Sept. 25, 1962 O. H. CLAUSSEN ET AL 3,055,080

APPARATUS FOR FLUID TREATMENT OF TOW AND YARN BUNDLES

Filed July 19, 1960 2 Sheets-Sheet 1

FIG. 1

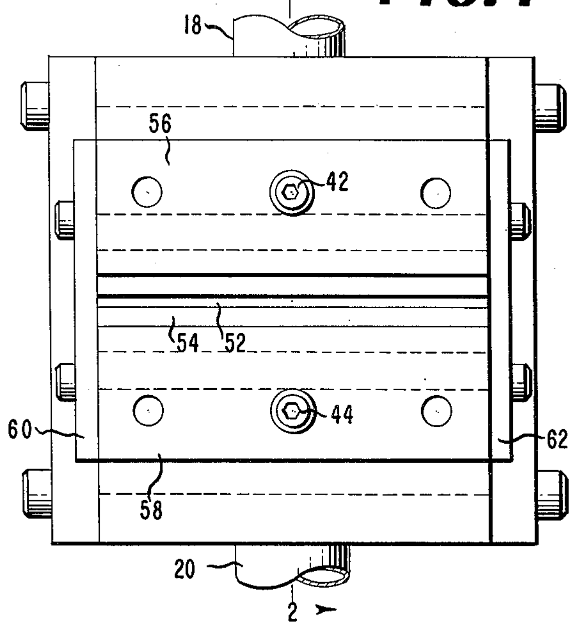
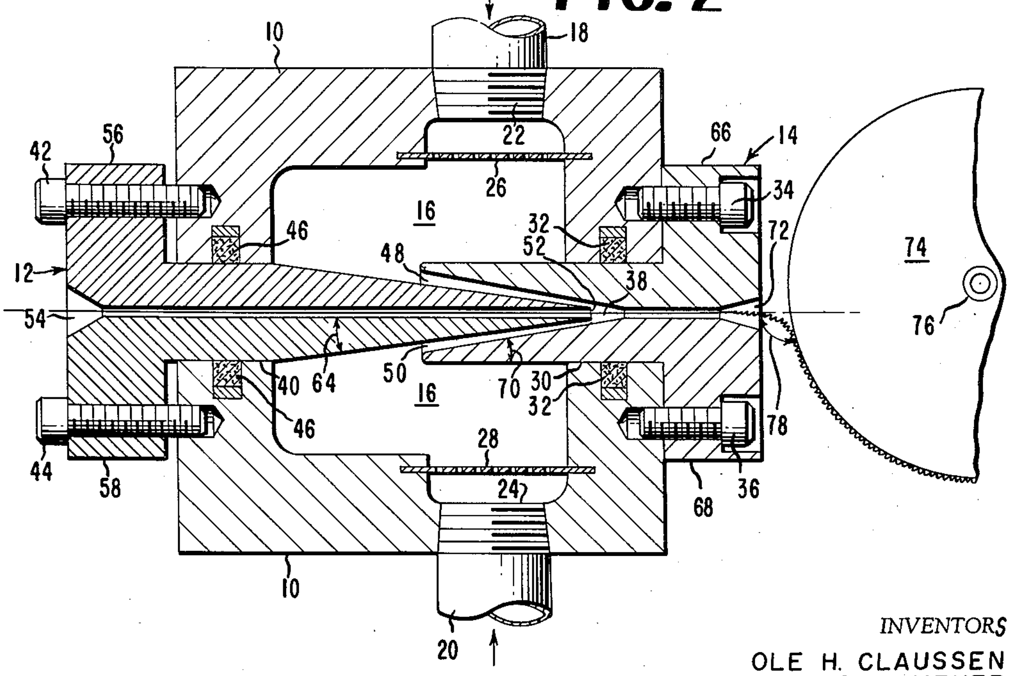


FIG. 2



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Filed July 19, 1960 2 Sheets-Sheet 2

FIG. 3

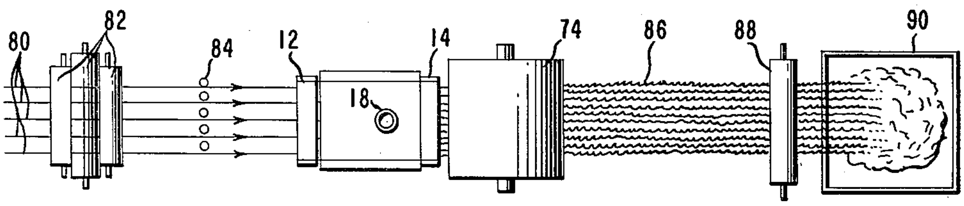


FIG. 4

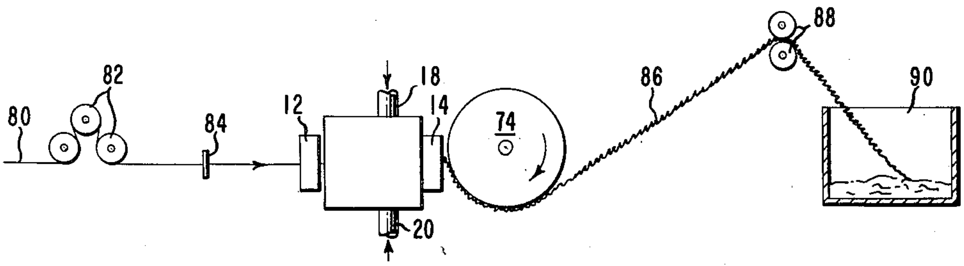
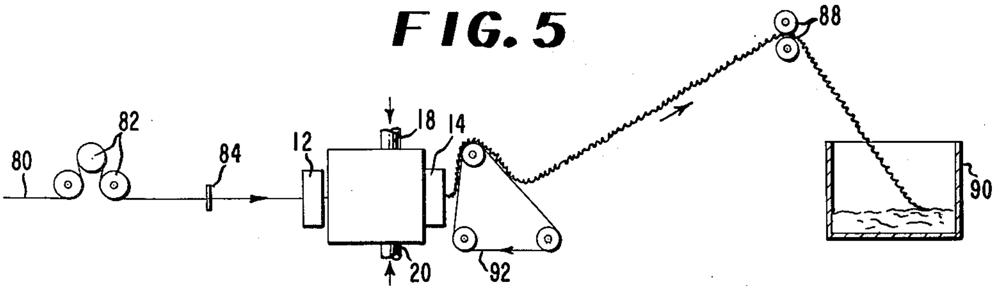


FIG. 5



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APPARATUS FOR FLUID TREATMENT OF TOW AND YARN BUNDLES

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This invention relates to apparatus for fluid treatment of yarn, and is more particularly concerned with apparatus useful in treating the filaments of yarn bundles to impart crimp, bulk and entanglement between filaments.

Fluid jets have been employed for bulking yarn by introducing a large number of loops in the filaments of the yarn bundle. The apparatus has been suitable for handling small bundles of filaments, such as one or two yarn ends. Fluid jets have also been employed for opening up large bundles of filaments, as in separating wet filaments of a tow for drying, but the apparatus has not been suitable for imparting bulk. Any increase in bulk which occurred was the result of an inherent property of the filaments to crimp during relaxed drying, and was not caused by the fluid treatment in the apparatus.

An object of the present invention is to provide an improved apparatus for fluid treatment of bundles of continuous filaments in the form of tow as well as yarn to impart such desirable properties as crimp, bulk or interlacing of filaments (controlled interfilament entanglement). Another object is to provide such an apparatus which is particularly suitable for imparting crimp and bulk to high denier bundles of filaments, i.e., for simultaneous treatment of a large number of filaments. A further object is to provide such an apparatus which is suitable for the simultaneous treatment of a plurality of yarns to crimp and bulk the yarns and also impart a high degree of entanglement between filaments of different yarn bundles to produce a product in the form of a cohesive sheet of highly entangled and bulked filaments. A still further object is to provide such an apparatus which is suitable for simultaneously treating a plurality of yarns to produce a sheet of crimped and bulked filaments, but wherein the individual yarn ends retain their identities and are easily separable. Other objects will become apparent from the description of the invention and the appended claims.

In accordance with the present invention, apparatus suitable for processing large bundles of continuous filaments, such as a tow or group of yarns, is provided which comprises fluid jet means having a slit-shaped nozzle to create a turbulent stream of high velocity fluid, yarn inlet means for feeding the filaments as a flattened bundle or sheet through the turbulent stream, a screen or other foraminous surface for receiving the filaments after passage through the turbulent stream and for separating the filaments from the treating fluid, and means for removing the treated filaments from the receiving surface in the form of a bulked sheet. The fluid jet is provided with means for supplying the slit-shaped nozzle with a high velocity stream of a compressible fluid having a plasticizing action on the continuous filaments. By "plasticizing action" is meant a softening of the filaments by heat or solvent, or a combination of both. Means are provided for directing the plasticizing fluid through the slit-shaped nozzle in a flat turbulent stream to soften and crimp the filaments and drive the filaments against the receiving surface with sufficient force to heighten the crimp of the filaments and bulk of the product. The apparatus has been found to provide a much more effective and uniform treatment of the filaments than is the case when apparatus having nozzles of circular cross-section are used, particularly when treating filament bundles of high total denier. Changes in the apparatus to handle different sizes of filament bundles are readily made. The sheet form of product is particularly useful in certain applications, but the apparatus is also adapted to process yarns so that the individual yarns can again be separated after treatment.

In the drawings, which illustrate preferred embodiments of the apparatus of this invention,

FIGURE 1 is an end view of a fluid jet forming a part of the apparatus, illustrating particularly the yarn inlet member,

FIGURE 2 is a cross-sectional side elevation of the fluid jet, on line 2—2 of FIGURE 1, showing also a screen roll for receiving filamentary material from the jet,

FIGURE 3 is diagrammatic plan view of an arrangement of apparatus, including means for feeding filamentary material, such as a yarn warp, to the jet for treatment and means for collecting the bulked product from the screen roll of the apparatus,

FIGURE 4 is a side elevation corresponding to FIGURE 3, and

FIGURE 5 is a side elevation similar to FIGURE 4 but having a screen belt instead of a screen roll in combination with the jet.

The construction of the fluid jet will be apparent from the cross-sectional view of FIGURE 2. The jet comprises a main housing **10**, a yarn entry member, **12**, a nozzle member **14**, and fluid supply means to the nozzle including a fluid chamber **16** within the main housing and fluid conduits **18** and **20** from a suitable source of of pressurized fluid. The fluid passes from conduits **18** and **20** into the chamber through ports **22** and **24**, respectively, in the main housing. Perforated plates **26** and **28** are arranged across the ports to provide uniform flow of fluid into all parts of the slit-shaped fluid exit from the chamber. The nozzle member **14** projects into the chamber through throat **30** in the main housing. A sliding fit is provided so that the member is adjustable for insertion, retraction or removal. A pressure-tight fit is provided by packing **32**. The member is held in position by bolts **34** and **36**. The fluid exits from the chamber through slit-shaped nozzle passageway **38**, where it acts on the yarn filaments.

Yarn entry member **12** projects into the chamber through throat **40** in the main housing on the opposite side from the nozzle member. This yarn entry member is likewise adjustable in or out, being held in position by bolts **42** and **44**, and a pressure-tight fit is provided by packing **46**. The inner end of the yarn member extends into the nozzle passageway **38** to provide a fluid opening **48** above and a fluid opening **50** below. Adjustment of the relative positions of the yarn member and nozzle member varies the size of these openings to control the flow of fluid into the nozzle passageway.

The yarn passageway **52** of the yarn entry member **12** is a slit-shaped orifice of generally rectangular cross-section, which may have sharp corners as shown in FIGURE 1. Rounded corners are also suitable and may be preferable if a one-piece yarn member construction is to be employed instead of that shown. The height of this slit should be sufficient to accommodate the filaments without appreciable friction and nevertheless prevent a back flow of fluid from the nozzle passageway. The width of the slit should be at least 10 times, and preferably at least 20 times, as wide as the height of the yarn passageway at the inner end where the filaments enter the fluid stream in the nozzle passageway. In FIGURES 1 and 2 the yarn passageway is shown as having uniform dimensions throughout, except for the flared entranceway **54** where the yarn is introduced. A passageway which has a decreasing taper towards the inner end is also suitable. The optimum dimensions will depend upon the denier and number of filaments in the case of tow, and also upon the size, twist and number of yarns when yarns are treated instead of tow. For example, when treating a warp of 120 ends of yarn, each yarn being of 1020 total denier and composed of 68 filaments, ½Z twist made from polyhexamethylene adipamide, suitable slit dimensions are 1⁄16 inch high and 4 inches wide. Suitable dimensions for other filament feed conditions are readily determined in actual practice. The apparatus construction shown makes substitution of different yarn members a simple matter.

The yarn entry member **12** is shown in FIGURE 1 as composed of similar upper and lower sections **56** and **58**, either or both being channeled on the surface to provide the yarn slit, which are locked together by side plates **60** and **62**. Each of these sections tapers down to a fine edge at the innermost end, the angle **64** shown being about 7.5° The nozzle member **14** is likewise formed of two sections **66** and **68** locked together by side plates, the external appearance being substantially the same as in FIGURE 2 except for the height of the nozzle slit. The inner end of the generally rectangular slit-shaped nozzle passageway **38** diverges at an angle of about 20° in the embodiment illustrated in FIGURE 2, i.e., the half-angle **70** on each section is about 10°, to form a wedge-shaped opening about the end of the yarn member. In general, the half angle **70** can be from 5° to 35°, and is preferably 5°–15°. For treating the 120 yarn warp indicated above, the height of this opening at the end of the yarn member **12** may suitably be about ¼ inch. The width is about the same as that of the yarn entry member slit, i.e., about 4 inches for the above exemplification. The wedge-shaped portion of passage **38** continues to taper for about ⅜ inch from the end of the yarn member to a height of about ⅛ inch.

As illustrated in FIGURE 2, the height of the nozzle slit remains at ⅛ inch for a distance of about 1⅜ inches. However, this portion of the passageway may be varied considerably in distance of travel and, instead of having the cross-section illustrated in FIGURE 2, may have a gradually increasing taper, or a straight section followed by a gradually increasing taper, or a decreasing stepped taper followed by an increasing taper. The height of the slit then increases to about ¼ inch in the last ½ inch to provide the jet outlet **72**. Optimum dimensions for treatment under other filament feed conditions, e.g., other deniers of yarn warp or tows, are readily determined in actual practice and the apparatus construction makes it simple to substitute other nozzle members.

A screen-surfaced roll **74** is positioned just beyond the jet outlet **72** to receive filamentary material and separate it from the exhausting fluid. The roll is supported by bearing **76**, which is adjustable vertically and horizontally to vary the position and angle of the screen surface relative to the jet outlet. The roll is rotated by means not shown to a suitable speed dependent upon the rate of yarn feed to the jet, the type of yarn and the treatment. When feeding the 120 yarn warp mentioned previously to the jet at a speed of 65 yards per minute, the roll is suitably driven at a surface speed of 25 yards per minute with the surface positioned at a distance of ¼ to 1 inch from the nozzle exit. The roll is also positioned so that the angle **78** formed by the axis plane of the jet slit **38** and the plane tangent to the roll surface at the line of intersection of said axis plane must be somewhat greater than a right-angle to avoid pile-up. An angle of about 100° is suitable. In general, the angle should be between 95° and 135°.

FIGURES 3 to 5 show complete embodiments of apparatus for processing a warp of yarns. Yarns **80** from a suitable source are forwarded at a controlled speed through feed rolls **82** and are directed by yarn guide **84** into yarn member **12** of the jet as a sheet of yarns. Normally several yarn ends will be fed through each opening of the yarn guide. Superheated steam or other plasticizing compressible fluid is fed to the jet through conduits **18** and **20** so that the yarns are sucked into the jet for treatment. The filaments of the yarns are softened and crimped by the turbulent action of the steam and deposited as a bulked sheet on the foraminous surface of roll **74**. The steam escapes through the surface and the bulked sheet is conveyed away from the jet until it has set sufficiently for removal. The sheet is then removed from the foraminous surface as a coherent bulked sheet **86** by take-up rolls **88**. The sheet is shown being deposited in a carton **90** as illustrative of various conventional packaging provisions which can be used. A screen belt **92** can be used instead of roll **74** to receive the yarn sheet from the jet, as shown in FIGURE 5.

The foraminous surface upon which the bulked yarn impinges after it leaves the exit of the jet will normally be in the form of a perforated screen having openings of suitable size, e.g., a 30-mesh screen, so that the plasticizing fluid my freely escape through the screen, whereas the bulked yarn will be impinged upon and deflected by the screen. The foraminous surface may be in the form of a cylinder, a belt, or a disc. Suitable embodiments include screens mounted on a roll, on a belt, or on any other supporting means, and unmounted screens passing over roller guides. The screen may be stationary or may be moved with respect to the jet. By using a stationary screen, angle **78** becomes more critical and, therefore, it is preferred to use a moving screen surface. The foraminous surface may be composed of a metal screen preferably made of stainless steel, but it may also be made of plastic, glass, ceramic or other material. It may also be a perforated sheet or belt, closely spaced parallel wires or the like. The perforations can be in the form of holes or slots of uniform or varying dimensions which will serve to retain the yarn on the surface and pass the treating fluid therethrough.

The turbulent fluid used to treat yarn in the apparatus of this invention may be any compressible fluid or vapor capable of plasticizing the filamentary material. Superheated steam, e.g., 400° F. steam at 24 pounds per sq. in., is the preferred fluid for treating most yarns and other filamentary material, but other fluids include air and organic vapors chosen because of their plasticizing action on the particular filamentary materials being treated. The filamentary material which may be treated in the apparatus of this invention may take different forms, such as monofilament yarns, tow, a sheet of warp ends, and the like. Particularly suitable for processing in the apparatus of this invention are a warp of yarn or a tow bundle having a total denier between 50,000 and 150,000 when using the particular dimensions of the jet given for the particular embodiment discussed in connection with FIGURES 1 and 2.

The apparatus of this invention may be used to crimp and bulk any natural or synthetic plasticizable fibrous structures composed of continuous filaments. Examples of such filamentary materials include polyamides, such as polyhexamethylene adipamide, polycaproamide, and copolyamides; polyesters and copolyesters, such as the condensation products of ethylene glycol with terephthalic acid (polyethylene terephthalate), ethylene glycol with a 90/10 mixture of terephthalic/isophthalic acids, ethylene glycol with a 98/2 mixture of terephthalic/5-(sodium sulfo)-isophthalic acids, and trans-p-hexahydroxylylene glycol with terephthalic acid; acrylonitrile polymers, such as polyacrylonitrile, polymers of acrylonitrile with vinylidene chloride, vinyl chloride or methyl acrylate; vinyl chloride and vinylidene chloride polymers and copolymers; polyurethanes, polyester amides, polyethylenes, polypropylenes, polycarbonates; fluorinated ethylene polymers and copolymers such as polytetrafluoroethylene and polymonochlorotrifluoroethylene; cellulose derivatives, such as cellulose acetate and regenerated cellulose; and the like.

The temperature of the fluid medium used in the jet must be regulated so that the filamentary material does not melt. Usually when treating filaments made from fusible polymers the most effective bulking and crimping is obtained when the temperature of the fluid is above the melting point of the fiber. In such a situation, the speed of the moving yarn should be great enough to prevent melting of the filaments sufficiently to cause loss of their fibrous nature. The foraminous surface upon which the bulked yarn impinges may be at ambient temperature or it may be independently cool.

The crimped and bulked yarns and other filamentary products treated in the apparatus of this invention possess the same general characteristics of crimp geometry; namely, a random curvilinear crimp essentially free of crunodal loops, and the bulked products having approximately the same tensile strength, crystallinity, dye rate and the like as the crimped products described by Breen and Lauterbach in copending U.S. application Serial No. 842,524, filed September 25, 1959. The filamentary materials fed to the apparatus of this invention may be either twisted or not twisted. By using twisted feed yarns having a twist above one turn per inch a sheet of bulked yarns is produced from which individual yarns may be easily separated from the sheet.

The chief advantage of this invention is the provision of an improved crimping apparatus that is particularly adapted for processing filamentary materials of high total denier (e.g., greater than 50,000) to produce a bulked product preferably in the form of a cohesive sheet-like structure wherein filaments from adjacent filamentary bundles are highly entangled. The sheet of bulked filaments has a higher uniformity of crimp geometry from filament to filament compared with products bulked by feeding through jets having circular entrances. This increased uniformity is due to the fact that the high denier filamentary material as it enters the slit or rectangular opening **52** of the jet illustrated in FIGURES 1 and 2 is in the form of a spread-out filamentary sheet of uniform density across the whole width of the opening **52**, and the uniformity is also due to the fact that at the point where the filamentary material contacts the plasticizing fluid inside the jet at the junction of yarn slit **52** and the fluid passageway **38**, the filamentary material is also in the form of a sheet and the application of steam is of uniform velocity, temperature, and other characteristics across the whole width of the passageway. This is in contrast to the effect obtained by feeding high denier filamentary bundles to similar jets of the prior art which have yarn entrances of circular or other non-rectangular cross sections. In such instances, the steam or other plasticizing fluid changes in velocity and temperature as it penetrates from the outside of the high denier bundle to the inside at the point of contact between the plasticizing fluid and bundle, and hence, the fluid does not affect each filament to the same extent with respect to the amount of crimp produced as well as its tensile and other physical properties. These non-uniformity effects become increasingly more pronounced the higher the total denier of the feed bundle, leading to greater variations in properties between each individual bulked filament. Highly bulked products may be produced by using low twist or zero twist yarns or tow where easy separation of the yarns or filaments is not essential in the bulked product. Alternatively, if yarn separation is desired in the bulked products some twist should be imparted to the yarn before processing in the apparatus of this invention. In this instance, the bulked product possesses yarns which are easily separated but the degree of bulk imparted to the yarns is somewhat lower than when using untwisted feed yarns. Instead of feeding twisted yarns to the treating apparatus of this invention, it is also possible to feed false twisted yarns or interlaced yarns.

Another advantage of the apparatus of this invention is that it is designed to permit changes in the width of the rectangular opening for the filamentary bundle so that it is possible to accommodate different sizes of high denier bundles and still obtain reproducible uniformity of crimp, bulk, tensile, and other physical properties between individual filaments in the bulked products. This is not possible when crimping high denier filamentary bundles in jet openings having non-rectangular cross sections.

The bulked filamentary cohesive sheets made from untwisted yarns in the apparatus of this invention are useful for interliners, cushions, pillows, or any other product where gross relative displacement of fibers is objectionable.

It is to be understood that the specific dimensions of the jet described above may be varied to a wide extent depending upon the particular filamentary material being fed to the apparatus.

Since many different embodiments of the invention may be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited by the specific illustrations except to the extent defined in the following claims.

We claim:

1. Apparatus for fluid treatment of filaments of tow and yarn bundles which comprises a jet housing, a nozzle member mounted in one side thereof having a slit-shaped nozzle orifice, a filament entry member in the form of a slit-shaped filament passageway of generally rectangular cross-section having a width at least 10 times the height mounted in the opposite side of the housing and projecting into the inlet end of said nozzle for feeding a flattened bundle of filaments to the slit-shaped orifice for treatment, fluid supply means to the nozzle including slit-shaped fluid openings between the filament entry member and the inlet end of the nozzle member for introducing streams of treating fluid to crimp the filaments and pass with the filaments through the slit-shaped orifice, filament receiving means positioned closely adjacent to the outlet of the slit-shaped orifice so that the portion of the receiving surface nearest to the outlet forms an angle of about 95° to 135° with the axis plane of the orifice slit for separating exiting filaments from the stream of treating fluid, said receiving means having a foraminous surface for receiving the filaments in the form of a bulked sheet and for passage of treating fluid therethrough, and means for removing the treated filaments from the receiving surface as a continuous sheet.

2. Apparatus as defined in claim 1 wherein the surface of said filament receiving means is positioned at a distance of ¼ to 1 inch from the the nozzle exit.

3. Apparatus as defined in claim 1 wherein means are provided for moving the receiving surface in a direction away from said axis plane to remove the bulked sheet from the stream of treating fluid.

4. Apparatus as defined in claim 1 wherein said filament receiving means is a rotating roll having a screen surface.

5. Apparatus as defined in claim 1 wherein said filament receiving means is a moving screen belt.

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