United States Patent

[11] **3,576,058**

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[33] **Germany**
[31] **P 17 60 168.2**

[54] **PROCESS AND APPARATUS FOR THE CONTINUOUS COMPRESSION CRIMPING AND SETTING OF A MULTIFILAMENT YARN**
18 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **28/1.3,** 28/72.11
[51] **Int. Cl.** **D02g 1/20**
[50] **Field of Search** 28/1.2, 1.3, 1.4, 1.6, 72.1, 72.11, 72.12, 72.14

[56] **References Cited**
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ABSTRACT: Process and apparatus for continuously crimping and heat setting a multifilament yarn in which the yarn is continuously conducted through a series of interconnected and interchangeable tubular passages, first through a restricted acceleration passage by a jet of steam injected through an annular nozzle surrounding the yarn inlet, then into an expansion chamber of substantially larger diameter and having lateral openings for the discharge of the major proportion of the steam, and then into a compression chamber as a tubular extension of the expansion chamber. The improved construction and operation permits the use of saturated steam and provides a crimped yarn with a low moisture content.

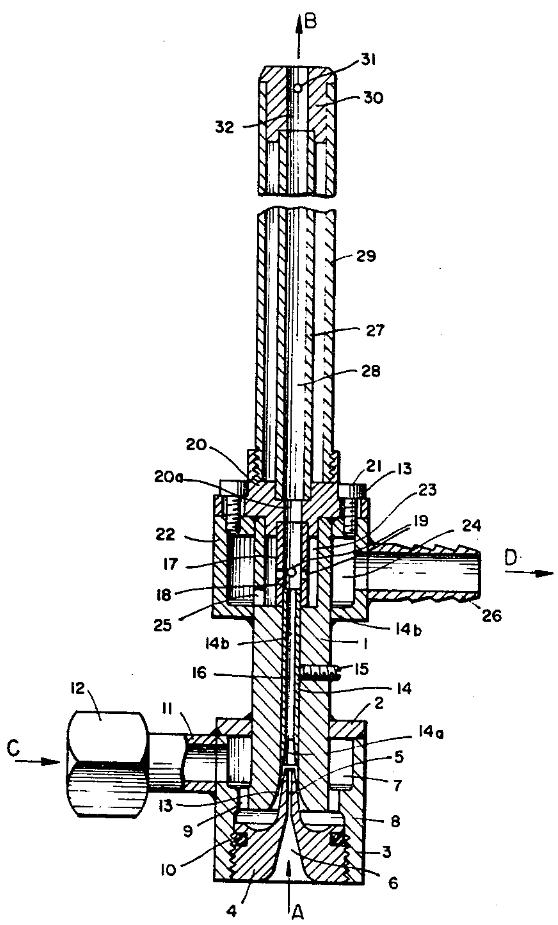
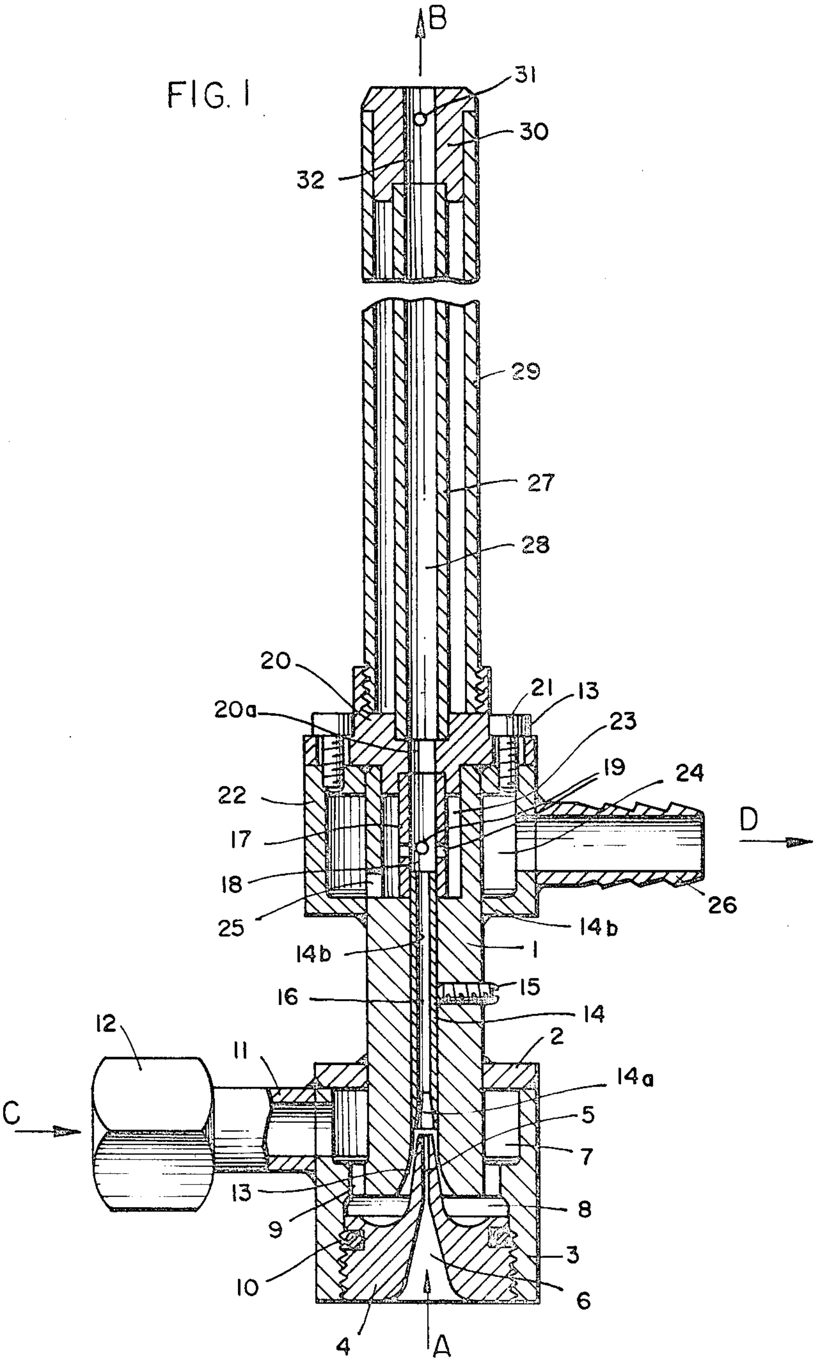


FIG. 1



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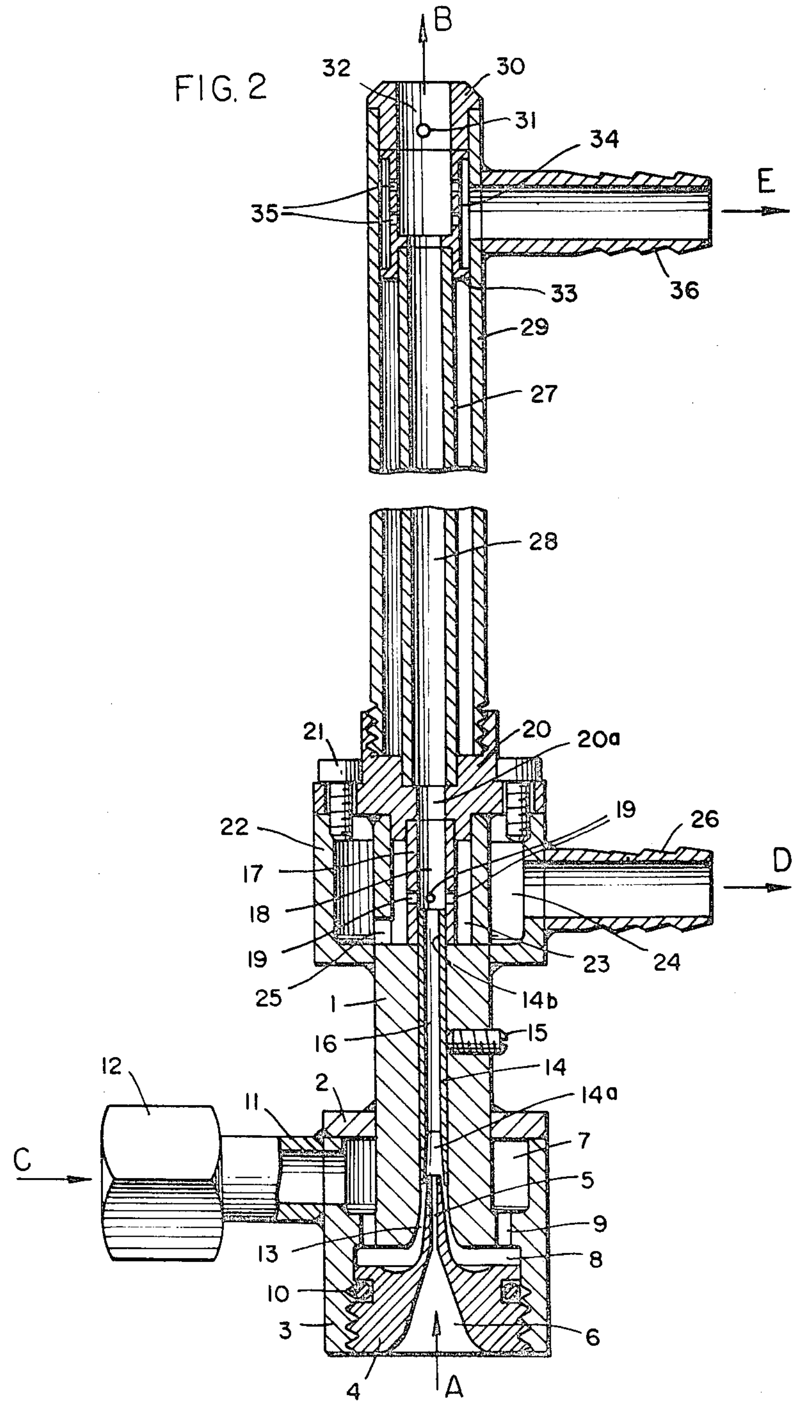

FIG. 2

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FIG. 3

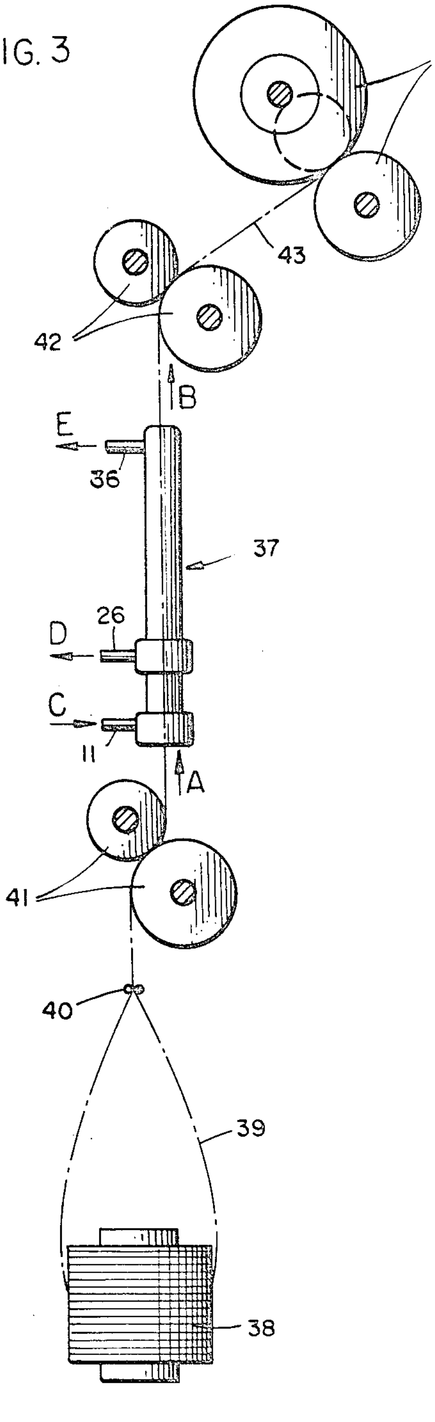
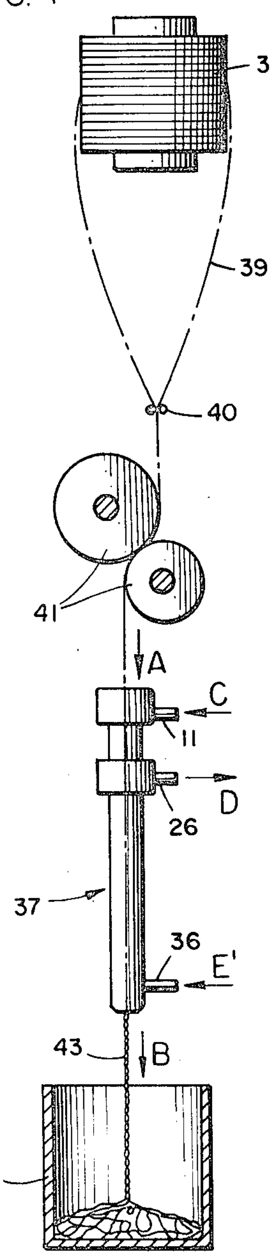


FIG. 4



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PROCESS AND APPARATUS FOR THE CONTINUOUS COMPRESSION CRIMPING AND SETTING OF A MULTIFILAMENT YARN

The invention generally relates to a process and apparatus for the continuous compression crimping of endless thermoplastic filaments, in which the compact yarn or bundle of filaments is conducted with the aid of a steam jet flowing through an injector nozzle into a compression chamber where the yarn is randomly deposited in three-dimensional winding lines, fixed or heat set in its crimped form and, by means of the force of subsequently introduced material, is pressed through this compression chamber. Processes of this type and suitable apparatus therefor are already known.

For example, in U.S. Pat. No. 3,296,677, there is described a process and apparatus in which the compact uncrimped yarn is introduced through a nozzle surrounded by a fluid jet plasticizing medium such as steam, hot air or their equivalent, and together with the fluid is then conducted first through a passage of constant diameter and then through a passage of diverging diameter, i.e. a so-called Venturi tube. In this last diverging passage the fluid jet gradually expands and causes the filament bundle to open up, whereupon the yarn is stuffed and heat set in a special crimp chamber. After the diverging passage of the Venturi tube, a small portion of the fluid medium escapes through two lateral openings in the wall of the crimp chamber into the atmosphere. The rest of the fluid medium, e.g. steam, accompanies the yarn through the short compression chamber, the end of which is closed by a leaf spring or spring-actuated clapper gate and then escapes into the atmosphere. The compressed and crimped yarn exits at the discharge end of the compression chamber, against the resistance of the leaf spring or clapper gate, and is drawn off for further processing or collection onto a bobbin by means of a suitable yarn transport mechanism.

This known process has a number of disadvantages. For example, when using steam as the fluid jet medium, there is required a vapor pressure of at least about 5 atmospheres gauge pressure and usually more as well as vapor temperatures which are higher than 200° C. With such high vapor pressures and temperatures it is no longer possible to operate the process with cheap waste steam. Instead, fresh steam is required, the production of which either severely burdens the existing sources of steam or else even requires a separate steam boiler installation of its own. Furthermore, as a result of the high vapor pressure and the fact that the steam freely emerges into the atmosphere from the two outlet openings of the crimp chamber, the proportion of the steam which escapes or is directed away from the yarn in the crimp chamber lies far below 50 percent, with reference to the total steam passing through the device. The yarn which leaves the compression crimping chamber therefore contains a high degree of moisture.

The yarn produced according to this type of known process has an irregular three-dimensional crimped structure. The leaf spring or gate acting as a compression member has an extremely hampering effect in operation. Individual filaments become stuck between the chamber and the leaf spring or gate, thereby leading to operational disturbances and to filament breakages. Such production of the crimped yarn thus causes considerable difficulties in any further processing.

According to another known process (British Pat. No. 953,782), the yarn after it has been surrounded by a fluid jet stream in an injector nozzle is conveyed by the jet through a wide passage. The wall of the passage has no apertures so that the vapor such as steam can act on the yarn over a path of several centimeters. This path is further lengthened by seating the coil spring acting as the compression chamber in a guide sleeve of several centimeters in length. It is only after this guide sleeve, i.e. at the free end of the compression chamber, that the steam can gradually separate itself from the crimped yarn. As a result of the long path which the steam and yarn travel in common, there is obtained according to this known process a crimped yarn which has a coarse, spiral curling structure. If such a yarn is twisted, as is required for many purposes of use, then one obtains only a yarn with a very low volume. This prior process also fails to assure a trouble-free conveyance of the yarn through the compression chamber, because individual filaments can be jammed or stuck between the windings of the coil spring. Furthermore, it is a disadvantage in this known process that the steam pressure must be higher than 2 kg./cm.^{2} with vapor temperatures of more than 160° C.

One object of the present invention is to continuously produce a crimped and heat-set yarn which, as compared to crimped yarns produced according to known processes, has an increased crimping stability, greater bulkiness or voluminosity, an improved dyeability and a high yarn uniformity.

It has been surprisingly found, in accordance with the invention, that an appreciable influencing factor on the properties of the yarn is the proportion of steam drawn off from the yarn, which should take place shortly before the compression chamber. Correspondingly, in the process according to the invention, the major proportion of the stream of steam, i.e. more than 50 percent, must be drawn off shortly before the compression chamber. In this connection, it is also desirable to regulate the amount of steam being withdrawn at this critical point.

A further influencing factor has been found to reside in the form of the transition between the acceleration passage and the immediately following expansion chamber. A gradually diverging transition leads to relatively unsatisfactory yarn properties whereas the transition according to the present invention takes place abruptly, i.e. at the junction between the acceleration passage and the expansion chamber. Furthermore, by providing an interchangeability of the inserts or elements forming the acceleration passage and the expansion chamber, the ratio of the diameter of the acceleration passage to the expansion chamber diameter can be varied within certain limits in such a way that for any type of yarn there can be achieved an easily determined optimum crimping process.

Another important object of the present invention is to provide the use of a cheap fluid jet and vaporous fixing agent which is readily available in most plants. As such, steam is the most advantageous fluid, especially saturated steam accumulating as a waste vapor in most plants.

The process according to the invention thus provides a substantial improvement in the continuous crimping and heat setting of a synthetic thermoplastic multifilament yarn. The steps of the process include the following: continuously propelling the initially uncrimped and compact yarn by a jet of steam through a tubular acceleration passageway having a substantially constant diameter of 2 to 4.8 times the diameter of said compact yarn; passing the yarn and steam flowing therewith directly from said passageway into an expansion chamber having a diameter of from 8 to 22 times the diameter of said compact yarn while drawing off a major proportion of said steam through lateral openings in said expansion chamber arranged at an interval spaced from the inlet side of said chamber of 0.5 to 2 times the diameter of said chamber, thereby suddenly expanding the flow of steam and opening up the compact yarn with the individual filaments being spread apart; depositing the spread-apart filaments in an elongated compression chamber arranged as a longitudinal extension of said expansion chamber, said filaments being crimped and forced through said compression chamber by the jet action of said steam; passing the remaining minor proportion of said steam through said compression chamber at a temperature sufficiently high to heat set said filaments; and withdrawing the crimped filaments at the outlet end of said compression chamber.

As noted above, saturated steam is preferred as the fluid jet or propellant introduced with the yarn into the acceleration passageway. The temperatures and vapor pressures of the saturated steam entering the injection nozzle have a lower limit caused by the requirement for a compressed, expansible vapor capable of yielding the necessary jet propulsion of the yarn and an upper limit caused by the requirement that the yarn must not be thermally damaged by the steam. The vapor properties of the steam (pressure, temperature, degree of saturation) have a pronounced effect on the essential properties of the crimped yarn (crimp stability, bulkiness, dyeability, and the like). With the use of saturated steam in the process of the invention, it has been unexpectedly found that optimum properties of the crimped yarn can be achieved with vapor temperatures between about 120° C. and 145° C. The crimp stability can of course be further improved by observing the preferred process steps presented hereinafter, all of which contribute to a reduction of the moisture content of the finished crimped yarn.

For example, the crimp stability can be increased provided that 70 to 90 percent of the steam is discharged laterally through the openings of the expansion chamber. In order to further lower the moisture content of the crimped yarn emerging from the compression chamber, the remaining portion of the steam flow can be drawn off laterally shortly before the free or discharge end of the compression chamber. The same result can also be achieved by injecting hot air at a temperature of from 100° C. to 150° C. near the free or outlet end of the compression chamber.

In order to preclude a condensation of steam on the compression chamber wall, there can be provided an additional heating of the chamber, e.g. by means of a heating jacket, electrical resistance heating elements or the like.

Finally, it is also possible to heat at least part of the injector nozzle in such a way that the steam originally present as saturated steam becomes superheated. Through these and similar measures, the moisture content of the crimped yarn can be lowered as required.

In general, it is especially desirable to maintain the moisture content, measured as percentage by weight with reference to the dry yarn, at values below 15 percent, preferably below 8-—10 percent.

The compressed, crimped and heat-set yarn, after leaving the compression chamber, can be collected or deposited in canisters or pots or wound onto a takeup bobbin by any suitable delivery or transporting mechanism.

It is also an object of the invention to provide apparatus embodying unique features for carrying out the above-described process of the invention. This apparatus essentially includes: an annular steam jet nozzle surrounding a tubular yarn entry passage with means to supply steam to said nozzle; an interchangeable elongated acceleration tube of substantially constant diameter arranged to receive steam and yarn from said nozzle and entry passage for propulsion longitudinally thereof; a separately interchangeable tubular expansion chamber concentrically mounted at the discharge end of said acceleration tube, said expansion chamber having a larger diameter than said acceleration tube and being provided with lateral openings for the discharge of steam therefrom; a steam discharge line in fluid connection with said expansion chamber through said lateral openings; a tubular extension of said expansion chamber connected thereto and adapted to receive said yarn for compression crimping; and means to collect the crimped yarn from the discharge end of said tubular extension.

If the residue of the steam flow is to be drawn off laterally shortly before the discharge end of the compression chamber, then the compression chamber is modified by providing a fluid conduit arranged near the free or discharge end of the chamber and in fluid connection therewith by means of lateral steam discharge openings in the wall of the chamber. A steam discharge line is thus connected by a manifold to the compression chamber so as to recover residual steam before it condenses or collects on the crimped yarn being withdrawn.

The steam discharge openings and manifold at the yarn withdrawal end of the compression chamber can also serve for the injection of hot air. For this purpose it is merely necessary to connect a hot air blower to the fluid conduit.

The compression chamber can, if desired, be heated in a conventional manner, e.g. by means of a heating jacket supplied with steam or other heat exchange fluid. The injector nozzle may be heated in the same manner.

The diameter of the entry passage for the yarn preferably has a value which is about 1.3 to 2.3 times as great as the thickness or diameter of the compact yarn being treated.

Reference to the diameter or thickness of the yarn is made herein with the understanding that it refers to the diameter of the initial compact yarn in the form of a cylinder with the individual filaments in parallel contact with one another. The diameter of the yarn is thus the sum of the diameters of the individual filaments on a diametrical line across the cylindrical bundle of filaments. When working with a yarn having a total yarn size of 1000 to 4000 denier, it has been found especially useful to use an expansion chamber with a diameter of about 4.5 to 7.5 mm. in order to avoid knotting of individual filaments.

The ratio of the cross-sectional area of the acceleration passage to the total cross-sectional area of all of the steam discharge openings in the expansion chamber is preferably between about 1:3 and 1:60.

The invention is explained in greater detail with the aid of the accompanying drawings wherein:

FIG. 1 is a sectional view along the longitudinal axis of one embodiment of the apparatus according to the invention, wherein the major proportion of the steam flow is drawn off laterally from the expansion chamber after passing through the acceleration passage;

FIG. 2 is a sectional view along the longitudinal axis of another embodiment of the apparatus according to the invention wherein the remaining portion of the steam flow is drawn off laterally shortly before the free end of the compression chamber;

FIG. 3 is a partially schematic side elevation view of a suitable combination of apparatus for carrying out the process of the invention wherein the compressed and crimped yarn, after leaving the compression chamber, is conducted to a takeup reel or spool; and

FIG. 4 is a partially schematic side elevational view of the apparatus combination illustrating a modification in which the compressed and crimped yarn is directly deposited into a canister.

Referring first to FIG. 1, a cylindrical casing 1 is welded to a steam inlet jacket 2 having annular wall 3 extending below the casing 1 to threadably receive a nozzle member 4 which contains a yarn entry passage 5 conically widening out at 6 to provide easy insertion of the yarn.

The jacket 2 with nozzle member 4 screwed into the extended wall 3 forms an upper annular chamber 7 and a lower annular chamber 8 which are connected for the passage of steam by the openings 9. The nozzle member 4 is secured against the wall 3 by means of a suitable sealing ring 10, and this nozzle member can be axially adjusted inwardly or outwardly of the casing 1. A steam feedline or conduit 11 is connected laterally to the upper chamber 7 of jacket 2 and can be provided with a cap nut 12 for connection to any suitable steam line (not shown) as the source of supply of saturated steam.

The nozzle member 4 with its yarn entry passage 5 extends into a flared opening of the casing 1 to provide a constricted annular steam passage 13 where the steam enters the casing from the lower annular chamber 8. The casing is axially bored, e.g. with a fitting bore or a profiled cross section, so that a tubular and preferably cylindrical sleeve 14 can be interchangeably installed and fixed in position by means of a threaded locking pin 15. The inlet end 14a of the tubular sleeve is preferably tapered to provide a continuation of the flared annular steam passage 13. This tubular sleeve 14 acts as the tubular acceleration channel or passage 16 having a substantially constant diameter.

Over the outlet end of the sleeve insert 14, a second tubular sleeve 17 is likewise interchangeably mounted and forms an expansion chamber 18. The cylindrical wall of this second sleeve 17 contains a number of steam discharge openings 19 which should be located at an interval of about 0.5 to 2 times the diameter of the chamber 18 from its inlet end, i.e. from the point of transition from the acceleration passage 16 into the expansion chamber 18. A sufficient number of these openings 19 must be provided to permit at least 50 percent and preferably 70 to 90 percent of the steam to be withdrawn laterally of the expansion chamber 18.

The upper end of the sleeve insert 17 is centered and held in place by means of a profiled cap or centering member 20 which fits onto the casing 1 is detachably fastened by means of bolts 21 onto a cylindrical jacket 22 welded to the casing 1.

Since it is possible to change both of the sleeves 14 and 17 to provide a suitable diameter D_1 of the acceleration passage 16 and the proportionately larger diameter D_2 of the expansion chamber 18, it is easily possible to vary the ratio D_1:$D$by appropriate choice of the inner and outer diameters of sleeve 14 and the inner diameter of sleeve 17. This ratio has a pronounced effect on the yarn properties so that by suitable choice of the diameters of these sleeves, one can strongly influence the quality of the yarn. If desired the upper or protruding end 14*b* of the sleeve 14 can be flanged or may have an annular shim or collar fitted around it to conform with a larger inner diameter of the sleeve 17. These and similar modifications can be easily accomplished to achieve a suitable construction or fitting of parts in the apparatus.

The casing 1 and sleeve insert 17 form an inner annular space 23 while the casing 1 and the jacket 22 form an outer annular space 24, both of these spaces being in fluid connection by means of relatively large openings 25 in the casing wall. The outer space 24 is also in fluid connection with a steam discharge line or conduit 26 which serves as an exhaust line for the steam.

On the profiled or recessed upper face of the centering member 20, there is inserted an elongated cylindrical tube 27 which provides a compression chamber 28 which together with a short central bore 20*a* in the centering member becomes attached as an extension of the expansion chamber 18. The compression chamber 28 thus has approximately the same diameter as the expansion chamber 18 or may be just slightly larger to accommodate the yarn as it is compressed therein. A protective tube or jacketing member 29 is threadably engaged with the centering member 20 and extends concentrically around the elongated tube 27. At the free or upper end of the protective tube 29, a second centering member 30 is constructed to engage both of the tubes 27 and 29 and is securely installed by means of a bayonet or slide lock with two locking pins 31. A central bore 32 in the second centering member 30 serves as the outlet or discharge end of the compression chamber 28.

In FIG. 2, the same apparatus as shown in FIG. 1 is modified only to the extent that it has a second means of discharging steam which may also serve to introduce hot air near the outlet end of the compression chamber. In this case, there is a slight modification in the structure of the free or upper ends of compression chamber tube 27 and the protective tube or jacket 29. A tubular insert 33, flanged outwardly at either end, is carried within the protective tube 29 as a centering extension of the cap 30, i.e. being suitably recessed at its lower end to receive the compression chamber tube 27. This flanged tubular insert 33 together with the protective tube 29 forms an annular space 34 which is in fluid connection with the outlet of the compression chamber through the openings 35 while also being in fluid connection with the larger steam discharge or air input conduit 36 welded to the wall of the protective tube 29. The upper cap 30 again serves as a locking member connected to the protective tube 29 to prevent any axial displacement of the flanged insert 33.

FIGS. 3 and 4 taken together with FIGS. 1 and 2 provide a more detailed explanation of the process of the invention. It will be noted that the jet-operated compression crimping device 37, as generally illustrated in FIGS. 3 and 4 may be in a vertical position with the yarn traveling either upwardly or downwardly therethrough. Other positions are also feasible since the propulsion of the yarn and its crimping are self-contained within the crimping device.

In FIG. 3, the initially uncrimped yarn as a compact bundle of filaments is withdrawn from a supply bobbin 38 over a rotating balloon path 39 to a thread guide 40 located over the bobbin. A pair of feed rolls 41 conducts the yarn in the direction of the arrow A into the yarn entry passage or nozzle of the crimping device 37. After the yarn has been crimped and heat set, it is withdrawn in the direction of the arrow B through the transporting rolls 42 so that the finished yarn 43 can be taken up by a suitable winding mechanism 44.

In FIG. 4, the yarn is initially supplied downwardly from bobbin 38 over the balloon path 39, through thread guide 40 and into the crimping device 37 by means of feed rolls 41. In this instance, the crimped and heat set yarn 43 is deposited directly into a canister or pot 44.

Referring again to FIGS. 1 and 2, the uncrimped yarn or compact bundle of filaments is initially funneled into the yarn entry passage 5 where it emerges into the acceleration passage 16. The steam employed as the propellant gas or vapor enters the device in the direction of the arrow C, i.e. through inlet line 11, passes through the upper annular chamber 7 and into the lower annular chamber 8 through openings 9. The velocity of the steam is then substantially increased as it passes through the constricted passage 13 surrounding the yarn entry passage 5. The axial movement of the threadably engaged nozzle member 4 permits a variation in the annular cross section of the steam passage 13 so as to accurately adjust the velocity of the steam.

The steam then conducts or propels the yarn rapidly through the acceleration passage 16 into the expansion chamber 18. At this point, the steam suddenly expands and the yarn opens up with an increase in its volume. After the steam flows only several millimeters from the point of entry from the acceleration passage 16 into the expansion chamber 18, a major proportion is discharged through the lateral openings 19. The number and arrangement of these openings can be varied in different interchangeable sleeve inserts 17 so as to adjust the proportion of steam being withdrawn laterally at this point.

Thus, from these steam discharge openings 19, the greatest part of the steam flow is drawn into the inner annular space 23, then through the passages or openings 25 into the outer annular space 24 and finally outwardly over the steam discharge line 26 in the direction of the arrow D. It is especially advantageous to connect this steam discharge line 26 with a low pressure source, e.g. a vacuum pump (not shown). This permits a larger pressure drop over the expansion chamber 18 and a more efficient withdrawal of the bulk of the steam.

By reason of the high kinetic energy imparted to the yarn by the steam jet, the more open or expanded yarn continues to move axially of the device into the compression chamber 28 where it is deposited with a random three-dimensional configuration of the individual filaments. Under the influence of wall friction, the yarn is stuffed and collected temporarily in the relatively elongated chamber 28 where it becomes more densely compressed and strongly crimped. At the same time, the steam serves to heat set or fix this crimp during the retention time of the yarn in the crimping chamber. The column of crimped yarn which builds up in this chamber 28 is steadily pressed therethrough by the force of subsequently introduced yarn and then emerges from the open or free outlet end of the compression chamber in the direction of the arrow B. The minor proportion of the steam also passes through this chamber and flows from the open end of the compression tube in the direction B when using the embodiment shown in FIG. 1.

If a yarn having a very low moisture content is desired, then the residue or minor proportion of the steam flowing through compression chamber 28 is preferably drawn off laterally shortly before the open or free outlet end of compression tube

27, e.g. by means of the arrangement shown in FIG. 2. In this case, the steam passes laterally through the discharge openings 35 into annular space 34 and then outwardly through the steam discharge line 36 in the direction of the arrow E. Again, it is advantageous to connect this steam discharge line to a low pressure or vacuum source (not shown).

A crimped yarn with a very low moisture content can also be achieved in an alternative manner by connecting a hot air source to the conduit 36 and injecting hot air into the outlet end of the compression chamber 28 in the direction of the arrow E' as shown in FIG. 4. Furthermore, a reduction in moisture content can be achieved merely by indirectly heating the compression chamber 28 in an conventional manner, e.g. by using the protective tube 29 as a heating jacket with a heat exchange fluid being introduced into the annular space surrounding the compression chamber tube 27. A more localized heating, e.g. towards the outlet end of the tube 27, can also be accomplished by means of suitable electrical resistance heating elements wrapped around the tube 27 within the protective tube 29. Such heating means have not been illustrated in detail since their general applications are well known.

It will be evident that the particular construction of the apparatus as presented in the various embodiments of the drawings can be easily modified in many different ways, especially as to the assembly or fitting together of individual parts, without omitting any of the essential features and limitations of the invention. Surprisingly, by using an elongated compression chamber of substantially constant diameter, one can avoid using a spring-urged constriction or gate at its outlet end because the frictional force exerted by the walls of this chamber is sufficient to cause a compression or stuffing effect on the yarn deposited therein. At the same time, it was surprising to find that the force of the expanded yarn being propelled into the compression chamber is sufficient to urge the stuffed yarn mass through this compression chamber even though the major proportion of the steam is withdrawn laterally from the expansion chamber. Moreover, when using the apparatus of the invention, it is possible to achieve much better yarn properties, a result which is believed to be at least partly due to the greatly reduced quantity of steam proceeding through the compression chamber and the much lower moisture content of the crimped yarn. Finally, operating temperatures and pressures are generally lower, and the process can be efficiently carried out with ordinary saturated waste steam.

The following examples serve to illustrate the application of the apparatus and process of the invention to a specific synthetic yarn, it being understood that other well-known thermoplastic multifilament yarns are equally useful for such a crimping effect as clearly taught by the prior art.

EXAMPLE 1

For the production of a crimped carpet yarn of polyamide (nylon 6) filaments with a total yarn size of 3420 denier (380 tex), a texturing device was used which corresponded to that shown in FIGS. 2 and 4 of the drawings, but in which the delivery mechanism 41 shown in FIG. 4 was not used. The dimensions of the apparatus were as follows:

Diameter of the acceleration passage 16 1.5 mm.
Inside diameter of sleeve insert 17 6.0 mm.
Diameter of the compression chamber 28 6.0 mm.
Number of steam discharge openings 19 in insert 17 16
Diameter of the steam discharge openings 19 1.3 mm.

At a steam pressure of 2 atmospheres gauge and a steam temperature of 130° C., the injector nozzle was operated to draw off the initial yarn under a thread tension of 12 grams and at a linear velocity of 360 m./min.

Approximately 80 percent of the steam passing through the acceleration passage 28 was withdrawn laterally from the expansion chamber 18, the remainder of the steam continuing through the compression chamber 28 with the compressed yarn.

The yarn was collected in the canister 41 and exhibited a spiral crimp with 20 percent crimping contraction, a high volume and excellent crimp stability. From this yarn it was possible to produce a carpet material by the usual methods, for example by twisting and tufting.

EXAMPLE 2

For the production of a voluminous textured yarn from a bundle of polyamide (nylon) filaments with a total yarn size of approximately 3000 denier (330 tex) and with an individual filament size of 18 denier (2 tex), there was used a continuous crimping device as shown in FIGS. 2 and 3. The dimensions of the apparatus were as follows:

Diameter of the acceleration passage 16 2.0 mm.
Inside diameter of sleeve insert 17 6.0 mm.
Diameter of the compression chamber 28 6.0 mm.
Number of steam discharge openings 19 in insert 17 24
Diameter of the steam discharge openings 19 1.3 mm.

The running speed of the feed rolls 41 amounted to 100 m./min., that of the second transporting rolls 42 amounted to 90 m./min., and that of the winding mechanism 43 amounted to 80 m./min. The injector nozzle was operated with steam (1.7 atmospheres gauge, 125° C.). Steam was withdrawn through lines 26 and 36 with approximately 80 percent of the total steam input at 11 being discharged through line 26.

The crimped and heat-set yarn produced in this manner was distinguished by a very high volume, very good crimping stability and a crimping contraction of 20 percent.

We claim:

1. A process for the continuous compression crimping and heat setting of a synthetic thermoplastic multifilament yarn which comprises:

continuously propelling the initially uncrimped and compact yarn by a jet of steam through a tubular acceleration passageway having a substantially constant diameter of 2 to 4.8 times the diameter of said compact yarn;

passing the yarn and steam flowing therewith directly from said passageway into an expansion chamber having a diameter of from 8 to 22 times the diameter of said compact yarn while drawing off a major proportion of said steam through lateral openings in said expansion chamber arranged at an interval spaced from the inlet side of said chamber of 0.5 to 2 times the diameter of said chamber, thereby suddenly expanding the flow of steam and opening up the compact yarn with the individual filaments being spread apart;

depositing the spread-apart filaments in an elongated compression chamber arranged as a longitudinal extension of said expansion chamber, said filaments being crimped and forced through said compression chamber by the jet action of said steam;

passing the remaining minor proportion of said steam through said compression chamber at a temperature sufficiently high to heat set said filaments; and

withdrawing the crimped filaments at the outlet end of said compression chamber.

2. A process as claimed in claim 1 wherein the steam jet introduced into said acceleration passageway is saturated steam.

3. A process as claimed in claim 2 wherein the saturated steam is maintained at a temperature of about 120° C. to 145° C.

4. A process as claimed in claim 1 wherein about 70 percent to 90 percent of the steam flow is withdrawn laterally from said expansion chamber.

5. A process as claimed in claim 1 wherein the minor proportion of steam flowing through said compression chamber is drawn off laterally at a short distance from the outlet end of said compression chamber.

6. A process as claimed in claim 1 wherein hot air at a temperature of about 100° C. to 150° C. is injected laterally at a short distance from the outlet end of said compression chamber.

7. Apparatus for the continuous compression crimping and heat setting of a synthetic thermoplastic multifilament yarn which comprises:

an annular steam jet nozzle surrounding a tubular yarn entry passage with means to supply steam to said nozzle;

an interchangeable elongated acceleration tube of substantially constant diameter arranged to receive steam and yarn from said nozzle and entry passage for propulsion longitudinally thereof;

a separately interchangeable tubular expansion chamber concentrically mounted at the discharge end of said acceleration tube, said expansion chamber having a larger diameter than said acceleration tube and being provided with lateral openings for the discharge of steam therefrom, said openings being arranged at an interval spaced from the inlet side of said expansion chamber of 0.5 to 2 times the diameter of said chamber;

a steam discharge line in fluid connection with said expansion chamber through said lateral openings;

a tubular extension of said expansion chamber connected thereto and adapted to receive said yarn for compression crimping; and

means to collect the crimped yarn from the discharge end of said tubular extension.

8. Apparatus as claimed in claim 7 wherein the diameter of said expansion chamber is approximately 2 to 10 times the diameter of said acceleration tube.

9. Apparatus as claimed in claim 7 wherein the diameter of said entry passage is about 1.3 to 2.3 times the diameter of the yarn entering therethrough.

10. Apparatus as claimed in claim 7 wherein the diameter of said expansion chamber is about 4.5 to 7.5 mm.

11. Apparatus as claimed in claim 7 wherein the ratio of the cross-sectional area of the acceleration tube to the total cross-sectional area of the lateral openings in said expansion chamber is from about 1:3 to 1:60.

12. Apparatus as claimed in claim 7 wherein at least one of said steam jet nozzle and said tubular extension of the expansion chamber is provided with means for heating the same.

13. Apparatus as claimed in claim 7 wherein a fluid conduit is arranged at the discharge end of said tubular extension in fluid connection with the crimping chamber formed by said extension through a second set of lateral openings.

14. Apparatus as claimed in claim 13 wherein the diameter of said expansion chamber is approximately 2 to 10 times the diameter of said acceleration tube.

15. Apparatus as claimed in claim 14 wherein the diameter of said expansion chamber is about 4.5 to 7.5 mm.

16. Apparatus as claimed in claim 13 wherein said fluid conduit is connected to means for blowing hot air into said tubular extension.

17. Apparatus as claimed in claim 13 wherein said fluid conduit is a second steam discharge line.

18. A process as claimed in claim 1 wherein the yarn being treated has a total yarn size of about 1000—4000 denier.