**.

In operation of the apparatus of the present invention, continuous filament yarn is fed by inlet means **12** into contact chamber **14** wherein heated fluid, such as steam, which is supplied under pressure to heated fluid chamber **34** through nozzle **31**, contacts the yarn in contact zone **26** (1) at an angle of not greater than about 85° with respect to the yarn passage axis, which in FIG. **1** is defined to coincide with longitudinal axis **22**, and (2) at a fluid velocity sufficient to cause the contacted yarn to vibrate so as to impact upon a portion of an impacting surface, such as chamber wall **15** of chamber **14**.

The impacted yarn together with heated fluid is then passed into energy tube passage **17** wherein the yarn vibrates substantially in the manner shown in FIG. **7** and wherein the yarn absorbs at least a portion of the heat from the heated fluid. As discussed above, alternate, external heating sources **23** may be applied to energy tube **16**, thereby further heating the yarn passing through passage **17**. Depending upon the condition of operation, e.g., the type yarn, the temperature and pressure employed, the yarn is reduced to a semi-plastic state, and thereafter the yarn is aspirated through passage **35** into texturizing passage **19** wherein the flow of yarn is impeded, thereby establishing a yarn plug as in conventional stuffer tube **18***a*, such as is described in U.S. Pat. No. 3,409,956. From texturizing passage **19**, which may be operated at a reduced pressure of from about 0 to 15 psig, heated fluid exits through heated fluid vents **20** located concentric to longitudinal axis **22**. Crimped and commingled yarn is preferably removed from stuffer tube **18***a* at a slower linear speed than the feed rate to texturizing passage **19** so as to maintain the yarn plug therein.

By contacting the yarn in contact zone **26** with heated fluid at an angle of not greater than about 85° with respect to the yarn passage axis, a certain amount of twist is imparted to the yarn, and the yarn is caused to impact upon an impacting surface, thereby effecting increased commingling of adjacent yarn filaments. In addition, the yarn which is thus impacted vibrates within the heat absorbing zone in an unconventional manner which is believed to further contribute to the crimp and commingling levels achieved. FIG. **6** illustrates vibration patterns in yarn **62** contacted in the apparatus of U.S. Pat. No. 3,490,956. As may be seen, this vibration pattern is substantially sinusoidal. FIG. **7** illustrates the substantially non-sinusoidal vibration which the yarn undergoes in energy tube passage **17** (i.e., the heat absorbing zone) in the apparatus of the present invention. As may be seen from FIG. **7**, adjacent yarn filaments are caused by the vibration to form a folded-wave pattern, the folds of which are exemplified by **60** and **61**. This folded-wave pattern is believed to enhance the crimp and commingling properties of the yarn.

The process and apparatus of this invention can be used to simultaneously crimp and commingle any natural or synthetic plastizible filamentary material. Thermal plastic material such as polyamides, e.g., poly(epsilon caproamide), poly(hexamethylene adipamide); cellulose esters; polyesters, e.g., polyethylene terephthalate, poly(hexahydro-p-xylene terephthalate), etc; and polyolefins and polyacrylics, e.g., polyethylene and polyacrylonitrile as well as copolymers thereof, can be treated by the process and apparatus of the present invention.

In addition, both monofilaments and yarns of textile deniers, as well as heavy carpet and industrial yarns (either singly or combined in the form of a heavy tow) may be treated by the process and apparatus of the present invention. When the yarn to be treated is composed of filaments which are made from synthetic materials, a filament of any cross-section type may be treated. Cruciform, Y-shaped, delta-shaped, ribbon, and dumbbell and other filamentary cross-sections can be processed at least as well as round filaments and usually contribute still higher levels of crimp and commingling than is obtained with round filaments.

The process and apparatus of the present invention may be further illustrated by reference to the following examples: In the examples the term "crimp bends per inch" is determined by examining a length of yarn under a microscope and counting the number of filament bendings for 1 inch of stretched length. The term "entanglements per meter" (E.P.M.), which reflects the level of commingling achieved, is determined by passing the yarn through a conventional testing device in which a needle is inserted between filaments. Each time the needle is pushed in the direction of yarn motion by a local entanglement, a counter in the device is activated to count the number of entanglements per meter of the stretched length of yarn. The term "crimp elongation after boil" (C.E.A.B.) is determined by measuring the length of a sample of crimped yarn at a tensile stress level of 0.002 gram/denier. The yarn is then boiled in water for 30 minutes at a pressure of 1 atmosphere. After this period, the yarn is dried at a temperature of 150°C. for 10 minutes and then conditioned for a period of 2 hours at a temperature of 223°C. and a relative humidity of 65 percent. The length of the conditioned yarn is then determined at a tensile stress level of 0.5 gram/denier. The value thereby obtained is compared to the length of unboiled yarn obtained at a tensile stress level of 0.002 gram/denier and the percent of the elongation calculated.

EXAMPLE 1

A continuous, 70 filament, 1,100 denier nylon 6 yarn, each filament having a Y-shaped cross-section, is fed at a speed of 700 ft/min into the feed tube of an apparatus of FIG. **1** along the longitudinal axis thereof. The yarn is contacted in the contact zone at an angle of 10° with respect to the yarn passage axis by steam supplied to the zone at a temperature of 260°C. and a pressure of 150 psig through a nozzle having an inside diameter of 0.04 inch and a nozzle length of 0.1 inch, thereby contacting the yarn with steam at a force of 5 lb_f/in^2. The contact zone is a cone defining a conical angle of 15°. After being contacted by the heated fluid, the yarn vibrates and impacts upon a portion of the contact chamber wall. The impacted yarn then passes into energy tube passage which has an inside diameter of 0.125 inch and a length of 3 inches, wherein the yarn temperature is raised to about 140°C. The heated yarn is then passed into the texturizing passage, which has a diameter of 0.5 inch and a length of 6.0 inches, in which the yarn forms a moving yarn plug and from which crimped and commingled yarn is continuously withdrawn. The treated yarn is determined to have 46 crimp bends per inch, a 35 percent elongation after boil and 40 entanglements per meter.

Nylon 6 yarn having the identical characteristics treated above, is processed by the conventional steam jet apparatus of U.S. Pat. No. 3,409,956 under the same conditions of treatment with the above apparatus. While the treated yarn is determined to have a comparable level of crimp, the yarn treated by the conventional jet texturizing apparatus achieved less than 10 entanglements per meter.

EXAMPLE 2

A continuous, 70 filament, 1,100 denier nylon 6 yarn is treated in an apparatus of the present invention similar to that employed in Example 1. The yarn is fed to the apparatus at a speed of 1,500 ft/min. and is contacted in the impacting zone by steam supplied at a temperature of 260°C., and a pressure of 75 psig through a nozzle having an inside diameter of 0.055 inch, thereby contacting the yarn with steam at a force of 5 lb_f/in^2. The energy tube has an inside diameter of 0.15 inch and a tube length of 5.625 inches. Other process conditions and apparatus dimensions are identical to those employed in Example 1. Under these conditions, the treated yarn is found to have 35 crimp bends per inch, a 29 percent crimp elongation after boil and 30 entanglements per meter.

EXAMPLE 3

Two ends of a continuous, 140 filament, 3,300 denier nylon **6** yarn, each filament having a Y-shaped cross-section, are fed as a yarn bundle to a series of two feeder rolls, such as are illustrated in FIG. **3**, between which a draw ratio of 1.1 is maintained. Feeder roll 2 is heated to 90°C., whereupon the yarn is heated to about 50°C. The yarn is then passed to a third feeder roll maintained at 145°C. and operated at a linear speed of 5,280 ft/min., thereby maintaining a draw ratio of 3:1 between rolls **3** and **1**. The yarn on roll **3** is heated to about 90°C.

The pre-heated yarn is then passed into the pre-crimp feeder tube of the apparatus of FIG. **2**. In the pre-crimp assembly, the yarn bundle is contacted with steam at a temperature of 232°C. and a pressure of 50 psi supplied through a coaxial nozzle having an inside diameter of 0.06 inch. The steam and contacted yarn enter the crimping tube which has an inside diameter of 0.145 inch and a length of 5.5 inches. The pre-crimped yarn is then passed through the feeder tube of apparatus **10** along the longitudinal axis thereof. The yarn is contacted in the contact zone at an angle of 8° with respect to the yarn passage axis by steam supplied to the zone at a temperature of 280°C., and a pressure of 150 psig. through a nozzle having an inside diameter of 0.076 inch and a nozzle length of 0.1 inch, thereby contacting the yarn with steam at a force of 3 lb_f/in^2. The contact zone is a cone defining a conical angle of 15°. The yarn contacted by the steam impacts upon a portion of the contact, chamber wall, and the impacted yarn is passed into the energy tube having an inside diameter of 0.16 inch and a length of 1.9 inches, wherein the yarn temperature is raised to about 145°C. The heated yarn then passes into a texturizing passage which has an inside diameter of 0.54 inch and a length of 7.0 inches, in which the yarn forms a moving yarn plug. Crimped and commingled yarn is continuously withdrawn from the texturizing passage by a series of two end rollers, rollers **4** and **5**. The draw ratio between rollers **4** and **3** is maintained at 0.74 and the pull-out ratio (the draw ratio between rollers **5** and **4**) is maintained at 1.03, so that a tension of **100** grams is maintained. After roll **5**, the yarn is passed to a Rieter winder at a tension of 100 grams.

The treated yarn is determined to have 35 crimp bends per inch, 30 percent elongation after boil and 38 entanglements per meter.

EXAMPLE 4

Example 3 is repeated employing a 3000 denier undrawn yarn for each end. The yarn bundle is fed by a pre-crimp feeder tube into a pre-crimp assembly to which steam is supplied at a temperature of 240°C., a pressure of 75 psi, and a contact force of 4 lb_f/in^2. The draw ratio between rollers **4** and **3** is maintained at 0.68 and a tension between rollers **4** and **5** is 120 grams. All other process conditions and apparatus dimensions are those employed in Example 3.

The treated yarn is found to have 40 crimp bends per inch, 31 percent elongation after boil and 46 entanglements per meter.

EXAMPLE 5

Example 3 is repeated employing a 3,150 denier yarn for each end using a pre-crimp assembly to which steam is supplied at a temperature of 270°C. and a pressure of 70 psi. Steam is supplied to apparatus **10** at a temperature of 260°C. and a pressure of 115 psi through a nozzle having an inside diameter of 0.06 inch, thereby contacting the yarn with steam at a force of 4 lb_f/in^2. The draw ratio between rolers **4** and **3** is maintained at 0.69 and the tension between rollers **4** and **5** is 120 grams. All other process conditions and apparatus dimensions are those employed in Example 3.

The treated yarn is found to have 40 crimp bends per inch, 30 percent crimp elongation after boil and 28 entanglements per meter.

Although certain preferred embodiments of the invention have been disclosed for purpose of illustration, it will be evident to one skilled in the art that various changes and modifications may be made therein without departing from the scope and spirit of the invention.

We claim:

1. A process for simultaneously crimping and commingling continuous filament yarn, which comprises:

a. feeding the yarn into a contact zone;

b. contacting the yarn in said contact zone with heated fluid at an angle of not greater than about 85° with respect to the axis of yarn passage through said contact zone, said heated fluid having a fluid velocity sufficient to vibrate the yarn and to cause the yarn to impact upon an impacting surface;

c. passing the impacted yarn and heated fluid into a heat absorbing zone wherein the yarn absorbs at least a portion of the heat from said heated fluid;

d. directing the yarn under the action of heated fluid into a texturizing zone wherein the flow of yarn is impeded, thereby establishing a yarn plug;

e. exhausting heated fluid from said texturizing zone; and

f. removing crimped and commingled yarn from said yarn plug.

2. A process according to claim **1** wherein said heated fluid is steam.

3. A process according to claim **1** wherein the yarn is contacted in said contact zone with heated fluid at an angle of not greater than about 45° with respect to the axis of yarn passage through said contact zone.

4. A process according to claim **1** wherein said contact zone conically converges in the direction of yarn passage therethrough and defines a conical angle of not greater than about 85°.

5. A process according to claim **1** wherein said contact zone is substantially cylindrical.

6. The process according to claim **1** wherein the yarn is fed to the contact zone substantially along the longitudinal axis of said zone and wherein the yarn is contacted in said contact zone with heated fluid at an angle of between about 5° and 45°.

7. An apparatus for simultaneous crimping and commingling continuous filament yarn, which comprises:

a. a contact chamber assembly including a contact chamber, yarn inlet means for feeding yarn into said contact chamber and fluid supply means for introducing heated fluid into said contact chamber substantially along an axis which forms an angle of not greater than about 85° with the axis of yarn passage through said contact chamber;

b. an energy tube wherein the yarn absorbs heat from said heated fluid, said energy tube communicating with said contact chamber; and

c. a stuffer tube assembly including a stuffer tube for texturizing said yarn and a stuffer receiver, said stuffer tube and said stuffer receiver communicating successively with said energy tube.

8. An apparatus according to claim **7** wherein said contact chamber defines a passage which conically converges in the direction of yarn passage therethrough and which defines a conical angle of not greater than about 85°.

9. An apparatus according to claim **7** wherein said fluid supply means is adapted for introducing heated fluid into said contact chamber substantially along an axis which forms an angle of not greater than about 45° with the axis of yarn passage through said contact chamber.

10. An apparatus according to claim **7** wherein said contact chamber defines a substantially cylindrical passage.

11. An apparatus according to claim **7** wherein said yarn inlet means is adapted for feeding yarn into the contact chamber substantially along the longitudinal axis of said chamber, and wherein said fluid supply means is adapted for introducing heated fluid into said contact chamber substantially along an axis which forms an angle of between about 5° and 45° with the axis of yarn passage through said contact chamber.

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